DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPER 338

SPRINGS OF CALIFORNIA

BY

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1915

INTRODUCTION.

By W. C. Mendenhall.

In 1903 the United States Geological Survey began an investigation of the underground water of California, generally with financial cooperation on the part of the State. Since that year ten papers on the underground water of the State have been issued by the Survey, each representing an investigation that has been completed. The field work which is to serve as the basis for two additional papers has also been done and the reports are in preparation. Investigations have been begun in two other areas in the State and their results will eventually be assembled and published.

Since a period soon after the inception of the California work those responsible for its conduct have realized the desirability of a special study of the springs, particularly those which yield mineral waters and which are utilized to a greater or less extent by citizens of the State and by tourists as recreation and health resorts. It did not become practicable to begin this work until the summer of 1908, when Mr. G. A. Waring, who had assisted in some of the earlier California studies and had investigated for the Survey certain areas in southern Oregon and Washington, was assigned to the task of collecting and assembling the necessary data.

California, with an area of 158,000 square miles, is the second largest State in the Union. It exhibits wide geographic diversity, since it includes the lowest area in the United States—Death Valley, 276 feet below sea level—and the highest—Mount Whitney, 14,501 feet above the sea; and accompanying this geographic diversity there is a corresponding range in scenic effects, climate, and vegetation. The records obtained at meteorological stations in the Salton Sink indicate a maximum temperature of 130° in the shade, the highest of record within the continental United States. It is probable that minimum temperatures on the higher peaks, like Mount Whitney and Mount Shasta, approach the minimum within our boundaries. Rainfall records in the most arid sections of the southern deserts of the State represent the extreme of aridity in the United States, with averages of less than 3 inches per annum and periods of 12 months or more with only traces of rain, whereas the precipitation in northwestern California is very heavy, an annual average of close to 100 inches being recorded at a few stations in Mendocino and Del Norte counties.

The immensity of the area of the State has made the collection of the field data required for the report a task of considerable magnitude, though its diversity has added greatly to the interest of the work. In the original plan it was estimated that two years of field studies would prove sufficient. Mr. Waring succeeded in visiting the more important localities during this period, although some of his examinations were, of necessity, rather cursory. In midsummer, 1910, after the completion of the field work and the assembling of the greater portion of his data in manuscript form he was called by the Government of Brazil to take charge of general water-supply investigations in the northeastern arid portion of that South American republic. The task of reviewing, editing, and supplementing in some respects the results of his studies was thus unavoidably left to others. This task was rendered light by the systematic form in which Mr. Waring's material was left.

It was a matter of regret to Mr. Waring, as it has been to those associated with him, that the financial limitations which controlled his work made it impracticable to procure the large number of new analyses which are particularly important in a paper of this type, in which waters of unusual chemical characteristics are discussed. Such analyses as are available have been assembled from all possible sources and combined with those which were prepared especially in connection with this investigation. The result, although it is in some respects unsatisfactory, furnishes a basis for a general view of the characteristics of the spring waters and serves to permit their classification in a general way. Mr. Herman Stabler has reviewed the chemical data and rearranged and interpreted the available analyses.

It is hoped that the report, setting forth as it does the results of impartial observations upon one of the important present and more important prospective resources of the State, will prove of value to its citizens as well as to its visitors, and that the assembled material will not be without interest to physicians, chemists, geologists, and teachers who may have especial need for the information contained in the volume.

SPRINGS OF CALIFORNIA.

By GERALD A. WARING.

PHYSICAL FEATURES OF CALIFORNIA.

NATURAL DIVISIONS.

As a basis for the discussion of springs and spring waters of California a brief outline of the physical features of the State is here presented, together with a few notes on the character of the rocks and their structure. Such an outline will in a measure serve to explain the topographic and geologic maps (Pls. I and II, in pocket) and will indicate in a general way the relations of the facts shown on these maps to the various springs.

Five main physiographic provinces may be recognized in the State: (1) The Coast Ranges, (2) the Great Central Valley, (3) the lava-covered region of the northeast, (4) the Sierra Nevada, and (5) the southeastern desert region. Not all of these provinces are distinctly separated from one another; neither do they consist entirely of marked topographic or structural features; but they form fairly well-defined natural divisions that are convenient in discussing the general features of the State.

COAST RANGES.

The term "Coast Ranges" is used in the present paper to designate the system of mountain ranges between the Great Valley and the Pacific, to which the term "Coast Range" has been applied, with different limitations, by several geologists.[1] In general, these ranges lie approximately parallel to the coast, but in the areas of more complex structure a few trend in other directions. To the ridges or groups that make up the system many names have been applied. The range in the extreme northwestern part of the State, forming the divide between the Smith and Klamath River basins and the boundary between Del Norte and Siskiyou counties, is called the Siskiyou Mountains, and the mountains that extend eastward along the course of Klamath River are also considered a part of the Siskiyou Moun-

[1] See Fairbanks, H. W., Review of our knowledge of the California Coast Ranges: Geol. Soc. America Bull., vol. 6, pp. 73–75, 1894. Lawson has used the term "Coastal system" in speaking of the main portions of the Coast Ranges, in the report of the California Earthquake Investigation Commission (The California earthquake of Apr. 18, 1906, vol. 1, pt. 1, p. 5).

tains. To the south, trending in general east and west and forming the northern boundary of Trinity County, are the Scott Mountains. The Trinity Mountains, and, farther southwest, the Bully Choop and Yolla Bolly mountains, form the eastern boundary of the same county. In the southwestern part of Trinity County, along the eastern side of Mad River, are the South Fork Mountains. Farther south, in southern Humboldt County, an area of sharply cut ridges and canyons, locally known as the Wildcat region, forms part of the Mendocino Range. A similar system of ridges continues southward through Mendocino County, but the mountains forming this portion of the Coastal system are not known by a distinctive name.

The name Klamath Mountains was suggested by Maj. Powell as a general title for this group of ranges in the northwestern part of the State, and this name has been adopted by Diller [1] in his publications on the region. These mountains, generally speaking, are less than 5,000 feet in elevation, but the higher peaks of Scott and Yolla Bolly mountains are more than 7,000 feet above sea level. They are composed mainly of slates, schists, and granitic rocks of Triassic, Carboniferous, or, perhaps, earlier geologic age,[2] and of a younger series of altered sandstones and shales associated with cherts and schists that probably belongs to the Franciscan formation, which is believed to be either Jurassic [3] or Lower Cretaceous in age.[4] The Franciscan sedimentary rocks generally contain intrusive masses of serpentine and of basaltic material that usually has the character of a diabase. These intrusive rocks are so commonly present in the Franciscan that they may be regarded as characteristically associated with that formation, although they do not properly form a part of it. Granitic rocks and gneisses are also exposed among the altered sediments of the northern Coast Ranges and are thought to be in part intruded in the sediments. The sedimentary rocks throughout the Klamath Mountain region have been sharply folded, and their structure is intricate and complex, but it is not known in detail because only reconnaissance studies have been made of these rocks.

A few sulphur springs issue from the schists of this region, occasional salt springs yield flows of slight amount from the slates and shales, and a few small carbonated springs are scattered through the areas of granitic rocks.

In Mendocino, Lake, and Sonoma counties, south of the region that is considered to compose the Klamath Mountains, there are

[1] Diller, J. S., Tertiary revolution in the topography of the Pacific coast: U. S. Geol. Survey Fourteenth Ann. Report. pt. 2, pp. 404–405, 1894.

[2] Diller, J. S., op. cit., Pl. XLV.

[3] Branner, J. C., Newsom, J. F., and Arnold, Ralph: U. S. Geol. Survey Geol. Atlas, Santa Cruz folio (No. 163), p. 2, 1909.

[4] Lawson, A. C., The California earthquake of Apr. 18, 1906: Rept. State Earthquake Investigation Comm., vol. 1, pt. 1, pp. 7–8, 1908.

other irregular but lower ranges. Perhaps the most distinctive of these is the St. Helena Range, which forms the boundary between Lake and Sonoma counties. The northern and western ranges in these counties are composed largely of altered sedimentary rocks that probably belong to the Franciscan formation. Glaucophane schists and serpentine are associated with them. The age of other altered sedimentary rocks in this area has not been determined. Some geologists believe that they belong to the Franciscan formation, others believe that they are of Lower Cretaceous age and are a part of the formation known as the Knoxville from the type locality near Knoxville in Napa County, where they are well exposed. As both series of sediments are more or less altered they are not differentiated on the geologic map (Pl. II, in pocket).

In Napa County and the southern part of Lake County several peaks and ridges are formed of lava that is probably of Tertiary age. This lava overlies the altered sediments, and tuffaceous phases of it form prominent cliffs at a number of localities. Numerous carbonated springs of slight flow issue in this region north of the bay, both from the sedimentary rocks and from the lavas, and hot springs exist at several places. A few springs of noticeably sulphureted water have also been examined but are less numerous and less important than those of the carbonated type.

The Coast Ranges between San Francisco and Los Angeles in general trend nearly parallel with the coast. Among them are the Santa Cruz Mountains, which lie along the boundary between Santa Clara and Santa Cruz counties; the Diablo Range, which separates San Joaquin, and San Benito valleys; and the Gabilan Range, which lies between San Benito and Monterey counties. The Santa Lucia Range forms a mountainous region in southern Monterey and northern San Luis Obispo counties, and the Temblor Range is in eastern San Luis Obispo and western Kern counties. The San Rafael and Santa Ynez mountains are in Santa Barbara County and trend in a general northwest direction. In Ventura County, Pine Mountain and, east of it, the Topatopa Mountains, extend in general from east to west, as do the Santa Susana Mountains, in western Los Angeles County. The Tehachapi Mountains trend northeastward through southern Kern County, and although bridging the gap between the Coast Ranges and the Sierra are, because of their rock types and structure, properly regarded as belonging to the latter rather than to the former. Most of the Coast Ranges south of San Francisco Bay are only 2,000 to 3,000 feet in elevation, but the highest parts of the Tehachapi Mountains attain heights between 5,000 and 6,000 feet. For the most part these Coast Ranges south of San Francisco Bay are composed of unaltered sedimentary rocks of Cretaceous and Tertiary age, but considerable masses of the Franciscan formation persist southward from

San Francisco Bay, and granite is exposed at several points. Limestone and slate also outcrop at a few localities near the coast.

The rocks that make up these ranges are usually folded into anticlines (archlike folds) and synclines (inverted arches). They are also faulted in many places, so that their structure is complex. The deposits of oil and of natural gas in these ranges and about their borders are of great economic importance, and their occurrence is closely related to the structure of the rocks.

A few carbonated springs and some scattered sulphur and saline springs are found in the unaltered sediments. In the arid region in the southern part of the Temblor Range, along the southwest side of San Joaquin Valley, a number of surface springs that yield small amounts of water of poor quality are of local importance because they furnish watering places for travelers and for stock. The springs of chief geologic interest in this region are, however, thermal, and like the others they issue mainly from the unaltered sediments.

The representatives of the Sierran and Coastal systems south of the Tehachapi are not so clearly differentiated nor so readily recognized as in middle California. At the southern end of the San Joaquin Valley the Sierra swings westward as the Tehachapi Range, separating the Great Valley lowland on the northwest from the desert lowland on the southeast. Mount Pinos, the culminating point on the divide between the Cuyama, the San Joaquin, and the southern Santa Clara drainage systems, lies at the center of a mountain group in which Coast Range and Sierran characteristics are both displayed. Extending southeastward from this central point, the San Gabriel, San Bernardino, and San Jacinto mountain groups resemble the Sierra, while the Santa Monica and the Santa Ana mountains are properly regarded as of the Coast Range type. The Santa Ana Mountains, however, merge southward with the spurs of the San Jacinto and Santa Rosa groups, to form the Peninsula Range,[1] which extends southward through San Diego County and forms the backbone of the peninsula of Lower California. This range, although lower than the Sierra, closely resembles it in geologic and physiographic characteristics.

Moderate altitudes are attained in these southern groups. Mount Pinos is about 9,000 feet high; San Antonio and San Jacinto peaks, the culminating points respectively in the San Gabriel and the San Jacinto mountains, are each more than 10,000 feet in elevation; and San Gorgonio, the highest point south of the Sierra, in the San Bernardino Mountains, is nearly 11,500 feet above sea level. Those of the southern mountains which have been described as belonging to the Sierran type are composed mainly of granitic and

[1] Fairbanks, H. W., Geology of San Diego County: California State Mineralogist Eleventh Rept., p 76, 1893.

highly altered metamorphic rocks, although limestones and quartzites, only slightly altered, occur in considerable masses in the San Bernardino Mountains. The rocks in the Coast Range types of mountains, on the other hand, are usually slates, shales, sandstones, and conglomerates, ranging in age from Triassic to late Tertiary or Pleistocene. A fringe of these later sediments lies along the Pacific border of the Peninsula Range in San Diego and Orange counties, and a similar belt encircles and probably underlies the Colorado Desert at the eastern base of this range.

GREAT CENTRAL VALLEY.

The Great Central Valley of California, about 16,000 square miles in area, includes the Sacramento and San Joaquin valleys, and as its name indicates, it occupies a central position in the State. The north end of Sacramento Valley is near Redding, where, at an elevation of about 600 feet, the lowland along Sacramento River is about 10 miles wide. The valley increases in width southward to about 20 miles at Red Bluff and 40 miles at Willows, and it continues at approximately the latter width to Suisun Bay, into which the Sacramento discharges. The broad lowland continues southeastward from Suisun Bay as San Joaquin Valley. Its width is only about 30 miles in the northern portion, in the vicinity of Stockton, but increases to about 60 miles at Hanford. Thence it narrows again to its south end at the base of the Tehachapi Mountains, where the valley floor is about 1,200 feet above sea level.

The Sacramento Valley drains through Sacramento River and its tributaries into Suisun Bay and thence to the Pacific. The northern part of the San Joaquin Valley also drains out through San Joaquin River, but the more arid southern section is an inclosed basin. A low alluvial divide that is formed by the delta of Kings River separates the drainage of the southern half from that of the northern. The Tulare basin, whose lowest point is occupied by Tulare Lake, receives a part of the drainage from Kings River and all excess waters from the valley tributaries south of it. This fluctuating lake, which occasionally dries up entirely, is merely a great evaporating pan, from whose surface the excess waters from Kings, Kaweah, Tule, Kern, and other rivers pass into the atmosphere.

The only notable interruption in the surface continuity of the Great Central Valley is formed by Marysville Buttes, a volcanic mass in the central part of Sacramento Valley. The valley surface is almost entirely covered by alluvium, but unaltered fresh-water and marine sediments form most of its bordering slopes and outlying hills, although east of the middle portions of both the Sacramento and San Joaquin valleys the alluvium of the valley directly overlies the granitic and metamorphic rocks of the Sierra. Along the northeastern border of

Sacramento Valley there is a considerable area of lava agglomerate and tuff that has been described by Diller [1] as the Tuscan tuff. It is considered to consist of volcanic material that was deposited in fresh water and hence is shown on the geologic map (Pl. II, in pocket) as a sediment, but in some places it closely resembles a lava.

There are very few springs in the Great Valley. Sulphur water seeps out at a few places along stream channels, and salt water issues in perhaps three or four localities, while a few springs that are not noticeably mineralized issue along its eastern margin.

LAVA-COVERED REGION.

The lava-covered region forms an extensive area in the northeastern part of the State. Its western boundary is formed approximately by Sacramento River and by Shasta River, a tributary of the Klamath. The southern boundary extends nearly east and west past the southern base of Lassen Peak; the northern and eastern limits are beyond the boundaries of the State. The central and northern portions of the lava mass form a plateau that is between 4,000 and 5,000 feet in elevation. In the northeast the Warner Mountains reach an altitude of 8,000 feet; on the south Lassen Peak rises to a height of more than 10,000 feet; to the west Mount Shasta towers to an elevation of 14,380 feet. Practically all of this region is covered with lava, which is probably of Tertiary and later geologic age. In a few places there are lake-bed deposits of partly consolidated sands and clays, and areas of alluvium form occasional patches of meadow and valley land.

A number of hot springs issue in the eastern part of this lava region and in the neighborhood of Lassen Peak; in the western portion there are many carbonated springs; and in the western and central portions are several large cold springs.

SIERRA NEVADA.

The Sierra Nevada, the dominating physical feature of the State and one of the most imposing mountain groups of the United States, extends east of south from the southern base of Lassen Peak to Tejon Pass. In the main it forms a great single range which rises in a long gentle slope eastward from the Great Central Valley to its crest, and thence descends abruptly to the desert region at its eastern base. Although as a whole its western side forms a comparatively uniform slope that is known to geologists as the Sierran peneplain, in detail it departs far from the character of a plain. Numerous peaks form prominent irregularities, though their summits conform approximately to the mean slope of a peneplain. Deep canyons score this surface in a westward direction and further add to the ruggedness of its detailed character. In its northern section the crest of the range

[1] Diller, J. S., Geology of the Lassen Peak district: U. S. Geol. Survey Eighth Ann. Rept., pt. 1, pp. 422-424, 1889.

reaches an elevation of 9,000 to 10,000 feet and rises southward to its culmination in Mount Whitney, at an elevation of 14,501 feet. Thence the elevation decreases southward to Tehachapi Pass.

In its northern and western parts there are large areas of more or less extensively altered sedimentary and igneous rocks that have yielded a great amount of gold and are known as the auriferous series. These rocks are associated with intrusive granitic material that makes up the larger portion of the range. Lava of Tertiary age overlies a considerable area in the north, but farther southward the range is composed almost wholly of granites and allied rocks, whose massive and homogeneous character has caused it to weather into prominent barren, dome-shaped mountains.

A number of small carbonated springs issue in several general groups in the Sierra. There are also a few hot springs in isolated localities and a number of cold perennial springs that yield large flows.

SOUTHEASTERN DESERT.

The southeastern desert region of California consists of a number of detached mountains and ranges which are separated by arid valleys and by flat areas of desert alluvium. In the northern section the ranges trend in general north and south. The White Mountains, in the southeastern part of Mono County and northern Inyo County, and the Inyo Mountains, farther west, have this trend. Between Owens Lake and the eastern border of the State there are several approximately parallel ranges which also extend from north to south. The Coso Range, which lies southeast of Owens Lake, is composed mainly of granitic rocks, though lava covers a small area in its central part. The Argus and the Slate ranges, which lie farther east, are composed largely of granitic rocks and altered sediments, as is also the Panamint Range, which borders the western side of Death Valley. The Amargosa Range, on the eastern side of the valley, includes the Grapevine, Funeral, and Black mountains, whose rocks are mainly quartzite, altered limestone, and other altered sediments. The Kingston Range lies in the northeast corner of San Bernardino County, and appears to have the same composition as the desert ranges farther north. To the south, in San Bernardino, Riverside, and Imperial counties, are a number of isolated ranges that appear to bear little relation to one another. Most of these are composed of granitic material, others are largely quartzite and other altered sediments, and still others are of lava. Elevations of 3,000 to 10,000 feet are reached by most of these mountain masses, the highest points being in the White Mountains, which are but little lower than the Sierra, and in the Panamint Range, where Telescope Peak attains an elevation of 11,045 feet.

Among the valley areas the Colorado Desert, in the southern part of the State, and the Mohave Desert and Death Valley region farther north, are the principal subdivisions.

The Colorado Desert, an abandoned and dried-out portion of the valley of the Gulf of California, is a great basin whose sides slope gently to the lowest point, 273½ feet below sea level, in Salton Sink. The Mohave Desert is a broken desert area of indefinite boundaries, lying mainly between the southern Sierra, the San Bernardino Mountains, and Colorado River. Death Valley, lying north of Mohave Desert, in Inyo County, is one of many similar arid valleys in southeastern California and southwestern Nevada and is the lowest point on the continent, being 276 feet below sea level. There are relatively few springs in this southeastern region that are worthy of note, except as their scarcity gives all sources of water in desert areas peculiar value. A few hot springs in the northern portion are the ones of chief geologic interest, while several artesian springs in the Colorado Desert are of considerable economic value. There are also a few saline springs that are of interest, while many surface springs of slight flow are of local importance to travelers as watering places.

FAULTS.

Several of the principal structural features in the State are related to faults, and these features also appear to be the most prominent ones associated with the springs, especially the hot springs. Of the major fault lines that have been traced in the State the San Andreas fault forms one of the principal zones of displacement, and is the one along a portion of which the movement took place that caused the earthquake of April 18, 1906. As a structural feature it extends from Humboldt County southeastward a distance of 600 miles to the Colorado Desert, and is marked throughout the greater part of this distance by long, trough-like valleys and steep mountain slopes. Another great fault extends along the eastern base of the Sierra. Displacement that took place along a portion of it in 1872 produced the Owens Valley earthquake of that year. The San Jacinto fault extends along the western base of San Jacinto Mountains. Along it also displacement has taken place within recent years, the latest movement having caused the San Jacinto earthquake of December 25, 1899. Other fault lines are shown on Plate III (in pocket), and still others that have not been traced probably exist in the Sierra and the northern Coast Ranges. Their close relation to the hot springs of the State is shown on Plate III by the proximity of the springs to the fault lines, and the relation of the individual springs to fault lines is mentioned in their descriptions. This map was originally prepared for reproduction on a smaller scale, and the positions of a few of the symbols showing springs are therefore less accurate than those on Plate I.

NATURAL WATERS.

USE OF TERMS "MINERAL WATER" AND "PURE WATER."

No natural water is chemically pure, even rain water containing notable amounts of dust, ammonia, and, especially near the coast, of saline material. All natural waters may therefore be said to be mineral waters. The terms pure and mineral are often used, however, to indicate the suitability of a water for some particular use. For example, a water considered for a municipal or industrial supply is called "pure" if it does not contain objectionable amounts of foreign matter. As waters with a markedly mineral taste and all waters bottled and sold as drinking water, regardless of their mineral content, are customarily termed mineral waters, it follows that a mineral water may be so called because it is notably free from mineral or other foreign ingredients.

To a greater or less degree water dissolves practically every substance with which it comes in contact. Temperature and pressure and the presence of dissolved matter greatly affect the solvent power of water, tending to increase or to decrease it. As natural waters encounter many minerals in their journeys through and over the ground, nearly all waters contain many mineral substances, though comparatively few of these substances are present in relatively large amount. Furthermore, many waters are saturated with respect to some of the less soluble minerals, but a natural water that will dissolve no more of any mineral is rare.

MINERAL ANALYSIS OF WATER.

To make a mineral analysis of water is to determine the proportions of the various mineral substances it holds in solution. The analyst is unable to determine what chemical compounds have been dissolved by the water, nor can he ascertain by the customary methods of analysis, what compounds, if any, exist in the solution. His work is limited, in the main, to the determination, by indirect methods, of certain roots or portions of compounds, known as radicles. On account of the indirect methods employed some of the radicles reported in analyses can not definitely be stated to be such, but are merely conventional terms for expressing the results of some chemical reaction in which several radicles may have taken part. With all its uncertainties, however, the statement of a mineral analysis of a water is a representation of the composition of the water solution, and from this statement can be inferred with a considerable degree of accuracy much of the story of the water's journey through and over the earth, and the effects that may be expected in various uses of the water.

In conformity with the modern form of expression the analyses are presented in this paper in terms of the radicles, the proportions being expressed in parts per million by weight and parts per million of reacting value. The principal radicles reported are listed below:

Positive and negative radicles.

Positive.		*Negative.*	
Alkali:		Strong-acid:	
Sodium	Na	Sulphate	SO_4
Potassium	K	Chloride	Cl
Lithium	Li	Bromide	Br
Rubidium	Rb	Iodide	I
Cæsium	Cs	Nitrate	NO_3
Ammonium	NH_4	Weak-acid and hydroxide:	
Alkaline-earth:		Carbonate	CO_3
Barium	Ba	Sulphide	S
Strontium	Sr	Phosphate	PO_4
Calcium	Ca	Metaborate	BO_2
Magnesium	Mg	Arsenate	AsO_4
Miscellaneous:		Hydroxide[2]	OH
Hydrogen[1]	H		
Iron	Fe		
Manganese	Mn		
Aluminum	Al		

To the radicles should be added three other determinations—silica (SiO_2), and the gases carbon dioxide (CO_2) and hydrogen sulphide (H_2S)—which are not listed as radicles because they are generally believed to be present in water in the colloidal state, or as dissolved gases, and are customarily so reported. Under certain conditions, however, these three substances may also perform the function of radicles in the solution.

In the foregoing list the hydrogen radicle represents acidity due to an excess (in reacting value) of strong-acid radicles over basic or alkali radicles. The carbonate radicle in many of the analyses given in this paper represents merely alkalinity due to an excess (in reacting value) of basic radicles over strong-acid radicles.

The analyses presented have been taken from various sources, where they were expressed in several different forms. The most feasible method of unifying these statements with reference to carbonate and bicarbonate radicles and carbon dioxide was to report all carbonates and bicarbonates as the carbonate radicle. It may be assumed that where carbon dioxide is reported present, sufficient so-called "half-bound" carbon dioxide is present to warrant the reporting of all carbonates as the conventional bicarbonate radicle; that where carbon dioxide is reported absent, a mixture of carbonate and bicarbonate radicles is represented by the carbonate radicle; and that where carbon dioxide is not reported, either condition may exist.

[1] Hydrogen (H)=true acid radicle. [2] Hydroxide (OH)=true basic radicle.

SOURCE AND AMOUNT OF SUBSTANCES IN WATER.

In studying the springs of California certain kinds of mineralized water were noted as occurring constantly with certain kinds of rocks. For example, salt springs were noted in areas of marine sediments, strongly magnesic springs in areas of serpentine, the more noticeably iron-bearing waters in areas of crystalline rocks containing iron minerals, and the most siliceous waters in hot springs that rise through granites or acidic lava rocks. This is mentioned in describing the individual springs.

The probable sources of some of the constituents of natural waters are indicated in the following paragraphs:

Silica is present in most waters in relatively small amount, 50 parts per million being an unusually high proportion. It is considered to exist nearly always as colloidal silica (SiO_2), though the presence of a silicate radicle is indicated by some analyses. Silica is the chief constituent of the earth's crust and its relative insignificance in water is accounted for by the fact that it is only slightly soluble except in strongly alkaline solutions.

Iron and aluminum are widely distributed in nature, though much less abundant than silica. In most waters iron is present in greater proportion than aluminum, but the sum of both seldom exceeds 25 parts per million. They are only slightly soluble except in acid solutions and, as might therefore be expected, are most prominent in acid waters. A small amount of iron in water may cause rusty spots on clothes that are washed in it, and the staining of porcelain plumbing fixtures.

Manganese, barium, and strontium are relatively rare constituents of rocks and are seldom present in water in weighable amounts.

Calcium and magnesium are normally derived from feldspar and from magnesian minerals and are among the most abundant and widely distributed substances in nature. In most waters the proportion of calcium is two to five times that of magnesium, and where magnesium is present in relatively large proportion its source is usually evident in near-by magnesia-bearing rocks, mainly serpentine. Magnesium is also likely to exceed calcium in highly concentrated saline waters. These two substances cause the "hardness" of many waters, and are the main constituents of the hard scale deposited in cooking utensils and in steam boilers.

Sodium and potassium are not markedly different from calcium and magnesium in abundance and distribution in rocks. Their compounds, with few exceptions, are more soluble than those of calcium and magnesium, and they are therefore relatively abundant in the more highly concentrated waters. Both are probably derived mainly from feldspathic material. Although about equally prominent in rocks, sodium is present in waters in much greater proportion than potassium. Sodium is usually responsible for the foaming of steam boilers.

Lithium is considered a valuable medicinal constituent of water but in most waters is present in too small proportion to warrant quantitative determination. When present in relatively great proportion it is often calculated as the carbonate, chloride, sulphate, or bicarbonate, but 5.3 parts per million of lithium carbonate, 6.1 parts of the chloride, 7.9 of the sulphate, and 9.7 of the bicarbonate, each contain only one part per million of lithium. Dole [1] states that since the medicinal value is due to the lithium, not to its compounds, a person would need to drink 200 tumblerfuls of water that contains one part per million of lithium in order to take a medicinal dose of this substance.

Carbonates are prominent constituents of limestones and dolomites and are presumably derived primarily from the action of carbon dioxide as a carrier of calcium, magnesium, and sodium. Carbon dioxide is always present in the atmosphere and is dissolved in considerable quantity by water. Its presence in excess greatly increases the solubility of most of the weak-acid compounds that are the chief constituents of common rocks. The carbonates are the dominant negative radicles in most waters.

Sulphate is thought to be usually produced by the complete oxidation of sulphur. Sulphated aluminic waters may be produced by the oxidation of pyrite (an almost insoluble iron sulphide) in the presence of moisture, forming iron sulphate, which is soluble. Reaction with the clay of shales then results in an exchange of part of the iron for aluminum and magnesium. It is believed that calcic sulphated waters exchange their calcium for magnesium and sodium in a similar manner when they pass through rocks containing magnesium and sodium compounds. Free sulphuric acid is present in a few natural waters, and acts as a vigorous corrosive.

Sulphide radicles, of which several more complex forms than the simple sulphide exist in water, are probably derived in some waters from the partial oxidation of sulphur and in others from the reduction of sulphates, especially by means of organic matter.

Chloride radicle is present in nearly all waters, and, since the chlorides of the bases or alkalies found in water are very soluble, is a prominent constituent of nearly all very highly concentrated waters. The chloride radicle in waters is probably derived from the direct solution of sodium and magnesium chlorides.

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[1] Capps, S. R., Ground waters of north-central Indiana: U. S. Geol. Survey Water-Supply Paper 254, p. 251, 1910.

Bromide and iodide radicles are found in a few spring waters. They are usually present in saline waters that obtain their mineral contents from marine deposits but seldom in great proportion.

Ammonium and nitrate radicles are usually supposed to be derived directly from organic matter and therefore to indicate pollution, but they may be derived from salts produced by organic matter and hence may not be evidence of direct contamination. They are seldom present in mineral spring waters, as these usually issue from uncontaminated rock sources.

Phosphate radicle is uncommon in spring water, but it may be taken into solution from phosphate minerals, such as apatite.

Borate is also an uncommon constituent in water, but some springs contain it in large amount. It is usually accompanied by sodium and is probably derived from the solution of borax.

Boric acid is commonly present in volcanic emanations in many parts of the world, and as boron is a rare constituent of rock-forming minerals, the presence in areas of volcanic rocks of waters containing borate is worthy of especial note in connection with mineral springs.[1]

Arsenate is a rare constituent of water, though there are many so-called "poison" springs that are popularly believed to contain it. It is seldom present in measurable proportion, but the water of Owens Lake, in California, contains 83.8 parts per million [2] of the element arsenic. (See p. 304.) This is one of the largest amounts reported in a natural water, but it is in a water that contains more than 213,000 parts of solids per million; so if this water were diluted to a more nearly normal strength, of, say, 2,000 parts of solids per million, there would be less than one part per million of arsenic.

The source of carbon dioxide, the gas of the "soda-fountain" beverages, which is also a common dissolved gas in natural waters, has been the cause of much discussion. In many lava regions there are strongly carbonated springs, and the source of their content of gas is plausibly considered to be carbon dioxide that is occluded in the underlying rocks, for this gas is known to be one of the prominent constituents of the vapors that are given off by volcanoes during eruption. The source of carbon dioxide has been treated fully by Delkeskamp,[3] whose writings have been reviewed by Lindgren.[4]

Delkeskamp believes that to some extent the carbon dioxide may be derived from inclusions of liquid carbon dioxide in the quartz grains of granite and porphyries and be set free by crushing or heat. It is also probably generated in some places from limestone (calcium car-

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[1] See Gale, H. S., The origin of colemanite deposits: U. S. Geol. Survey Prof. Paper 85, pp. 3-9, 1913.

[2] Stone, C. H., and Eaton, F. M., A new analysis of the water of Owens Lake, California: Am. Chem. Soc. Jour., vol. 28, No. 10, pp. 1164-1170, 1906.

[3] Delkeskamp, Rudolph, Juvenile and vadose springs: Balneol. Zeitung, vol. 16, No. 5, Feb., 1905. Also other papers by the same author.

[4] Lindgren, Waldemar, Econ. Geology, vol. 1, No. 6, pp. 602-612, 1906.

bonate) and other carbonate rocks by the action of acids. The decomposition of organic matter also gives rise to carbon dioxide.

Hydrogen sulphide (the gas which gives the "rotten-egg" odor to sulphur waters) is believed to be sometimes derived by the action of organic matter on calcium sulphate, in the presence of carbon dioxide, and this seems to be a plausible source for it in many saline meadow and marsh waters. In hot alkaline waters it may be produced by the action of steam on metallic sulphides. When present in notable amount it is apt to cause corrosion, rotting, and discoloration of articles and fabrics left within its reach.

Organic matter is present in small amount in many waters and is probably derived from vegetable material in the surficial layers of soil. Several hypothetical compounds so derived, including crenic and apocrenic acids, have been calculated by chemists, but it is not certain that they actually exist. Beregin is a transparent, gelatinous, mucus-like substance, the product of certain algæ that grow in thermal sulphur springs and impart the odor and flavor of flesh broth to the water. These algæ are probably the peculiar feature of so-called chicken-soup springs.

Vegetable growths that are characteristic of certain classes of waters are found in many mineral springs. Perhaps the most noticeable of these are the varieties of algæ that live in warm and hot springs and especially in sulphur springs. The color and texture of the growths vary with the temperature of the water and the rapidity of the current, as well as with the variety of the organism itself. The following observations by Weed on the algæ in Yellowstone National Park illustrate this change.[1]

> The general sequence of colors is well illustrated by the occurrence of such growths in overflow streams with a constant volume, such as the outlet of the Black Sand [a spring in Yellowstone Park]. As the water from this spring flows along its channel it is rapidly chilled by contact with the air and by evaporation, and is soon cool enough to permit the growth of the more rudimentary forms which live at the highest temperature. These appear first in skeins of delicate white filaments which gradually change to pale flesh-pink farther downstream. As the water becomes cooler this pink becomes deeper, and a bright orange, and closely adherent fuzzy growth, rarely filamentous, appears at the border of the stream, and finally replaces the first-mentioned forms. This merges into yellowish-green which shades into a rich emerald farther down, this being the common color of fresh-water algæ. In the quiet waters of the pools fed by this stream the algæ present a different development, forming leathery sheets of tough gelatinous material with coralloid and vase-shaped forms rising to the surface, and often filling up a large part of the pool. Sheets of brown or green, kelpy or leathery, also line the basins of warm springs whose temperature does not exceed 140° F., but in springs having a higher temperature the only vegetation present forms a velvety, golden-yellow fuzz upon the bottom and sides of the bowl. This growth is rarely noticed in springs where the water exceeds 160° except at the edge

[1] Weed, W. H., *Formation of travertine and siliceous sinter by the vegetation of hot springs*: U. S. Geol. Survey Ninth Ann. Rept., pp. 657-658, 1899.

of the pool. If the basin is funnel-shaped * * * with flaring or saucer-shaped expansion, algæ grow in the cooler and shallower water of the margin, forming concentric rings of yellow, old gold and orange, shading into salmon-red and crimson, and this to brown at the border of the spring. Around such springs the growth at the margin often forms a raised rim of spongy, stiff jelly, sometimes almost rubber-like in consistency, and red or brown in color.

Crenothrix is a small filamentous plant that has a gelatinous sheath colored by ferric oxide. It grows especially in ground waters that contain considerable iron, and is probably the brown flocculent material that is found in some iron springs. It sometimes causes rusty stains on clothing, and when excessive it may clog faucets and pipes.

Sulphuraria is a slender green plant that secretes silica and grows in sulphur waters that have a temperature of less than 122°.

DEGREE OF CONCENTRATION OF NATURAL WATERS.

It is probable that none of the several ways of reporting water analyses conveys to the nontechnical person a clear idea how much solid matter is present in solution. The amount of any constituent stated in parts per million indicates the proportion, by weight, of the amount of that constituent to the solution. For instance, if the amount of calcium radicle is stated as 210 parts per million it is to be inferred that each million pounds of the natural water contains 210 pounds of the calcium radicle. To correlate this form of expression with better known values, it may be stated that one heaping teaspoonful of a substance dissolved in one gallon of water represents approximately 4,000 parts per million; a rounding teaspoonful, about 2,500 parts; a thimbleful, about 600 parts; and the amount that can be held on the point of a penknife, 10 to 20 parts. The minimum amount of solid material in solution that is perceptible to the taste varies greatly with the material, and to a less degree but notably with the individual. Experiments on taste sensitiveness have been made by Whipple,[1] and from his tables and from summaries by Dole[2] it appears that as small amounts as 2 or 3 parts per million of iron are distinctly perceptible to some people, while several times as much aluminum is barely so. The alkalies and alkaline earths are much less readily detected by the taste. About 200 parts per million of calcium and magnesium render a water noticeably "hard;" but it seems probable that the negative radicles (chloride, carbonate, and sulphate), rather than the positive ones, give the distinctive tastes to most mineral waters. About 250 parts per million of chloride renders a water distinctly "salty." Of the dissolved gases which occur in

[1] Whipple, G. C., The value of pure water, pp. 65-67, Wiley & Sons, New York, 1907.

[2] Capps, S. R., Ground waters of north-central Indiana: U. S. Geol. Survey Water-Supply Paper 254, pp. 237-239, 1910.

natural waters, 4 or 5 parts per million of hydrogen sulphide is unpleasant to some people.

The following three analyses of water from Lake Tahoe, California (which contains relatively small amounts of dissolved solids), of an average sample from Sacramento River above Sacramento (which is probably a fair sample of a slightly mineralized river water), and of ocean water show the general character of natural waters, both as to nature and amounts of dissolved solids.

Analyses of natural waters of different degrees of concentration.

[Parts per million.]

Constituents.	1		2		3	
	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	7.4	0.32	12	0.52	10,550	459
Potassium (K)	3.3	.08			381	9.7
Calcium (Ca)	9.4	.47	12	.60	412	20.5
Magnesium (Mg)	3.0	.24	6.7	.55	1,294	106
Sulphate (SO_4)	5.5	.11	18	.37	2,643	55.0
Chloride (Cl)	2.3	.07	7.0	.20	18,984	535
Bromide (Br)	....	....	....	....	65	0.8
Carbonate (CO_3)	28	.93	35	1.17	71	2.4
Silica (SiO_2)	14	.46	26	.86	....	....
	72.9	....	116.7	....	34,400	....

1. Water from Lake Tahoe, Cal. Analyst, F. W. Clarke. U. S. Geol. Survey Bull. 330, p. 122.
2. Water from Sacramento River above Sacramento, Cal. Average of 10 daily samples June 18–27, 1908, an average sample for the year. Total solids varied during the year from 80 in May 19–28 to 140 in Dec. 25–31. Analyst, Walton Van Winkle. U. S. Geol. Survey Water-Supply Paper 237, p. 32, 1908.
3. Ocean water. Mean of 77 analyses. Dittmar, Challenger Reports, Physics and chemistry, vol. 1, p. 204, 1884.

PROPERTIES OF MINERAL WATERS.

Practically all natural waters contain dissolved substances that give them both saline and alkaline properties. In some waters the saline properties are dominant, in others the alkaline, but seldom is one group of substance present to the exclusion of the other. In the following paragraphs some of the more important properties of water are briefly discussed. The properties of reaction are defined substantially as proposed by Palmer,[1] and are expressed in per cent based on reacting values, the sum of all properties (except tertiary alkalinity) being 100.

Salinity is a property of reaction such as is caused by the solution of strong-acid salts. (See table, p. 16.) Primary salinity is salinity such as is caused by the solution of strong-acid salts of the alkalies, chiefly sodium and potassium chlorides and sulphates; secondary salinity, by the solution of strong-acid salts of the alkaline earths, chiefly calcium and magnesium chlorides and sulphates; and tertiary salinity or persalinity by the solution of strong-acid salts of the

[1] Palmer, Chase, Geochemical interpretation of water analyses: U. S. Geol. Survey Bull. 479, 1911.

miscellaneous group of positive radicles, including iron and aluminum chlorides and sulphates, and free strong acids.

Alkalinity is a property of reaction such as is caused by the solution of weak-acid salts. Primary alkalinity is alkalinity such as is caused by the solution of weak-acid salts of the alkalies, chiefly sodium and potassium carbonates, sulphides, and borates; secondary alkalinity, by the solution of weak-acid salts of the alkaline earths; and tertiary alkalinity or subalkalinity[1] by the solution of weak-acid salts of the miscellaneous group of positive radicles, including "free" weak acids. Under this term are grouped the colloids silica, alumina, and iron oxide; the gases carbon dioxide and hydrogen sulphide; and other similar substances that occupy an unstable position in the water solution and which, under favorable conditions, may contribute to one of the other properties of reaction. Tertiary alkalinity, because of its rather indeterminate value, is not included in the summation of properties to the value 100 and is expressed as a per cent of the sum of all other properties of reaction.

Hardness is a property of the water solution caused by the positive radicles other than the alkalies. Hardness is the property that results in the decomposition of soap. Temporary hardness, which is dissipated by boiling, is measured by secondary alkalinity; and permanent hardness, which is not dissipated by boiling, is measured by secondary salinity and tertiary salinity.

Carbonated is a term applied to waters containing the gas carbon dioxide.

Sulphureted is a term applied to waters containing the gas hydrogen sulphide, or sulphureted hydrogen.

Odor in spring water is noticed chiefly in water from sulphur springs, where it is produced by hydrogen sulphide, which is a gas that has the odor of decaying eggs. The amount of this gas that escapes at some springs is so large that it is perceptible at a distance of hundreds of yards. A slight oily odor is perceptible in the water of a few springs, but the fishy and musty odors that are often noticeable in well waters are rarely present in spring waters.

Color is not nearly so common in spring waters as it is in stream and well waters. A very few strongly sulphureted spring waters have a clear greenish-yellow color that is probably due to complex sulphides in solution. The waters of white-sulphur springs may be opalescent or even milky from the finely divided white, allotropic form of sulphur in suspension; and the waters of blue-sulphur and black-sulphur springs are possibly tinted by other finely divided allotropic forms of sulphur or by very small amounts of iron sulphide in suspension.

[1] The terms persalinity and subalkalinity have been proposed instead of tertiary salinity and tertiary alkalinity, for tertiary salinity or persalinity represents more than salinity, being an acid property, whereas tertiary alkalinity or subalkalinity is less than true alkalinity.

Some spring waters are rendered opalescent or slightly milky by finely divided silica or calcium carbonate. A few spring waters are rendered black by iron sulphide in suspension.

Radioactivity is a property that is possessed by some waters, and it has been offered as an explanation of the curative virtues of some mineral springs. No acceptable proof of its healing value has been made, however, and it has been shown to be a property that is rapidly lost.[1] In connection with it may be mentioned the electrical or magnetic property that is claimed for some waters, chiefly well waters. Careful examination, however, has always shown that such property, if present, belongs to the well casing, not to the water, and is a magnetized condition that probably has been produced by the action of the drill used in sinking the well.

TEMPERATURE OF NATURAL WATERS.

The temperature of the water of many springs remains nearly constant throughout the year and practically coincides with the mean annual temperature of the locality. Springs that are fed by melting snow are of course noticeably below the normal temperature; others are considerably above it. Observations of the temperature in deep mines and deep borings indicate that in regions of comparatively uniform and undisturbed rock, below the first 50 feet (in which the underground temperature is affected by seasonal variation in temperature of the air), the temperature increases at the rate of 1° F. for about each 50 or 60 feet of increase in depth. In favorable localities this increment may be safely assumed in estimating the depth from which the heated water rises. In the greater number of places where thermal springs issue, however, this increment is valueless as a basis for estimating the depth from which the water rises. The high temperature of the water of most hot springs can usually be assigned to faults or displacements in the rock formations, to volcanic activity, or to chemical action, rather than to normal increase of temperature with depth. The rocks along fault zones are probably heated considerably above a normal temperature by the great pressure and friction that have been produced. Water from deep sources passes upward along these zones and is additionally heated by contact with the heated rocks. In some areas of volcanic rocks there are probably masses below the surface that have not yet cooled to a normal temperature, and they heat water which comes near them. Chemical reactions—notably the oxidation of pyrite—liberate heat and may increase the temperature of underground water.

[1] Schlundt, Herman, and Moore, R. B., Radioactivity of the thermal waters of Yellowstone National Park: U. S. Geol. Survey Bull. 395, 1909.

Temperature close to the boiling point is found in many springs. As the boiling point decreases with increase in elevation, and as the temperature of the water in several springs in California is at or near the boiling point although considerably below the usually assumed boiling temperature of 212° F., the following table of boiling points and approximate elevations is given. The boiling point also varies with the barometric pressure, but since a variation of one-quarter of an inch in the barometric pressure, which is extreme, causes a change of only about one-half degree in the boiling point, it is not of great importance. Solids in solution increase the boiling point slightly and gases decrease it, but both of these factors are negligible in nearly all thermal spring waters.

The assumption that an increase of 525 feet in elevation causes a decrease of 1° F. in the boiling point of water gives approximately accurate results.

Relation of boiling point of water to barometric pressure and to elevation.[a]

Boiling point.	Barometric pressure.	Approximate elevation.	Boiling point.	Barometric pressure.	Approximate elevation.
°F.	*Inches.*	*Feet.*	*°F.*	*Inches.*	*Feet.*
185	17.05	14,350	199	22.97	6,825
186	17.42	13,800	200	23.45	6,300
187	17.81	13,250	201	23.94	5,775
188	18.20	12,700	202	24.44	5,250
189	18.59	12,150	203	24.95	4,725
190	19.00	11,600	204	25.46	4,200
191	19.41	11,050	205	25.99	3,675
192	19.82	10,500	206	26.52	3,150
193	20.25	9,975	207	27.07	2,625
194	20.68	9,450	208	27.62	2,100
195	21.13	8,925	209	28.18	1,575
196	21.58	8,400	210	28.75	1,050
197	22.03	7,875	211	29.33	525
198	22.50	7,350	212	29.92	0

[a] Boiling points and barometric pressures taken from Smithsonian physical tables, 3d ed., 1904, p. 170. Approximate elevations computed from scale used on aneroid barometers, which gives an approximate rise of 525 feet in elevation for a decrease of 1° F. in the boiling point, up to 10,500 feet in elevation, and a rise of 550 feet for a decrease of 1° in the higher computed elevations.

CLASSIFICATION OF MINERAL WATERS.

Many plans for the chemical classification of waters have been proposed. These plans have in general been based on units of weight, and, since such units are obscure indices to chemical energy, the class names proposed convey little idea of the character of the water solution and amount to little more than an enumeration of the names of the radicles or supposititious compounds included in analytical statements. Palmer's classification [1] is a rational one, expressing the properties of reaction as percentages of their sum, and affords a serviceable key to the character of waters. In this paper, although any rigid numerical classification is scarcely warranted because many

[1] Palmer, Chase, loc. cit.

of the analyses presented are proximate only, the properties of reaction are nevertheless tabulated with each analysis to facilitate comparison.

THERAPEUTIC VALUE OF WATERS.

The use of mineral waters under the direction of competent physicians at mineral-spring health resorts and sanatoriums is attended by most beneficial results. It must be admitted that one of the chief sources of benefit is the change of habits—the throwing off of business cares, the relaxation, fresh air, and exercise—that usually accompanies the use of mineral waters at resorts. This change in itself, without the associated mineral-water treatment, is sufficient to accomplish many apparently wonderful cures. That the use and misuse of waters is accompanied by marked physiological effects is, however, well demonstrated. The cases of misuse have been among the most instructive examples in hydrotherapy and have given point to the lesson that medicines, whether administered as drugs or as mineral waters, should be taken under the advice of those who understand their physiological effects. Anderson [1] says:

> The indiscriminate use of mineral waters, either for drinking or bathing purposes, can not be too strongly condemned, for while they look bland and harmless, they are potent therapeutic agents which may accomplish much good if judiciously employed but may also do much harm and may be followed by serious if not fatal results in careless hands.

Crook [2] says:

> It may be said without fear of dispute that the most frequent as well as the most important component of a mineral spring is the water itself. Aside from its absolute necessity to the preservation of all forms of life, this agent possesses certain very important therapeutic properties.

Among these properties he mentions the activity of water as a diuretic. The copious use of water in many afflictions of the kidneys and genitourinary passages is therefore beneficial. Water tends to stimulate perspiration in warm weather, thus cooling the body and assisting in the reduction of fevers. The use of quantities of water also tends to increase intestinal activity and flush out the bowels. The foregoing passages indicate in a general way the value of water as a therapeutic agent, but for a complete discussion of the manifold functions of water in maintaining and improving the health of the human system, the reader should consult a physiological treatise.

The mineral substances in natural waters tend to augment or modify the effects of the water in which they are dissolved. The scope of this paper does not permit a detailed discussion of the

[1] Anderson, Winslow, Mineral springs and health resorts of California, p. 13, Bancroft & Co., San Francisco, 1892.

[2] Crook, J. K., The mineral waters of the United States and their therapeutic uses, p. 39, Lea Bros. & Co , New York and Philadelphia, 1899.

character and amount of these modifications. The following general notes on the subject are, however, presented. In preparing them free use has been made of the works of Gutmann,[1] Anderson,[2] Schweitzer,[3] Crook,[4] and Bailey.[5]

1. Alkaline waters, and especially waters characterized by primary alkalinity, are useful to correct acidity of the stomach and therefore alleviate certain forms of indigestion. Such waters have an augmented diuretic action and are used in the treatment of fevers, rheumatism, gout, vesical irritation, and diabetes.

2. Waters in which salinity, measured by the chloride radicle, is relatively marked stimulate the appetite and have a general stimulating effect on the organs of digestion, increasing the flow of the digestive juices. Waters in which salinity, measured by the sulphate radicle, is relatively marked have a cathartic effect; highly concentrated waters of this type are much used as purgatives. The salinity of waters also serves to augment their diuretic action. Acid waters are astringents and are useful in the treatment of relaxed conditions of the mucous membrane, especially when characterized by diarrhea and dysentery. Such waters are likely to contain relatively large amounts of iron and then are markedly tonic.

3. The free use of waters characterized by a high degree of secondary salinity and secondary alkalinity is believed to have contributed to the formation of calculi. For this reason water in which primary salinity or primary alkalinity is pronounced is generally to be preferred for use in the treatment of the kidneys or bladder. Waters containing lithium are generally supposed to be especially efficacious for such use, but a natural water containing sufficient lithium materially to affect its character is rare.

4. Waters slightly carbonated are of very common natural occurrence. The carbon dioxide not only serves to augment the solubility of many mineral substances, but gives the water an agreeable taste, aids the flow of saliva, and allays gastric irritation.

5. Sulphureted waters generally contain the sulphide radicles to which their value is believed to be in great part due. Under the name "sulphur waters" such solutions are widely used internally and for baths. Waters of this type are particularly valuable in the treatment of skin diseases, affections of the liver, and chronic malaria.

6. The concentration of mineral substances probably does not materially affect the character of their therapeutic action, but it

[1] Gutmann, Edward, Watering places of Germany, Austria, and Switzerland, 1880.

[2] Anderson, Winslow, Mineral springs and health resorts of California, San Francisco, Bancroft & Co., 1892.

[3] Schweitzer, Paul, A report on the mineral waters of Missouri: Missouri Geol. Survey, vol. 3, 1892.

[4] Crook, J. K., The mineral waters of the United States and their therapeutic uses, Lea Bros. & Co., New York and Philadelphia, 1899.

[5] Bailey, E. H. S., Special report on mineral waters: Kansas Univ. Geol. Survey, vol. 7, 1902.

determines the quantity of the water that should be drunk. It is generally believed, however, that the therapeutic action of a certain quantity of mineral is most effective when it is administered in a relatively large quantity of water.

7. Hot waters produce more notable effects than cold waters.

In regard to the temperature of waters used for bathing, it is known that a temperature as low as 66° F. reduces the bodily temperature about 2° within 10 or 15 minutes, reduces the frequency of the pulse, and produces a flow of blood to the brain, lungs, kidneys, and other internal organs; but after a cold bath of short duration a reaction takes place that causes the blood to return to the skin and the pulse becomes normal or even slightly quickened. Water 88° to 95° in temperature is considered to be indifferent in its effect on the body temperature, but baths at this temperature are considered of value in the treatment of nervous debility and sleeplessness. Hot baths accelerate the circulation, induce a flow of blood to the surface, and increase the quantity of blood in the superficial blood vessels, thereby causing congestions and profuse sweating. Such baths are beneficial in the treatment of partial paralysis and of rheumatic troubles. The high temperature is probably the main element of value in mud and sand baths, though the weight of the material may help somewhat.

ANALYSES OF CALIFORNIA SPRING WATERS.

SOURCES OF ANALYSES.

Most of the chemical analyses that are given in this report are taken from a book by Anderson,[1] who made analyses of most of the important springs of the State in 1888–89. A few earlier analyses that were made by Oscar Loew in connection with the Wheeler Survey[2] are available. A number of others have been taken from the reports of the California State Mining Bureau, and others have been obtained from advertising folders and from private files. A few analyses were made by Mr. F. M. Eaton, at Oakland, Cal., for use in this report.

The source of each analysis is given in the tables, so that the hypothetical forms may be consulted by those who wish. The following abbreviations have been used to indicate the principal references, and others are self-explanatory:

Wheeler report .... Wheeler, G. M., Annual report upon the geographical surveys west of the one-hundredth meridian, 1876.
Winslow Anderson .... Anderson, Winslow, Mineral springs and health resorts of California, 1892.

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[1] Anderson, Winslow, Mineral springs and health resorts of California, Bancroft & Co., San Francisco, 1892.

[2] Wheeler, G. M., U. S. Geog. Surveys W. 100th Mer. Ann. Rept., 1876, pp. 189–199.

6th Cal	Sixth report of California State Mineralogist, Sacramento, 1886 (similarly for the other reports).
U. S. Geol. Survey Bull. 32	Peale, A. C., Mineral springs of the United States: U. S. Geol. Survey Bull. 32, 1889. Similar indications are given for other publications of the Survey.
Advertising matter	Analysis obtained from advertising literature relative to the spring.
Owner	Analysis obtained from the files of the owner of the spring.

CONVERSION OF ANALYSES.

The tedious work of converting the analyses (most of which were originally expressed in hypothetical forms in grains per gallon) to ionic forms in parts per million has been largely done by Gertrude E. Goodman, to whom credit is due for reducing them to the standard form and thus rendering them available for comparison. In this work conversion tables prepared for the various salts by R. B. Dole from the atomic weights of 1897 (oxygen=16.00) have been used.

In amounts of less than 1 part per million by weight two decimals have in most analyses been retained; in amounts of 1 to 10 parts, one decimal; and amounts greater than 10 parts are expressed in the nearest unit. The totals by summation are given as a check on the other figures as well as to show the approximate total solid contents.

Where sodium and potassium are reported together in an analysis the reacting value has been calculated on the assumption that the figures given represent only sodium; similarly where calcium and magnesium or iron and aluminum are reported together the values are assumed to be all calcium or all iron.

The properties of reaction have in each analysis been made to aggregate 100 per cent without tertiary alkalinity, any excess from the other properties being combined with this property.

Temperatures are expressed in degrees Fahrenheit in the text and in both Fahrenheit and Centigrade in the analyses.

A few typographical errors have been corrected by comparing analyses that appear in two or more publications.

The notes concerning the principal characteristics of the waters, as shown by the analyses, have been made by Mr. Herman Stabler, who also calculated the reacting values and the properties of reaction.

Many of the analyses report only the most common substances, and a few contain questionable figures, but all are believed to show the general character of the waters and, in the absence of better analyses, are presented as furnishing the best information available concerning the chemical character of the springs. Two or more analyses of water from the same spring are given wherever they are available, as they afford valuable checks on unusually high amounts of certain substances. The widely differing results of analyses of water of the same spring by different persons may be ascribed to actual differences in the composition of the water at different times.

Analyses which were originally reported in grams per liter have been converted to standard form by assuming that 1 gram per liter is equivalent to 1 part per thousand. This assumption is true only when the specific gravity of the water under examination is unity. As the specific gravity is seldom stated in an analysis, errors from this source could not be corrected, but they are small. In an analysis of ocean water, for example, which has an average specific gravity of 1.026,[1] this assumption would make recalculated figures too large by about 2.6 per cent, but in less concentrated waters the error involved is much smaller. Other notes concerning assumptions that were made appear as footnotes to the several analyses.

CLASSES OF SPRINGS.

It was found impracticable to discuss the springs of California with any regard to order of importance, for this depends on the extent to which they are or may be improved. Some of the springs, most remarkable from the viewpoint of the geologist or the chemist, were in 1908–1910 unused, while those at several large resorts are of relatively minor scientific interest. A discussion based on either geographic or topographic arrangement was also considered impracticable, as it would bear no relation to the character of the springs. A strictly chemical grouping was not deemed advisable, because sufficient analyses are not available for that purpose, and also because according to such a classification, springs that are of different character according to the popular view, would be brought together. The plan of presentation adopted therefore has been determined by the most generally recognized characteristics of the springs and includes nine groups, which can not, however, be precisely defined, for some springs may be placed nearly equally well under two or more heads. The groups are characterized as follows:

1. Hot springs; temperature higher than about 90° F., or 20° higher than that customarily fixed as the dividing point between thermal and nonthermal springs.

2. Carbonated springs; contain notable amounts of free carbon dioxide.

3. Sulphur springs; contain notable amounts of hydrogen sulphide or other unstable sulphides.

4. Saline springs; contain notable amounts of chlorides or sulphates, or both.

5. Magnesic springs; contain large amounts of magnesium; brought together under one heading in order to call attention to their magnesic character.

6. Iron springs; deposit notable amounts of iron; grouped under one heading on account of this fact.

[1] Geikie, Archibald, Textbook of geology, 3d ed., p. 35, Macmillan & Co., London, 1893.

7. Springs of artesian origin; rise in valleys, yield fairly pure, warm water and differ in origin from most of the hot springs. In making this class, the customary grouping of the spring waters into thermal and nonthermal classes, with 70° F. as the division point, has not been followed. Some artesian springs have higher temperature than 70°, and some that are locally considered to be warm but are probably not of artesian origin have lower temperatures.

8. Large cold springs; springs of nearly constant flow, whose origin is considered to be somewhat different from that of the springs included in the next group.

9. Perennial springs; springs of perennial flow but essentially of surface origin, or "hillside" springs. It was impracticable to visit or to obtain descriptions of all of the many springs of this kind in the State. In the well-watered mountainous sections many comparatively large springs are of little interest because they are so numerous; in the arid districts small springs of similar character are of much greater importance. Although the list of perennial springs is by no means complete, attempt has been made to include those which are of sufficient importance to have received names; others which have not been considered of sufficient importance to indicate on the map (Pl. I, in pocket) are discussed more generally.

The foregoing classification is conceded not to be logical from the usual standpoint, that of the chemist; for relatively unimportant constituents, as carbon dioxide or hydrogen sulphide, may determine the heading under which a spring is discussed. It is considered justifiable, however, in order best to serve one purpose of this paper as a popular catalogue of the springs of California.

ORDER OF DISCUSSION.

As the hot springs are most important, because of the extent to which they have been improved as resorts and of their relations to the geologic structure, they are first discussed. Within this group the order is both geologic and geographic. Springs that issue in areas of granitic rocks, beginning in the south and proceeding northward, are first considered; then those in the older sediments of the northern part of the Coast Ranges, next the hot springs in the lava fields of the northeastern part of the State, and last those along the eastern front of the Sierra and in the desert area to the south. (See Pls. I and III, in pocket.) As Plate III was originally prepared for reproduction on a smaller scale, the positions of a few of the symbols showing springs are less accurate than those in Plate I.

The carbonated springs are described mainly in geographic order, beginning with the most prominent group and proceeding northward through the Coast Ranges, and then southward through the Sierra. (See Pls. I and III, in pocket.)

The sulphur springs, most of which issue in the Coast Ranges, are described in an order that takes partial account of their present importance by beginning with those north of San Francisco Bay and proceeding northward through the Coast Ranges, then considering those in the western part of the State, south from San Francisco, next those in the Siskiyous and the Sierra, and finally a few in the eastern desert region. (See Pls. I and III, in pocket.)

The more notable saline springs are taken up in geographic order beginning in the north. Saline springs and salt licks and desert alkaline springs worthy of special note are then considered, after which several magnesic springs and a few iron springs are described. (See Pl. I, in pocket.)

The artesian springs are discussed in geographic order, beginning in the south, where some of the most noteworthy rise; the large cold springs are taken up in order from the north, as the most important are found in that part of the State. (See Pl. I, in pocket.)

As the perennial springs have no distinctive features that warrant their separation into groups, they are taken up in geographic order, beginning in the north and proceeding southward through the eastern part of the State and then northward through the Coast Ranges. (See Pl. I, in pocket.)

In the order of discussion of the springs as well as their classification it was found impracticable to adhere strictly to definite rules. Although the arrangement does not permit consecutive numbering of the springs, the method of numbering by counties is believed to enable the position of any spring to be readily found on the map (Pl. I).

HOT SPRINGS.

ARROWHEAD HOT SPRINGS (SAN BERNARDINO 36).

Along the western base of the San Bernardino Mountains in southern California hot springs issue at several places. The largest group, Arrowhead Hot Springs, is situated on the granitic slopes about 7 miles east of north from San Bernardino and about 500 feet above the valley land. The approximate position of these springs is marked on the mountain side above them by an area of scanty vegetation in the shape of an arrowhead several acres in extent (Pl. IV, *A*). Indian legends associate this peculiar landmark with the springs, and the early immigrants also attached significance to the remarkable sign.

At these springs a hotel and baths were early erected. This hotel was burned several years ago and the present structure, a three-story building containing 90 furnished rooms, was completed about 1907. Very good bathing arrangements are provided and the place is easily reached by electric car from San Bernardino.

A. ARROWHEAD HOT SPRINGS, SAN BERNARDINO COUNTY.

C. PARAISO HOT SPRINGS, MONTEREY COUNTY.

B. ORRS HOT SPRINGS, MENDOCINO COUNTY.

D. WILBUR HOT SPRINGS, COLUSA COUNTY.

The springs form two groups situated about 400 yards apart. The upper group comprises perhaps half a dozen springs whose observed temperatures range from 110° to 145°. The water is confined in two concrete storage basins that are in part the foundations of the original bathhouse, and it is thence piped to the baths and to heating pipes throughout the hotel, which is about 200 yards southwest of the basins. The Palm Spring, on the mesa north of the hotel, is in this group. The second group lies in a ravine to the west and also comprises about half a dozen springs. Water from one of these is pumped to the storage basins at the upper group to augment the supply for the hotel. The hottest water is in the spring known as El Penyugal, in the lower group. This spring is surrounded by a concrete basin and the water is used for drinking. A temperature of 187° was recorded in the basin and in sampling for one of the analyses the basin was drained and a temperature of 202° registered. The spring discharges perhaps 15 gallons a minute. Granite Spring is on the mesa on the west side of Penyugal Canyon.

The total yield of the Arrowhead Hot Springs is hard to estimate, but it is probably not far from 50 gallons a minute.

Water from a cool spring, Fuente Frio, situated about a quarter of a mile north of the hotel, was placed on the local market as a table water during 1909. Agua Fria is the water of Cold Canyon, at the head of the pipe line leading to the main reservoir on the high mesa north of the hotel. Analyses of several of the springs are given on page 34.

WATERMAN HOT SPRINGS (SAN BERNARDINO 35).

About three-fourths mile west of Arrowhead Hot Springs smaller hot springs rise from fissures in the granite on the eastern side of Waterman Canyon. These springs have been used to some extent for bathing, but when visited in 1908 the accommodations had evidently not been kept in repair for several years and there was only a slight flow of water from a small marshy area and a pool beneath a bank at the creek side. An analysis of the water of the only spring that has been walled in is tabulated with analyses of the Arrowhead Hot Springs.

Analyses of water from Arrowhead Hot Springs and Waterman Hot Springs, San Bernardino County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5		6		7		8		9	
Temperature	Hot.		89° C. (193° F.).		94° C. (202° F.).		Hot.		70° C. (158° F.).		82° C. (180° F.).		Cool.		Cool.		70° to 93° C. (158° to 200° F.)	
Properties of reaction:																		
Primary salinity	86		93		89		86		82		82		50		42		82	
Secondary salinity	0		3		2		1		0		0		0		0		0	
Tertiary salinity	0		0		0		0		0		0		0		0		0	
Primary alkalinity	0		0		0		0		6		8		18		18		8	
Secondary alkalinity	14		4		9		13		12		10		32		40		10	
Tertiary alkalinity	47		21		30		42		26		27		18		71		23	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	313	13.6	291	12.6	289	12.6	315	13.7	254	11.0	222	9.65	35	1.52	15	0.65	249	10.8
Potassium (K)	Trace.	Trace.	31	.79	31	.79	10	.26	18	.46	11	.28	0.3	.01	1.2	.03	12	.31
Lithium (Li)	....	....	Trace.	Trace.	Trace.	Trace.	....	....	Trace.	Trace.	Trace.	Trace.	....	....	....	....	Trace.	Trace.
Barium (Ba) and strontium (Sr)	....	....	Trace.	Trace.	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Calcium (Ca)	44	2.20	16	.80	29	1.45	43	2.15	29	1.45	21	1.05	11	.55	5.0	.25	24	1.20
Magnesium (Mg)	Trace.	Trace.	2.1	.17	2.0	.16	Trace.	Trace.	1.4	.12	0.7	.06	2.1	.17	2.6	.21	0.6	.05
Iron (Fe)	Trace.	Trace.	....	....	....	....	Trace.	Trace.	....	....	....	....	....	....	Trace.	Trace.	....	....
Sulphate (SO_4)	542	11.3	548	11.4	532	11.1	565	11.8	424	8.83	360	7.50	15	.31	4.2	.09	402	8.37
Chloride (Cl)	81	2.28	85	2.40	90	2.54	78	2.20	65	1.83	55	1.55	29	.82	14	.39	63	1.78
Carbonate (CO_3)	66	2.20	18	.60	58	1.93	64	2.13	77	2.57	71	2.37	30	1.00	14	.47	67	2.23
Metaborate (BO_2)	....	....	....	....	6.4	.15	....	....	....	....	....	....	....	....	....	....	....	....
Silica (SiO_2)	224	7.43	85	2.82	99	3.28	205	6.80	91	3.02	73	2.42	16	.53	30	1.00	81	2.69
	1,270	....	1,076.1	....	1,136.4	....	1,280	....	959.4	....	813.7	....	138.4	....	86.0	....	898.6	....
Hydrogen sulphide (H_2S)	....	....	4.3	.25	8.5	.50	....	....	2.2	.13	2.3	.13	....	....	....	....	2.4	.14

1. El Penyugal. Analyst, Oscar Loew, 1876; Wheeler report, p. 193.
2. El Penyugal. Analyst, E. W. Hilgard; Crook, pp. 116–117.
3. El Penyugal. Analyst, G. E. Bailey, 1910; advertising matter.
4. Spring near hotel. Analyst, Oscar Loew, 1876; Wheeler report, p. 193.
5. Granite. Analyst, G. E. Bailey, 1910; advertising matter.
6. Palm. Analyst, G. E. Bailey, 1910; advertising matter.
7. Fuente Frio. Analyst, G. E. Bailey, 1910; advertising matter. (An earlier analysis of this water by Dr. Frederick Salathe is very similar.)
8. Agua Fria. Analyst, G. E. Bailey, 1910; advertising matter.
9. Waterman. Analyst, G. E. Bailey, 1910; advertising matter.

The analyses indicate that the hot springs of this group are about equal in concentration, the total mineral content being so high as to render the waters unfit for many uses but suitable for use medicinally. The waters are essentially primary saline in character, tertiary alkalinity, though not fully reported, being noteworthy. The differences with respect to primary alkalinity and secondary salinity are of interest but are not sufficient to affect materially the character of the waters. The cool waters are soft and only slightly mineralized. Primary salinity, primary alkalinity, and secondary alkalinity, though not fully reported, are prominent.

WARM SPRING IN LYTLE CANYON (SAN BERNARDINO 34).

About 13 miles in a direct line north of west from the Waterman Springs, in Lytle Canyon, a hot spring forms a pool in the creek bed. The water was at one time used for bathing and the place was known as Tyler's Bath. It is now unimproved, however, the flow is small, and the water is only about 90° in temperature. A qualitative test of the water from this spring was made in 1876 by Loew,[1] who found it to contain 568 parts per million of solids in solution.

WARM SPRING AT BALDWIN LAKE (SAN BERNARDINO 33).

Baldwin Lake is a small intermittent water body at the upper end of Bear Valley, in San Bernardino Mountains. In a marsh at the western end of the lake warm water rises in a pool about 20 feet in diameter and has been used to some extent for bathing, but as the flow is slight and the temperature of the water is only 88° it has not become important.

HARLEM HOT SPRING (SAN BERNARDINO 37).

Hot water formerly issued at Harlem Hot Spring on the alluvial slope about 2 miles below the base of the San Bernardino Mountains. A well casing has been sunk in the former spring and the water is pumped for bathing, and in summer for irrigation also. During periods following seasons of abundant rainfall the well overflows, but the water level usually stands a few feet below the surface. The property is beside an electric car line and is only a few minutes' ride eastward from San Bernardino. It has been made a recreation and picnic ground and the water supplies a swimming plunge and tub and mud baths. A partial analysis of the water, which has a local market as a table water, is tabulated beyond, with that of water from Urbita Hot Springs. Primary salinity is dominant in both waters.

[1] Loew, Oscar, U. S. Geog. Surveys W. 100th Mer., 1876, p. 196.

URBITA HOT SPRINGS (SAN BERNARDINO 38).

About 1 mile south of San Bernardino a recreation park known as Urbita Hot Springs has been built about a group of artesian wells that yield thermal water. This water supplies a swimming plunge, tub baths, and a small lake. The warmest well yields about 200 gallons a minute of mildly sulphureted water that is said to have a temperature of 106°. The following partial analysis shows that, like the water at Arrowhead and at Harlem springs, it is not highly mineralized, but small amounts of sulphur and iron constituents in the water cause it to stain the enameled bathtubs:

Analyses of water from Urbita Hot Springs and Harlem Hot Spring, San Bernardino County, Cal.

[Analyst, E. W. Hilgard. Authority, advertising matter. Constituents are in parts per million by weight.]

	Urbita.	Harlem.
Properties of reaction:		
Primary salinity	Dominant.	Dominant.
Secondary salinity	0	(?)
Tertiary salinity	0	0
Primary alkalinity	Small.	(?)
Secondary alkalinity	Small.	Small.
Tertiary alkalinity	Present.	Present.
Residue:		
Combined water	80	60
Soluble in water	310	260
Insoluble in water	25	90
	415	410
Portion soluble in water:		
Sulphate (SO_4)	133	144
Chloride (Cl)	21	10
Carbonate (CO_3)	42	16
Chiefly sodium (Na) and potassium (K)	114	90
Portion insoluble in water:		
Silica (SiO_2)	10	50
Calcium (Ca), magnesium (Mg), carbonate (CO_3) and sulphate (SO_4), chiefly calcium	15	40

As has been previously stated, the area along the western base of San Bernardino Mountains is a faulted zone. The issuance of hot water within this area therefore seems to be due to a fault or structural break in the granitic rocks, which allows deep-seated thermal water to reach the surface. The abnormal temperature of Harlem Hot Spring is possibly due to leakage into the alluvium of heated water that rises in the faulted zone. This may also be the source of the warm water at the Urbita wells, though there is a bedrock area 1 mile south of these thermal wells that may cause underground alluvial water to rise from a depth sufficient to account for its high temperature. Warm water is also obtained from other flowing wells in this locality. The sulphurous elements of the water from the Urbita wells are probably derived from material in the alluvium rather than from constituents in deep-seated hot water that may enter the alluvium.

FAIRVIEW HOT SPRING (ORANGE 1).

A warm spring or well at Fairview Hot Spring, in the coastal plain south of Santa Ana, resembles in occurrence the Harlem and Urbita springs. Originally the Fairview Spring was a natural flow, but a casing that was sunk to a depth of 700 feet into it has converted it into a flowing artesian well. In 1908 a hotel and cottages provided accommodations for about 50 people. The water rises with a temperature of 96° and supplies a swimming plunge and tub baths. The discharge varies somewhat with the season; in December, 1908, it was about 15 gallons a minute. An odorless, inflammable gas rises with the water and is burned for cooking and lighting. The water, which is colored brown, doubtless from organic stain, has been placed on the local market for table use under the label "Amberis Water." Although the water has a faint oily taste, it is thought to be essentially ground water that here rises through the deep alluvium which forms this part of the coastal plain. Its origin is probably not related to the shales of the oil-bearing series of southern California that form low hills a mile southward, except as these shales act as an underground dam that forces the alluvial water of the artesian basin of this region to the surface.

EDEN HOT SPRINGS (RIVERSIDE 8).

Along the western base of San Jacinto Mountains are several hot springs that have already been mentioned in their relation to the San Jacinto fault. At Eden Hot Springs, the northernmost group along this fault, about eight small springs rise within a distance of 100 yards at the base of a steep granitic slope. The water issues less than 200 yards beyond the southeastern border of a series of shales and sandstones of Tertiary age, in which there are dislocations that were probably caused by the uplift of the San Jacinto Range; but the springs seem not to be related causally to the sediments. The maximum temperature of the water is about 110°. It is moderately sulphureted but does not seem to be otherwise notably mineralized. During 1909 water from two of the springs was placed on the local market for table use under the labels "Iron Lithia" and "White Sulphur."

A small resort has been maintained at the place for a number of years. In 1908 cottages and tents provided accommodations for about 50 people, and a bathhouse and small swimming pool allowed use of the water for bathing.

SAN JACINTO HOT SPRINGS (RIVERSIDE 9).

San Jacinto Hot Springs, formerly known as Relief Hot Springs, are situated at the valley edge, 6 miles southeast of the Eden springs. About half a dozen springs here issue from a bank of granitic alluvium and form a marshy area several acres in extent.

The place has been a resort for more than 20 years, a frame hotel and cottages and tents forming a little settlement in a grove adjacent to the springs. Besides the usual tub baths there are mud baths that use material from the tule marsh.

The waters are sulphureted and they also taste distinctly alkaline. Efflorescent alkaline salts form in small amounts on the banks beside the springs, and the iron and sulphide contents cause the water to stain the towels and enameled tubs. The following partial analysis of the water that is used chiefly for bathing shows the general character of the water, though the several springs differ somewhat in chemical characteristics:

Analysis of water from Black Spring, San Jacinto Hot Springs, Riverside County, Cal.

[Analyst, E. W. Hilgard (?). Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	Dominant.
Secondary salinity	(?)
Tertiary salinity	0
Primary alkalinity	(?)
Secondary alkalinity	Prominent.
Tertiary alkalinity	Present.
Residue:	
Soluble in water	3,770
Insoluble in water	2,120
	5,890
Portion soluble in water.	
Sulphate (SO_4)	366
Chloride (Cl)	1,920
Carbonate (CO_3)	30
Metaborate (BO_2)	Trace.
Nitrate (NO_3)	Trace.
Sodium and potassium (Na+K), chiefly sodium	1,454
Portion insoluble in water:	
Silica (SiO_2)	20
Calcium (Ca), magnesium (Mg), carbonate (CO_3), and sulphate (SO_4), chiefly calcium	2,100
Hydrogen sulphide (H_2S)	Present.

The analysis indicates that the water is highly concentrated, is chiefly primary saline in character, and has secondary alkalinity as a prominent property. The water is unsuited for industrial or agricultural use.

RITCHEY HOT SPRINGS (RIVERSIDE 10).

Ritchey Hot Springs, about 5 miles southeast of the San Jacinto springs, are also situated near the base of the mountains, but they issue along the side of a ravine. Six springs, which range in temperature from 70° to 111°, furnish water for domestic use and irrigation. Although in 1908 the place had not yet been opened as a public resort, a few guests were taken care of during the summer, and several tubs were provided for bathing. In a tunnel that has been driven into the hillside for a distance of 55 feet a temperature of 82° was registered. This unusually high temperature has led to the use of the tunnel as a sweat chamber. Gypsum and efflorescent alum salts form on its walls and indicate that the tunnel water may be mineralized to a notable extent by acid constituents. There was formerly a sour spring in the ravine above the main group, but at the time the place was visited it either had been covered by a landslide or overgrown by vegetation.

Water from one of the springs was formerly marketed as a table water as "Soboba Lithia Water." Its sale was discontinued when interrupted by the high-water stage of San Jacinto River in 1904, but it was placed on the local market again in 1909.

The following analysis of this water has been published:

Analysis of water from "lithia" spring at Ritchey Hot Springs, Riverside County, Cal.

[Analyst, L. J. Stabler. Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	44
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	54
Secondary alkalinity	2
Tertiary alkalinity	18

Constituents.	By weight.	Reacting values.
Sodium (Na)	55	2.37
Potassium (K)	71	1.81
Lithium (Li)	Trace.	Trace.
Calcium (Ca)	1.7	.08
Magnesium (Mg)	Trace.	Trace.
Iron (Fe)	Trace.	Trace.
Aluminum (Al)	Trace.	Trace.
Sulphate (SO_4)	52	1.08
Chloride (Cl)	28	.79
Carbonate (CO_3)	72	2.40
Silica (SiO_2)	23	.76
	302.7	....

Primary alkalinity is the dominant property, and its high percentage is specially noteworthy. Primary salinity and tertiary alkalinity are also prominent, though the latter is not fully reported. The relatively high proportion of potassium is unusual and in the absence of confirmation by other analyses should not be given weight.

The ravine in which these springs issue is steep, with narrow, precipitous sides, and the rock exposed is largely a crushed gneiss. Recent landslide patches within it also indicate the broken and disturbed character of this area and furnish local evidence that the thermal character of the springs is due to crushing and slipping of the rocks.

PILARES HOT SPRING (RIVERSIDE 7).

In the channel of San Jacinto River, about 6 miles west of the base of the San Jacinto Range, warm water rises and forms a tule area several acres in extent. The water was formerly piped to a bathhouse on the higher land, but in 1910 a hut among the tules formed the local bathing place. Though the abnormal temperature of this water may be due in part to leakage of deep-seated hot water upward through the San Jacinto fault into the alluvium of the valley, it is more probable that a buried spur of a granitic ridge that here borders the valley acts as a dam and forces alluvial water to the surface from a depth sufficient to account for its temperature. A well that was drilled a couple of hundred yards west of the spring obtained a warm artesian flow.

PALM SPRINGS (RIVERSIDE 11).

At Palm Springs, at the southern base of San Jacinto Peak, a rise of thermal water tends to confirm the topographic evidence that faulting has taken place in this vicinity. The water, which has a temperature of about 100°, is used for bathing, and there is a small health resort here on the edge of the desert. These are the same springs that were formerly known as Aguas Calientes (hot waters), and the following partial analysis of the water was early made:

Analysis of water from Palm Springs, Riverside County, Cal.

[Analyst, Oscar Loew. Wheeler report (1876). Constituents are in parts per million.]

Temperature	38° C. (100° F.)
Properties of reaction:	
Primary salinity	77
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	23
Secondary alkalinity	Trace.
Tertiary alkalinity	?

Constituents.	By weight.	Reacting values.
Sodium (Na)	158	6.87
Lithium (Li)	Trace.	Trace.
Calcium (Ca)	Trace.	Trace.
Magnesium (Mg)	Trace.	Trace.
Sulphate (SO_4)	Trace.	Trace.
Chloride (Cl)	188	5.30
Carbonate (CO_3)	47	1.57
Silica (SiO_2)	Trace.	Trace.
	393	....
Hydrogen sulphide (H_2S)	Trace.	Trace.

MUD VOLCANOES (IMPERIAL 5).

About 7 miles south of west from Imperial Junction, in the alluvium on the eastern side of Colorado Desert, is an area in which vapor and hot water vents are numerous. They were submerged by the rise of Salton Sea[1] during 1905–1907, but they will become accessible again as the water subsides. They were early visited by Le Conte [2] and by Veatch,[3] who describe them as covering a space of about 350 by 500 yards in an area of blue clay slightly elevated above the desert surface. Vapor and hot water issued from numerous low conical mounds in this area, and from some of the vents water was formerly thrown to a height of 15 to 40 feet. Veatch reports that the water was strongly saline and had a specific gravity of 1.075. He also reported unmistakable evidence of free boracic acid in it. Small amounts of sulphur and of a salt that was considered by Le Conte to be sal ammoniac (ammonium chloride), were deposited around the vents, and small, coral-like stalagmites of lime carbonate were built up by the spray from several of the more active springs. In 1905, before their submergence by the rising water of Salton Sea, they had become much less active, and the locality contained only pools of hot water and boiling mud, with the usual vapors and sulphur and saline deposits that are characteristic of solfataric regions. There was a smaller group of extinct or at least quiescent craters about a mile southeast of the main group.[4]

These solfataras are near a row of knobs or small buttes of obsidian, pumice, and other varieties of volcanic rock which extend southwestward from a point about 6 miles west of Imperial Junction, and the presence of the hot waters probably represents a final phase of the volcanic activity that produced the lava knobs. Since the rise of Salton Sea these have become islets and have been made breeding places by pelicans.

A similar but more extensive group of mud volcanoes is found on the western side of Volcano Lake, in Mexico, near the base of the Cerro Prieto, about 20 miles south of the international boundary, and

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1 Salton Sea occupies the central part of Colorado Desert. Normally it receives only the occasional overflow from distributaries of this river, and it has been dry during a considerable portion of the last half century. In the spring of 1905 Colorado River during its flood stage greatly enlarged the intake of a canal which supplied irrigation water to a portion of Imperial Valley, and a large part of its discharge, and finally the entire stream flowed northward to Salton Sea or Salton Sink. Several attempts were made to close the break and stop the destruction that was being wrought in the valley, the river finally being forced back to its natural channel in February, 1907. Since the summer of that year the sea has been gradually subsiding as its water has been removed by evaporation.

2 Le Conte, J. L., Account of some volcanic springs in the desert of the Colorado in Southern California: Am. Jour. Sci., 2d ser., vol. 19, pp. 1–6, 1855.

3 Veatch, J. A., Notes of a visit to the mud volcanoes in the Colorado Desert in the month of July, 1857: Am. Jour. Sci., 2d ser., vol. 26, pp. 288–295, 1858.

4 Mendenhall, W. C., Ground waters of the Indio region, California, with a sketch of the Colorado Desert: U. S. Geol. Survey Water-Supply Paper 225, p. 14, 1909.

60 miles in a direct line south of east from the mud volcanoes near Imperial Junction.

A great fault extends southeastward through San Gorgonio Pass, which is eastward from San Bernardino, and this fault is believed to continue through Colorado Desert, where physiographic evidence of its existence is buried by the valley alluvium. If it does extend through the desert, it may have determined the presence of the small area of volcanic rocks near the mud volcanoes, and hence they may furnish evidence of more extensive geologic phenomena than the lava knobs.

GLEN IVY HOT SPRINGS (RIVERSIDE 3).

West of the San Jacinto Range another fault has been traced along the eastern base of the mountains that border Elsinore and Murrieta valleys. Heated waters rise along this fault zone at three localities. The most northern of these is at Glen Ivy Hot Springs, which was formerly known as Temescal Hot Springs.

One principal spring, having a temperature of 102° and yielding about 15 gallons a minute here issues at the mouth of a ravine in which fractured granitic and porphyritic rocks are exposed. Small warm springs issue at several other points for half a mile northward, but only the one spring is improved. Its water is sulphureted and slightly alkaline in taste but is not unpleasant.

The springs were early known to local settlers, but for a number of years they were in private hands, and more recently were the property of an automobile club. In 1908 the place was opened to the public. The improvements at that time consisted of a hotel containing 10 or 12 rooms, a swimming pool, dancing hall, and tennis court, all of which were situated in a grove overlooking the valley land.

ELSINORE HOT SPRINGS (RIVERSIDE 5).

Many small hot springs formerly issued along the northeast side of Elsinore Lake. In the early nineties, however, a canal was cut and the water of the lake was conducted northward for irrigation, and since that time most of the springs have ceased to flow. Hot sulphureted water is still obtained, however, from shallow wells. In 1888 a large bathhouse was built near the railroad depot; and in 1908 these baths were still supplied by water pumped from three wells that were formerly springs. A large swimming plunge and tub and mud baths were provided, while Lakeview Hotel, under the same management, furnished accommodations for about 100 people.

Partial analyses of water from two of the wells at this resort are tabulated on page 43.

BUNDYS ELSINORE HOT SPRING (RIVERSIDE 4).

Bundys Elsinore Hot Spring is the name of another resort, about 250 yards north of Elsinore depot. One well at this resort supplies warm sulphureted water for drinking and bathing, and a hotel and cottages provide rooms for about 75 guests. A partial analysis of this water is tabulated below, with the two from the Elsinore springs:

Analyses of water from Bundys Elsinore Hot Spring and Elsinore Hot Springs, Riverside County, Cal.

[Analyst, E. W. Hilgard. Authority, advertising matter. Constituents are in parts per million, by weight.]

	1	2	3
Properties of reaction:			
Primary salinity	Dominant.	Dominant.	Dominant.
Secondary salinity	0	0	0
Tertiary salinity	0	0	0
Primary alkalinity	Small.	Small.	Small.
Secondary alkalinity	Small.	Small.	Small.
Tertiary alkalinity	Present.	Present.	Present.
Residue:			
Soluble in water	220	225	203
Insoluble in water	95	65	90
Combined water and organic matter	15	50	40
	330	340	333
Portion soluble in water:			
Sulphate (SO_4)	55	80	45
Chloride (Cl)	17	35	52
Carbonate (CO_3)	60	26	26
Chiefly sodium (Na) and potassium (K)	88	84	80
Portion insoluble in water:			
Silica (SiO_2)	60	32	50
Calcium (Ca), magnesium (Mg), sulphate (SO_4), and carbonate (CO_3), chiefly calcium	35	33	40
Hydrogen sulphide (H_2S)	Present.	....	....

1. Bundys Elsinore Hot Spring. Temperature, 44° C. (112° F.).
2. Elsinore Hot Springs; original hot spring.
3. Elsinore Hot Springs; white sulphur spring.

These partial analyses show the waters to be very similar in concentration and properties. They are soft waters, chiefly primary saline in character.

It is said that previous to the construction of the irrigating ditch portions of the land near the present hot wells formed quagmires, but most of this saturated land has since become dry. Although the fault through this region is mapped as passing through Elsinore Lake, 2 or 3 miles southwest of the springs, the disturbed zone probably extends to the eastern edge of the valley and includes the locality where the heated waters now rise. The sulphureted character of the waters is possibly derived from beds of tule mud through which they pass before reaching the surface.

MURRIETA HOT SPRINGS (RIVERSIDE 6).

About 12½ miles in a direct line southeast of Elsinore, on the eastern side of Murrieta Valley, a third group of hot springs issues along the Elsinore fault zone. The locality is among rolling hills of granitic material, that are covered in part by gravels of Quaternary age. The heated waters, which are distinctly sulphureted in odor and taste, rise at the base of a gravel bluff, on the border of an open drainage course. Three springs that rise within 10 yards of each other, with a maximum temperature of about 136°, furnish an ample supply of water for the resort that has been built up. In 1908 a frame hotel afforded accommodations for about 75 people, and the hot baths were patronized largely for their efficiency in cleansing the system from alcoholic poisoning.

The principal spring is known as Siloam, and one of the others as Bethesda, while Ramona Spring is also near by. A small cooler mud pool at the base of the slope, some distance beyond the main springs, has been occasionally used as a foot bath, and one other cool spring of slight flow furnishes a wayside drinking place. The following analysis of the water of Siloam Spring was made a few years ago:

Analysis of water from Siloam Spring, Murrieta Hot Springs, Riverside County, Cal.

[Analyst, C. E. Wagner. Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		94
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		2
Secondary alkalinity		4
Tertiary alkalinity		35
Constituents.	**By weight.**	**Reacting values.**
Sodium (Na)	249	10.8
Calcium (Ca)	9.0	.45
Magnesium (Mg)	Trace.	Trace.
Iron (Fe)	[a] 3.6	.13
Sulphate (SO_4)	15	.31
Chloride (Cl)	364	10.3
Carbonate (CO_3)	20	.67
Silica (SiO_2)	[b] 47	1.57
	707.6	....
Carbon dioxide (CO_2) / Hydrogen sulphide (H_2S)	52	2.36(?)

[a] Reported as iron; recalculated from Fe_2O_3.
[b] Reported as soluble silicate; recalculated from SiO_3.

The analysis indicates that this water is essentially a solution of common salt in water containing the gases carbon dioxide and hydrogen sulphide.

JACUMBA SPRINGS (SAN DIEGO 19).

The southeastern portion of San Diego County is largely a rolling plateau-like granitic area. A few miles east of the divide that separates the coastal drainage from that of the Colorado Desert and within half a mile of the Mexican boundary are situated the Jacumba Springs. In 1908 the water issued at two main points near the channel of a small creek. Heavy rains in 1891 and slight earthquake shocks in 1892 and 1900 altered the position of the outlets to some extent, but the total yield, perhaps 15 gallons a minute, has remained about the same. The water is 96° in temperature, is slightly sulphureted, and is soft and excellent for laundry and bathing. A small ranch and supply store are situated here, and the location of the springs, together with the accommodations afforded, make the place a welcome camping spot for travelers between Imperial Valley and the coastal settlements.

The springs were formerly used by a group of Indians, who within recent years have made their camp near similar springs a few miles to the southeast across the Mexican boundary. They are said to designate their present springs as Jacumba and to call those to the north Jamati.

Though no extensive fault is mapped as passing near these springs, local faulting, which is indicated by the effect of earthquakes at this place, suggests that deep fracturing of rocks here permits the escape of thermal water. The springs are only half a mile beyond the southern boundary of a small area of lava, however, whose presence suggests another cause for the existence of thermal springs in this region.

WARNER HOT SPRINGS (SAN DIEGO 4).

Warner Hot Springs are situated on the eastern side of Warner Valley, near the base of Palomares Mountains in the northern part of San Diego County. Half a dozen or more vents here appear in a ravine and discharge about 150 gallons a minute of water whose maximum observed temperature is 139°. The place has long been known to the Indians and Mexicans as Las Aguas Calientes (the hot waters) and hence it has been sometimes confused by strangers with Palm Springs and with those in the valley of Vallecito Creek (San Diego 9, p. 46; Riverside 11, p. 40), which are also known as Aguas Calientes. For many years a band of Indians made their home here and their mortars for grinding acorns have been worn in the bowlders close to the springs. In 1904, however, the Indians were removed to the Pala Reservation and since that time a resort has been built up at the springs. In 1908 there were about 20 adobe cottages and an equal number of tents, the former Indian school building being used as a dining hall. The water was conducted to a wooden tank, where it was allowed to cool somewhat, and was thence piped to a bathhouse. An analysis of the water, which is noticeably sulphureted, follows:

Analysis of water from main spring at Warner Hot Springs, San Diego County, Cal.

[Analyst and authority, Curtis and Tompkins (1904). Constituents are in parts per million.]

Temperature	59° C. (138° F.)
Properties of reaction:	
Primary salinity	39
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	58
Secondary alkalinity	3
Tertiary alkalinity	40

Constituents.	By weight.	Reacting values.
Sodium (Na)	120	5.22
Potassium (K)	3.3	.08
Lithium (Li)	Trace.	Trace.
Ammonium (NH_4)	.50	.03
Barium (Ba)	0	.00
Strontium (Sr)	Trace.	Trace.
Calcium (Ca)	2.6	.13
Magnesium (Mg)	.29	.02
Iron (Fe) Aluminum (Al)	.42	.02
Manganese (Mn)	Trace.	Trace.
Sulphate (SO_4)	68	1.43
Nitrate (NO_3)	0	.00
Chloride (Cl)	26	.73
Bromide (Br), iodide (I), and fluoride (F)	0	.00
Sulphide (S)	25	1.62
Carbonate (CO_3)	26	.87
Metaborate (BO_2)	.64	.01
Arsenate (AsO_4)	0	.00
Phosphate (PO_4)	1.1	.03
Silica (SiO_2)	85	2.81
	358.85	....
Carbon dioxide (CO_2)	0	.00
Hydrogen sulphide (H_2S)	3.0	.18

The foregoing analysis contains a detailed report on substances for which often no test is made. The primary alkaline character of the water—alkalinity due largely to weak acid radicles other than the carbonate—and the appearance as primary alkalinity of constituents generally tabulated as tertiary alkalinity are of special interest.

The region is one of granitic rocks, and a fault that passes along the east side of Warner Valley has been recognized by geologists who have visited the locality. Warm springs of small flow issue at several places in the valley west of the springs and suggest that there is also leakage at these points from deep sources.

AGUA CALIENTE SPRINGS (SAN DIEGO 9).

In the valley of Vallecito Creek, 35 miles southeast of Warner Hot Springs, are small, unimproved warm springs known as Agua Caliente Springs. These are near the extension of the fault through Warner Valley, and possibly they issue along a continuation of this line of structural weakness.

AGUA TIBIA SPRINGS (SAN DIEGO 2).

Near the southern base of Agua Tibia Mountain and 25 miles in a direct line north of west from Warner Hot Springs, warm water (agua tibia), issues along a fault zone that is parallel to the one in Warner Valley. The water rises with a temperature of 92°, in a marshy area that covers perhaps an acre. It is conducted from a board-curbed pool to tubs in a near-by house, for bathing and laundry use. Bubbles continually rise in the pool and the water is distinctly sulphureted.

Analysis of water from main spring, Agua Tibia Springs, San Diego County, Cal.

[Analyst, M. E. Jaffa. Authority, owner of spring. Constituents are in parts per million, by weight.]

Temperature	33° C. (92° F.)
Properties of reaction:	
Primary salinity	Dominant.
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	Moderate.
Secondary alkalinity	Small.
Tertiary alkalinity	Present.
Residue:	
Soluble in water	326
Insoluble in water	51
Combined water and organic matter	33
	410
Portion soluble in water:	
Sulphate (SO_4)	100
Chloride (Cl)	70
Carbonate (CO_3)	36
Chiefly sodium (Na) and potassium (K)	120
Portion insoluble in water:	
Silica (SiO_2)	21
Calcium (Ca), magnesium (Mg), sulphate (SO_4), and carbonate (CO_3), chiefly calcium	30

This water is essentially primary saline in character, being a soft water of moderate mineralization.

DELUZ WARM SPRINGS (SAN DIEGO 1).

In the bed of Deluz Creek, near the northwestern boundary of San Diego County, warm water rises, which is slightly sulphureted and ferruginous. The thermal character of the springs has been assigned to the presence of a dike of dark, aphanitic diorite, about 6 feet thick, that cuts through the granitic country rock and crosses the creek at this point.[1] Three springs, 84° to 88° in temperature, here yield about 5 gallons a minute.

The water has long been used in rock-walled pools for bathing. In 1888–89 a small hotel was erected and opened as a resort, but heavy rains in the spring of 1890 washed out the railroad between Deluz station and the main line at Oceanside and the property was abandoned as a resort for a number of years. In 1908, however, it was reopened as a camping and rest resort and was improved to some extent.

SAN JUAN CAPISTRANO HOT SPRINGS (ORANGE 2).

Hot springs rise in San Juan Canyon, about 13 miles northeast of San Juan Capistrano. Like most of the hot springs thus far described, these also issue from granitic rocks and near the base of the steeper slopes of a portion of the coastal ranges. Two main springs, four minor ones, and several marshy patches are here situated on the western side of the canyon on slopes near the creek. The highest temperature recorded was 124°, and the total yield was estimated at about 35 gallons a minute. Other warm springs issue in a canyon half a mile westward. The water is slightly sulphureted, but, like the other hot waters of this region, it is not highly mineralized.

Analysis of water from main spring, San Juan Capistrano Hot Springs, Orange County, Cal.

[Analyst, Oscar Loew (1876). Authority, Wheeler report. Constituents are in parts per million.]

Temperature	49° to 51° C. (120° to 123° F.)
Properties of reaction:	
Primary salinity	46
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	54
Secondary alkalinity	Trace.
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Sodium (Na)	89	3.89
Potassium (K)	Trace.	Trace.
Lithium (Li)	Trace.	Trace.
Calcium (Ca)	Trace.	Trace.
Magnesium (Mg)	Trace.	Trace.
Sulphate (SO_4)	Trace.	Trace.
Chloride (Cl)	64	1.80
Carbonate (CO_3)	63	2.10
Silica (SiO_2)	77	2.55
	293	....

[1] Fairbanks, H. W., Geology of San Diego County: California State Mineralogist Eleventh Rept., p. 99, 1893.

The analysis indicates a slightly mineralized soft water, primary-alkaline saline in character.

These springs were formerly visited by the Indians, who built mud huts (temescals), for use as vapor-bath chambers. The springs are mentioned in the records of the Franciscan friars, who visited them when in charge of the mission at San Juan Capistrano. About 1885 two or three small buildings were constructed here, and the place also became a resort for campers as well as for the ailing. In 1908 the improvements consisted of a small hotel, bathhouse, and three cottages. There are ample camp grounds, and the place has been used mainly as a camping resort.

CALIFORNIA HOT SPRINGS (TULARE 18).

A number of hot springs in the Sierra issue from the granitic rocks that form the main part of the range. California Hot Springs, formerly known as Deer Creek Hot Springs, are situated about 35 miles southeast of Portersville. Four springs here issue at points 5 to 20 yards apart along the southern bank of Deer Creek Canyon, 20 or 30 feet above the stream bed. This group yields about 35 gallons a minute of water 120° to 126° in temperature. Half a mile upstream on the northern side of the creek, another group of one main and two minor springs discharges about one-third as much water at a temperature of 105°. All of the springs are noticeably sulphureted, but they are not highly mineralized.

Within the last few years a company of investors had made extensive improvements here. In 1908 a frame hotel and annex provided accommodations for about 100 people, and small cottages and tents erected in an ample camp ground near by have sheltered several hundred people at one time. Water from the upper springs, which are the only ones that were originally available, is piped to a tank, and thence to the baths and grounds for a cool water supply, while pipes from the lower group conduct the hot water about 275 yards to baths near the hotel. The springs of the lower group are also used to some extent for drinking, and are now easily reached by a footbridge and a path along the canyon side.

The springs issue from seams in coarse-textured gray granitic material, which is the country rock of this region. Although no large fault is recognized at this locality, other faults have been traced in this portion of the Sierra, and it seems probable that at least local fracturing has afforded escape to deep-seated water at this point. An analysis of what is locally known as the House Spring is presented herewith.

Analysis of water from House Spring, California Hot Springs, Tulare County, Cal.

[Analyst and authority, Curtis and Tompkins (1911). Constituents are in parts per million.]

Temperature	51° C. (124° F.).
Properties of reaction:	
Primary salinity	27
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	68
Secondary alkalinity	5
Tertiary alkalinity	63

Constituents.	By weight.	Reacting values.
Sodium (Na)	60	2.61
Potassium (K)	.92	.02
Lithium (Li)	.36	.05
Ammonium (NH_4)	.005	.00
Barium (Ba) and strontium (Sr)	0	.00
Calcium (Ca)	1.7	.08
Magnesium (Mg)	.19	.02
Iron (Fe), Aluminum (Al)	.77	.03
Manganese (Mn)	0	.00
Sulphate (SO_4)	5.5	.12
Nitrate (NO_3)	.31	.00
Chloride (Cl)	27	.75
Bromide (Br) and iodide (I)	Trace.	Trace.
Carbonate (CO_3)	55	1.82
Metaborate (BO_2)	3.6	.08
Arsenate (AsO_4)	1.7	.04
Phosphate (PO_4)	Trace.	Trace.
Silica (SiO_2)	54	1.78
	211.055	....
Carbon dioxide (CO_2)	0	.00
Hydrogen sulphide (H_2S)	0	.00

The analytical data show that the water is soft, only slightly mineralized, and primary alkaline in character. Tertiary alkalinity and primary salinity are noteworthy properties. The proportion of arsenate radicle is an unusual feature and should be taken into account in using this water.

HOT SPRINGS NEAR KERNVILLE (KERN 11).

The hot waters that rise at a number of places along Kern River suggest that the lower course of the river, as well as its upper portion, which is so mapped (see Pl. III, in pocket), may follow a fault zone.

About 2 miles northeast of Kernville, at the base of steep slopes on the eastern side of the river valley, warm water seeps out at several places, but the main point of issuance is in a small marshy area in an open cove on the valley side. A small frame bathhouse has been erected here and is used locally. The temperature of the water is about 103°, its flow is small, and it does not taste distinctly mineralized. The rock at this locality is a coarse-textured granitic gneiss whose planes of schistosity dip steeply eastward and strike parallel with the valley side.

A. KELLYS HOT SPRING, MODOC COUNTY.

B. DELONEGHA SPRINGS, KERN COUNTY.

C. THE GEYSER, PLUMAS COUNTY.

NEILLS HOT SPRING (KERN 10).

About 7 miles west of south from Kernville hot water rises near the center of Hot Spring Valley, about 1 mile east of the present channel of Kern River. Like several other hot springs in the State, this was known as Agua Caliente to the Spanish settlers, and has been referred to under this name in a few publications. There is a small seepage pool 75 yards from the main spring, but the entire flow is now from one vent. About 40 feet of well casing was sunk into this spring a few years ago, and the yield was thereby materially increased. The water, which has a temperature of 131° and a flow of about 115 gallons a minute, is used for domestic purposes and irrigation. The ranch house is a stopping place for travelers and is occasionally visited by people who wish to use the baths.

The water is noticeably sulphureted, and fragments of a white mineral, possibly magnesite, are said to have been brought up when the casing was being sunk.

The topography of Hot Spring Valley suggests that Kern River formerly flowed through it along the fault zone that is believed to exist here.

CLEAR CREEK HOT SPRINGS (KERN 9).

Hot water issues at three or four places among the bowlders at the southern edge of Kern River 200 yards below the mouth of Clear Creek. In 1908 the springs were seldom visited, but a few years earlier, during the construction of a power canal near by, they were made use of by the workmen for bathing and washing and became known locally as the Hobo Springs. The water is mildly sulphureted.

DELONEGHA SPRINGS (KERN 8).

At the western edge of Kern River, about 6 miles below the Clear Creek springs, is a group of three hot springs that are called after a prospector named Delonegha. These springs (Pl. V, *B*) issue a few feet above the river surface from crevices in fractured, massive granite. The water is distinctly sulphureted, but it does not seem to be otherwise notably mineralized. In 1908 there was a resort here, consisting of a small hotel and two bathhouses. The flow of two of the springs was collected in cement basins and used in the bathhouses, which were perched on the rocks above the river. The third spring issues too close to the river to be easily available.

DEMOCRAT SPRINGS (KERN 7).

At Democrat Springs, which are 5 miles below Delonegha Springs, hot water issues on the southwest side of Kern River, within 150 feet of its edge, but 50 or 75 feet above its surface. In 1908 there was a substantial hotel, having accommodations for 100 people, at this place. One spring, having a temperature of 115° and a flow of about 20 gallons a minute, furnished the supply for bathing. About 400 yards downstream from this spring, and near the hotel, a reservoir has been constructed around other warm springs. At a third place another small spring forms a drinking pool. The waters of these springs are sulphureted, but they do not seem to carry notable amounts of other mineral matter.

With reference to the fault origin of these springs it was learned that although the earthquake of April 18, 1906, was not severely felt here, the main spring ceased flowing at that time. It was reopened a few months later by making a cut into the slope about 8 feet below the former point of issuance of the spring.

WILLIAMS HOT SPRINGS (KERN 17).

At the north edge of Walker Basin, about 10 miles southeast of the canyon of lower Kern River, on the Williams ranch, is a group of small thermal springs. One spring, 97° in temperature, yields about 8 gallons a minute of water that supplies a private bathhouse, and another, 150 yards eastward, with a temperature of 75°, furnishes a domestic supply. There are several cool springs of small flow in the same locality, and half a mile westward other seepages form a meadow of several acres. The waters are distinctly sulphureted, but they are not otherwise noticeably of mineral character.

The rock at the springs and to the north and west is granitic and is cut by occasional quartz ledges. One-fourth mile south of the springs there is a belt of granitic gneiss whose planes of schistosity, where noted, are nearly vertical and strike eastward. These springs are near the southern end of a fault that is mapped as extending down the canyon of North Fork of Kern River. (See Pl. III, in pocket.) A probable explanation of their origin is thus offered by the fracturing that has taken place along this zone of displacement.

PARADISE SPRINGS (SAN BERNARDINO 9).

In the desert of western San Bernardino County there is an isolated group of thermal springs that may properly be described here. They are 25 miles by road north of Daggett and on the eastern slope of a granitic mountain. Two warm springs and a few seepages issue in a belt 250 yards long, on the side of a wide drainage slope that opens southeastward to the desert. The highest temperature observed was 102° and the total flow is perhaps 25 gallons a minute.

In the early emigrant days these springs were a favorite camping place for travelers, and the area of green in this stretch of desert earned them the name of Paradise Springs. The locality is still used as a camping place by prospectors, and in 1908 a 1½-inch pipe line extended from the springs southward and westward 2 miles to the Paradise Mountain gold mine.

The water issues on slopes 500 feet above the desert floor, but evaporation in the region is so great that a considerable alkaline deposit has formed at the springs. The water rapidly corroded the pipe leading to the mine.

A prospect drift exposes iron-stained graphic granite about 40 yards above the warmest spring, and there is a ledge of crumpled, quartzitic rock near by. It seems probable that these dikes or ledges may act as dams that here bring water to the surface from moderate depths, at a locality where intrusive rocks have produced an abnormal temperature gradient.

JORDAN HOT SPRINGS (TULARE 7).

All of the thermal springs that have been thus far described issue from granitic rocks, are not highly mineralized, and have not formed notable spring deposits. In the higher parts of the Sierra, however, hot waters that do contain considerable amounts of dissolved solids, issue at several places. Jordan Hot Springs, which are situated on a tributary of the upper Kern River, have formed prominent deposits of lime carbonate, the principal one of which is shown in Plate VIII, *B* (p. 124), and the water is noticeably hard. About 14 springs issue in a little flat along the banks of Ninemile Creek. Four of them have been excavated to form bathing pools, and several others are used as drinking springs. The water of the latter is distinctly carbonated, but that of the larger springs tastes mainly of calcium or sodium. The principal springs that are used range in temperature from 95° to 123° and yield from 1 to 10 gallons a minute.

The springs are named after the man who first blazed a trail across this part of the mountains, and although the locality is remote, there are usually parties of campers at the springs throughout the summer. A grove of trees and a convenient meadow make it a very good camping ground, and an old log cabin and rude tables show that it has long been a campers' resort.

In connection with the deposit of lime carbonate at Jordan Hot Springs may be mentioned a deposit of this material at Natural Bridge, about 10 miles in a direct line west of north from these springs, in an area of lava overlying granitic rocks. There are only a few pools of slightly carbonated water near Natural Bridge now, but springs of considerable size apparently issued there at a former time. On the eastern side of Kern River canyon, about 20 miles in a direct line west of south from the Jordan springs, there is also an extensive deposit of lime carbonate beneath a capping of lava. Cool springs of small flow issue along the slopes at this place.

Jordan Hot Springs rise through lime-cemented, granitic gravel, and the surrounding slopes are of granitic rocks. Three or 4 miles northward, however, there is some lava, and although it was not noted in the immediate vicinity of the Jordan springs, its presence near the lime carbonate deposits at Natural Bridge and in Kern River canyon suggests that the presence of carbonates or bicarbonates and free carbon dioxide in the water of Jordan Hot Springs is in some way related to lava rocks.

BLANEY MEADOWS HOT SPRINGS (FRESNO 5).

About 75 miles northward from the Jordan springs, in the canyon of South Fork of San Joaquin River, about a mile above the upper end of Blaney Meadows, three or four small springs issue on each side of the river and, like the Jordan springs, are used as a mountain camping resort. They have been dug out to form bathing pools. The water has a maximum temperature of about 110°, and the yield on each side of the river is perhaps 20 gallons a minute. The following is an analysis of water from the largest spring on the east side of the river:

Analysis of water from main spring (east side of river) at Blaney Meadows Hot Springs, Fresno County, Cal.

[Analyst and authority, F. M. Eaton (1909). Constituents are in parts per million.]

Temperature	48° C. (118° F.)
Properties of reaction:	
Primary salinity	71
Secondary salinity	24
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	5
Tertiary alkalinity	13

Constituents.	By weight.	Reacting values.
Sodium (Na)	198	8.59
Potassium (K)	2.4	.06
Calcium (Ca)	70	3.51
Magnesium (Mg)	Trace.	Trace.
Iron (Fe) Aluminum (Al)	2.1	.08
Sulphate (SO_4)	58	1.22
Chloride (Cl)	365	10.30
Carbonate (CO_3)	17	.58
Silica (SiO_2)	48	1.61
	760.5	....
Carbon dioxide (CO_2)	Present.	Present.

The water of the springs is characterized chiefly by primary salinity with secondary salinity as a subdominant property. The concentration is sufficient to render the water undesirable for many industrial uses, and its salinity is sufficient to be noticeable in taste.

The canyon is large and rugged and is cut through massive granitic material. At the springs a band of gneiss is exposed, whose planes of schistosity dip nearly vertically to the west and strike about N. 10° W. at a considerable angle to the canyon, which here trends about N. 75° E.

LOWER SPRINGS ON SOUTH FORK OF SAN JOAQUIN RIVER (FRESNO 4).

About 10 miles below the Blaney Meadow Springs, on the south side of the stream, another group of hot springs and seepages forms a considerable area of moist land on the slopes above the river. The four larger springs are used as bathing pools by campers who visit the place during the summer months.

REDS MEADOWS HOT SPRINGS (MADERA 6).

In the high Sierra east and southeast of Yosemite Valley are numerous meadows that are favorite summer camping places for those who enjoy the mountains. Reds Meadows, in the northeastern end of Madera County, is one of the chief of these, for it lies at the junction of trails that lead east to Mono Valley, and north, south, and west to other portions of the mountains. On the eastern side of this meadow several small thermal springs issue. A bathing pool has been made at the largest spring, in which a temperature of 120° was recorded. The pool is excavated in a small deposit of lime carbonate that has formed at the spring. The following analysis shows the character of the water:

Analysis of water from main spring, Reds Meadows Hot Springs, Madera County, Cal.

[Analyst and authority, F. M. Eaton (1909). Constituents are in parts per million.]

Temperature	49° C. (120° F.)
Properties of reaction:	
Primary salinity	12
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	53
Secondary alkalinity	35
Tertiary alkalinity	42

Constituents.	By weight.	Reacting values.
Sodium (Na)	140	6.09
Potassium (K)	6.4	.16
Calcium (Ca)	62	3.08
Magnesium (Mg)	3.3	.27
Iron (Fe), Aluminum (Al)	4.5	.16
Sulphate (SO_4)	36	.76
Chloride (Cl)	12	.35
Carbonate (CO_3)	243	8.10
Silica (SiO_2)	133	4.41
	640.2	....
Carbon dioxide (CO_2)	Present.	Present.

The analysis indicates water of moderate concentration in which salinity is relatively small, primary alkalinity, secondary alkalinity, and tertiary alkalinity all being prominent properties.

The predominant rock in Reds Meadows is granitic, and the springs issue from such material, but on the slopes about 100 yards above them is a small bluff of dark, columnar lava. Along the western border of the meadows also there is much of this columnar rock, and at the Devils Post Pile, a mile northwest of the springs, columnar jointing is exceptionally well developed. The presence of the lava may account for an abnormal temperature gradient that gives rise to the heated water, and the high content of bicarbonates in the water is also worthy of note in connection with the lava. The existence of several carbonated springs in this locality may here be mentioned, though their discussion will be taken up later.

HOT SPRINGS AT HEAD OF FISH VALLEY (FRESNO 2).

At the head of Fish Valley and 3 or 4 miles eastward from a carbonated spring (Fresno 1, p. 239) in this valley are two warm springs and subsidiary seepages on the mountain side. The springs yield only a small flow, are not near a main trail, and have not been often visited. Their occurrence in the same region as Reds Meadows Hot Springs is of geologic interest, however, because thermal springs are not common in the high Sierra.

SLATES HOT SPRINGS (MONTEREY 4).

In the Coast Ranges of Monterey County thermal springs of note issue at four places. The southernmost is at Slates Hot Springs on Mr. J. A. Little's ranch. The water here issues at ten principal points in a distance of 125 yards, halfway up the face of bluffs that here border the ocean. A small private bathhouse has been built near the easternmost spring. The waters range in temperature from 110° to 121°, are mildly sulphureted, and the run-off streams are lined with abundant green algous growth. Small deposits of alum, gypsum, and carbonate of lime or magnesia were noted at the edge of one spring. The waters taste distinctly sweetish.

About one-fourth mile northwest of the main group, on the left bank of Hot Creek, is another spring, 98° in temperature. This spring yields perhaps 5 gallons a minute and is used for laundering clothes.

It is said that the location of the springs was described by an Indian to Mr. Thomas B. Slate, who made his way southward with difficulty along the steep, brushy slopes, and succeeded in finding only the warm spring beside the creek. Later, however, he came down the coast in a boat, found the springs on the bluff, and settled near them in 1868. The locality is occasionally made a camping place by deer hunters, but as it is about 17 miles by trail beyond the southern end of the wagon road it is not often visited.

The formation exposed along the bluffs is of slates that have been described by Fairbanks[1] as being probably of Jurassic age. They are overlain by 30 or 40 feet of gravel that is deposited on an ocean terrace along this portion of the coast. The heated water apparently emerges at the base of the gravel, though small warm flows also issue from the slate, close to the surf. It is said that when garden land on the terrace back of the springs has been irrigated for several weeks by a mountain stream the seepage water has so reduced the temperature of the hot springs that they are only tepid.

DOLANS HOT SPRING (MONTEREY 5).

A warm and mildly sulphureted spring exists on North Fork of Big Creek, about 1½ miles from the ocean and 7 miles by trail south of Slates Hot Springs (Monterey 4, p. 56). The water issues in a deep portion of the canyon, which is heavily timbered with redwoods, and as the place is known only locally and is not easily accessible, the spring has not been made use of and has been seldom visited.

HOT SPRINGS ON NORTH FORK OF LITTLE SUR RIVER (MONTEREY 1).

Several thermal springs rise in the bed and along the banks of North Fork of Little Sur River, about 2 miles above the point at which the stage road crosses the stream. The springs in the stream bed form a warm pool, and on its right bank two or three flows, having a maximum temperature of 114°, issue from crevices in the rock and fill a small natural basin. The springs are in a narrow, rugged section of the canyon, in a granitic area, and possibly rise along fractures that have been produced by local faulting. The water is mildly sulphureted but it is not otherwise noticeably mineralized. A considerable amount of fibrous algous growth, from white to reddish purple in color, is found in the stream and the adjacent pools.

During the nineties the water was piped to a grove of redwoods in a flat some distance below the springs, and it was the intention to build a hotel and bathhouse. High water washed out the pipe line, however, and in 1908 the attempt to develop the springs had not been renewed.

TASSAJARA HOT SPRINGS (MONTEREY 3).

A large amount of hot water issues at Tassajara Hot Springs, which are in the canyon of Arroyo Seco, in the southern part of Monterey County. About 17 thermal springs may be counted here, in the bed

[1] Fairbanks, H. W., Stratigraphy at Slates Springs, with some further notes on the relation of the Golden Gate series to the Knoxville: Am. Geologist, vol. 18, pp. 350-356, 1896.

of the creek and along its southern bank. They range in temperature from about 100° to 140° and from mere seepages to flows of 7 or 8 gallons a minute.

The thermal waters issue from a gneiss that is exposed along the creek for a distance of 200 yards or more. Above and below this exposure the rock is granitic and in some places contains small garnets. The crystalline rocks are overlain by a series of shale, sandstone, and limestone whose structure in the area north of Arroyo Seco is well shown by the beds of massive, buff-colored sandstone that dip about 45° NE. A western limb of this structure was not seen, though it may exist in the mountains farther coastward. The observed dips suggest that Arroyo Seco here crosses a zone of intense pressure in the crystalline rocks.

The springs received their name from an Indian or Mexican word that means "the place where meat is cured by drying," and dates from the early days of the cattle industry. The springs have thus been known and used for many years, and they were early visited by campers, when the only access was by means of a difficult trail. Several years ago a well-graded wagon road was built southward from Jamesburg across the mountains and down into the canyon, and the springs are now easily reached by stage. In 1904 a stone hotel was built, and other improvements have been added yearly, so that in 1909 there were ample accommodations for 75 people, though a larger number has been taken care of by the use of tents. Water from two of the largest springs has been piped to tub and plunge baths, and a vapor bath has been constructed over the hottest spring, which issues in the creek bed.

Analyses of two of the thermal waters were made. These waters are noticeably sulphureted, and the analyses show them to be only moderately mineralized. The water of the Arsenic Spring has a distinctly yellow color, which in a few other springs has been ascribed to alkaline sulphides in solution.

At the north edge of the creek, a few yards above the hot springs, there are two cool springs in which iron is deposited. An analysis of the easternmost of these springs is tabulated with the hot springs.

The identity of an early analysis[1] purporting to be of water from these springs seems questionable, as it does not accord with the later analysis.

[1] California State Mineralogist Thirteenth Rept., p. 514, 1896.

Analyses of water from Tassajara Hot Springs, Monterey County, Cal.

[Analyst and authority, F. M. Eaton (1909). Constituents are in parts per million.]

	1		2		3	
Temperature	59° C. (138° F.)		39° C. (103° F.)		18° C. (64° F.)	
Properties of reaction:						
Primary salinity		63		65		19
Secondary salinity		0		0		16
Tertiary salinity		0		0		0
Primary alkalinity		30		26		0
Secondary alkalinity		7		9		65
Tertiary alkalinity		138		104		(?)
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	81	3.51	75	3.26	14 (Na + K)	0.59 (Na + K)
Potassium (K)	4.6	.12	4.8	.12		
Calcium (Ca)	5.3	.27	4.0	.20	33	1.64
Magnesium (Mg)	Trace.	Trace.	1.3	.11	11	.87
Iron (Fe)	1.5 (Fe + Al)	.05 (Fe + Al)	2.0	.07	0.8	.03
Aluminum (Al)					1.9	.21
Sulphate (SO_4)	110	2.29	109	2.27	36	.75
Chloride (Cl)	6.5	.18	5.0	.14	12	.32
Carbonate (CO_3)	41	1.37	38	1.28	61	2.03
Arsenate (AsO_4)	....	....	[a] 0	.00	....	....
Silica (SiO_2)	118	3.90	116	3.84	(?)	....
	367.9	....	355.1	....	169.7	....
Carbon dioxide (CO_2)	0	.00	0	.00	Present.	Present.
Hydrogen sulphide (H_2S)	25	1.47	Present.	....	(?)	....

[a] Not detected in 1 liter of water.

1, Lower of two main springs; 2, Arsenic Spring; 3, Iron Spring.

The two hot springs were apparently from the same general source, showing only slight differences in composition. Primary salinity and primary alkalinity are the chief stable properties, but the waters are characterized by high tertiary alkalinity of which silica is the chief component. The carbonate radicle reported is presumably calculated from the alkalinity determination and doubtless includes sulphides and possibly silicates. The apparent absence of arsenic in the Arsenic Spring is noteworthy.

The iron spring is of markedly different character from the hot springs, being less than half as concentrated and having secondary alkalinity as the dominant property. Tertiary alkalinity is not reported but is probably relatively low. The spring is probably of essentially surface origin and is not directly related to the thermal waters.

The following notes concerning algous growths in the creek below the hot springs are here given, as the growths are related to the sulphureted character of the water. Although they are common to thermal sulphur springs, the relatively large volume of water at Tassajara Hot Springs, its comparatively slow cooling, and the presence of both swift currents and of quiet pools in the run-off stream, afford an unusually good opportunity to observe the variation in character of the growths.

At the main springs, where the temperature of the water was 110° to 140°, the material was mainly fibrous and white, green, and reddish-brown in color.

About 75 yards below, at a temperature of 96°, there was a dark-green layer on the bottoms of pools, with a small amount of white material on the surface of the green. Where the current was swiftest, a purple-brown, furry growth, one-eighth to one-quarter inch thick, covered the rocks.

At 125 yards, where the temperature was 91°, a green, leathery growth covered portions of the bottom, with white, feathery streamers attached to it where the current was rapid.

At 200 yards, in a temperature of 87°, a thick, leathery growth coated the entire stream channel, being green and white on its upper surface, pale purplish-red inside, and black on the under surface. A number of pale purple, feathery, and white threadlike streamers extended from it.

At 250 yards, in a temperature of 83°, there was a layer of green material in the pools and white material in the swifter water.

At 275 yards, where the temperature was 81°, the lower limit of white growths was reached. Below it a dark-green moss coated the rocks for a distance of about 50 yards to a point where the temperature was 78°. Below this point there was no notable growth in the channel.

The material showed a tendency toward brighter colors in the hotter water and more somber ones in the cooler places. White material (probably due to the deposition of sulphur) was more common in the hottest water and in the portions of the algous growth nearest the bottom of the channel. Smooth, leathery growths lined the pools, while fibrous growths were formed in the swiftest currents. The discharge of the stream was approximately 100 gallons a minute. The water first rose at a point about 50 yards above the main springs. Above this point the stream channel was dry.

PARAISO HOT SPRINGS (MONTEREY 2).

Paraiso Hot Springs (Pl. IV, *C*, p. 32) are situated near the head of a small valley that opens eastward to Salinas Valley. Underground water lies at a shallow depth near the springs, beneath an area of several acres within which at least five mineral springs rise. The largest of these, which is known as the Soda Spring, has an observed temperature of 111° and a discharge of perhaps 8 gallons a minute. About 40 yards away two small sulphur springs rise with temperatures of 88° and 102°, and 100 yards farther east there are two drinking springs, each of which yields perhaps one-fourth gallon a minute. These are known as the Iron Spring and the Arsenic Spring and have temperatures respectively of 68° and 65°.

The springs at this place were known to the Catholic mission fathers, who at one time lived here. Their extensive modern use dates back more than 20 years, and their accessibility has made them an objective point for automobile parties. In 1908 accommodations were provided in hotels and cottages for about 200 guests, while tub and plunge baths at the Soda and the Sulphur springs, and a swimming plunge that was also supplied by these springs, gave ample opportunity for use of the waters. Analyses of the springs, made a number of years ago, are available and are here presented in the standard form.

Analyses of water from Paraiso Hot Springs, Monterey County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5	
Temperature	48°C.(118°F.)		48°C.(118°F.)		46°C. (114°F.)		21°C. (70°F.)		21°C. (70°F.)	
Properties of reaction:										
Primary salinity	81		85		69		51		82	
Secondary salinity	2		0		10		0		17	
Tertiary salinity	0		0		0		0		1	
Primary alkalinity	0		2		0		11		0	
Secondary alkalinity	17		13		21		38		0	
Tertiary alkalinity	22		12		39		28		51	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	253	11.00	252	10.96	233	10.13	234	10.18	179	7.78
Potassium (K)	2.9	.07	3.1	.08	6.4	.16	80	2.05	58	1.48
Calcium (Ca)	41	2.04	32	1.60	28	1.40	30	1.50	23	1.15
Magnesium (Mg)	7.5	.62	......	......	38	3.13	74	6.09	9.8	.81
Iron (Fe)	7.3	.26	} 19	.68	9.7	.35	12	.43	3.9	.14
Aluminum (Al)	5.1	.56								
Sulphate (SO_4)	493	10.27	463	9.64	520	10.83	23	.48	22	.46
Chloride (Cl)	38	1.07	39	1.10	29	.82	342	9.65	387	10.92
Carbonate (CO_3)	79	2.63	56	1.87	94	3.13	304	10.13	......	......
Arsenate (AsO_4)	......	......	......	......	......	......	Trace.	Trace.	......	......
Silica (SiO_2)	50	1.66	45	1.49	44	1.46	156	5.18	176	5.84
	976.8	......	909.1	......	1,002.1	......	1,255	......	858.7	......
Carbon dioxide (CO_2)	25	1.14	(a)	(a)	17	.77	(a)	(a)	......	......
Hydrogen sulphide (H_2S)	......	......	......	......	60	3.52	......	......	......	......

a Present.

1. Hot Soda Spring. Analyst and authority, Winslow Anderson, 1889.
2. Hot Soda Spring. Analyst, A. Cihi, 1871. Authority, U. S. Geol. Survey Bull. 32.
3. Hot Sulphur Spring. Analyst and authority, Winslow Anderson, 1889.
4. Arsenic Spring. Analyst, A. Cihi (?). Authority, advertising matter.
5. Iron Spring No. 2. Analyst, A. Cihi (?). Authority, advertising matter.

The Hot Soda Spring is primary saline in character with secondary alkalinity as a subdominant property. The name "Soda," given to this spring, is a misnomer, as the word usually applies to primary alkaline waters. The Hot Sulphur Spring differs from the Hot Soda Spring chiefly by reason of higher secondary salinity and its content of hydrogen sulphide. The analyses of the Arsenic and Iron springs are of doubtful authenticity. It is of interest that only a trace of arsenic was found in the Arsenic Spring and very little iron in the Iron Spring. Both have primary salinity for the principal property. High magnesium in proportion to calcium is indicated for the Hot Sulphur and Arsenic springs.

The hills on each side of the little valley at Paraiso Hot Springs consist of gravelly sandstone that dips gently away from Salinas Valley. Granitic bowlders scattered along the ravines indicate that crystalline rocks are exposed to the west. Although a fault is mapped through Salinas Valley it is not believed that such structure has given rise to the Paraiso springs. It seems more probable that some local fold or bedrock obstruction here forces underground water to the surface, and that its thermal character may be due to the depth from which it rises, in a locality of unusually high temperature gradient.

VICKERS HOT SPRINGS (VENTURA 3).

The Coast Ranges in Ventura and Santa Barbara counties are composed largely of shales and sandstones of Tertiary age. At several places where canyons cut deeply into these sediments, thermal springs issue, and this is especially true of Matilija Canyon, in western Ventura County. In this canyon the westernmost point of note at which hot waters rise is at Vickers Hot Springs. The water here issues at the northeast edge of the creek from a low bank of stream gravel and crushed shale. A hotel and baths were constructed here in 1873, but the buildings were washed away by high water in the spring of 1884, and when visited in 1908 the place had evidently been abandoned for a number of years. These are said to be the original Matilija Springs, and the following analysis is believed to be of water from this place:

Analysis of water from main spring, Vickers Hot Springs, Ventura County, Cal.

[Analyst, R. B. Riggs (1888). Authority, U. S. Geol. Survey Bull. 60. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		87
Secondary salinity		2
Tertiary salinity		0
Primary alkalinity		0
Secondary alkalinity		11
Tertiary alkalinity		1
Constituents.	**By weight.**	**Reacting values.**
Sodium (Na)	546	23.72
Potassium (K)	32	.83
Calcium (Ca)	65	3.24
Magnesium (Mg)	3.4	.28
Sulphate (SO_4)	17	.35
Chloride (Cl)	877	24.73
Carbonate (CO_3)	58	1.93
Silica (SiO_2)	41	1.37
	1,639.4	....

This water is essentially an impure solution of common salt, primary salinity being the predominant property. The concentration is sufficient to impart a distinctly salty taste to the water. The water is sulphureted, though this is not indicated by the analysis.

STINGLEYS HOT SPRINGS (VENTURA 5).

About one-half mile below Vickers Hot Springs, at the southwest edge of the creek on the property of Mr. S. G. Stingley, thermal water also issues. A small pool in which a temperature of 100° was recorded has here been used for bathing.

In connection with the thermal springs of this locality, three small sulphur springs may be mentioned that have temperatures of 66°, 76°, and 65°. They issue respectively one-fourth mile west of Stingleys Hot Springs, one-eighth mile northeast of them, and three-fourths mile eastward. The first mentioned is a strongly sulphureted pool at the base of the canyon slope and was formerly used as a drinking spring. The second spring issues from a short tunnel in the hillside and yields about 2 gallons a minute of water that furnishes a domestic supply to Mr. Stingley's home. This water rises clear but becomes milky from suspended sulphur after flowing a few yards. The third spring rises in a canyon on the property of Mrs. Gertrude A. Lyons and is piped to a small resort (see Lyons Spring, Ventura 6), which is described among the sulphur springs (p. 278).

MATILIJA HOT SPRINGS (VENTURA 7).

Matilija Hot Springs are situated about 2½ miles below Vickers Hot Springs and 6 miles northwest of the railroad terminus at Nordhoff. There has been a resort at the springs since about 1890 and improvements have been added until in 1908 there were accommodations for 200 people. At the northern edge of the creek sulphureted water rises, which is said to have a maximum temperature of 116°. It is pumped to baths and to a large swimming plunge about 200 yards downstream. Two warm sulphur springs, at which there are cemented drinking basins, also issue on opposite sides of the creek near the baths. Each yields about 1 gallon a minute of moderately sulphureted water.

The following analyses of the springs at this place have been published:

Analyses of water from Matilija Hot Springs, Ventura County, Cal.

[Constituents are in parts per million.]

	Hot Sulphur.		Fountain of Life.		Mother Eve.		Lithia.	
Properties of reaction:								
Primary salinity		52		67		32		14
Secondary salinity		0		0		0		0
Tertiary salinity		0		0		0		0
Primary alkalinity		0		26		15		60
Secondary alkalinity		48		7		53		26
Tertiary alkalinity		1001		186		433		39
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na) / Potassium (K)	16	0.70	140	6.09	89	3.87	51	2.22
Calcium (Ca)	3.5	.17	8.9	.44	57	2.84	4.1	.20
Magnesium (Mg)	5.8	.48	0.5	.04	18	1.48	6.9	.57
Sulphate (SO_4)	12	.25	....	....	78	1.62	10	.21
Chloride (Cl)	16	.45	156	4.40	36	1.02	7.3	.21
Carbonate (CO_3)	20	.67	65	2.17	166	5.53	76	2.53
Silica (SiO_2)	27	.90	19	.63	17	.56	36	1.19
	100.3	....	389.4	....	461	....	191.3	....
Hydrogen sulphide (H_2S)	218	12.8	198	11.6	594	34.9	....	....

These analyses were taken from a letterhead and recomputed on the assumption that hydrogen sulphide was expressed in cubic inches per United States gallon and other constituents in grains per United States gallon. The date of analysis and name of analyst are not given. Under such conditions not much confidence can be placed in the tabulated values. It is likely, however, that the general character of the waters is indicated at least approximately. The first three appear to be strongly sulphureted. Primary salinity and secondary alkalinity characterize the Hot Sulphur Spring. The Fountain of Life contains primary saline water in which primary alkalinity is prominent. The water of Mother Eve Spring, though of higher concentration and having a less salinity, approaches that of the Hot Sulphur Spring in general character. The Lithia Spring is markedly alkaline in character, primary alkalinity being the dominant property.

WHEELERS HOT SPRINGS (VENTURA 2).

Wheelers Hot Springs are situated in the canyon of North Fork of Matilija Creek and are about 2½ miles north from the Matilija springs. Three warm sulphureted springs rise at Wheelers and the place has been a resort since about 1895. The Main Hot Spring, 102° in temperature, discharges about 35 gallons a minute into a swimming plunge. The two other springs, which are known as

Bucket Spring and Genoveva Spring, have observed temperatures, respectively, of 62° and 75°. Each yields about one-half gallon a minute, of mildly sulphureted water, and forms a drinking pool. A fourth spring, also sulphureted but cool, issues at the side of a small storage reservoir and yields perhaps 5 gallons a minute.

In 1908 the improvements at these springs included a hotel and annex, about 35 tent cottages, a dancing floor, and bathing facilities. Electric light was supplied by a small water-power plant.

The following analyses are of the springs at this place:

Analyses of water from Wheelers Hot Springs, Ventura County, Cal.

[Analysts, Wade and Wade (1900). Authority, advertising matter. Constituents are in parts per million.]

	Main.		Bucket.		Genoveva.	
Temperature	39° C. (102° F.)		17° C. (62° F.)		24° C. (75° F.)	
Properties of reaction:						
Primary salinity	47		48		20	
Secondary salinity	0		0		30	
Tertiary salinity	0		0		0	
Primary alkalinity	48		45		0	
Secondary alkalinity	5		7		50	
Tertiary alkalinity	6		6		8	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	333	14.49	328	14.26	48	2.07
Potassium (K)	4.7	.12	3.5	.09	7.0	.18
Calcium (Ca)	6.8	.34	12	.58	144	7.29
Magnesium (Mg)	4.5	.37	6.8	.56	20	1.61
Iron (Fe)	....	....	Trace.	Trace.	....	....
Sulphate (SO_4)	16	.34	26	.55	259	5.39
Chloride (Cl)	245	6.90	243	6.86	6.4	.18
Carbonate (CO_3)	242	8.08	243	8.09	167	5.58
Silica (SiO_2)	27	.91	30	.99	27	.91
	879	....	892.3	....	678.4	....
Hydrogen sulphide (H_2S)	Excess.	....	Present.	Present.	Present.	Present.

The Main and Bucket springs are apparently much alike in composition and concentration, though differing in temperature. Both give soft waters characterized by primary alkalinity and primary salinity. The Genoveva Spring differs markedly from the others, giving a hard water in which secondary alkalinity is the dominant property. The three springs are alike in that alkalinity and salinity are of about equal value as properties in each. Genoveva Spring is, however, of secondary alkalinity and salinity, while that of the others is primary; and the salinity of Genoveva Spring is characterized by the sulphate radicle, while that of the other springs is almost free from sulphate.

Although the analyses of springs in Matilija Canyon do not show unusually high mineral contents, there are small deposits of salts at a few places. The most notable deposit of this kind that was observed is a patch a few yards in diameter about 25 yards east of the main spring at Wheelers Hot Springs. At this place crystals of sulphur, alum, and probably Epsom salt are mingled with shale, but a hard conglomerate ledge is exposed near by. The waters differ widely in character and may differ in origin, though the differences in character may be accounted for on the assumption that the waters pass through shales and sandstones of different composition.

The group including Vickers, Stingleys, Matilija, and Wheelers springs is in a region of sandstones and shales. These rocks are steeply inclined and have been subjected to great pressure.

It may be that the abnormal temperatures of the waters in this region are due in part to chemical action of the minerals within the shales, but in such a region of steeply inclined beds the underground temperature is probably abnormally high.

SESPE HOT SPRINGS (VENTURA 1).

In the canyon of Sespe Creek, about 20 miles in a direct line northeast of Matilija Canyon, hot water issues from at least four groups of springs. These are situated on the bank above the creek and also in the gravel wash of the stream bed. The highest temperature noted here was 191° in a spring that issues on the steep slope, about 15 feet above the creek bed. The springs on the bank issue from fissures in partially decomposed granitic material that is here exposed beneath crushed shale for 300 or 400 yards.

Although a fault has not been mapped at this locality, the San Andreas fault line passes about 15 miles northward, and the fractured condition of the rocks at the Sespe springs indicates that subsidiary faulting has taken place.

The springs are best reached by road and trail from Fillmore, a small town on the railroad, 23 miles southward, and are visited by a few campers and deer hunters during the summer months.

WARM SPRINGS IN ELIZABETH LAKE CANYON (LOS ANGELES 1).

In Elizabeth Lake Canyon, about 25 miles east of the Sespe springs, there is a small group of thermal springs. They are not of high temperature nor notable flow, however, and are seldom visited. The San Andreas fault line is mapped as passing about 8 miles north of these springs, and its proximity suggests that the existence of the warm water may be due to subsidiary fracturing of the rocks where it issues.

MONTECITO HOT SPRINGS (SANTA BARBARA 7).

Montecito Hot Springs are situated about 5 miles northeast of Santa Barbara, in a canyon on the steep mountain side. At this place 11 separate springs may be counted, which issue from seams in thick-bedded sandstone at the upper boundary of an area of shale that geologically overlies the sandstone.[1] These springs range in observed temperature from 111° to 118°, and in discharge from about 2 to 10 gallons a minute. The total yield is probably not far from 50 gallons a minute. All of the springs are mildly sulphureted and seem to be otherwise of similar mineral character. The following is an analysis of water from the main spring:

Analysis of water from main spring, Montecito Hot Springs, Santa Barbara County, Cal.

[Analyst and authority, Winslow Anderson (1888). Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		51
Secondary salinity		40
Tertiary salinity		9
Primary alkalinity		0
Secondary alkalinity		0
Tertiary alkalinity		113

Constituents.	By weight.	Reacting values.
Sodium (Na)	110	4.80
Potassium (K)	Trace.	Trace.
Calcium (Ca)	30	1.52
Magnesium (Mg)	27	2.20
Aluminum (Al)	7.9	.87
Hydrogen (H)	Trace.	Trace.
Sulphate (SO_4)	393	8.18
Chloride (Cl)	18	.51
Carbonate (CO_3) [a]	21	.70
Arsenate (AsO_4)	Trace.	Trace.
Silica (SiO_2)	20	.67
	626.9	....
Carbon dioxide (CO_2)	163	7.40
Hydrogen sulphide (H_2S)	60	2.55

[a] If correct, this indicates an unstable condition. From the form in which the analysis was stated, however, it appears likely that this represents alkalinity, on evaporation of the residue, soluble in water and may be due in part to loss of chloride on ignition. It has been so considered in stating the properties of reaction.

This water belongs to the laxative class of medicinal waters, being characterized by sulphate salinity of primary and secondary bases. The tertiary alkalinity is prominent and adds to its medicinal value.

Two small bathhouses and a hotel and cottages have been erected here, and the place was formerly conducted as a resort but was closed during 1909 and 1910.

A portion of the water from the springs forms part of the supply of the Montecito Water Co. It is aerated in a screened tank and part of the sulphide content is thereby precipitated as sulphur and removed before the water enters the mains.

SAN MARCOS HOT SPRINGS (SANTA BARBARA 2).

San Marcos Hot Springs, which are sometimes referred to as Mountain Glen Hot Springs, are situated about 20 miles by road northwest of Santa Barbara, in a deep, brushy stream canyon. Warm sul-

[1] See Arnold, Ralph, Geology and oil resources of the Summerland district, Santa Barbara County, Cal.: U. S. Geol. Survey Bull. 321, Pl. I, 1907.

phureted water rises at about six places in this locality, for a distance of 150 yards, in the bed of the creek and along its sides. Bathing pools have been excavated and the place is frequently visited by campers, who find good camp grounds a few hundred yards below the springs. As at the Montecito springs, the country rock is sandstone, which here dips about 30° E.

A fault which has been traced through the valley of Santa Ynez River passes a few miles north of these springs. Local fracturing in connection with this extensive movement possibly has taken place near the San Marcos springs and has afforded escape to deep-seated water.

LAS CRUCES HOT SPRINGS (SANTA BARBARA 1).

Las Cruces Hot Springs issue on a hillside about 18 miles west of San Marcos Hot Springs and 4 miles northward from Gaviota railroad station on the coast. Four warm springs here furnish about 50 gallons a minute of mildly sulphureted water and in two of the springs inflammable gas rises. A ledge of calcareous material back of the largest springs probably has been formed by deposition from the water. In 1908 there was a bathhouse at the largest spring, and the place was occasionally visited by campers.

The topographic position of the springs is worthy of note, as they are in a little swale on the mountain side one-half mile from and 400 feet above the main drainage canyon of this region. Thick-bedded sandstone here dips about 30° SW. and strikes nearly in the direction of steepest slope.

NEWSOMS ARROYO GRANDE WARM SPRING (SAN LUIS OBISPO 9).

Newsoms Arroyo Grande Warm Spring is situated in a small open canyon 2½ miles east of the town of Arroyo Grande, in San Luis Obispo County. The spring yields about 15 gallons a minute and rises in a board-curbed pool that supplies tub baths and a small swimming plunge. The temperature of the water is 98°. The water tastes moderately sulphureted, and a small amount of sulphur is deposited along the run-off channel. A small amount of acid salt also forms on the curbing of the spring, and when these salts are placed in the water, which is clear, a black precipitate that is probably iron sulphide immediately forms. The constituents render the water unsuitable for laundry uses, but they are not objectionable for bathing. The following is an analysis of the water:

Analysis of water from Newsoms Arroyo Grande Warm Spring, San Luis Obispo County, Cal.

[Analyst and authority, Winslow Anderson (1888). Constituents are in parts per million.]

Temperature	38° C. (100° F.)
Properties of reaction:	
Primary salinity	34
Secondary salinity	3
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	63
Tertiary alkalinity	86

Constituents.	By weight.	Reacting values.
Sodium (Na)	62	2.70
Potassium (K)	24	.61
Calcium (Ca)	60	3.01
Magnesium (Mg)	40	3.30
Iron (Fe)	33	1.18
Aluminum (Al)	3	.33
Sulphate (SO_4)	116	2.41
Chloride (Cl)	43	1.20
Carbonate (CO_3)	216	7.19
Silica (SiO_2)	35	1.10
	632	....
Carbon dioxide (CO_2)	127	5.76
Hydrogen sulphide (H_2S)	23	1.38

The water of this spring is secondary alkaline and primary saline in character, tertiary alkalinity being also an important characteristic.

The property has been open to the public as a resort since 1864. In 1908 there were accommodations for about 30 people in a hotel building and small cottages. The baths have been much patronized on Sundays by people from Arroyo Grande, and the water has been carbonated and bottled by the local soda works.

The siliceous shales that form the hills of this locality have been steeply uplifted and exhibit dips which show that the structure here is disturbed, and indicate that the spring probably rises along fractures produced at a zone of sharp change in the inclination of the beds.

PECHO WARM SPRINGS (SAN LUIS OBISPO 7).

In the canyon of Islay Creek, west of San Luis Obispo, and about 2 miles from the coast, are two warm, disagreeably sulphureted springs which are known as Pecho Warm Springs. When visited in 1908 there was a wooden trough tub and a screen of gunny sacking at the larger spring, while the other was used only as a drinking pool. Their observed temperatures were 95° and 72° and their flows, respectively, about 15 gallons and 2 gallons a minute. The larger spring issues at the creek edge, at the base of a 10-foot bank of crushed shale, the other rises about 150 yards farther downstream, and at the roadside 10 yards from the creek.

The hills of this vicinity are composed of shales of Miocene age, in which the structure indicates that there has been sufficient local folding and crushing to account for the existence and temperature of the springs.

The place has long been resorted to on holidays by picnic parties from the neighboring sheep and cattle ranches; but it has been comparatively seldom visited by campers, as it is not a desirable spot for a vacation retreat.

SAN LUIS HOT SPRING (SAN LUIS OBISPO 8).

Southward from San Luis Obispo and near the ocean is a resort of considerable importance that utilizes the artesian flow of an unsuccessful oil well. This well was begun in the fall of 1885 and abandoned in March, 1887, when at a depth of 937 feet. Quantities of gas and warm, sulphureted water were obtained, but no oil was yielded. A number of years ago the water is reported to have had a temperature of 103° and discharge of 100 gallons a minute.[1] In 1908 a temperature of 107° was recorded. The discharge seemed to have materially decreased but was not measured. The following is an analysis of the water:

Analysis of water from San Luis Hot Spring, San Luis Obispo County, Cal.

[Analyst, E. W. Hilgard (1885). Constituents are in parts per million.]

Temperature	39° C. (103° F.)
Properties of reaction:	
Primary salinity	45
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	32
Secondary alkalinity	23
Tertiary alkalinity	210

Constituents.	By weight.	Reacting values.
Sodium (Na)	182	7.91
Calcium (Ca)	20	1.01
Magnesium (Mg)	17	1.41
Iron (Fe)	49	1.74
Manganese (Mn)	16	.57
Sulphate (SO_4)	96	2.00
Chloride (Cl)	94	2.64
Bromide (Br) and iodide (I)	1.2	.01
Sulphide (S)	205	12.82
Carbonate (CO_3)	171	5.69
Arsenate (AsO_4)	3.1	.07
Silica (SiO_2)	27	.91
	881.3	....
Carbon dioxide (CO_2)	120	5.44
Hydrogen sulphide (H_2S)	42	2.48

This analysis is stated in per cent in the thirteenth report of the California State Mining Bureau and in grains per United States gallon in an advertising folder, but the figures are the same in both, except that arsenic is given as 16.06 in the report of the mining bureau and 0.06 in the folder. The recomputation to the foregoing statement was made on the assumption that in the original statements the gases were expressed in cubic inches per gallon and other constituents in grains per gallon, the value 0.06 being taken for arsenic. The most notable feature of the analysis is the large pro-

[1] California State Mineralogist Tenth Rept., p. 577, 1890.

portion of sulphide radicle or free sulphur. Although the details of the analysis can not be considered reliable, the general primary-saline-alkaline character of the water and the relatively high tertiary alkalinity in which sulphur is prominent are probably fairly represented.

The well is located at the south edge of the canyon of San Luis Obispo Creek, 100 yards from the stream and at the border of a sycamore grove. A resort was early established here, and the place became known as Sycamore Spring, but in recent years the name was changed to the present title. Extensive accommodations have been provided, and the creek is made use of for boating. The rocks exposed in this locality consist of shales and sandstones of Miocene or Pliocene age which dip mainly to the north or northeast. Anticlinal or low-arched structure which would be favorable to the existence of oil was not noted, though it may exist.

In the summer of 1908 a well was being drilled for oil half a mile east of the San Luis spring, and in it a flow of gas and water similar to that in the early well had been obtained.

BIMINI HOT SPRING (LOS ANGELES 11).

In connection with San Luis Hot Spring, two hot-spring resorts on the outskirts of Los Angeles may properly be mentioned here, as they are also unsuccessful oil wells in which flows of warm water were obtained.

Bimini Hot Spring has been improved as a bathing resort, and also as a sanitarium, since about 1903. Tub baths and three large swimming plunges are here provided, and the place is extensively patronized by bathers. A sanitarium hotel near by is also conducted under the same management. The well is reported to yield 100 gallons a minute of water 104° in temperature. An analysis of the water is tabulated beyond for comparison with that of another warm artesian well of the locality. The primary alkalinity of the water gives it a peculiar soft feeling that has led to the appellation "the velvet baths."

The well is said to have been drilled 1,750 feet deep in the sediments of Tertiary age that make up the oil formation of this locality.

RADIUM SULPHUR SPRING (LOS ANGELES 10).

About 2 miles northwest of Bimini Hot Spring a sanitarium was started in 1905 at another unsuccessful oil well. In 1908 the property changed ownership, and improvements were made, consisting of a pumping and heating plant for the water, a number of bathtubs, and offices and rest rooms. The water is claimed to be notably radioactive. In the fall of 1908 it was placed on the local market as a table and medicinal water. The following is an analysis of the water, tabulated with an analysis of Bimini Hot Spring.

Analyses of water from Radium Sulphur Spring and Bimini Hot Spring, Los Angeles County, Cal.

[Constituents are in parts per million.]

	1		2	
Temperature	34° C. (93° F.)			
Properties of reaction:				
Primary salinity		48		18
Secondary salinity		0		0
Tertiary salinity		0		0
Primary alkalinity		33		81
Secondary alkalinity		19		1
Tertiary alkalinity		3		3
Constituents.	**By weight.**	**Reacting values.**	**By weight.**	**Reacting values.**
Sodium (Na)	476	20.70	722	31.40
Potassium (K)	26	.67	21	.54
Lithium (Li)	Trace.	Trace.		
Calcium (Ca)	46	2.29	6.0	.30
Magnesium (Mg)	34	2.80	2.0	.16
Iron (Fe)	Trace.	Trace.	.56	.02
Sulphate (SO_4)	380	7.91		
Chloride (Cl)	164	4.63	200	5.64
Carbonate (CO_3)	416	13.87	801	26.70
Arsenate (AsO_4)	Trace.	Trace.		
Phosphate (PO_4)	Trace.	Trace.		
Silica (SiO_2)	21	.70	26	.86
	1,563		1,778	
Carbon dioxide (CO_2)	Present.	Present.		
Helium (He)	Present.	Present.		

1. Radium Sulphur Spring. Analyst, R. Leeman (1906?). Authority, advertising matter.
2. Bimini Hot Spring. Analyst, L. J. Stabler. Authority, advertising matter.

These two waters are of about equal concentration and both are primary in character. However, primary salinity is the dominant property in the Radium Sulphur Spring, whereas primary alkalinity predominates in the Bimini Hot Spring. The addition of calcium and magnesium sulphates to Bimini spring water would change its character to approximately that of the Radium Sulphur Spring.

The well at the Radium Sulphur Spring was drilled to a depth of 1,000 feet or more in the oil formation. A strong flow of water was encountered, which was with difficulty shut off, but several years prior to 1908 the well ceased to flow.

PASO ROBLES HOT SPRINGS (SAN LUIS OBISPO 2).

Thermal waters issue at a number of places near Paso Robles, in the upper portion of Salinas Valley. As early as 1865 a warm sulphureted spring in the southern part of the town was improved for bathing, the spring being cemented and covered by a large masonry dome, and a swimming plunge being constructed. Another spring near by was also inclosed by masonry walls and made use of for bathing. These springs have been abandoned for several years, however, apparently because they have nearly or entirely ceased to flow.

Hotel El Paso de Robles was built about 1888. It is situated in the western part of town, within extensive grounds that also inclose a clubhouse and a dozen cottages. A few years ago a large and very complete bathhouse, with modern apparatus for the therapeutic use of water, was built adjoining the hotel. These baths are supplied by a flowing artesian well 10 inches in diameter at the top and 640 feet deep, that was put down behind the bathhouse and is known as the Main Sulphur Spring. Its temperature is reported to be 105° and its yield to be 2,500,000 gallons a day (1,736+ gallons a minute), but this amount seems excessive.[1] The city of Paso Robles has also erected a bathhouse about one-fourth mile east of Hotel El Paso de Robles. Its baths are supplied by a flowing well 427 feet deep, which yields water at a temperature of 105°.

PASO ROBLES MUD BATH SPRINGS (SAN LUIS OBISPO 1).

About 2½ miles north of Paso Robles there are natural warm springs which are used for bathing. These are locally known as the Mud Bath Springs. A large amount of warm water here issues about 100 yards from the edge of Salinas River. The springs rise mainly within concrete walls that were built as foundations for a bathhouse, but plans were changed and the springs are now of secondary importance to Paso Robles Hot Springs. There is a building at the Mud Bath Springs, however, below whose floor there are about half a dozen cemented plunges, with perforated bottoms that admit the water. About 30 yards west of the bathhouse is a 4-inch flowing well that in 1908 yielded about 8 gallons a minute of water 118° in temperature. The water is said to have been struck at a depth of 140 feet. This is known as the Lithia Spring and is used for drinking, its water being faintly sulphureted and salty. Two natural springs near by are also used for drinking. One of these, the Soda Spring, is about 75 yards west of north from the bathhouse. When visited it was inclosed by a concrete curb and was equipped with a hand pump, but it discharged about 4 gallons a minute of warm water. This water has been carbonated and bottled for several years by the local soda works. A cool iron spring issues in a ravine 175 yards northwest of the bathhouse. Water from this spring was piped to a drinking faucet near the bathhouse, and the overflow, about 1 gallon a minute, supplied a cattle-watering trough in the ravine.

Southeast of the bathhouse at least half a dozen warm pools and seepage springs are scattered for half a mile or more along the river flat that borders the present channel. Mud from one or two of these pools is used in the plunges at the bathhouse, and two or three of the flowing springs are used locally for bathing and for laundry. The following are analyses of several of the springs:

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[1] This amount would be furnished by a vertical discharge pipe 10 inches in diameter above whose top the water domed up approximately 10 inches.

Analyses of water from Paso Robles Hot Springs and Paso Robles Mud Bath Springs, San Luis Obispo County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5		6		7		8		9		10		11	
Temperature	41° C. (107° F.)		42° C. (108° F.)		43° C. (110° F.)		40°-50° C. (104°-122° F.)		40°-50° C. (104°-122° F.)		50° C. (122° F.)		15° C. (59° F.)		26° C. (79° F.)		25° C. (77° F.)		25° C. (77° F.)		18° C. (64° F.)	
Properties of reaction:																						
Primary salinity	36		48		51		83		85		87		68		82		64		56		54	
Secondary salinity	0		0		0		13		4		6		21		2		7		0		0	
Tertiary salinity	0		0		0		0		0		0		0		0		0		0		0	
Primary alkalinity	46		38		44		0		0		0		0		0		0		13		10	
Secondary alkalinity	18		14		5		4		11		7		11		16		29		31		36	
Tertiary alkalinity	29		24		61		36		45		90		20		19		22		21		2	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	331	14.37	463	20.14	387	16.83	665	28.86	825	35.88	764	33.22	366	15.92	897	39.00	419	18.24	343	14.92	313	13.61
Potassium (K)	20	.51	34	.87	5.6	.14	11	.28	35	.90	Tr.	Tr.	198	5.06	116	2.97	7.4	.19	17	.43	Tr.	Tr.
Lithium (Li)	Tr.	Tr.	Tr.	Tr.			Tr.	Tr.	Tr.	Tr.					Tr.	Tr.	Tr.	Tr.				
Barium (Ba)															Tr.	Tr.						
Calcium (Ca)	38	1.89	23	1.15	13	.65	119	5.91	93	4.64	75	3.74	48	2.39	126	6.28	132	6.57	69	3.44	45	2.24
Magnesium (Mg)	16	1.34	29	2.38	2.2	.18	1.2	.10	25	2.06	13	1.07	91	7.48	32	2.63	45	3.71	43	3.54	66	5.43
Iron (Fe)	Tr.	Tr.	8.8	.31	4.0	.14	.91	.03	1.4	.05			Tr.	Tr.	2.4	.09	.91	.03	Tr.	Tr.	12	.43
Aluminum (Al)			2.3	.25	1.6	.18			7.3	.81			7.6	.84	11	1.22			7.7	.85	2.3	.25
Manganese (Mn)									Tr.	Tr.			Tr.	Tr.	1.4	.04					Tr.	Tr.
Sulphate (SO_4)	31	.65	189	3.94	115	2.40	538	11.21	644	13.41	576	12.00	595	12.39	677	14.10	310	6.46	251	5.23	224	4.67
Chloride (Cl)	206	5.80	280	7.90	235	6.63	805	22.70	894	25.21	834	23.52	532	15.00	101.7	28.68	496	14.00	261	7.36	241	6.80
Bromide (Br) and iodide (I)	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.			Tr.	Tr.	Tr.	Tr.	Tr.	Tr.				
Sulphide (S)													39	2.43								
Carbonate (CO_3)	350	11.66	381	12.70	265	8.83	27	.91	146	4.87	74	2.47	31	1.03	246	8.20	142	4.72	292	9.75	308	10.27
Metaborate (BO_2)	Tr.	Tr.	Tr.	Tr.			14	.33									Tr.	Tr.			Tr.	Tr.

Phosphate (PO_4)	Tr.	Tr.	......	......	......	......	1.3	.04	......	......	......	......	......	......	......	......	Tr.	Tr.	......	......	......	......
Silica (SiO_2)	66	2.19	30	1.00	6.3	.21	105	3.48	43	1.43	16	.53	18	.60	111	3.68	107	3.53	16	.53	15	.50
	1,058	......	1,440.1	......	1,034.7	......	2,287.4	......	2,713.7	......	2,352	......	1,926.6	......	2,321.5	......	1,659.3	......	1,299.7	......	1,226.3	......
Carbon dioxide (CO_2)	Tr.	Tr.	76	3.44	150	6.82	195	8.86	362	16.43	683	31.05	45	2.03	100	4.55	137	6.22	78	3.56	Tr.	Tr.
Hydrogen sulphide (H_2S)	52	3.04	25	1.45	65	3.81	7.1	.42	27	1.61	46	2.48	62	3.64	22	1.32	.53	.03	11	.62	Tr.	Tr.

1. Main Sulphur Spring. Analysts, Jaffa and Hogland (1910?). Authority, advertising matter.
2. Main Sulphur Spring. Analyst and authority, Winslow Anderson, 1889.
3. Main Sulphur Spring. Analysts, Price and Hewston, (1885 ?). Authority U. S. Geol. Survey Bull. 32.
4. Mud Bath Springs. Analysts, Jaffa and Hogland (1910?). Authority, advertising matter.
5. Mud Bath Springs. Analyst and authority, Winslow Anderson, 1889.
6. Mud Bath Springs. Analysts, Price and Hewston (1885?). Authority, U. S. Geol. Survey Bull. 32.
7. White Sulphur Spring. Analyst and authority, Winslow Anderson, 1889.
8. Sand Spring. Analyst and authority, Winslow Anderson, 1889.
9. Soda Spring. Analysts, Jaffa and Hogland (1910?). Authority, advertising matter.
10. Soda Spring. Analyst and authority, Winslow Anderson, 1889.
11. Iron Spring. Analyst and authority, Winslow Anderson, 1889.

The Main Sulphur Spring has a flow of primary alkaline saline water in which secondary alkalinity and tertiary alkalinity are minor properties. The three analyses of this spring indicate a gradual change in character toward secondary alkalinity at the expense of primary salinity. The Mud Bath and Sand springs are essentially primary saline and are similar both in character and concentration. The White Sulphur Spring is distinguished from the others by a higher secondary salinity and large relative proportion of magnesium. Anderson's analyses of the Soda and Iron springs show them to yield primary saline waters in which secondary alkalinity is a prominent and primary alkalinity a minor property. The Jaffa and Hogland analysis of Soda Spring represents a water of rather complex character, such as would be obtained by adding calcium sulphate to the water represented by Anderson's analysis. This may be accounted for by a change in the character of the water, but it is not unlikely that different springs were sampled for the two analyses.

A fault is mapped as extending southward along Salinas Valley nearly to Paso Robles, and two other faults have been traced in the hills to the west. Such broken structure may also exist at Paso Robles and give rise to the springs, but the warm water that issues naturally, and is also obtained from deep wells here, may be of artesian origin and be drawn from the deep alluvium.

SANTA YSABEL SPRINGS (SAN LUIS OBISPO 3).

About 4 miles southeast of Paso Robles a large volume of warm sulphureted water rises in a ravine on the eastern side of Salinas Valley. In the late eighties a resort was started here, but the plans were not carried out, and in 1908 there was only a small private bathhouse at the springs. One main spring rises beneath the bathhouse and discharges about 150 gallons a minute of water 94° in temperature. At the northeast corner of the bathhouse another warm spring of slight yield rises in a concrete basin. The water flows northward half a mile to a storage reservoir or artificial lake, and is used for irrigation.

Small incrustations of gypsum form on stones over which the water flows near its source, and a small amount of acid salt is also deposited. The following is an analysis of water from the main spring. An analysis of water from the spring at the northeast corner of the bathhouse shows that it is practically the same as that of the main spring.

Analysis of water from main spring at Santa Ysabel Springs, San Luis Obispo County, Cal.

[Analyst and authority, Winslow Anderson (1888). Constituents are in parts per million.]

Temperature	36° C. (96° F.)
Properties of reaction:	
Primary salinity	43
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	32
Secondary alkalinity	25
Tertiary alkalinity	37

Constituents.	By weight.	Reacting values.
Sodium (Na)	350	15.20
Potassium (K)	8.1	.21
Barium (Ba)	Trace.	Trace.
Calcium (Ca)	28	1.42
Magnesium (Mg)	46	3.78
Iron (Fe)	8.1	.29
Aluminum (Al)	6.6	.73
Manganese (Mn)	1.4	.04
Sulphate (SO_4)	173	3.61
Chloride (Cl)	188	5.30
Bromide (Br) and iodide (I)	Trace.	Trace.
Carbonate (CO_3)	361	12.02
Metaborate (BO_2)	Trace.	Trace.
Silica (SiO_2)	29	.96
	1,199.2	....
Carbon dioxide (CO_2)	100	4.54
Hydrogen sulphide (H_2S)	31	1.80

This water is similar in character to that of the Main Sulphur Spring at Paso Robles Hot Springs. Primary salinity is the dominant property, but primary, secondary, and tertiary alkalinity are prominent.

About a quarter of a mile farther up the ravine other sulphureted springs issue, but they are of small flow and are unimportant.

Like the wells and springs of Paso Robles, Santa Ysabel Springs may be of artesian origin, but their position, 50 feet above the river valley, suggests that faulting has here taken place and allows the escape of water from a moderate depth.

CAMETA WARM SPRING (SAN LUIS OBISPO 5).

Cameta Warm Spring is about 30 miles southeast of Paso Robles and near the road toward Bakersfield. It rises in a board-curbed pool about 5 feet square, at the lower end of a tule patch in a creek channel, and yields about 3 gallons a minute, of moderately sulphureted water 74° in temperature. Its flow is conducted a short distance in a pipe to another pool beneath a shed, where it is used by the residents for bathing.

The water rises in a region of low gravelly hills and is similar in its character and occurrence to Santa Ysabel Springs (San Luis Obispo 3), which are farther west.

FRESNO HOT SPRINGS (FRESNO 9).

Fresno Hot Springs are situated on a branch of Waltham Creek, in the hills of the west side of San Joaquin Valley. Several small warm springs issue along the west side of the canyon, from beds of shale and sandstone, which are the principal rocks of this region.

The springs have long been known and were early improved as a resort. A new bathhouse was built in 1904 and other improvements have been made, so that in 1908 there were accommodations for about 200 people. It is said that the water was formerly warmer, but during recent years it has become necessary to heat it for the baths. The springs are distinctly sulphureted, as would be expected of water rising through shales, but they are not otherwise of notably mineralized character. Some crushing and faulting has possibly taken place in this locality and has furnished a point of escape for the springs, but their relatively small flow and temperatures that are not especially notable render them of no great geologic interest.

MERCEY HOT SPRINGS (FRESNO 8).

Mercey Hot Springs rise near the extreme western edge of Fresno County, among the barren hills that border San Joaquin Valley. The main spring has been excavated to form a reservoir, is lined with concrete, and is housed. It yields warm water of a peculiar "soft" taste.

The following analysis has been published:

Analysis of water from main spring, Mercey Hot Springs, Fresno County, Cal.

[Analyst, Marvin Curtis. Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	94
Secondary salinity	3
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	3
Tertiary alkalinity	6

Constituents.	By weight.	Reacting values.
Sodium (Na)	808	35.12
Potassium (K)	5.9	.15
Lithium (Li)	Trace.	Trace.
Barium (Ba) and strontium (Sr)	Trace.	Trace.
Calcium (Ca)	40	1.98
Magnesium (Mg)	4.5	.37
Iron (Fe)	Trace.	Trace.
Sulphate (SO_4)	12	.25
Chloride (Cl)	1,278	36.03
Carbonate (CO_3)	36	1.19
Metaborate (BO_2)	2.0	.05
Phosphate (PO_4)	.4	.15
Silica (SiO_2)	70	2.32
	2,256.8	....

This water is essentially a solution of common salt with minor impurities. Bubbles of gas rise in the spring and the water there has a faint sulphureted odor, but at the baths, 85 yards away, it has lost this odor.

The spring has been known since 1848, and was first used to supply sheep-watering troughs. Water is scarce in this region, and the Mercey spring is still valuable for stock watering, as well as for its mineral character. There was formerly a small resort here, and the bathing accommodations were in 1908 still patronized by people from the surrounding towns. For several years prior to the earthquake of April 18, 1906, the water was bottled for table use, but the market was interrupted at that time, and in 1908 had not been resumed.

The main spring rises in an open draw at the base of low, cherty gravel slopes. About 100 yards eastward, at the opposite side of a low ridge, another small warm spring issues that is more strongly sulphureted, and 400 yards westward, in a ravine, is a small cool spring that is not noticeably mineralized.

A dike of serpentinous gabbro 50 yards or more in thickness cuts across the slopes a short distance south of the springs. It may partially account for their issuance, though it is on the slope above, not below them.

GILROY HOT SPRING (SANTA CLARA 9).

Gilroy Hot Spring is situated on the side of Coyote Creek canyon, in the southeastern part of Santa Clara County. The spring, which has an observed temperature of 110° and a flow of perhaps 15 gallons a minute, issues in a ravine on the western side of the canyon, 200 feet above Coyote Creek. The rocks of the area are chiefly sandstones, cherts, and conglomerate. Some serpentinous and gabbroid rocks were noted on the slopes to the southeast, within half a mile of the spring, and suggest that intrusive rock may have given rise to the heated water at this place. The following is an analysis of water from the spring:

Analysis of water from Gilroy Hot Spring, Santa Clara County, Cal.

[Analyst and authority, Winslow Anderson (1888). Constituents are in parts per million.]

Temperature	43° C. (110° F.)
Properties of reaction:	
Primary salinity	60
Secondary salinity	31
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	9
Tertiary alkalinity	62

Constituents.	By weight.	Reacting values.
Sodium (Na)	228	9.93
Potassium (K)	17	.42
Calcium (Ca)	66	3.30
Magnesium (Mg)	43	3.57
Iron (Fe)	2.1	.075
Sulphate (SO_4)	185	3.85
Chloride (Cl)	422	11.91
Iodide (I)	Trace.	Trace.
Carbonate (CO_3)	46	1.53
Arsenate (AsO_4)	Trace.	Trace.
Silica (SiO_2)	57	1.88
	1,066.1	....
Carbon dioxide (CO_2)	114	5.16
Hydrogen sulphide (H_2S)	61	3.58

The large amount of magnesium in proportion to calcium is worthy of note in connection with the presence of serpentine in the locality. This is a primary-saline water in which secondary salinity is a notable property. Tertiary alkalinity is also high, adding to its medicinal value.

The spring has been used as a resort since the seventies, and in 1908 a hotel, annex, and cottages provided rooms for about 125 guests. From a cemented and covered reservoir that has been excavated at the spring the water flows into two small plunge baths and is also piped to bathtubs. Besides its use for bathing, the water is much used for drinking and has been carbonated and bottled for a number of years by the soda works at Gilroy.

WARM SPRINGS (ALAMEDA 3).

Four warm springs that issue on the hillside bordering the lowland at the southeast end of San Francisco Bay have given the small town of Warm Springs its name. They are situated about 2 miles northeast of the town, within the private grounds of Mr. Joseph W. Stanford. One of the springs rises in the lawn adjacent to Mr. Stanford's residence. It has been inclosed to form a covered reservoir about 12 feet square, which furnishes part of the domestic supply and yields perhaps 5 gallons a minute. Two other springs rise beside a walk a few yards away, in open basins, from which there are flows of approximately 1 and 4 gallons. The larger of these two springs has a temperature of 86°. The fourth spring is 200 yards southward, in a little swale on the southern side of a knoll. It yields perhaps 5 gallons a minute, of water 90° in temperature, which is collected in a small covered reservoir and piped to the grounds for domestic and garden use.

The water of all the springs is faintly sulphureted and is considered to be somewhat mineralized by sodium salts.

Sandstone, gravel, and some calcareous material form the hill slopes here. A fault is mapped on Plate III (in pocket) along these slopes; and a landslide scar some distance above the springs, and other, cooler springs on the higher slopes furnish local evidence that faulting has taken place and has probably given rise to the warm springs. At the time of the earthquake in April, 1906, a fifth small spring broke forth in the lawn near the residence and flowed for a month.

ROCKY POINT SPRING (MARIN 3).

In the Coast Ranges north of San Francisco Bay are a number of thermal springs that form a general group in the older sediments of this part of the State. A warm spring that is mildly sulphureted rises on the beach about 6 miles northwest of Point Bonita. It is locally known as Rocky Point Spring, but it is exposed only at low tide and is of little importance. Pyritiferous rock that borders the coast here possibly furnishes the sulphur constituent of the water, and the oxidation of the pyrite may account for the abnormal temperature of the spring.

SKAGGS HOT SPRINGS (SONOMA 8).

Along the southwestern bank of a tributary of Warm Spring Creek in northern Sonoma County three hot springs issue in a distance of 75 yards. At this locality is one of the oldest resorts of the State, opened to the public in 1857. The region is composed of old sedimentary rocks, and the springs rise from crevices in buff-colored material that is probably sandstone, though its appearance is tuffaceous. Eastward along the road to Geyserville, a few schistose ledges, serpentine belts, and a little opalized rock, all of which are probably of the Franciscan formation, were noted. The sediments are crushed and slickensided at many places and show that the rocks have been much disturbed. Such crushing, which was possibly accompanied by some faulting, may account for the escape of hot water at Skaggs Springs and at other places in these disturbed sediments. The water at Skaggs is not perceptibly sulphureted, but it has a distinct oily odor and taste.

Analyses of water from main spring, Skaggs Hot Springs, Sonoma County, Cal.

[Constituents are in parts per million.]

	1		2	
Temperature	54° C. (129° F.).			
Properties of reaction:				
Primary salinity		5		4
Secondary salinity		0		0
Tertiary salinity		0		0
Primary alkalinity		81		84
Secondary alkalinity		14		12
Tertiary alkalinity		119		9
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	879	38.22	898	39.05
Potassium (K)	9.8	.25	3.8	.096
Lithium (Li)	Trace.	Trace.	.19	.028
Barium (Ba)	3.0	.04	2.9	.042
Strontium (Sr)	Trace.	Trace.	.25	.006
Calcium (Ca)	26	1.30	15	.75
Magnesium (Mg)	61	5.03	55	4.51
Iron (Fe)	5.0	.18	.45	.016
Aluminum (Al)	Trace.	Trace.	.04	.004
Sulphate (SO_4)	26	.54	2.4	.050
Chloride (Cl)	60	1.68	63	1.77
Iodide (I)	1.9	.015	Trace.	Trace.
Carbonate (CO_3)	1,157	38.58	1,146	38.19
Metaborate (BO_2)	176	4.10	193	4.49
Silica (SiO_2)	151	5.01	120	3.98
	2,555.7		2,500.03	
Carbon dioxide (CO_2)	1,057	48.00		

1. Analyst and authority, Winslow Anderson, 1888.
2. Analyst, E. W. Hilgard. Authority, U. S. Geol. Survey Bull. 32.

The analyses indicate that the water is preeminently primary alkaline in character, resembling a solution of ordinary baking soda through which carbon dioxide has been passed. The presence of barium, strontium, lithium, and iodine, the excess of magnesium over calcium, and the relatively large proportion of borates are of interest. The apparent lack of agreement in the tertiary alkalinity of the two analyses is accounted for by the omission of the carbon dioxide determination in Hilgard's analysis.

In 1909 water from the lowest spring was piped to baths, that from the central spring was piped across the creek to the laundry, and that from the upper spring rose in a cemented drinking basin. The observed temperatures were, respectively, 120°, 122°, and 135°, and estimated flows about 7, 5, and 3 gallons a minute.

A fourth spring, which is cool and of small flow, formerly issued from the sandstone at the creek side 100 yards above the upper hot spring and formed a drinking pool, but in recent years it has ceased to be important. In 1909 a frame hotel and about a dozen cottages provided accommodations for 150 guests, and there is ample space for the erection of tents.

HOODS HOT SPRINGS (SONOMA 1).

Warm water issues at Hoods Hot Springs in the canyon of Dry Creek, near the north edge of Sonoma County. The springs are of small flow and have been used only locally for bathing. They are probably the same that have been sometimes referred to as Fairmount Hot Springs. The rocks in their vicinity, as at Skaggs, are chiefly crushed sediments, but garnet and glaucophane schists were observed at a few places eastward along the road.

POINT ARENA HOT SPRINGS (MENDOCINO 33).

Point Arena Hot Springs are situated in the canyon of Garcia River, about 15 miles by road south of east from Point Arena. The property has been a resort since about 1895, and in 1910 a hotel, several cottages, and a number of tents provided accommodations for 100 guests. A steep trail leads from the buildings, on the canyon side, to the springs and the stream 200 yards away. Close to the northeastern side of the stream two hot springs rise in cemented basins about 6 feet apart and yield flows of about 1½ and 3 gallons a minute of mildly sulphureted water 112° and 110° in temperature. The water supplies tub baths in two small houses that are built over the stream, and a pool in the stream itself is also much used for bathing. The springs issue in an area of basaltic lava which extends for about 8 miles northwestward along Garcia River and probably also for some distance eastward from the springs. In 1910 graphite was being shipped from workings about 6 miles northeast of the springs. Shales extend from the western border of the lava to the coast at Point Arena.[1]

ORRS HOT SPRINGS (MENDOCINO 20).

Orrs Hot Springs (Pl. IV, *B*, p. 32) issue along the eastern edge of the main fork of Big River, which here flows in a deep, wide canyon. The locality is a resort and stage station on the road between Ukiah and Mendocino. A hotel and two or three cottages furnish accommodations for about 50 guests, and tents are erected during the summer when needed. Five springs rise near the hotel. They range in temperature from about 70° to 104° and have individual flows of 4 or 5 gallons a minute. One of the springs rises in a small swimming plunge, and the others supply tub and plunge baths. Near one side of the plunge is also a drinking spring, 85° in temperature and of seeping flow, and at the edge of the stream, 250 yards below the main group, another spring that is used for drinking issues with an observed temperature of 63° and a flow of about 2 gallons a minute.

A hydrocarbon gas that was formerly used for lighting issues at the main springs, but the earthquake of April 18, 1906, apparently so altered the points of escape of the gas that in 1909 it was no longer used. The water is noticeably sulphureted, but an early analysis[2] indicates that it is only moderately mineralized, though it has a considerable silica content.

The rocks of the region are of the Franciscan formation and near the springs consist of crushed sandstone with some chert. Serpentine and siliceous shales were noted on the higher slopes of the canyon.

The effect of the San Francisco earthquake on the springs suggests that faults subsidiary to the San Andreas rift exist in this part of the mountains. Local evidence of alteration in the sediments, however, indicates that crushing alone may be sufficient to account for the issuance of warm water at this point, along the bottom of the deep canyon.

THE GEYSERS (SONOMA 4).

The Geysers of Sonoma County have become widely known, both for their scenic features and for their scientific interest, but it is only proper to state that there are no true geysers, intermittently throwing out hot water, at this place. The locality is said to have been first brought to public notice in 1846 by a party of hunters. Its unusual character soon became of more than local interest, a resort

[1] Shale cliffs at the port of this settlement form a noticeable feature from the ocean, and expose beds that dip 40° to 65° northward. A 4-foot bed of oil sand is also exposed near the boat landing, and some prospecting for oil has been done near by.

[2] California State Mineralogist Tenth Rept., p. 313, 1890.

was early opened near the springs, and a hotel and baths have been erected for nearly half a century. During recent years several cottages and additional bathing facilities have been constructed, so that in 1909 about 75 people could be comfortably taken care of. A narrow but well-graded road extends from Cloverdale to the hotel

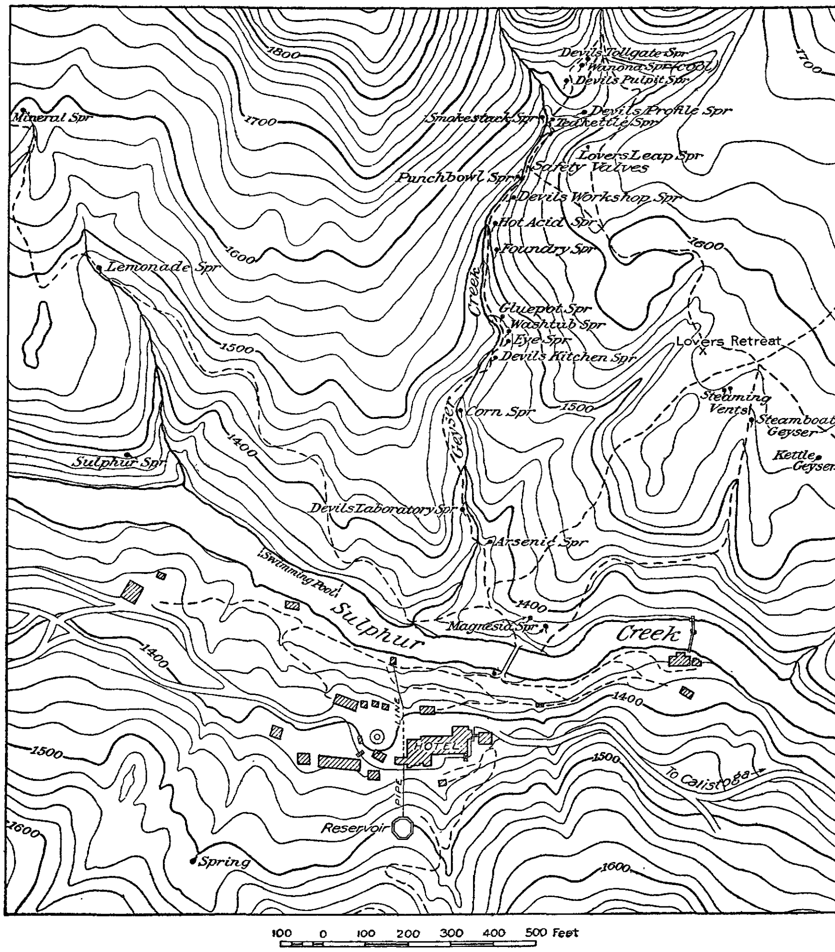

FIGURE 1.—Map of The Geysers, Sonoma County, Cal.

grounds. In the spring of 1910 a better road was completed from Healdsburg into the locality, and it was thus made easily accessible to automobiles.

The main group of hot springs and vapor vents that constitute the so-called geysers issue on the northern side of the canyon of Sulphur Creek, within an area that extends about 300 yards along the canyon side and about an equal distance north from the creek, nearly the entire active area being shown in Plate X, *A* (p. 140). In this area 12 flowing hot springs of note, 10 hot pools, and 12 vapor vents and areas of vaporous exhalations were counted. A cool iron spring at the north edge of the creek and a cool sulphureted drinking spring near its southern bank may be added to the number of springs in this area. The approximate positions of the numerous vents are shown on the contour map, figure 1, which is reproduced from a map of the property that was kindly loaned by the owner, Mr. H. A. Powell. Most of the springs and vents are along a ravine that extends northward up the canyon side. Several cooler pools are used for bathing the feet or the eyes and have received such names as the Corn Spring and the Eye Spring. A number of others have been given descriptive names such as Teakettle, Washtub, and Gluepot. Most of the hot water is strongly acid, or sulphureted, or both. Crystals of native sulphur and of acid salts are deposited at many small vents, and efflorescent deposits of Epsom salt are formed under several overhanging banks. Although most of the springs issue in the ravine, those of perhaps largest flow issue 175 yards eastward, on the steep slope 50 feet above the stream. Water from these springs is piped across the stream and supplies the baths. Vapor from a large vent at the base of the slope below the springs is also piped across, and supplies vapor baths. The most noted vent, which is known as Steamboat Geyser, issues on the slope 150 yards north of the large springs, it being the single steam vent shown on the right side of the illustration, Plate X, *A*. The steam is said to have issued originally from a small orifice, but a few years ago a short piece of 1½-inch pipe was firmly inserted over it in a vertical position. In 1909 the vapor issuing through this pipe had a temperature of 205°. A steam whistle was at one time attached to the pipe, but its noise so disturbed the guests that it was removed.

Analyses of a number of the waters at this locality have been published. These are here republished in standard form, and the names of the several springs, as nearly as they could be identified, are also placed on the map (fig. 1).

Analyses of water from The Geysers, Sonoma County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5		6		7		8		9		10		11		12	
Temperature	22° C. (72° F.)		21° C. (70° F.)		58° C. (137° F.)		42° C. (108° F.)		59° C. (138° F.)		100° C. (212° F.)		100° C. (212° F.)		37° C. (98° F.)		59° C. (139° F.)		58° C. (136° F.)		58° C. (136° F.)		39° C. (103° F.)	
Properties of reaction:																								
Primary salinity	Trace.		0		11		8		12		16		35		6		2		2		2		16	
Secondary salinity	98		98		10		0		6		14		27		26		34		30		29		22	
Tertiary salinity	2		0		0		0		0		70		38		68		64		68		69		62	
Primary alkalinity	0		0		0		5		0		0		0		0		0		0		0		0	
Secondary alkalinity	0		2		79		87		82		0		0		0		0		0		0		0	
Tertiary alkalinity	136		35		182		28		242		8		15		30		37		27		13		18	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	Tr.	Tr.	.....	.....	22	0.96	29	1.26	18	0.78	322	14.00	130	5.67	40	1.74	19	0.81	17	0.73	32	1.37	177	7.69
Potassium (K)	Tr.	Tr.	.....	.....	Tr.	Tr.	1.6	.04	.....	.....	.....	.....	2.1	.05	Tr.	Tr.	Tr.	Tr.	.....	.....	5.5	.14	37	.95
Barium (Ba)	Tr.	Tr.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Tr.	Tr.	.....	.....	.....	.....	.....	.....	.....	.....
Calcium (Ca)	20	1.00	17	0.85	42	2.11	50	2.49	45	2.24	22	1.10	35	1.76	12	.61	.....	.....	19	.96	22	1.12	.....	.....
Magnesium (Mg)	9.5	.78	8.7	.72	69	5.70	76	6.25	40	3.29	135	11.11	33	2.74	82	6.76	125	10.28	119	9.81	316	25.98	141	11.58
Iron (Fe)	1.2	.04	1.0	.04	1.3	.07	.6	.02	.7	.03	.....	.....	.....	.....	39	1.41	45	1.60	35	1.22	80	2.87	59	2.11
Aluminum (Al)	2.1	.23	1.5	.18	5.1	.56	1.6	.18	.5	.06	84	9.34	7.9	.88	156	17.28	170	18.85	173	19.15	56	6.19	87	9.60
Manganese (Mn)	.....	.....	.....	.....	Tr.	Tr.	.....	.....	.....	.....	.....	.....	.....	.....	Tr.	Tr.	.....	.....	.....	.....	.....	.....	.....	.....
Hydrogen (H)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	53	52.52	5.5	5.46	.86	.85	3.2	3.15	3.7	3.65	57	56.81	22	21.33
Sulphate (SO_4)	88	1.83	75	1.56	88	1.83	40	.83	55	1.15	4,230	88.07	795	16.56	1,376	28.65	1,665	34.69	1,706	35.52	4,540	94.48	2,570	52.70
Chloride (Cl)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Tr.	Tr.	.00	.00	.....	.....	.....	.....	20	.56
Carbonate (CO_3)	.....	.....	1.0	.03	.....	.....	279	9.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Metaborate (BO_2)	.....	.....	.....	.....	330	7.68	.....	.....	.....	.....	.....	.....	.....	.....	*a* 20	.47	Tr.	Tr.	.....	.....	Tr.	Tr.	.....	.....
Silica (SiO_2)	25	.83	17	.56	137	4.51	81	2.69	614	20.37	220	7.26	75	2.47	161	5.32	281	9.30	295	9.76	361	11.94	282	9.34
	145.8	.....	121.2	.....	694.4	.....	558.8	.....	773.2	.....	5,066	.....	1,083.5	.....	1,886.86	.....	2,308.2	.....	2,367.7	.....	5,469.5	.....	3,395	.....

Carbon dioxide (CO_2)	Tr.	Tr.	......	......	......	......	......	......	......	......	......	......	......	......	5.1	.23	......	......	......	......	......	......	......	......
Hydrogen sulphide (H_2S)	28.1	1.65	......	......	183	10.73	(b)	......	(b)	......	(b)	......	(b)	......	41.9	2.46	62	3.63	(b)	......	(b)	......	(b)	......

a Reported as "borates"; recalculated from HBO_2 by comparison with the other analyses.

b Excess.

1. Iron Spring. Analyst and authority, Winslow Anderson (1888).
2. Iron Spring. Analyst, Thomas Price (1888). Authority, Winslow Anderson.
3. Bathing water spring. Analyst and authority, Winslow Anderson (1888).
4. Indian Spring. Analyst, Thomas Price (1888). Authority, Winslow Anderson.
5. Eye Spring. Analyst, Thomas Price (1888). Authority, Winslow Anderson.
6. Devils Tea Kettle Spring. Analyst, Thomas Price (1888). Authority, Winslow Anderson.
7. Witches Cauldron Spring. Analyst, Thomas Price (1888). Authority, Winslow Anderson.
8. Alum Spring. Analyst and authority, Winslow Anderson (1888).
9. Hot Alum Spring. Analyst and authority, Winslow Anderson (1888).
10. Hot Alum Spring. Analyst, Thomas Price (1888). Authority, Winslow Anderson.
11. Hot Acid Spring. Analyst, Thomas Price (1888). Authority, Winslow Anderson.
12. Lemonade Spring. Analyst, Thomas Price (1888). Authority, Winslow Anderson.

The waters form a remarkable series. The analyses indicate that all are alike in being sulphureted and nearly free from chloride radicle and in containing a relatively small proportion of primary bases. The bathing water and Indian and Eye springs are similar in many respects. Secondary alkalinity is the most prominent property in the three, but in the bathing water the alkalinity is due to borates, in the Indian Spring to carbonates, and in the Eye Spring to silicates, if the analyses are correct and complete. In all the other waters tertiary salinity is specially noteworthy, being an unusual characteristic of natural waters. Excess of magnesium over calcium is also of interest.

The rocks of this region consist of crushed and altered sandstones and shales, with cherts, schists, and associated serpentine, which form a part of the Franciscan formation. In the localities where the vapors and hot waters issue the sandstone is greatly altered, being changed to a clinker-like siliceous material. Serpentine is exposed along the canyon side between Steamboat Geyser and the main ravine. The presence of the serpentine at this place is of interest from the fact that two magnesia springs issue near what appears to be its southern border. Water from one of these springs is carbonated and bottled as Geyser Water.

At several places on the north side of Sulphur Creek, both above and below The Geysers, there are areas where the rock has been bleached and decomposed by solfataric action, and at a few of them hot water and vapor still issue. Indian Spring, of which an analysis has been given, is a warm pool about three-quarters of a mile west of the hotel.

LITTLE GEYSERS (SONOMA 5).

About 4 miles above The Geysers, at a locality known as Little Geysers, vapor and hot water issue in notable amounts. At this place there is an area of perhaps one-quarter of a square mile on open slopes within which the rock has been bleached and altered, but the surface activity of heated water is now mainly confined to an area about 200 yards in diameter. Three small hot springs, seven hot pools, and four vapor vents were counted here. A cabin has been built near by and a small bathhouse at one of the springs has been used by miners and, in summer, by campers. About 250 yards below the cabin the largest hot spring that was noted in this locality rises at the creek edge and is used as a drinking pool. It yields about 5 gallons a minute of faintly sulphureted water, 160° in temperature.

About 1 mile southward from Little Geysers is the Socrates quicksilver mine. The relation of the quicksilver deposits to hot springs and to areas of lava has been mentioned by Becker,[1] with special ref-

[1] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, p. 404, 1888.

erence to areas northward and eastward from Little Geysers, but his conclusions are probably just as applicable to the area in the canyon of Sulphur Creek. He considers that the cinnabar in the Knoxville, Ætna, and Sulphur Bank localities has been deposited by the action of the hot waters.

ANDERSON SPRINGS (LAKE 55).

Anderson Springs are situated about 5 miles northwest of Middletown, along a branch of Putah Creek. A resort has been conducted at this place for many years, and in 1910 a hotel and several cottages provided accommodations for 150 guests.

Nine springs that differ in character of water emerge at rather widely separated points on the property, but are reached by paths that form pleasant walks along the wooded canyon. The Cold Sulphur Spring, which is the farthest downstream, issues from schistose material at the creek edge 300 yards east of the hotel. It has been protected by a cement basin and yields a small flow of cool, clear, rather strongly sulphureted water used for drinking. About 400 yards by trail eastward and southward from the hotel, in a little gulch on the side of a ravine, is the Sour Spring, which yields a slight flow of water that tastes of alum. The spring is perennial, but it seems to be supplied by surface water that becomes mineralized by seeping through crushed sedimentary material. Across the creek and about 100 yards northeast of the hotel, in a rock-walled pool at the creek edge, is Father Joseph Spring, which yields mildly sulphureted water that is pleasant for drinking and is considered to be a gentle laxative. Belmer Spring is 675 yards west of the hotel and beneath a gravel bank at the north side of the creek. The water rises in a pool a few feet in diameter and also in a barrel sunk near by. It is much used for drinking, but it tastes disagreeably strong of sulphides. The other five springs form a group about 325 yards farther upstream, where they issue from banks of greatly altered sedimentary rock. The Hot Spring, which is the principal one, rises in a barrel that forms a drinking pool. The water is thence piped to a small reservoir and a bathhouse near by. This water is mildly sulphureted and when cooled somewhat it is a palatable drinking water. Near it are two short tunnels that also yield warm water of similar character, and a few yards away vapor vents are utilized in small steam-bath cabinets. The other two springs are a few yards westward, across the creek. One forms a pool about 3 feet across, which is normally covered with an iridescent film, possibly of iron, and is known as the Iron Spring. Efflorescent salts—probably sulphates of aluminum and of iron—crystallize on the adjacent banks. The other spring is about 60 yards away, in a branch ravine. It yields clear water that tastes strongly of alum, and the banks near by are also usually coated with alum.

The waters of these last two springs have been only slightly used and are not fit for drinking, as they are too astringent.

The following tables give the approximate temperatures and flows of the springs and the results of analyses that were made a number of years ago:

Approximate temperature and flow of Anderson Springs, Lake County, Cal.

Spring.	Temperature.		Flow (gallons a minute.)
	°C.	°F.	
Cold Sulphur Spring	17	63	¼
Sour Spring	17	63	⅛
Father Joseph Spring	18	64	¼
Belmer Spring	24	75	2
Hot Spring	63	146	1½
Tunnel south of Hot Spring	38	100	½
Tunnel west of Hot Spring	36	97	1
Unused pool	34	93	⅛
Unused spring	36	97	1

Analyses of water from Anderson Springs, Lake County, Cal.

[Authority, Winslow Anderson. Constituents are in parts per million.]

	1		2		3		4		5	
Temperature	17° C. (63° F.)		23° C. (74° F.)		18° C. (64° F.)		51° C. (124° F.)		63° C. (146° F.)	
Properties of reaction:										
Primary salinity	20		19		7		19		20	
Secondary salinity	18		36		42		79		30	
Tertiary salinity	0		0		51		0		0	
Primary alkalinity	0		0		0		0		0	
Secondary alkalinity	62		45		0		2		50	
Tertiary alkalinity	411		504		61		220		355	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting valnes.	By weight.	Reacting values.
Sodium (Na)	111	4.81	54	2.36	3.2	0.14	21	0.92	35	1.52
Potassium (K)	Trace.	Trace.	Trace.	Trace.	6.7	.17	9.0	.23	11	.27
Lithium (Li)	......	......	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Ammonium (NH_4)	......	......	......	......	.7	.04	......	......	......	......
Calcium (Ca)	185	9.25	132	6.61	10	.52	56	2.79	92	4.59
Magnesium (Mg)	117	9.60	43	3.50	17	1.39	25	2.09	30	2.48
Iron (Fe)	3.9	.14	1.0	.035	6.7	.24	9.8	.35	1.1	.04
Aluminum (Al)	......	......	Trace.	Trace.	19	2.13	.8	.09	Trace.	Trace.
Manganese (Mn)	......	......	......	......	1.1	.04	14	.52	5.2	.19
Sulphate (SO_4)	413	8.60	317	6.60	220	4.57	283	5.88	206	4.28
Chloride (Cl)	11	.32	6.7	.19	.8	.02	1.9	.05	4.6	.13
Carbonate (CO_3)	446	14.87	172	5.72	......	......	27	.91	139	4.64
Metaborate (BO_2)	......	......	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Arsenate (AsO_4)	Trace.	Trace.	Trace.	Trace.	......	......	......	......	Trace.	Trace.
Phosphate (PO_4)	......	......	......	......	......	......	1.6	.05	1.7	.05
Silica (SiO_2)	42	1.39	72	2.39	68	2.24	72	2.40	113	3.75
	1,328.9	......	797.7	......	353.2	......	521.1	......	638.6	......
Carbon dioxide (CO_2)	2,072	94.20	1,273	57.80	......	......	220	10.00	598	27.20
Hydrogen sulphide (H_2S)	28	1.62	62	2.67	8.1	.48	......	......	22	1.30

1. Sulphur Spring. Analyst, Winslow Anderson (1888).
2. Belmer Spring. Analyst, Winslow Anderson (1889).
3. Sour Spring. Analyst, G. E. Colby (1889).
4. Iron Spring. Analyst, G. E. Colby (1889).
5. Hot Spring. Analyst, G. E. Colby (1889).

The analyses indicate that the waters of the Sulphur, Belmer, and Hot springs do not differ greatly in chemical character. All three are secondary waters in which salinity and alkalinity are about equally prominent, but the differences in concentration and the unusually large content of manganese in the Hot Spring are of interest. The Iron Spring is characterized by somewhat lower concentration and a higher content of iron than the other three, and it differs from them in properties of reaction chiefly by reason of a greater proportion of sulphate and a smaller proportion of carbonate. The Sour Spring is characterized by a still greater proportion of sulphate and absence of carbonate, and, as is common in waters having tertiary salinity, contains notably large amounts of iron and aluminum. Considering the springs as a group, it appears that the differences in character may have been acquired in the passage of water of the Sour Spring type through calcareous shale and magnesian limestone, the Iron Spring representing a phase in which the water encountered but little limestone.

East of Anderson Springs lava covers the surface, but near the Cold Sulphur Spring a schist is exposed which forms the surface rock westward, and through which the several springs issue. At the group near the Hot Spring it has been altered by solfataric action to the characteristic white, siliceous material that is so plentiful at The Geysers, a few miles to the northwest. In a tunnel-like chamber excavated in it near the Hot Spring, quantities of Epsom salt form a thick efflorescence on the walls, and on the surface slopes outside a yellow coating is deposited that has been collected and used as a catarrh powder. An analysis of a sample of it that was made by Anderson[1] showed that it consists largely of calcium carbonate, with the sulphates of calcium, magnesium, and sodium, and the carbonates of the latter two bases in smaller amounts.

This small area at Anderson Springs that shows the effects of solfataric action is of especial geologic interest in its resemblance to the areas at Little Geysers (Sonoma 5, p. 88), and The Geysers (Sonoma 4, p. 83), which are respectively about 4 and 7 miles in a direct line northwestward across the St. Helena Range.

CASTLE HOT SPRINGS (LAKE 54).

Castle Hot Springs are situated about 1 mile by steep trail on the mountain side west of Anderson Springs (Lake 55, p. 89). Basins or small reservoirs have been excavated and cemented at two hot springs that issue a few yards apart in a ravine that is tributary to Putah Creek. The observed temperatures in these basins were 160° and 164°. Their combined flow—about 8 gallons a minute—could probably be increased by developing two or three near-by seepages

[1] Anderson, Winslow, Mineral springs and health resorts of California, p. 88, 1892.

of hot water. The water is mildly sulphureted but is otherwise only slightly mineralized, as is shown by the following partial analysis:

Analysis of water from Castle Hot Springs, Lake County, Cal.

[Analyst, Curtis and Tompkins (1909 ?). Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	Small.
Secondary salinity	Small.
Tertiary salinity	0
Primary alkalinity	Moderate.
Secondary alkalinity	Dominant.
Tertiary alkalinity	(?)
Residue:	
Combined water	19
Soluble in water	152
Insoluble in water	175
	346
Portion soluble in water:	
Sulphate (SO_4)	24
Chloride (Cl)	6
Carbonate (CO_3)	60
Sodium (Na) and potassium (K), chiefly sodium	62
Portion insoluble in water:	
Silica (SiO_2)	113
Calcium (Ca), magnesium (Mg), and carbonate (CO_3), chiefly calcium	62

The analysis indicates a secondary alkaline, primary alkaline water in which silica is present in relatively large proportion.

The position of these hot springs high on the mountain side is worthy of note, and it is also of geologic interest with respect to the hot springs at Anderson Springs, a mile eastward and 800 feet lower, and at The Geysers, a few miles northwestward across the range and 1,000 feet lower. In another ravine, about 700 yards by path from Castle Hot Springs, but perhaps half that distance in a direct line and 100 feet lower two groups of cool sulphur springs seep from the banks. The rock near the hot springs consists of hard schistose material that is not greatly decomposed, but near the cool springs it has been altered, apparently by solfataric action, and is impregnated with sulphur and sulphate salts.

The property was formerly known as Mills Hot Springs and was at one time conducted as a small resort, the hot water being used for bathing and the water of the cool sulphur springs for drinking. In the summer of 1910 the property had recently changed ownership and was being reimproved as a resort. A hotel, a bathhouse containing a swimming plunge, and a dancing pavilion were being erected, and several tent cottages provided accommodations for a few guests.

A. HOUGH SPRINGS, LAKE COUNTY.

B. HARBIN SPRINGS, LAKE COUNTY.

C. HOWARD SPRINGS, LAKE COUNTY.

The buildings are about one-fourth mile from the hot springs, on a ridge that commands a good view of the valley of Putah Creek and the mountains eastward.

GORDON HOT SPRING (LAKE 46).

Gordon Hot Spring rises on the eastern side of Cobb Valley Creek, near the head of a small meadow. A number of years ago this spring was used to some extent for bathing, but in 1909 the small bathhouse had been removed and the spring was unused. It yielded about five gallons a minute of water at a temperature of 92°. The water has a slightly oily taste, like that at Skaggs Hot Springs. (See p. 81.)

The following is an early analysis of the water:

Analysis of water from Gordon Hot Spring, Lake County, Cal.

[Analyst and authority, Winslow Anderson (1888). Constituents are in parts per million.]

Temperature	38° C. (100° F.)	
Properties of reaction:		
Primary salinity	38	
Secondary salinity	32	
Tertiary salinity	0	
Primary alkalinity	0	
Secondary alkalinity	30	
Tertiary alkalinity	5	
Constituents.	By weight.	Reacting values.
Sodium (Na)	211	9.18
Potassium (K)	7.0	.18
Calcium (Ca)	195	9.72
Magnesium (Mg)	68	5.60
Aluminum (Al)	32	3.57
Sulphate (SO_4)	532	11.08
Chloride (Cl)	216	6.08
Carbonate (CO_3)	226	7.52
Silica (SiO_2)	39	1.29
	1,526.0	....
Carbon dioxide (CO_2)	Excess.	....

The analysis indicates a primary and secondary saline water in which secondary alkalinity is prominent. Tertiary alkalinity is not fully reported but is probably high. The large proportion of aluminum shown by the analysis is unusual for such a water and is probably in error.

The rocks of this locality are sediments that are overlain by lava and by siliceous tuff in which opaline silica is common. A ledge of quartzitic schist that contains considerable amounts of albite and chlorite is exposed 50 yards northeast of the spring.

HARBIN SPRINGS (LAKE 56).

Harbin Springs (Pl. VI, *B*) are in southern Lake County, about 3½ miles north of Middletown. Three springs, known as the Arsenic, Iron, and Sulphur springs, rise close together in a ravine on the western side of a branch of Putah Creek, and yield water at temperatures of 90°, 116°, and 120°, at a rate of 1, ½, and 8½ gallons a minute, respectively. The property has been a resort for many years and the water of the Iron and Sulphur springs is used in tub and plunge baths. Buildings have been erected from time to time, so that in 1909 accommodations for about 200 people were provided by a hotel, a three-story rooming house, 8 or 10 cottages, and a dozen tent houses. A large building containing a gymnasium and dancing floor provides means for entertainment. The waters of four springs at this place have been analyzed. One of the springs, which was called the Magnesia Spring, was originally of slight flow and is no longer important, but the following analyses show the characters of the three others:

Analyses of water from Harbin Springs, Lake County, Cal.

[Analyst and authority, Winslow Anderson. Constituents are in parts per million.]

	1		2		3	
Temperature	50° C. (122° F.)		47° C. (116° F.)		32° C. (90° F.)	
Properties of reaction:						
Primary salinity		47		40		28
Secondary salinity		22		0		0
Tertiary salinity		0		0		0
Primary alkalinity		0		28		12
Secondary alkalinity		31		32		60
Tertiary alkalinity		34		38		24
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	252	10.98	192	8.35	121	5.28
Potassium (K)	17	.43	17	.43	40	1.02
Lithium (Li)	....	....	....	....	Trace.	Trace.
Calcium (Ca)	136	6.79	14	.71	46	2.28
Magnesium (Mg)	72	5.90	42	3.43	86	7.11
Iron (Fe)	11	.39	16	.56	7.7	.27
Aluminum (Al)	15	1.66	6.6	.73	20	2.21
Manganese (Mn)	....	....	....	....	Trace.	Trace.
Sulphate (SO_4)	476	9.92	144	3.00	63	1.32
Chloride (Cl)	239	6.76	78	2.19	110	3.09
Carbonate (CO_3)	234	7.80	248	8.27	345	11.49
Metaborate (BO_2)	....	....	....	....	Trace.	Trace.
Arsenate (AsO_4) [a]	0.8	.017	....	....	3.1	.067
Silica (SiO_2)	47	1.56	24	.79	33	1.09
	1,499.8	....	781.6	....	874.8	....
Carbon dioxide (CO_2)	36	1.65	80	3.62	53	2.41
Hydrogen sulphide (H_2S)	78	4.56	....	....	Trace.	Trace.

[a] Reported as "arsenious salts" and recalculated from sodium arsenate.

1. Sulphur Spring. Analyst and authority, Winslow Anderson (1888).
2. Iron Spring. Analyst and authority, Winslow Anderson (1889).
3. Arsenic Spring. Analyst and authority, Winslow Anderson (1889).

The water of the Sulphur Spring appears from the analysis to be of mixed type and rather high concentration; its most noteworthy peculiarity is the content of hydrogen sulphide. The Iron and Arsenic springs are similar in concentration and character, both possessing marked primary alkalinity as well as primary salinity and secondary alkalinity. The relatively high proportion of magnesium is of interest and, in connection with the relative amounts of other radicles, it indicates probable contact with magnesium-rich rocks. As its name implies, the Arsenic Spring contains an exceptionally large proportion of arsenic and its content of aluminum is also uncommon for an alkaline water. All the springs contain iron in unusual proportion.

Shale that dips at steep angles is exposed on the hillsides near Harbin Springs, but about 25 yards above the springs a belt of amphibolite schist appears. Its observed thickness is about 25 yards and its lower side apparently crosses the ravine very near the point at which the springs emerge. As the high tilting of the sediments is the only other geologic feature noticed that might account for the springs at this place, it appears probable that the schist at least furnishes a point of escape for deep waters, and it possibly also aids in giving the water its abnormal temperature. The conditions presented by this rock cutting through the sediments just above the springs may be similar to those at Mercey Hot Springs, in Fresno County. (See p. 78.)

HOWARD SPRINGS (LAKE 51).

About 9 miles southwest of the town of Lower Lake a group of mineral springs (Pl. VI, *C*, p. 92), several of which are notably warm, issue in a line about 50 yards long at the base of a slope that borders the south side of a drainage course. A number of seepages have been dug out and cemented to form drinking basins, so that about 26 improved springs may be counted, although the group is said to include 42 springs. Of the 8 springs that are of chief importance 5 are used for drinking and have been named Bohemia, Neptune, Lithia, and Magnesia Twins. They have observed temperatures, respectively, of 66°, 70°, 73°, 71°, and 100°. When the writer visited it in 1909, Bohemia Spring discharged about 1 gallon a minute, while the other three rose in basins from which there was no appreciable overflow. The largest three springs are used mainly for bathing. Of these, the Hot Soda or Hot Sulphur Spring has a temperature of 110° and discharges approximately 125 gallons a minute into a plunge bath. Excelsior or Borax Spring, with a temperature of 95° and a flow of perhaps 5 gallons a minute, also supplies a plunge bath. Water from Eureka Spring is piped to tub baths, its temperature being 107° and its yield perhaps 2 gallons a minute. The available analyses of several of the springs are here given in form convenient for comparison.[1]

[1] The analyses of Lithia Spring and Bohemia Spring, published in advertising matter, have not been reproduced, as they appear to be incorrectly stated.

Analyses of water from Howard Springs, Lake County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5	
Temperature	43° C. (110° F.)		24° C. (75° F.)		29° C. (85° F.)		39° C. (102° F.)		16° C. (60° F.)	
Properties of reaction:										
Primary salinity		27		77		34		24		16
Secondary salinity		0		0		0		0		0
Tertiary salinity		0		0		0		0		0
Primary alkalinity		28		18		Trace.		26		22
Secondary alkalinity		45		5		66		50		62
Tertiary alkalinity		100		152		142		61		141
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	628	27.29	846	36.78	200	8.70	556	24.17	240	10.44
Potassium (K)	230	5.88	10	.26	132	3.38	177	4.53	115	2.94
Lithium (Li)	0.3	.04	1.0	.14	0.2	.03	0.1	.01	....	....
Calcium (Ca)	25	1.25	27	1.33	136	6.79	46	2.30	151	7.53
Magnesium (Mg)	313	25.72	8.0	.65	208	17.11	324	26.63	169	13.90
Iron (Fe)	60	2.30	10	.36	2.4	.09	6.1	.22	1.0	.04
Aluminum (Al)	0.9	.10	0.3	.03	1.7	.19	1.4	.16	1.2	.13
Chloride (Cl)	580	16.36	1,069	30.18	427	12.04	481	13.58	202	5.70
Carbonate (CO_3)	1,317	43.82	280	9.32	721	23.97	1,331	44.28	875	29.11
Silica (SiO_2)	58	1.92	224	7.43	143	4.74	158	5.24	119	3.95
	3,212.2	....	2,475.3	....	1,971.3	....	3,080.6	....	1,873.2	....
Carbon dioxide (CO_2)	1,277	58.00	1,140	51.80	1,021	46.40	659	29.95	996	45.27

1. Eureka Spring. Analyst, W. T. Wenzell. Authority, Winslow Anderson.
2. Excelsior Spring. Analyst, W. T. Wenzell. Authority, 12th Cal.
3. Neptune Spring. Analyst, W. T. Wenzell. Authority, Winslow Anderson.
4. Magnesia Twins Spring. Analyst, W. T. Wenzell. Authority, Winslow Anderson.
5. Soda spring, not identified. Analyst, W. T. Wenzell. Authority, 12th Cal.

The analyses show that the waters of these springs are alike in many respects, the chief points of difference being the small proportion of secondary bases and alkalinity in the Excelsior and the small proportion of primary alkalinity in the Neptune. The high concentration, high tertiary alkalinity, and magnesic character of all the springs and the iron content of the Eureka are specially noteworthy. The absence of any report on the sulphate radicle casts doubt on the trustworthiness of the analyses.

All the springs issue in an area of serpentine within the shales and sandstones that form the principal part of the hills in this locality.

The springs have been improved as a resort since about 1880. In 1909, besides a main hotel building and the baths, the improvements included a large annex to the hotel and four or five small cottages.

Waters from the Lithia, Bohemia, and Eureka springs were formerly bottled for table use, but their sale was discontinued several years prior to 1909.

SEIGLER SPRINGS (LAKE 49).

Seigler Springs are situated about 2 miles northwest of Howard Springs, across a ridge and in the drainage basin of another creek. Like Howard Springs, they have been used as a resort for many years. The group includes 13 that in 1909 were improved to some extent. Of this number 6 are of small flows, range in temperature from 68° to 107°, and are used in a minor way for drinking. Two others, known as the Magnesia and Hot Geyser springs, also used for drinking, yield perhaps one-eighth and 2 gallons of water a minute, at temperatures, respectively, of 64° and 98°. The Hot Geyser, which has been in part developed by sinking a 3-inch casing 90 feet deep, is said to have received its name because prior to the earthquake of April 18, 1906, it spouted about once a day, but since the earthquake this action has nearly or entirely ceased. Its water has a slight oily taste and odor, such as was noted at Skaggs and at Gordon springs. A ninth spring, known as the Arsenic Spring, yields water 96° in temperature, at a rate of about 5 gallons a minute, and is used both for drinking and bathing, and two other springs with somewhat warmer water and about the same flow supply Hot Iron baths. The two hottest springs, with temperatures of 119° and 126° and flows of perhaps 4 and 13 gallons a minute, respectively, issue at the edge of Seigler Creek and supply tub baths near by.

The Seigler Springs, like the Howard Springs, issue from serpentine and are situated on a gentle slope that borders the southern side of the creek, but they are scattered over a larger area, about 250 yards across. Near the southeast border of the spring area is a prominent ledge of siliceous rock. The higher slopes are covered with lava, and downstream, below the springs, the usual crushed sediments appear.

The available analyses of springs at this place are here presented:

Analyses of water from Seigler Springs, Lake County, Cal.

[Analyst, not given. Authority, advertising matter. Constituents are in parts per million.]

	1		2		3		4		5	
Temperature	19° C. (66° F.)		22° C. (72° F.)		32° C. (90° F.)		38° C. (100° F.)		37° C. (98° F.)	
Properties of reaction:										
Primary salinity	33		49		50		49		51	
Secondary salinity	7		0		0		0		0	
Tertiary salinity	0		0		0		0		0	
Primary alkalinity	0		11		12		16		12	
Secondary alkalinity	60		40		38		35		37	
Tertiary alkalinity	24		27		27		30		54	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	127	5.50	208	9.05	230	10.00	272	11.81	221	9.61
Potassium (K)	26	.66	52	1.33	80	2.05	51	1.30	52	1.33
Calcium (Ca)	42	2.09	22	1.10	26	1.30	22	1.10	21	1.05
Magnesium (Mg)	126	10.33	71	5.84	74	6.08	75	6.17	64	5.26
Iron (Fe)	9.1	.33	2.3	.08	1.4	.05	4.4	.16	1.3	.05
Sulphate (SO_4)	0.4	.01	27	.56	1.7	.04	20	.42	3.7	.08
Chloride (Cl)	266	7.50	282	7.96	344	9.70	336	9.48	312	8.80
Carbonate (CO_3)	342	11.40	266	8.88	292	9.74	319	10.64	253	8.42
Silica (SiO_2)	124	4.11	141	4.68	156	5.17	180	5.97	182	6.04
	1,062.5	......	1,071.3	......	1,205.1	......	1,279.4	......	1,110.0	......
Carbon dioxide (CO_2)	......	......	......	......	......	......	......	......	69	3.16

1. Soda Spring.
2. Magnesia Spring.
3. Arsenic Spring.
4. Iron Spring No. 3.
5. Geyser Spring.

The names of the springs are apparently misleading as to their mineral content, for the analyses show that the waters of the Magnesia, Arsenic, Iron No. 3, and Geyser springs are practically identical in character, and the water of the Soda Spring differs from them chiefly in its greater proportion of magnesium.

A frame hotel, a large stone dining room, and four or five cottages in 1909 provided accommodations for about 150 guests. In addition to the mineral water tub and plunge baths, bathing facilities were provided by a dam across the creek, which made a swimming pool.

HOT SPRINGS AT SULPHUR BANK (LAKE 38).

Near the southeast edge of the eastern arm of Clear Lake there are abandoned sulphur and quicksilver workings. During the period of mining, water at a temperature of 176° was encountered at the fifth level in what is known as the Hermann shaft.[1] In January, 1910, the water stood about 15 feet below the surface in this shaft, and its observed temperature was 120°. Many bubbles were rising and the water had the odor of sulphureted hydrogen. About 200 yards east of north from the shaft, in an area of decomposed basalt where sulphur was formerly obtained, water stands in several pools and issues from numerous vents. The highest temperature observed in these pools was 118° in a small one over which there was a bathing hut. Two analyses of water from this locality, made a number of years ago, are reproduced, as they probably show the general character of the water that still rises.

Analyses of water from mine shafts at Sulphur Bank, Lake County, Cal.

[Analyst, W. H. Melville (1884?). Authority, U. S. Geol. Survey Water-Supply Paper 237. Constituents are in parts per million.]

	Hermann shaft.		Parrott shaft.	
Properties of reaction:				
Primary salinity	26		48	
Secondary salinity	0		0	
Tertiary salinity	0		0	
Primary alkalinity	72		50	
Secondary alkalinity	2		2	
Tertiary alkalinity	17		136	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	1,706	74.19	1,320	57.39
Potassium (K)	25	.65	39	1.01
Ammonium (NH_4)	24	.13	1.1	.06
Calcium (Ca)	21	1.07	20	1.02
Magnesium (Mg)	5.5	.45	1.6	.13
Iron (Fe)	....	....	.5	.02
Sulphate (SO_4)	17	.35	466	9.70
Chloride (Cl)	693	19.54	667	18.79
Carbonate (CO_3)	1,140	38.00	220	7.32
Metaborate (BO_2)	800	18.60	1,023	23.80
Silica (SiO_2)	37	1.23	42	1.39
	4,468.5	....	3,800.2	....
Carbon dioxide (CO_2)	262	11.82	1,751	79.60
Hydrogen sulphide (H_2S)	4.6	.27	.74	.04

[1] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, p. 259, 1888.

The analyses indicate that the waters are strongly primary alkaline in character. They differ chiefly in tertiary alkalinity and the relative prominence of salinity and alkalinity. The difference would be practically eliminated if sulphuric acid or sulphate of iron or other heavy metals were added to the water of the Hermann shaft.

The slopes near the Sulphur Bank mines are composed mainly of sediments that have been considered Lower Cretaceous in age, but where the waters rise the rock is basalt that has been extensively altered by solfataric action.

In his description of the quicksilver deposits at this place Becker[1] has remarked on the apparent absence of any quicksilver minerals in solution and has spoken of the presence of boron in the water. The boron and the thermal character of the water are especially noteworthy in connection with the presence of the lava at this locality. A small cold carbonated spring that issues from the gravel near the lake edge, one-fourth mile west of the Hermann shaft, may also be mentioned in connection with the lava at Sulphur Bank.

Warm carbonated waters emerge at a number of places along the western border of Clear Lake, notably at Soda Bay and at John Behr's ranch, and are described with the carbonated springs (pp. 191–193), but are here mentioned as they are also thermal and rise from volcanic rocks.

WILBUR HOT SPRINGS (COLUSA 9).

In the valley of Sulphur Creek, in southwestern Colusa County—a region where considerable mining for quicksilver has been carried on—are several groups of springs that yield hot sulphureted water. The lowest, easternmost group is at Wilbur Hot Springs, which has been a resort for more than 40 years. It was originally known as Simmons Hot Springs, and the resort to which the name Wilbur Hot Springs was applied was 4 miles to the northwest, near the Elgin quicksilver mine; a number of years ago, however, after the hotel at the latter place burned, the Simmons property was purchased by the owners of Wilbur Hot Springs and the upper place was abandoned. In 1908 the present Wilbur Hot Springs (Pl. IV, *D*, p. 32) again changed ownership, and most of the buildings, which were in poor condition, were removed and new cottages built.

The hot springs issue along the borders of Sulphur Creek, for a distance of about one-half mile on the Wilbur property, but are mainly in a barren, saline area that borders the west side of the creek from 75 to 200 yards west of the hotel. The position and approximate extent of this area are shown at the left in Plate IV, *D*. The principal springs have been numbered by the owners, beginning at the western border of the property, on the assumption that eventually

[1] Op. cit., pp. 259, 260. A detailed description of the geology at Sulphur Bank is given on pp. 251–257.

there will be 30 developed springs, though only 12 have been of importance. Several of the group yield cold water.

Spring No. 1, a hot sulphur spring, issues mainly in a pool a few feet west of the Wilbur property, on land that belongs to the Manzanita Mining Co., but warm water also seeps out several yards east of the main pool. This pool has been used occasionally as a foot bath, but in 1910 the adjacent seepages had not been developed.

The Hot Black Sulphur Spring (No. 10) is a few hundred yards east of No. 1 and about 500 yards west of the Wilbur Hotel. Its water issues at the southeast edge of the creek, and when visited formed a pool that was covered by a tent and used as a foot bath.

The Main Springs (No. 22) are about 200 yards west of the hotel, at the upper edge of the barren area along the creek. Two concrete basins or small reservoirs, a few feet apart, are built around the springs, which yield a flow of hot, strongly sulphureted, and salty water at a measured rate of 30,000 gallons a day (21 gallons a minute). The water is clear and its color is distinctly yellow, like that of the water from Lower Blue Lick Springs, Ky., whose color has been assigned by Palmer [1] to alkaline sulphides in solution. The more strongly mineralized waters of the Wilbur springs probably contain alkaline sulphides in solution in medicinal amounts, but this character was not shown in the form in which the analyses were reported. The water is piped to cooling tanks and thence to tubs in an adjacent bathhouse, opposite the hotel. A thin crust of white, apparently amorphous sulphur rapidly collects on the surface of the water in the cooling tanks. On being disturbed it settles as a sludge, of which a considerable quantity has been used as a salve.

A few feet north of the Main Springs is a smaller one, over which a men's mud-bath house has been built. A continual flow of water in the mud bath is thus directly obtained. A women's mud-bath house has been constructed in the same way, over another spring 30 or 40 yards eastward. Near the northeast corner of the men's mud-bath house there is a shallow pool, about 4 feet in diameter, called the Chromatic Spring, for material that changes color from day to day and is probably of algous (vegetable) nature usually coats its bottom. On one morning it was bright green in the central part of the bottom and reddish purple over the marginal third. On the following morning the coating had a uniform dark-olive tint. The water is said to be sometimes as black as ink and to contain a black substance (probably iron sulphide) that gradually settles. At other times the pool is clear and contains no noticeable growth. In connection with the water of this spring, a red water may be mentioned, that during hot dry weather collects in a few small depressions

[1] Matson, G. C., Water resources of the bluegrass region, Kentucky, with a chapter on the quality of the waters by Chase Palmer: U. S. Geol. Survey Water-Supply Paper 233, p. 209, 1909.

in the rock surface of the barren area. It is usually crusted with salts and is a saturated solution. On evaporation it forms crystals that have been examined microscopically by R. C. Wells and are considered to be probably potassium sulphate and sodium chloride, the former predominating. The red coloring matter easily passes through filter paper and is rendered only slightly less distinct by boiling. It may be a minute vegetable organism, but a bottled sample of the water retained its color after standing four years.

The Catarrh and Complexion Spring (No. 20) issues on the south side of the creek, about 120 yards east of the Main Springs. Like the other springs its water is sulphureted and strongly salty, its chemical character being shown by the analysis on page 102. It has been used as a tonic drinking water, as a douche, and as a shampoo, being considered to be efficacious in removing dandruff. Three small springs are in basins a few feet apart in a spring house southeastward, across the creek from the hotel. The western one (No. 24), which is called the Cold Magnesia Spring, is the pleasantest for drinking and is the one most patronized. The central one (No. 26), which is also a magnesia spring, tastes more noticeably of magnesia. No. 28 is a cold sulphur spring. The Cold Black Sulphur Spring (No. 30) is on the south side of the creek, beyond the stable and about 125 yards east of the hotel. It has been protected by a board curbing and cover and yields a moderately sulphureted but palatable water. Jackson Sulphur Spring seeps from the road bank across the creek from No. 30. Its water tastes sulphureted and magnesic, and has been used slightly for drinking, but it is locally believed that its use tends to produce headache. Eastward, downstream from the Jackson Spring, there are several other cool, sulphureted seepages, but in 1910 these had not been developed.

The following tables give the approximate temperatures and flows of the principal springs, and analyses of those that had been chemically examined prior to August, 1910:

Approximate temperature and flow of principal springs at Wilbur Hot Springs, Colusa County, Cal.

	Temperature.		Flow (gallons a minute).
	°C.	°F.	
Spring No. 1, a hot sulphur spring	43	110	$\frac{1}{4}$
Spring No. 10, Hot Black Sulphur Spring	49	120	5
Spring No. 22, Main Springs	60	140	21
Men's mud-bath spring	43	110	1
Women's mud-bath spring	43	110	1
Chromatic Spring	49	120	1
Spring No. 20, Catarrh and Complexion Spring	47	116	5
Spring No. 24, Cold Magnesia Spring	16	60	$\frac{1}{4}$
Spring No. 26, a magnesia spring	16	60	$\frac{1}{4}$
Spring No. 28, a cold white sulphur spring	18	64	$\frac{1}{4}$
Spring No. 30, Cold Black Sulphur Spring	21	69	2
Jackson Sulphur Spring	18	65	$\frac{1}{4}$

Analyses of water from Wilbur Hot Springs, Colusa County, Cal.

[Analyst and authority, W. H. Sloan (1910). Constituents are in parts per million.]

	1		2		3		4		5		6	
Temperature	43° C. (110° F.)		47° C. (116° F.)		60° C. (140° F.)		16° C. (60° F.)		18° C. (64° F.)		21° C. (69° F.)	
Properties of reaction:												
Primary salinity		70		70		70		12		47		46
Secondary salinity		0		0		0		0		9		1
Tertiary salinity		0		0		0		0		0		0
Primary alkalinity		27		29		29		3		0		0
Secondary alkalinity		3		1		1		85		44		53
Tertiary alkalinity		13		8		6		5		8		18
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	4,784	208.00	8,175	355.43	8,370	363.91	71	3.09	439	19.09	295	12.83
Potassium (K)	189	4.83	390	9.97	412	10.54	3.1	.08	15	.38	10	.26
Lithium (Li)	6.9	1.00	10	1.44	13	1.87	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Ammonium (NH_4)	122	6.76	270	14.96	293	16.24	1.6	.09	0.3	.02	0.4	.02
Calcium (Ca)	3.9	.19	0.7	.04	7.7	.38	30	1.50	73	3.64	56	2.79
Magnesium (Mg)	95	7.81	52	4.28	53	4.36	211	17.35	223	18.34	153	12.58
Iron (Fe) } Aluminum (Al) }	2.8	.10	2.1	.08	3.4	.12	1.1	.04	4.2	.15	1.0	.04
Sulphate (SO_4)	31	.65	160	3.33	149	3.10	77	1.60	93	1.94	47	.98
Nitrate (NO_3)	108	1.74	Trace.	Trace.	Trace.	Trace.	0.6	.01	17	.28	6.6	.16
Chloride (Cl)	5,577	157.28	9,447	266.41	9,763	275.31	38	1.07	743	20.95	432	12.18
Bromide (Br)	2.7	.03	18	.23	11	.14	....	....	Trace.	Trace.	0.8	.01
Iodide (I)	10	.08	18	.14	15	.12	....	....	Trace.	Trace.	0.9	.01
Carbonate (CO_3)	1,826	60.85	3,066	102.20	3,276	109.20	559	18.63	528	17.60	382	12.72
Metaborate (BO_2)	245	5.70	443	10.29	418	9.73	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Silica (SiO_2)	77	2.55	118	3.91	175	5.80	33	1.09	32	1.06	74	2.45
	13,080.3	....	22,169.8	....	22,959.1	....	1,025.4	....	2,167.5	....	1,458.7	....
Carbon dioxide (CO_2)	566	25.72	452	20.54	196	8.91	20	.91	54	2.45	61	2.77
Hydrogen sulphide (H_2S)	46	2.70	169	9.91	165	9.68	....	....	6.9	.40	38	2.23

1. Hot Black Sulphur Spring (No. 10).
2. Catarrh and Complexion Spring (No. 20).
3. Main Springs (No. 22).
4. Cold Magnesia Spring (No. 24).
5. A cold white-sulphur spring (No. 28).
6. Cold Black Sulphur Spring (No. 30).

Springs 10, 20, and 22 (analyses 1, 2, and 3) yield waters practically identical in character; that is, they give primary saline waters in which primary alkalinity is rather prominent. The lithium, ammonium, nitrate, bromide, iodide, and metaborate determinations in the analyses are of interest. The waters of springs 24, 28, and 30 (analyses 4, 5, and 6) are characterized by primary salinity and secondary alkalinity of about equal prominence. The relatively high proportion of magnesium in these three cold springs is noteworthy.

The barren area along Sulphur Creek apparently consists of a conglomerate containing fragments of sandstone, and several of the springs issue from fissures in it. The main country rock of the locality is, however, serpentine. This material extends eastward nearly a mile to an area of shales and sandstones along Bear Valley, and westward about three-fourths of a mile from the Wilbur Hotel to an area of shales along Sulphur Creek. A belt of sandstone 100 yards wide is apparently included in the serpentine between springs 10 and 22, and small patches of sandstone that also appear to be inclusions in the serpentine were noted. The locality is one in which intense geologic action has taken place and there has been much secondary mineralization of the rocks.[1] The thermal character of the water is evidently closely related to the geologic structure, and its mineral character to the close association of serpentine (a magnesia-bearing rock), with marine sediments which probably furnish the saline and sulphur constituents.

JONES HOT SPRINGS (COLUSA 11).

Jones Hot Springs are near Sulphur Creek and about three-fourths mile west of Wilbur Hot Springs (Colusa 9, p. 99). The resort that has been built up at the place in recent years is patronized during the summer by many people who use the water. Accommodations for guests are supplied by a hotel and several cottages and by camping grounds near by.

The principal yield is from a well that was bored near the creek at a place where gas formerly issued. Hot, sulphureted, salty water was obtained, which rises under considerable artesian pressure in a concrete tower to a height of about 12 feet, whence it flows to a bathhouse near the hotel. Gas intermittently rises with the water and causes it to spurt above the top of the tower. This characteristic has led to the well being named Fountain of Life.

The well is near the western border of a serpentine area; but its water probably comes mainly from sedimentary rocks, for siliceous shales are exposed across the creek, a short distance north of it, in the workings of a quicksilver mine.

[1] Fairbanks, H. W., Some remarkable hot springs and associated mineral deposits in Colusa County, Cal.: Science, vol. 23, pp. 120–121, 1894.

HOT SPRINGS ON MANZANITA MINING PROPERTY (COLUSA 10).

Between Jones and Wilbur hot springs, on a strip of land that is part of the Manzanita mining property, similar hot sulphur springs issue in at least three places. The spring farthest east, which has been mentioned in connection with Wilbur spring No. 1, forms a pool a few feet in diameter that yields perhaps 1 gallon a minute of sulphureted, salty water, 110° in temperature. It is clear and distinctly yellow in color, like that of the Main Springs at Wilbur's, and like the latter shows a deposit of sulphur on its surface. In 1910 the spring was protected by a roof and was occasionally used as a foot bath. Another spring farther upstream, on the northwest edge of the creek, was protected by a tent and used for bathing; the third spring is about 100 yards northeast of Jones's Fountain of Life spring. The third spring, which is between the creek and the wagon road, issued from a wooden curbing near an old, unused bathhouse and yielded perhaps 1½ gallons a minute of sulphureted salty water, 142° in temperature. All three of these springs issue in an area of serpentine, but the saline content of their water is probably derived from the altered sediments that outcrop a short distance to the west along the upper course of Sulphur Creek.

BLANCKS HOT SPRINGS (COLUSA 12).

A number of years ago there was a small hot-spring resort, known as Blancks Hot Springs, about half a mile west of Jones Hot Springs (Colusa 11, p. 103). When the Wideawake mining shaft was sunk near by, Blancks Hot Springs ceased flowing and the resort was closed, but of late years, since the shaft has been abandoned and has become partly filled up, the springs have resumed their flow. In 1910 there were two springs in a small ravine behind a former rooming house. One of them yielded perhaps 2 gallons a minute from a vertical pipe that extended a foot above the surface, and the other, a few yards away, discharged about an equal amount through a pipe that extended to a tub in a small bathhouse near by. The water is sulphureted and salty, and, like that of several other springs in the locality, it is clear yellow in color. It issues from sandstone that is well exposed and dips almost vertically to the northwest.

HOT SPRINGS AT ELGIN MINE (COLUSA 7).

The Elgin quicksilver mine is situated on the western side of Sulphur Creek, on steep slopes 400 to 500 feet above the stream. Much work has been done in these mines and occasional rich pockets of cinnabar have been found, but the tunnels have been very difficult to work in because of the high temperature, the hot water, the sulphureted and ammoniacal vapors, which affect the eyes as well as the respiration, and the acid salts, which quickly destroy clothing. In addition to the cinnabar considerable amounts of sulphur were formerly obtained from higher slopes near the quicksilver tunnels, and a few hundred dollars worth of gold is said to have been obtained incidentally from one quicksilver working.[1]

Hot springs, from which water was formerly piped down the slope to a bathhouse at the original Wilbur Hot Springs resort, still yield a flow of several gallons a minute on the steep slope, and a short distance away a flow of about 10 gallons a minute at 140° temperature issues from the Judge Moore tunnel, which extends 200 feet into the hill. The following analysis, made a number of years ago, probably is of water from the formerly used spring at this locality:

Analysis of water from original Wilbur Hot Springs, Colusa County, Cal.

[Analyst and authority, Winslow Anderson (1889). Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	45
Secondary salinity	38
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	17
Tertiary alkalinity	73

Constituents.	By weight.	Reacting values.
Sodium (Na)	304	13.23
Potassium (K)	7.4	.19
Calcium (Ca)	162	8.07
Magnesium (Mg)	104	8.58
Iron (Fe)	26	.94
Aluminum (Al)	36	3.95
Sulphate (SO_4)	910	18.95
Chloride (Cl)	209	5.90
Iodide (I)	10	.08
Carbonate (CO_3)	182	6.08
Silica (SiO_2)	119	3.95
	2,069.4	....
Hydrogen sulphide (H_2S)	290	17.01

The analysis indicates that the water is primary and secondary saline in character. Iron, aluminum, silica, and hydrogen sulphide are notably prominent. The water is evidently not nearly so strongly mineralized as that of the Main Springs at Wilbur Hot Springs.

The spring known as the Big Pool is about 250 yards farther northwest along the hillside and at the front of a large mining cut. Soft mud surrounds and nearly fills this pool, which is about 15 feet across and 2 feet deep. When visited in 1910 gas rising in the pool caused vigorous ebullition in two places, and water 153° in temperature overflowed at a rate of perhaps 15 gallons a minute. The water tasted strongly of hydrogen sulphide, ammonia, and salt. During the operation of the mine this water was used in a mill near by, but it rapidly corroded the machinery.

Two carbonate formations in this locality are of geologic interest in connection with the springs. One, a hard, white material that incloses fragments of shale, is best exposed on slopes below the Judge

[1] Fairbanks, H. W., loc. cit.

Moore tunnel, and forms a prominent ledge from which bowlders have rolled down to the lower slopes. A specimen of the material was examined qualitatively by R. C. Wells, who found that it consisted mainly of calcium and magnesium carbonates, with only small amounts of silica and water. It is not dolomite but is probably similar in composition to the material from Phillips Soda Springs (Napa 8), of which a quantitative analysis is given (p. 162). It differs chiefly from the latter in being much harder and in containing very little water. About one-half mile upstream from the Elgin mine a ledge of onyx marble crosses the creek. This material is of interest in connection with the hot springs farther downstream, as it is considered to be a hot-spring formation. The deposit has not been worked commercially, but a few specimens, of a brown color, have been made into paper weights and other small articles.

The hot springs near the Elgin mine issue from sediments in which secondary minerals, especially cinnabar, sulphur, and gypsum, have formed. In several places the rock has been greatly altered by solfataric action, and in these places a siliceous sinter has been produced which resembles that at The Geysers (Sonoma 4, p. 83). The rock formation is also apparently similar to that at The Geysers, as it consists of sediments with associated serpentine. Although notable amounts of efflorescent salts were not observed near the springs of the Elgin mine, and there are no vapor vents, in several other respects these hot springs are intermediate in character between those farther down the creek and The Geysers of Sonoma County.

The water of Sulphur Creek is warm and salty in the neighborhood of the hot springs, and between the Elgin mine and Jones Hot Springs it contains great numbers of slender, jointed creatures that attain a length of about 2 inches. These organisms, which are locally called "duck worms," were also found in two or three small, warm, salty streams a few miles to the northeast; but they were not observed in a fresh-water stream that enters Sulphur Creek between Jones Hot Springs and the Elgin mine nor do they thrive below Jones Hot Springs, where the water is possibly rendered uninhabitable to them by tailings from the quicksilver mill opposite these springs. They were not observed elsewhere in the State. Their presence is noteworthy, as it appears to be closely connected with the chemical character of the water.

CRABTREE SPRINGS (LAKE 5).

Crabtree Springs are situated in a narrow part of the canyon of Rices Fork of Eel River, 14 miles by road northwest of Bartlett Springs (Lake 9, p. 200). The springs were filed on by Mr. Crabtree about 1875 and a road was built to the property, but high water soon washed out the greater part of this road, and for many years the springs have been accessible only by trail. In 1910 the property changed ownership, however, and the road was rebuilt.

The principal spring emerges at the northeast edge of the stream in a natural rock basin at the foot of a small cliff, and yields perhaps 10 gallons a minute of water 105° in temperature. Considerable gas, probably carbon dioxide, issues with the water. The latter is mildly carbonated and is distinctly mineralized by salts of soda and probably also of iron. The pool formed by this spring has long been used for bathing and the water is locally considered efficacious in the treatment of skin and blood diseases. About 20 yards southeastward, upstream from the main spring, a smaller flow of similar water issues from a seam in the rock at the creek edge, while 100 yards upstream from the main spring there were, in 1910, three vigorously bubbling, iron-stained pools that contained water 68° to 75° in temperature. An area several yards in diameter in the creek channel near by was also vigorously bubbling. It is said that there was formerly a carbonated spring of considerable flow at this spot, but that it was buried by a landslide a number of years ago and during recent years has been in evidence chiefly by the large amount of gas that escapes.

The springs are probably submerged during periods of high water, but during the summer the stream carries only a few miner's inches, and in some years may become dry for a short time.

The springs issue from siliceous rock similar in character to that at Ætna Springs in Napa County (p. 156) and at other localities in the State where quicksilver has been mined. A number of years ago two tunnels were driven into the canyon side a short distance below the Crabtree Springs, in search of quicksilver. The rock contains noticeable amounts of cinnabar, but this mineral was not found in paying quantity. The siliceous rock is closely associated with serpentine, which is exposed for a few yards between the two groups of springs on the northeast bank, and for a short distance on the southwest side of the stream. There is also a cliff of the siliceous rock opposite the main spring; but the principal material on the southwest side of the canyon near the springs, and on the slopes both above them and upstream from them, consists of altered shale and sandstone. The serpentine of this locality appears to be the northward continuation of a narrow belt that extends, with some branching or perhaps widening of the main zone, northward from Bartlett Springs to this place, where it appears to be less than 100 yards wide. The close relation of several carbonated springs to this belt of serpentine is later referred to in the description of Royal Spring (Lake 6, p. 202). Like these others, the presence of Crabtree Springs and the temperatures of their waters seem to be closely related to the serpentine and the siliceous rock. The association of serpentine, siliceous rock, and altered sediments with warm carbonated water at this place is apparently similar to their association farther southward, at Ætna Springs (Napa 2, p. 156).

CALISTOGA HOT SPRINGS (NAPA 4).

At Calistoga,[1] near the head of Napa Valley, are several hot springs at which during the seventies there was a large resort. The hotel burned in the late seventies or early eighties, however, and since that time the springs have not been of more than local importance. In 1910 the caretaker of the property had provided two bathhouses of two tubs each, half a dozen small cottages on the place were rented, and a few campers had pitched their tents near by. Hand pumps supplied hot water directly to the tubs, and cool water was piped from a tank.

Four main springs rise at the base of a knoll of buff-colored tuffaceous material at the northern border of the meadow land, and a few pools and seepages of hot water appear in the meadow itself. The observed temperatures of the principal springs range from 126° to 173° and their flows from about one-fourth gallon to 5 gallons a minute. The hottest spring, which yields about 1 gallon a minute, appears to be the most strongly mineralized, though its mineralization is only slightly perceptible to the taste. Algæ probably give it the slight flavor that has caused it to be called a chicken-soup spring.

At Calistoga Hotel, about 400 yards west from the springs, a dug well supplies warm water for tub baths and a swimming plunge. Warm water is also obtained in several other wells near by and there is one strongly flowing artesian well. The following analyses show that the waters are primary saline in character:

Analyses of water from Calistoga Hot Springs, Napa County, Cal.

[Analyst and authority, Winslow Anderson (1888). Constituents are in parts per million.]

	1		2		3	
Temperature	41° C. (106° F.)		50° C. (122° F.)		35° C. (95° F.)	
Properties of reaction:						
Primary salinity	85		90		75	
Secondary salinity	0		2		10	
Tertiary salinity	0		0		0	
Primary alkalinity	10		0		0	
Secondary alkalinity	5		8		15	
Tertiary alkalinity	33		43		41	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	174	7.57	212	9.22	188	8.15
Potassium (K)	Trace.	Trace.	8.2	.21	Trace.	Trace.
Calcium (Ca)	2.3	.11	12	.60	38	1.90
Magnesium (Mg)	3.1	.25	5.7	.47	10	.82
Iron (Fe)	1.3	.05	6.0	.21	....	....
Aluminum (Al)	4.2	.38	2.4	.22	4.2	.38
Manganese (Mn)	Trace.	Trace.	Trace.	Trace.	....	....
Sulphate (SO_4)	68	1.42	110	2.29	68	1.42
Chloride (Cl)	188	5.30	255	7.21	276	7.80
Iodide (I)	1.2	.01	13	.10	2.3	.02
Carbonate (CO_3)	36	1.20	27	.90	49	1.63
Silica (SiO_2)	30	1.00	62	2.06	78	2.59
	508.1	....	713.3	....	713.5	....
Hydrogen sulphide (H_2S)	28	1.64	42	2.44	31	1.84

1, Spring near creek; 2, swimming pool; 3, well at Calistoga Hotel.

[1] This name is said to be formed from the words California and Saratoga, but the springs are not at all like those of Saratoga Springs in New York.

A. BYRON HOT SPRINGS, CONTRA COSTA COUNTY.

B. KLAMATH HOT SPRINGS, SISKIYOU COUNTY.

C. FETTERS HOT SPRINGS, SONOMA COUNTY.

The position of the springs near the base of the knoll of volcanic tuff that rises in the valley land and the fact that a fault has been traced along this part of the valley furnish suggestive evidence that faulting has here provided escape for deep-seated water. The lava may also produce a high temperature gradient that aids in giving the abnormal temperatures to the water. The amount of heated water that rises is probably better indicated by the area of meadowland that is formed than by the visible flow of hot water, for there is doubtless much seepage that is not observable.

BYRON HOT SPRINGS (CONTRA COSTA 7).

On the western border of San Joaquin Valley, near the southeastern corner of Contra Costa County, a number of mineralized springs—Byron Hot Springs—rise in a saline flat that is partly inclosed by low hills (Pl. VII, *A*). A large, well-appointed hotel[1] and four or five cottages have here formed one of the most noted spring resorts of the State. The place is easily reached by automobile from the eastern side of San Francisco Bay. In 1908 eight springs were improved and used. A small warm sulphur spring supplies a drinking basin in the main grounds; warm sulphur mud and water baths and a sulphur plunge are about 250 yards southeast of the hotel grounds. A strongly sulphureted spring, 83° in temperature, forms a slightly used drinking pool at one side of Sulphur Plunge, and on the opposite side is a well from which mineral water is pumped to bathtubs in the hotel. In the summer of 1908 the water in this well stood about 8 feet below the surface and its temperature was 112° to 115°. About 250 yards beyond the Sulphur Baths and Sulphur Plunge is an inclosed swimming pool, known as the Gas Plunge, in which the temperature is. about 88°. Between the two bathing establishments are two cemented drinking springs, known as the Hot Salt and the Liver and Kidney springs. The Hot Salt Spring, with a temperature of 120° and a flow of about 2 gallons a minute, rises in a small, domed, concrete house; the Liver and Kidney Spring rises in a concrete basin 25 yards southward. In 1908 its temperature was 73°, but its flow was not appreciable. Near the base of a low hill 250 yards to the southwest is a tile-lined basin or well, marked "Surprise," which contains strongly saline water about 70° in temperature.

The following are analyses of waters from five of the springs.[2]

[1] This hotel was destroyed by fire in July, 1912, but the resort was not closed, and a new hotel was opened in July, 1914.

[2] An iron spring, of which an analysis is given by Winslow Anderson, could not be identified in 1908.

Analyses of water from Byron Hot Springs, Contra Costa County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5		6		7		8		9		10		11	
Temperature	24° C. (75° F.)		24° C. (75° F.)		21° C. (70° F.)		19° C. (67° F.)		19° C. (67° F.)		14° C. (58° F.)		50° C. (122° F.)		50° C. (122° F.)		49° C. (120° F.)		32° C. (90° F.)		23° C. (74° F.)	
Properties of reaction:																						
Primary salinity	51		46		50		84		85		83		82		82		79		93		82	
Secondary salinity	0		0		0		13		12		15		15		15		19		3		17	
Tertiary salinity	0		0		0		0		0		0		0		0		0		0		0	
Primary alkalinity	31		36		39		0		0		0		0		0		0		0		0	
Secondary alkalinity	18		18		11		3		3		2		3		3		2		4		1	
Tertiary alkalinity	178		141		23		Trace.		2		1		1		1		1		10		Trace.	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	143	6.20	149	6.49	269	11.67	4,250	184.80	4,193	182.30	4,353	189.24	3,735	162.40	3,741	162.67	3,886	168.96	2,661	115.70	103,840	4,515.00
Potassium (K)	17	.42	23	.59	4.9	.12	296	7.56	307	7.84	43	1.09	318	8.12	324	8.28	33	.84	324	8.29	1,277	32.66
Lithium (Li)	.....	.....	.....	.....	0	.00	Tr.	Tr.	.....	.....	2.0	.29	Tr.	Tr.	.....	.....	12	1.71	.....	.....	.....	.....
Ammonium (NH_4)	.....	.....	.....	.....	.1	.01	17	.93	18	.98	13	.71	.....	.....	.5	.03	10	.57	Tr.	Tr.	Tr.	Tr.
Barium (Ba)	Tr.	Tr.	.....	.....	Tr.	Tr.	13	.18	11	.16	7.8	.11	Tr.	Tr.	2.0	.03	6.2	.09	Tr.	Tr.	1.4	.02
Strontium (Sr)	.....	.....	.....	.....	Tr.	Tr.	Tr.	Tr.	.....	.....	.9	.02	Tr.	Tr.	.....	.....	.8	.02	.....	.....	.....	.....
Calcium (Ca)	10	.50	10	.52	15	.77	554	27.67	538	26.81	583	29.09	604	30.16	605	30.19	701	34.96	113	5.61	14,980	747.44
Magnesium (Mg)	12	.98	12	1.01	8.8	.72	91	7.51	94	7.71	130	10.65	70	5.76	69	5.66	109	8.98	51	4.22	3,473	285.75
Iron (Fe)	2.1	.07	a 2.2	.08	1.5	.05	5.6	.20	5.9	.21	3.2	.12	7.0	.25	7.0	.25	2.5	.09	5.9	.21	22	.80
Aluminum (Al)	.....	.....	.....	.....			.....	.....	.....	.....			.....	.....	.....	.....			.....	.....	.....	.....
Manganese (Mn)	.....	.....	.....	.....	0	.00	.....	.....	.....	.....	0	.00	.....	.....	.....	.....	0	.00	.....	.....	.....	.....
Sulphate (SO_4)	38	.80	22	.45	60	1.25	15	.31	13	.28	Tr.	Tr.	11	.23	10	.21	Tr.	Tr.	38	.80	797	16.59
Nitrate (NO_3) and nitrite (NO_2)	.....	.....	.....	.....	0	.00	.....	.....	.....	.....	0	.00	.....	.....	.....	.....	0	.00	.....	.....	.....	.....
Chloride (Cl)	117	3.29	125	3.52	190	5.34	7,861	221.68	7,755	218.70	7,982	225.09	7,125	200.92	7,142	201.40	7,527	212.27	4,504	127.02	195,050	5,500.66
Bromide (Br)	.....	.....	.....	.....	1.9	0.2	Tr.	Tr.	Tr.	Tr.	18	.23	Tr.	Tr.	Tr.	Tr.	18	.22	1.8	.02	.7	.01
Iodide (I)	.....	.....	.....	.....	2.1	.02	9.3	.07	10	.08	17	.13	Tr.	Tr.	0.4	Tr.	16	.13	9.8	.08	1.4	.01
Sulphide (S)	.....	.....	.....	.....	6.2	.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Carbonate (CO_3)	122	4.08	142	4.72	179	5.98	204	6.79	209	6.95	127	4.24	166	5.54	165	5.50	72	2.40	183	6.11	1,932	64.40
Metaborate (BO_2)	Tr.	Tr.	.....	.....	15	.35	Tr.	Tr.	.....	.....	69	1.60	Tr.	Tr.	.....	.....	48	1.11	.....	.....	.....	.....
Arsenate (AsO_4)	.....	.....	.....	.....	0	.00	.....	.....	.....	.....	0	.00	.....	.....	.....	.....	0	.00	.....	.....	.....	.....

Phosphate (PO_4)	....	....	....	....	1.0	.03	....	....	....	....	Tr.	Tr.	....	....	....	....	Tr.	Tr.	....	....	....	....
Silica (SiO_2)	54	1.78	a51	1.70	46	1.54	17	.57	17	.57	31	1.02	34	1.12	34	1.13	30	.99	19	.62	15	.48
	515.1	....	536.2	....	800.5	....	13,332.9	....	13,170.9	....	13,379.9	....	12,070.0	....	12,099.9	....	12,471.5	....	7,910.5	....	321,389.5	....
Carbon dioxide (CO_2)	223	10.15	180	8.18	0	.00	....	....	66	3.02	14	.65	25	1.15	26	1.16	8.7	.40	218	9.90	Tr.	Tr.
Hydrogen sulphide (H_2S)	42	2.47	38	2.25	25	1.49	....	....	....	....	0.4	.02	....	....	....	....	.6	.04	53	3.10	....	....

a The silica and ferrous carbonate in the Anderson analysis were interchanged before recomputation, comparison with the other analyses indicating that a typographical error had resulted in a misstatement of these values.

1. White Sulphur Spring. Analyst, G. E. Colby (1887). Authority, advertising matter.
2. White Sulphur Spring. Analyst and authority, Winslow Anderson (1889).
3. White Sulphur Spring. Analyst and authority, Curtis and Tompkins (1911).
4. Liver and Kidney Spring. Analyst, G. E. Colby (1887). Authority, advertising matter.
5. Liver and Kidney Spring. Analyst and authority, Winslow Anderson (1889).
6. Liver and Kidney Spring. Analyst and authority, Curtis and Tompkins (1911).
7. Hot Salt Spr ng. Analyst, G. E. Colby (1887). Authority, advertising matter.
8. Hot Salt Spring. Analyst and authority, Winslow Anderson (1889).
9. Hot Salt Spring. Analyst and authority, Curtis and Tompkins (1911).
10. Black Sulphur Spring. Analyst and authority, Winslow Anderson (1889).
11. Surprise Spring. Analyst and authority, Winslow Anderson (1889).

The water of the White Sulphur Spring is characterized chiefly by primary salinity and primary alkalinity with high tertiary alkalinity. It is possible that the latest analysis represents a different water from that represented by the other two analyses, though the spring name is the same for all. If, however, the three analyses represent the same water, they indicate that a gradual loss of carbon dioxide and hydrogen sulphide, accompanied by increase in concentration, has been taking place. The net result of these changes has been increase in primary alkalinity, decrease in secondary alkalinity, and a very great decrease in tertiary alkalinity.

Though the analyses of the other springs show differences in concentration and in proportion of minor constituents, their waters are much alike in general properties of reaction, approaching sea water in character but differing from it in containing a less proportion of magnesium and sulphate radicles. The presence of rare constituents in waters of such high concentration is to be expected. The water of the Black Sulphur Spring appears to be a relatively pure solution of common salt, and the "Surprise" is noteworthy for its great concentration—more than nine times that of sea water.

The adjacent hills are composed of cherty gravels and other finer sediments that represent marine deposits, but the origin and character of the springs seem to be due to the local formation of a saline marsh. Several unsuccessful attempts have been made to obtain fresh water here, and in 1908 the domestic supply was pumped from a well 1¾ miles eastward.

BOYES HOT SPRINGS (SONOMA 20).

A number of small warm springs issue along Sonoma Creek, a few miles north of San Pablo Bay. Artesian wells that also yield warm water have been drilled at several places on the eastern side of Sonoma Valley, and at three places where such wells have been obtained resorts have been built up that are well patronized during the summer months, as they are only a two and a half hours' ride by train from San Francisco. Boyes Hot Springs, about 2 miles northwest of Sonoma, is the southernmost of these resorts. Here a hotel and several cottages and tent houses are situated in a grove of oaks, and a quarter of a mile northwest of the hotel a large swimming plunge and tub baths are supplied by water pumped from two wells. These are said to be 200 feet deep, and the temperature of the water is reported to be 114° and 118°. The wells, the first of which was drilled about 1890, flowed until a short time after the earthquake of April 18, 1906, but the water usually stands a few feet below the surface. A third, unused well 300 or 400 yards to the east was flowing about 3 gallons a minute in December, 1909. The water is bottled for table use, and an analysis of it is tabulated (p. 113) for comparison with analyses of other similar waters of this valley.

OHMS SPRING (SONOMA 21).

About one-half mile southeast of Boyes Hot Springs is another drilled well whose water was used to some extent in 1909 for bathing. The property was open to the public under the name of Ohms Spring, and accommodations were provided for about 20 guests.

AGUA CALIENTE SPRINGS (SONOMA 18).

About 1 mile northwest of Boyes Hotel a similar resort has been built up at Agua Caliente Springs. A hotel and cottages here provide for about 300 people. A large swimming plunge and tub baths are supplied by five flowing wells one-third of a mile southward. The wells are drilled about 300 feet deep and the reported temperatures of the waters range from 97° to 108°. In 1909 Agua Caliente water was bottled and marketed, both carbonated and natural, for table use. The following analyses represent the water from wells at Agua Caliente Springs and Boyes Hot Springs:

Analyses of water from Boyes Hot Springs and Agua Caliente Springs, Sonoma County, Cal.

[Authority, advertising matter. Constituents are in parts per million.]

	1		2		3	
Temperature	46° C. (114° F.)		41° C. (105° F.)		46° C. (114° F.)	
Properties of reaction:						
Primary salinity		87		81		78
Secondary salinity		0		0		0
Tertiary salinity		0		0		0
Primary alkalinity		5		9		9
Secondary alkalinity		8		10		13
Tertiary alkalinity		29		24		1
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	249	10.83	168	7.30	173	7.54
Potassium (K)	8.9	.23	40	1.02	42	1.08
Lithium (Li)	Trace.	Trace.	3.2	.46	3.2	.46
Calcium (Ca)	19	.95	9.8	.49	10	.50
Magnesium (Mg)	1.0	.08	6.0	.49	10	.82
Iron (Fe)	.5	.02	.7	.03	.7	.03
Sulphate (SO_4)	3.3	.07	41	.85	44	.91
Chloride (Cl)	369	10.41	249	7.03	256	7.22
Carbonate (CO_3)	49	1.63	57	1.91	69	2.30
Metaborate (BO_2) [a]	Trace.	Trace.	2.4	.05	2.5	.06
Silica (SiO_2)	103	3.42	69	2.29	1.4	.05
	802.7	....	646.1	....	611.8	....
Hydrogen sulphide (H_2S)	1.5	.09	....	....	....	....

[a] Reported as boracic acid. Recalculated from H_3BO_3.

1. Boyes Hot Springs, main well. Analyst, not given.
2. Agua Caliente Springs, well No. 3. Analyst, R. Brainard.
3. Agua Caliente Springs, well No. 5. Analyst, J. B. Clifford.

The analyses show that the three waters are much alike in concentration and character; that is, all are primary saline waters having secondary and primary alkalinity as minor properties. The relatively high proportion of silica in the first two is noteworthy. It is not unlikely that the third also is characterized by a high proportion of silica, and that a typographical error in the analytical statement is responsible for its apparently low silica content.

FETTERS HOT SPRINGS (SONOMA 19).

During the summer of 1909 a bathing establishment which is supplied by four drilled wells was erected about 200 yards east of the Agua Caliente baths. A hotel was opened on the grounds and the place was advertised in 1910 as Eleda Hot Springs, but it has since become known as Fetters Hot Springs (Pl. VII, *C*, p. 108).

The hills that border the eastern side of Sonoma Valley are of rhyolitic lava, and the wells at the several resorts are drilled into volcanic tuff that underlies the thin layer of alluvium in this part of the valley. The presence of the lava, which is thought to be of a relatively recent geologic period of effusion, suggests that a rather high temperature gradient accounts for the thermal character of the waters and that the structure probably furnishes the artesian conditions.

WARM SPRINGS OF STATE HOME AT ELDRIDGE (SONOMA 16).

Warm springs that seem to be similar in origin to the artesian waters of the resorts just described issue at several points north of Sonoma Valley. At the vegetable and dairy farm of the State Home at Eldridge water 72° in temperature is obtained from a spring that yields about 10 gallons a minute of water that is used in the dairy and for irrigation. The water broke forth at this spring at the time of the earthquake of April 18, 1906, and a flowing well 50 yards northward ceased to flow. A light-colored tuffaceous rock is exposed a few yards from the spring.

LOS GUILICOS WARM SPRINGS (SONOMA 15).

On the banks of Sonoma Creek, about 1½ miles southwest of Kenwood are two springs which yield, respectively, about 2 and 3 gallons a minute of water at temperatures of 78° and 82°. In 1909 there was a small bathing pool and an old hall or pavilion at the spring near the eastern bank of the creek; at the other spring, on the opposite bank, there was a small pool inclosed by an old bathhouse. The place was used as a camping resort, and several cottages had been erected among the trees near by.

WARM SPRINGS ON McEWAN RANCH (SONOMA 14).

Large warm springs that are probably similar in origin to the Los Guilicos springs and others farther south, issue on the McEwan ranch, about 1½ miles west of Los Guilicos Warm Springs. A part of their yield is used for irrigation, but the springs have not been efficiently developed and improved.

The hilly country several miles southeast of Santa Rosa is composed largely of lavas, and it is probable that tuffaceous layers associated with the more compact phases of the stone afford storage for the warm water that issues on the McEwan ranch and in other similar warm springs in this region.

MARK WEST WARM SPRINGS (SONOMA 11).

In the canyon of Mark West Creek, about 9 miles north of Santa Rosa, are three warm springs that issue a few yards apart along the east bank of the creek and supply a small plunge bath and a bathhouse containing a few tubs. The waters are not notably thermal, being about 65° to 85° in temperature, but the springs are most appropriately mentioned in connection with the other thermal springs of eastern Sonoma County. The waters of the three springs are noticeably sulphureted. On the west edge of the creek a small, cool, sulphur spring forms a drinking pool, and five other cool mineralized springs issue on the property. Of these, Magnesia Spring forms a drinking pool at the creek side near the baths, and two others, known as Arsenic and Iron springs, seep from a tuffaceous bank in a small gulch north of the main grounds. On the west bank of the creek, below the baths, are two other small iron-stained pools.

The Mark West springs have been improved as a resort since 1880 or earlier. In 1909 accommodations were provided chiefly by tents and it was visited mainly as a boating and fishing resort.

The rocks of this region consist of lavas and associated tuffs that are similar to those near Sonoma. A high temperature gradient, due to the presence of the lava, possibly exists along this part of the coastal ranges and may be the main cause for the rise of warm water at Mark West Warm Springs and other warm springs in eastern Sonoma County.

BIG BEND HOT SPRINGS (SHASTA 8).

In the northeastern part of California hot springs, seemingly related to lava flows and possibly also to local faulting that has not yet been recognized, issue at a number of places. Such springs rise along the course of Pit River, the lowermost noteworthy locality being at Big Bend near Henderson post office, where hot water issues at numerous places for a distance of about 350 yards along the southern bank of the river. Near the eastern end of this zone, on a gravel bluff about 15 yards from the river's edge, a bathhouse containing several tubs and vapor chambers has been built over one of the largest springs. The temperature of the water of this spring is 180° and the discharge is perhaps 25 gallons a minute. Another spring that yields perhaps 8 gallons a minute, of water 170° in temperature emerges at the south side of the bathhouse. These springs were formerly on the northern bank of a creek that entered the river near this point, but about 1897, to protect the springs, the discharge of the creek was diverted by a ditch that was cut several yards to the east. The stream has deepened this ditch to a steep-sided gully in the bed of which hot water forms pools at two places, and near its mouth a stream of hot water that discharges perhaps 8 gallons a minute issues from the gravel bluff halfway down its side. At places about 85 and 150 to 175 yards west of the bathhouse small amounts of warm water issue near or below high-water mark, and along the lower 65 yards of the zone of hot springs water with observed temperatures of 100° to 165° and flows of 4 to 10 gallons a minute issues in at least six places.

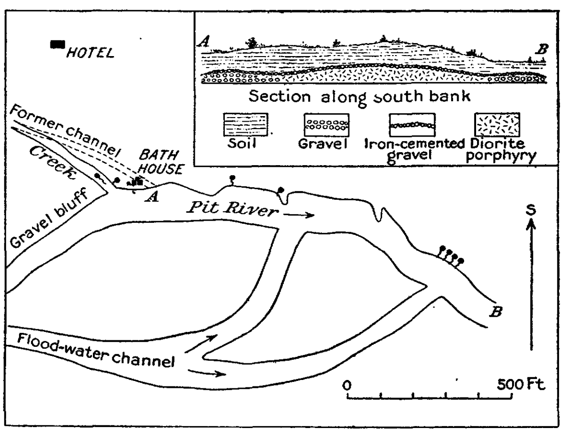

FIGURE 2.—Sketch map showing positions of Big Bend Hot Springs, Shasta County, Cal.

The water is not noticeably sulphureted and, as it is hard, it probably contains a rather large amount of calcium.

The upper and lower groups of springs issue from the gravel that borders the river, but the warm seepages between them issue from a porphyritic quartz diorite that appears to be intruded into the old sediments of the locality. The hot springs probably afford a good example of underground water that has become heated by rock of this character. The position of the springs and the exposure of the intrusive rock at Big Bend are shown in figure 2.

The property has been open as a resort by the present owners since about 1905. Accommodations for guests have been provided by a small hotel near the springs and in summer by tents also. The situation of the springs is remote, but they are yearly visited by a number of people who desire a quiet vacation.

HOT SPRINGS ON KOSK CREEK (SHASTA 7).

About 2 miles north of Big Bend Hot Springs two or three other thermal springs rise along the bed of Kosk Creek. One of these flows into a small rock basin and is occasionally used for bathing.

In general character the springs seem to be similar to the large group on Pit River, but their waters are not so hot and their discharges not nearly so large.

BASSETT HOT SPRING (LASSEN 1).

About 2½ miles north of east from Bieber, in Big Valley, is a hot spring that has been improved and for a number of years has been used for bathing, and as the place was formerly owned by a Mr. Bassett, it is locally known as Bassett Hot Spring. The water rises with a temperature of 173° from a fissure in tuffaceous sandstone that is exposed in a small depression 6 or 8 feet below the normal valley level. A pool about 20 by 40 yards across is formed here, and from it the water flows into another somewhat smaller pool. It is further cooled before reaching bathtubs in a building a few yards beyond, by flowing in open wooden troughs. The total flow is approximately 175 gallons a minute. The water is used for irrigating a vegetable garden near by, and boxes of earth that contain tomato and other tender plants are kept on the low tuffaceous ridge at the spring and are thus prevented from freezing. The water has no distinct odor nor taste, and the following analysis shows it to be a moderately mineralized primary saline water of the sulphate type:

Analysis of water from Bassett Hot Spring, Lassen County, Cal.

[Analyst and authority, F. M. Eaton (1909). Constituents are in parts per million.]

Temperature	78° C. (173° F.)	
Properties of reaction:		
Primary salinity		85
Secondary salinity		9
Tertiary salinity		0
Primary alkalinity		0
Secondary alkalinity		6
Tertiary alkalinity		(?)
Constituents.	By weight.	Reacting values.
Sodium (Na) Potassium (K)	224	9.74
Calcium (Ca)	34	1.68
Magnesium (Mg)	Trace.	Trace.
Sulphate (SO_4)	377	7.85
Chloride (Cl)	101	2.85
Carbonate (CO_3)	21	.70
	757	....
Carbon dioxide (CO_2)	0	.00

STONEBREAKER HOT SPRINGS (LASSEN 2).

About 3½ miles southeast of Bassett Hot Spring a number of hot pools and springs rise near the southeast edge of Big Valley, in meadow land that formerly belonged to a Mr. Stonebreaker. Six pools and springs were counted in a belt extending for 275 yards in a southerly direction, and between 235 and 350 yards east of the southernmost of these are four other hot pools. The highest temperature recorded was 165°, and the total flow, which comes mainly from the hottest spring, is about 125 gallons a minute. In 1909 there was a small bathhouse at one spring; a large warm pool was also occasionally used for bathing and a hot one was employed for scalding hogs. The water has been used to some extent, half a mile or more away, for garden irrigation.

As at Bassett Hot Spring, the hot water of the Stonebreaker springs probably rises from tuffaceous sandstone that underlies the meadow alluvium, for the sandstone is exposed in a hill and in gullies near by. Along Pit River at Bieber are good exposures of diatomaceous earth, whose presence, as well as that of the sandstone, indicates that the valley was formerly occupied by a lake.

HOT SPRINGS IN LITTLE HOT SPRING VALLEY (MODOC 3).

About 16 miles in a direct line, or 27 miles by road, northwest of Bieber hot water rises on the eastern side of Little Hot Spring Valley at two points, about 60 yards apart, at the base of low basaltic slopes. Much seepage water is added from a strip of marshland, and the resulting stream discharges about 225 gallons a minute. In the northern of the two springs a temperature of 127° was recorded. Its water is used for laundry purposes. At the lower spring, where a temperature of 170° was noted, a hotbed for vegetables has been constructed. Like that of the Bassett and Stonebreaker springs the water has no noticeable odor or taste, though small amounts of calcium or magnesium salts are deposited on stones along the stream.

Faults in Big Valley and in Little Hot Spring Valley are not known to have been recognized, but the rise of comparatively pure, hot water in these valleys hardly indicates that the rocks are sufficiently open to permit atmospheric waters to reach the deeper, heated portion of the lava mass and then to return to the surface.

KELLYS HOT SPRING (MODOC 4).

Along the upper course of Pit River hot water rises at several places, most notably at Kellys Hot Spring (Pl. V, *A*, p. 50) 4 miles northwest of Canby or 21 miles west of Alturas. A pool about 12 yards in diameter is here formed in a semicircular depression in the alluvium of the northern side of the river valley. In the center of this pool water rises with such force as to dome up about a foot high. It is said that the water was formerly thrown to a height of 2 or 3 feet, but its action has been subdued by throwing stones into the center of the pool. The water has been locally considered to be several degrees above the boiling point, but a temperature of 199½° in the pool 6 feet from its edge, at a place where the water was 1 foot deep, was the highest measured. Water boils at 204° at the elevation of the pool (4,400 feet), and it is probable that it rises with this temperature in the spring. The measured discharge was 325 gallons a minute. The water is used several hundred yards away as a domestic supply and for irrigation. A small area near the spring and between two outflow streams is used for growing tomatoes. The water has no distinctly mineralized taste, though it is said to stimulate the action of the kidneys.

HOT SPRINGS ON HOT CREEK (MODOC 6).

About 8 miles north of east from Kellys Hot Spring a stream known as Hot Creek is formed by numerous thermal springs that rise on the north side of the valley that borders Pit River. A maximum temperature of 92° was recorded here, at the side of a small house used as a laundry and for bathing. The stream, which carries approximately 700 gallons a minute, irrigates meadow land along its course of a mile to the river. Half a mile northeast of the main group another spring, with a temperature of 85° and a yield of about 8 gallons a minute, has been used to irrigate a potato field.

WARM SPRING IN WARM SPRING VALLEY (MODOC 5).

About halfway between Kellys Hot Spring and the springs on Hot Creek, a spring issues in Warm Spring Valley on gentle slopes that border a northern extension of the valley along Pit River. The temperature measured in this spring was 81°, and its flow was approximately 275 gallons a minute. The water is employed for domestic uses as well as for irrigation. The following analysis shows it to be a slightly mineralized water of the primary alkaline type:

Analysis of water from spring in Warm Spring Valley, Modoc County, Cal.

[Analyst and authority, F. M. Eaton (1909). Constituents are in parts per million.]

Temperature	27° C. (81° F.)
Properties of reaction:	
Primary salinity	30
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	64
Secondary alkalinity	6
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Sodium (Na) Potassium (K)	55	2.40
Calcium (Ca)	3.1	.15
Magnesium (Mg)	Trace.	Trace.
Sulphate (SO_4)	7.4	.15
Chloride (Cl)	22	.62
Carbonate (CO_3)	53	1.77
	140.5	....
Carbon dioxide (CO_2)	0	.00

This analysis probably also represents the general character of the springs of Hot Creek and also of Kellys Hot Spring.

WARM SPRINGS NEAR RATTLESNAKE CREEK (MODOC 8).

Warm springs that are similar to those of Hot Creek and Warm Spring Valley issue along the slopes that border Rattlesnake Creek, about 7 miles above its junction with Pit River and 8 or 9 miles (by road) northwest of Alturas. They form a small area of natural meadow land but have not been developed so as to water it efficiently.

WARM SPRINGS NEAR CANYON CREEK (MODOC 7).

Near the head of Canyon Creek, south of the valley of Pit River, warm springs that are similar in character to those already mentioned in this region are used to irrigate a small amount of land on a ranch.

The region including the five groups of thermal springs last described forms a rather mountainous plateau covered with lava. Faults near the springs are not mapped on Plate III (in pocket), but crustal movement is suggested by the unusually high temperature of Kellys Hot Spring, and the rise of heated waters at this and the other thermal springs of the region may perhaps be ascribed to the heat of the lavas themselves.

KLAMATH HOT SPRINGS (SISKIYOU 7).

Klamath Hot Springs form an isolated group near the north-central edge of the State. The springs rise in meadow land that borders Klamath River near the mouth of Shovel Creek and were formerly known as Shovel Creek Mud Springs. The property has been improved as a resort for more than 20 years and is much visited for the fishing that is afforded by the river, as well as for the benefit derived from the baths. In 1909 the improvements included a two-story stone hotel (Pl. VII, *B*, p. 108) and four cottages, besides bathing facilities.

Five springs and tule-grown pools are formed by the rise of thermal water in a meadow on the south side of the river, and two other small springs issue near the northern bank of the stream. Three springs on the southern side are those chiefly used. The hottest of these, 152° in temperature, forms a small drinking spring near the river and about 175 yards from the hotel. There is a small bathhouse at another hot spring near by, and the main bathhouse is 100 yards to the southwest, at the border of a tule area. Hot-mud baths and also clear-water baths are here furnished by water that rises in the marshy area. The following are analyses of the main drinking and bath springs:

Analyses of water from Klamath Hot Springs, Siskiyou County, Cal.

[Analyst, William Irelan, jr. (1896). Authority, advertising matter. Constituents are in parts per million.]

	1		2	
Temperature	69° C. (156° F.)		44° C. (112° F.)	
Properties of reaction:				
Primary salinity		76		66
Secondary salinity		20		5
Tertiary salinity		0		0
Primary alkalinity		0		0
Secondary alkalinity		4		29
Tertiary alkalinity		9		7
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	543	23.60	443	19.28
Potassium (K)	4.8	.12	1.4	.04
Lithium (Li)	....	....	Trace.	Trace.
Calcium (Ca)	143	7.13	183	9.13
Magnesium (Mg)	2.9	.24	12	.99
Iron (Fe)	4.1	.15	1.8	.06
Sulphate (SO_4)	365	7.62	337	7.02
Chloride (Cl)	788	22.23	490	13.82
Carbonate (CO_3)	0	.00	241	8.03
Metaborate (BO_2)	60	1.39	27	.63
Silica (SiO_2)	82	2.72	63	2.09
	1,992.8	....	1,799.2	....

1. Hottest drinking spring; 2. Main bath spring.

The analyses represent primary saline waters of the chloride type, the drinking spring being characterized by secondary salinity and the bath spring by secondary alkalinity. Tertiary alkalinity is not fully reported. The presence of borates in both springs is noteworthy.

Along this portion of its course Klamath River has cut a wide canyon, 1,200 feet or more deep, into lava. Prominent bluffs of tuffaceous material are exposed along its north side one-third of a mile west of the Klamath springs. Faulting might again be appealed to in an attempt to explain the rise of the thermal water here, but it is possible that an abnormal temperature gradient in the bottom of this deep canyon in the lavas, combined with local fracturing or with the presence of porous beds that allow the escape of deep-seated water, may furnish a satisfactory explanation for the existence of the hot springs.

HOT SPRINGS ON BIDWELL CREEK (MODOC 10).

In the western part of the United States there is a large area from which no streams flow to the ocean and which is therefore called the Great Basin. Many of the mountain ranges and intervening valleys in this area have been formed by extensive faulting, a mode of formation here so common that its result is known as "Basin Range" structure. One of the minor divisions of the Great Basin along the northeast border of California is Surprise Valley, whose formation was ascribed by Russell[1] to faulting along both sides of the valley, subsidiary faulting having produced its minor features. The hot springs that rise in the valley are considered to furnish confirmatory evidence of its fault origin.

The northernmost of the hot springs that are noteworthy are found at the base of lava slopes on the west side of the canyon of Bidwell Creek, about 1 mile north of Fort Bidwell. From five vents within 6 or 8 yards of each other about 75 gallons of water a minute is discharged, the highest recorded temperature being 108°. In 1909 the water was conducted to a plunge in a small bathhouse and was also used for irrigation and domestic supply.

On standing the water deposits a small amount of sulphur. The following analysis shows that the water is characterized by primary alkalinity and primary salinity and, to a small degree, by secondary alkalinity. Tertiary alkalinity, though not fully reported, is important. The softness of the water and its suitability for use in laundries is recognized, and it is a good boiler water but is only fair for irrigation.

Analysis of water from main hot springs on Bidwell Creek, Modoc County, Cal.

[Analyst and authority, F. M. Eaton (1909). Constituents are in parts per million.]

Temperature	38° C. (100° F.)
Properties of reaction:	
Primary salinity	47
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	42
Secondary alkalinity	11
Tertiary alkalinity	58

Constituents.	By weight.	Reacting values.
Sodium (Na)	78	3.39
Potassium (K)	7.7	.20
Calcium (Ca)	3.7	.18
Magnesium (Mg)	2.9	.24
Iron (Fe), Aluminum (Al)	2.8	.10
Sulphate (SO_4)	58	1.20
Chloride(Cl)	24	.69
Carbonate (CO_3)	62	2.08
Silica (SiO_2)	65	2.15
	304.1	....
Carbon dioxide (CO_2)	Present.	Present.
Hydrogen sulphide (H_2S)	2.8	.16

HOT SPRINGS NEAR SOUTHWEST SIDE OF UPPER LAKE (MODOC 11).

At points about 2 miles and 3 miles, respectively, north of Lake City, hot water rises in meadowland that borders Upper Lake. The quantity of flow and the temperature of the water are rather indefinitely known, as the water rises in tule-grown areas. It has been

[1] Russell, I. C., A geological reconnaissance in southern Oregon: U. S. Geol. Survey Fourth Ann. Rept., pp. 449-450, 1884.

used mainly for irrigating the meadowland, but the supply could be developed and more efficiently used by proper ditching.

HOT SPRINGS ON EAST SIDE OF SURPRISE VALLEY (MODOC 14).

Between Upper and Middle lakes, on the east side of Surprise Valley, three small hot springs rise in a small depression on a gentle greasewood-covered slope. The discharge from the springs is increased by seepage from a marshy strip along the overflow, 75 or 100 yards beyond. In 1909 the water was used for irrigating meadowland and a small vegetable garden. The soil near the springs showed an efflorescence of common salt and soda, but the water did not taste noticeably mineralized.

HOT SPRINGS AT EAST BORDER OF SURPRISE VALLEY (MODOC 13).

One mile west of the hot springs between Upper and Middle lakes near the base of slopes that encroach on the valley, scalding water issues from small vents within a space of 20 yards. Corrals and vats have been constructed here and the water has been used in preparing sheep dip. The water is without appreciable odor or taste and is not notably mineralized. About 100 yards east of the springs is a ledge of iron-stained silicified rock that resembles in appearance an andesitic dike rock that has been silicified by the action of heated water. A prospect pit for limestone has been dug in a small deposit of calcareous tufa, half a mile southward, but this material was not observed at the springs.

HOT SPRING NEAR EAST SIDE OF MIDDLE LAKE (MODOC 15).

Near the eastern side of Middle Lake is a hot spring that is said to form a pool 25 feet in diameter and 6 feet deep. Its flow has been estimated at more than 300 gallons a minute, and like the other springs of the valley it forms a meadow area bordering the lake.

HOT SPRINGS NEAR WEST SIDE OF LOWER LAKE (MODOC 16).

About 5 miles south of Eagleville hot water issues at half a dozen or more places in the gravel of the valley side, in a depression similar to the depressions in which other hot springs in Surprise Valley issue. The water has no appreciable taste or odor. There was formerly a small bathhouse at these springs, and later a dam was constructed that made a swimming pool, but in 1909 the water was used only to irrigate 30 or 40 acres of meadow and alfalfa.

HOT SPRINGS NEAR SOUTHWEST SIDE OF LOWER LAKE (MODOC 17).

Three miles south of the springs just described is another group of hot springs that are said to irrigate about 160 acres of meadow. The water at this place forms a pool and is considered to be somewhat warmer than that of the springs a few miles northward. There are also several small warm springs near the road between these two groups of springs.

WARM SPRINGS AT SOUTH END OF SURPRISE VALLEY (MODOC 18).

A small amount of warm water rises in meadowland at the south end of Surprise Valley. This water may rise along a fault zone, as the principal springs of the valley are considered to rise, but it may also be of alluvial artesian character.

BOYD SPRING (MODOC 12).

Boyd Spring is marked on some maps as Boyd Hot Spring, but its recorded temperature in 1909 was only 67°. The water has no noticeable taste, and in several respects it seems to be a spring of alluvial artesian origin rather than one whose existence is due to the rock structure. It is mentioned with the hot springs of Surprise Valley, however, because it is to some extent thermal and may have a structural origin. It is situated near the eastern side of Upper Lake, on a gentle greasewood-covered slope. A tule-grown pool has formed here, about 15 by 25 yards in dimensions, in which there are many small fish. The discharge flows westward in a sluggish stream of perhaps 1,000 gallons a minute, though at the point where the stream was measured the current was so slight that its volume could be only roughly approximated. In 1909 it was used for irrigating meadow half a mile or more to the northwest.

SHAFFER HOT SPRINGS (LASSEN 16).

In Honey Lake valley there are two large groups of hot springs—one, the more interesting, near Hot Springs railroad station and the other near Amedee. At the former locality, near the northeastern side of Honey Lake, a belt of calcareous tufa extends from the base of steep slopes that border the valley near the railroad station southwestward for nearly half a mile. The continuity of the surface exposure of the material is then broken, but the course of the deposit is marked for two-thirds of a mile farther by prominent crags and knolls of the material that rise in meadow and salt-grass land that extends to the lake. One of these crags is shown in Plate VIII, *A*. Seepage springs rise at several points along the middle part of this tufa belt, but the springs of chief interest issue beyond its most lakeward outcrop. They are not known locally by a definite name, but as they were referred to in 1882 by Russell as Shaffer Hot Springs, this name is here used.

The principal spring rises with vigorous ebullition in a pool about 10 yards in diameter and 1 or 2 feet deep. The water was formerly

A. CALCAREOUS TUFA NEAR SHAFFER HOT SPRINGS, LASSEN COUNTY.

B. CARBONATE DEPOSIT OF JORDAN HOT SPRINGS, TULARE COUNTY.

thrown up to a height of 3 or 4 feet, but this action has been partially stopped by stones that have been cast into the pool. A temperature several degrees above boiling has been claimed for this spring, but 204°, near the center of the pool, was the highest temperature recorded. This is the same temperature at which water boiled in a bucket over a fire near the spring and is practically the calculated boiling point for this elevation (3,975 feet). A bathhouse that extended over a part of the pool was in 1909 used as a vapor bath. In 1882 Russell [1] estimated the flow of this spring to be 100 cubic feet a minute (748 gallons a minute), but in September, 1909, the average of three float measurements indicated a discharge of only about 175 gallons a minute. It does not seem probable that this great difference is due to error in measurement, and it is believed to show that the flow has actually decreased, possibly because of the partial choking of the vent with stones. Two other hot springs that discharge about 65 and 10 gallons a minute, respectively, and 6 or more hot pools that have no surface outflow, are formed in the nearly level salt-grass area in a distance of about 125 yards southwest of the main spring.

In his monograph on Lake Lahontan [2] Russell says of these springs and the associated tufa:

> This spring occurs at the southern end of a long row of tufa crags, fully 50 feet high and somewhat greater in breadth, a few of which still have small springs issuing from their bases. The tufa at the base of the crags, and forming the nucleus of the deposit, is amorphous, but is coated with a heavy deposit of the dendritic variety. * * * The former was a direct precipitate from spring water, but the latter was plainly deposited from the former lake. The evidence is such as to lead to the conclusion that this spring was fully as copious during the existence of Lake Lahontan as now, and that its point of discharge was crowded southward along a fissure as its former outlets became filled with calcareous tufa deposited from its own waters.

Russell also gives an analysis of the water, which is here reproduced, together with analyses that were made of the spring and lake waters in 1909. The analyses show that the spring water is a primary saline solution containing a large proportion of silica. The comparatively small amounts of calcium and carbonate present are of interest with respect to the large tufa crags, but calcium carbonate is easily formed and precipitated, so that large amounts are not necessarily present for the production of prominent deposits. The lake water is characterized by primary alkalinity as well as primary salinity.

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[1] Russell, I. C., Geological history of Lake Lahontan: U. S. Geol. Survey Mon. 11, p. 51, 1885.

[2] Lake Lahontan is the name that has been given to a body of water that occupied Honey Lake Valley and adjacent valleys during early Quaternary time.

Analyses of water from Shaffer Hot Springs and Honey Lake, Lassen County, Cal.

[Constituents are in parts per million.]

	1		2		3	
Properties of reaction:						
Primary salinity		93				55
Secondary salinity		0				0
Tertiary salinity		0				0
Primary alkalinity		2				39
Secondary alkalinity		5				6
Tertiary alkalinity		31			(?)	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	304	13.22			622	27.04
Potassium (K)	9.4	.24				
Calcium (Ca)	12	.60			21	1.05
Magnesium (Mg)	.4	.03			7.9	.65
Sulphate (SO_4)	349	7.27	353	7.32	264	5.50
Chloride (Cl)	207	5.84	203	5.73	365	10.29
Carbonate (CO_3)					383	12.78
Metaborate (BO_2)			Trace.	Trace.		
Silica (SiO_2)	131	4.34	120	3.98		
	1,012.8		676		1,662.9	
Carbon dioxide (CO_2)					0	.00

1. Main spring, Shaffer Hot Springs. Analyst, F. W. Clarke (1883). Authority, U. S. Geol. Survey Bull. 9.
2. Main spring, Shaffer Hot Springs. Analyst, G. E. Colby (1909). Authority, owner of springs.
3. Honey Lake. Analyst and authority, F. M. Eaton (1909). Sample collected 75 yards from northeast shore, where water was 18 inches deep.

Dana[1] has made a close examination of the calcareous tufa deposited in the basin of Lake Lahontan. Three varieties are recognized, which differ chiefly in physical characteristics. The variety at Shaffer Hot Springs, which assumes mushroom shapes, is much the commonest and is known as dendritic tufa. An analysis of the material is here reproduced, because, though not strictly a hot spring deposit, the crags near Shaffer Hot Springs are evidently closely related to the presence of the hot water.

Analysis of dendritic tufa from basin of Lake Lahontan.

[Analyst, D. O. Allen (1882 ?). Authority, U. S. Geol. Survey Mon. 11, p. 203.]

Insoluble residue	5.06
Iron and alumina ($Fe_2O_3+Al_2O_3$)	1.29
Calcium oxide (CaO)	49.14
Magnesium oxide (MgO)	1.99
Chlorine (Cl)	Trace.
Sulphate (SO_4)	Trace.
Phosphate (P_2O_5)	Trace.
Carbon dioxide (CO_2)	40.31
Water (H_2O)	2.01
	99.80

[1] Dana, E. S., A crystallographic study of the thinolite of Lake Lahontan: U. S. Geol. Survey Bull. 12, 1884.

AMEDEE HOT SPRINGS (LASSEN 17).

The second group of hot springs in Honey Lake Valley is about 5 miles southeast of Shaffer Hot Springs, near Amedee depot. The land here is alluvial and slopes very gently westward toward Honey Lake. Scalding water forms several groups of shallow pools, mainly at six places in a belt about 600 yards long that trends nearly southward, but one-third of a mile S. 30° W. (magnetic) from the southernmost of these main groups another hot spring forms a pool in salt-grass land, and hot water probably rises at other places still farther toward the lake. Temperatures of 172° to 204° (practically the boiling point at this elevation, 4,000 feet) were noted in the several springs, and the total discharge of hot water as measured by the flow of six run-off streams is about 700 gallons a minute.

In 1909 the springs had not been improved to great extent, but there was a small bathhouse beside the railroad, near one of the largest groups of springs. At the southernmost of the main groups there was also an old bathhouse, and water from one of the northernmost springs was used in preparing sheep dip. At the Amedee Hotel a shallow well 80 yards east of the nearest springs supplied water at a temperature of 134° for kitchen use.

There are no prominent deposits of tufa at Amedee, such as there are near Shaffer Hot Springs, but near the southernmost of the main groups tufa appears over a small area. The hottest spring rises from this material. The following analysis of the water from this spring shows that it is a primary saline water almost identical in character with that of the Shaffer spring but of slightly less concentration.

Analysis of water from Amedee Hot Springs, Lassen County, Cal.[a]

[Analyst and authority, F. M. Eaton (1909). Constituents are in parts per million.]

Temperature	96° C. (204° F.)
Properties of reaction:	
Primary salinity	91
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	1
Secondary alkalinity	8
Tertiary alkalinity	28

Constituents.	By weight.	Reacting values.
Sodium (Na)	232	10.18
Potassium (K)	4.9	.13
Calcium (Ca)	18	.90
Magnesium (Mg)	Trace.	Trace.
Iron (Fe) } Aluminum (Al) }	1.8	.06
Sulphate (SO_4)	269	5.60
Chloride (Cl)	164	4.62
Carbonate (CO_3)	27	.91
Silica (SiO_2)	94	3.12
	810.7	....
Carbon dioxide (CO_2)	Present.	Present.

[a] Spring 150 yards southwest of Amedee depot.

HIGHROCK SPRING (LASSEN 19).

A large thermal spring rises on the Highrock ranch, about 10 miles south of east from Amedee. Its water is used for domestic supply and for irrigation, and the spring forms a convenient watering place on the road between Honey Lake Valley and Reno, Nev. Measurements in 1909 showed its flow to be about 525 gallons a minute and its temperature 86°.[1] The water does not have a distinctive alkaline taste, but it is said to rust tinned-iron vessels quickly.

The spring rises at the edge of Honey Lake Valley, from basaltic lava that forms the hills to the east. No deposit of note is observable immediately at the spring, but 30 yards northwestward are prominent calcareous tufa crags from which the ranch takes its name. The deposit covers an area of perhaps 2 or 3 acres, and its well-developed crags are coated with dendritic tufa. Water does not now issue from the tufa, but there is said to be an Indian legend that the main spring formerly did so.

KRUGER SPRING (PLUMAS 11).

At the upper end of Indian Valley in Plumas County, in meadowland a mile east of Greenville, there is a thermal spring that has been known as Kruger Spring since the late eighties. During the more prosperous days of mining in this region it was extensively patronized as a bathing place. Of late years, however, the bathhouse has not been kept in repair and it has not been open to the public. In 1909 about 1 gallon a minute of water 94° in temperature flowed from a board-curbed pool in the bathhouse. Both the temperature and the yield could probably be increased by sinking a well casing into the spring. A few bubbles of gas rise in the pool, but the water has no distinctive taste or odor. The spring may furnish evidence that there has been faulting through Indian Valley. It seems more probable, however, that alluvial artesian water is here brought to the surface, possibly by a buried ridge.

MARBLE HOT WELLS (PLUMAS 16).

In Sierra Valley, in the southeastern part of Plumas County, several flowing artesian wells discharge water of unusually high temperature. The most remarkable of these wells are on the Marble ranch, at Kettle post office, where, in 1885 and 1888, two wells, 4 inches in diameter, were sunk about 100 yards apart to a depth of 350 feet. Each of these wells discharges about 175 gallons a minute of scalding water, the recorded temperatures being 156° and 161°. A third well, 150 yards west of the other two, was sunk to a depth of 450 feet, at which

[1] In 1882 Russell reported its temperature to be 100° (U. S. Geol. Survey Mon. 11, p. 52), but it is doubtful whether such a marked reduction in temperature has really taken place.

depth the drill encountered "quartz," possibly bedrock. The well did not yield a large flow. In 1909 its discharge was about 1 gallon a minute, and the temperature of the water was 125°.

About 350 yards north of the northernmost well is a spring that formerly yielded hot water, but its flow and temperature were reduced by a well, since abandoned, that was sunk a short distance north of it. When this spring was visited it formed a pool from which there was a flow of perhaps 3 gallons a minute. The highest temperature recorded in it was 87°.

Water from the two principal wells is used for domestic supply and for irrigation. It is considered to be of good quality, though it acts as a laxative. An examination of the water by Mr. J. W. Montague, a chemist of San Francisco, has shown that it contains 1,400 parts per million of solids in solution. Of this amount, 40.81 parts are reported as sodium chloride (common salt). Small incrustations of calcium or magnesium carbonate form on the discharge pipes. The fact that the water will deposit a rust-colored stain on clothes that are allowed to soak in it for some time indicates that it contains also a noticeable amount of iron. Baths have been provided and they are occasionally used for relieving rheumatism, but when visited in 1909 no attempt had been made to develop the property as a bathing resort. About 6 miles southeast of the Marble wells is another hot well, but its flow is smaller and the temperature of its water is lower.

Several other flowing wells that yield warm water are situated along a belt that extends for several miles southeastward.

A fault that passes through Sierra Valley has been mentioned by Diller [1] and by Turner [2] and is shown on Plate III (in pocket). The movement along this fault is considered to account for the existence of hot water beneath the valley, as the fracturing has probably furnished places for the escape of deep-seated water upward into the alluvium.

CAMPBELL HOT SPRINGS (SIERRA 1).

At the extreme southern border of Sierra Valley, about 2 miles by road southeast of Sierraville, eight thermal springs are scattered for a distance of a mile along the low slopes that border this end of the valley and in the adjacent meadowland. The property has been improved as a resort since the early eighties, and in 1909 a three-story hotel and an annex provided accommodations for 100 guests.

One of the largest hot springs rises on the hillside, 50 feet above the valley. It discharges about 15 gallons a minute of slightly sulphureted water 102° in temperature. The water has been piped to tubs

[1] Diller, J. S., Notes on the geology of northern California: U. S. Geol. Survey Bull. 33, p. 14, 1886.

[2] Turner, H. W., Mohawk lake beds: Philos. Soc. Washington Proc., vol. 2, pp. 396–397, 1892.

and to a plunge, and has also been used for garden irrigation. Water from another spring that rises at the edge of the meadow, 800 yards to the southeast, has been used to supply a wooden swimming plunge near by. The observed temperature of this spring was 98° and its flow was about 30 gallons a minute. Its water is more noticeably sulphureted than that of the first-mentioned spring, and it also has a corrosive effect on the boards that curb it.

A cool spring beside the hotel and another at camp grounds to the southeast have been used for drinking. The other springs have been slightly used for irrigating vegetable patches. The water of one of them, called the Hobo Spring, issues with a temperature of 111°, which is the highest that was observed in this group. An old bathhouse at the westernmost spring was apparently little used.

The following are analyses of water from the main hot spring and the cool spring at the hotel:

Analyses of water from Campbell Hot Springs, Sierra County, Cal.

[Analyst, not given. Authority, advertising matter. Constituents are in parts per million.]

	Main hot spring.		Cool spring.	
Temperature	40° C. (104° F.)		....	
Properties of reaction:				
Primary salinity	54		62	
Secondary salinity	38		14	
Tertiary salinity	0		0	
Primary alkalinity	0		0	
Secondary alkalinity	8		24	
Tertiary alkalinity	70		57	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	69	3.00	97	4.22
Calcium (Ca)	44	2.19	44	2.19
Magnesium (Mg)	4.5	.37	4.2	.35
Iron (Fe) Aluminum (Al)	21	.75	13	.47
Sulphate (SO_4)	143	2.98	154	3.20
Chloride (Cl)	75	2.11	70	1.96
Carbonate (CO_3)	14	.47	48	1.60
Silica (SiO_2)	117	3.88	116	3.85
	487.5	....	546.2	....

The analyses indicate that these two springs yield waters of the same general type, but the water of the cool spring is characterized by greater proportions of primary bases and alkalinity as well as somewhat greater concentration.

The hills near the springs are of lava that is probably andesite. The fault that passes through Sierra Valley has been mapped on Plate III (in pocket) as passing close to the Campbell Hot Springs. Hence the origin of the hot springs, like that of the hot wells farther north, seems to be properly assigned to the presence of this structural break, through which deep-seated water rises.

BROCKWAY HOT SPRINGS (PLACER 8).

The only noteworthy thermal springs in the basin of Lake Tahoe are at the north end of the lake, near Stateline Point, at a fishing and boating resort, known as Brockway, where in 1909 a hotel and four cottages provided accommodations for 100 people. The springs rise in the lake within a few feet of the shore, bubbling up from numerous vents, principally at two localities. One of these localities is at the boat pier, where one spring has been cemented so as to form a drinking basin near the lake edge. A temperature of 137° was recorded in this spring, and the discharge was about 3 gallons a minute. A plan had been considered for making a warm swimming pool by constructing a concrete wall around the springs in the lake at this place. Water from another group of springs, which is situated in the lake near its edge, about 150 yards northwestward, is pumped to a tank near by and used for bathing and for laundry purposes. The water is faintly sulphureted but seems to be only slightly mineralized otherwise, for it is very soft and excellent for laundry use.

The springs rise from granodiorite which is overlain on the slopes above by andesitic lava. A probable fault has been mapped by Lindgren [1] as passing southeastward through the lake, about one-third of a mile west of the springs.[2] This fault appears to furnish the most plausible explanation for the existence of the springs.

GROVERS HOT SPRINGS (ALPINE 1).

In Alpine County, about 4 miles west of Markleeville and near the southern extension of the Sierra Valley fault, considerable heated water rises at Grovers Hot Springs from a dozen springs and seepages in two marshy areas about 100 yards apart, at the edge of a meadow on the southern side of Markleeville Creek. The principal springs range in temperature from 128° to 146° and their combined discharge—perhaps 100 gallons a minute—irrigates the meadow.

In 1909 a pool 3 or 4 feet deep and about 30 feet square was used for bathing, and the place has been visited as a camping resort for many years.

Lime carbonate has been deposited by the springs and is especially noticeable below several of the springs that flow down over a terrace or bank that has probably been formed by the carbonate material. The slopes that surround the springs are granitic, but less than half a mile to the east there is lava that possibly has some relation to the hot water and to its content of lime carbonate. The fact that an extensive fault passes close to the springs suggests, however, a more plausible cause for the issuance of the hot water.

[1] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Truckee folio (No. 39), 1897.

[2] This fault is not shown on map No. 1 of the atlas accompanying the report of the California State Earthquake Commission, probably through oversight.

FALES HOT SPRINGS (MONO 1).

Fales Hot Springs are about 13 miles northwest of Bridgeport, on the main road to Minden, Nev. In 1908 there was a stage station and road house at the place, and plunge and tub baths were provided for use of the water. The place was too inaccessible to have become much of a resort, but during the summer months it was visited by campers.

The hot water rises along the bed of a small creek that has been dammed to form a bathing pool and to keep the water at a comfortable temperature, for in the main group the temperature ranges from 129° to 141°. Measurements indicated that the total discharge was about 300 gallons a minute. Much gas, probably carbon dioxide, rises with the water, which is too hard for use in laundry work. Hard, shiny nodules occasionally found in the creek are probably composed mainly of lime carbonate, though they may contain considerable silica. No other deposit of note is formed at the springs, but on the hillside 400 yards north of east from and 125 feet higher than the present springs there is a circular lime-carbonate basin, about 100 feet in diameter and 25 feet deep, with a rim 50 to 150 feet thick. Another smaller lime carbonate deposit lies halfway between this basin and the springs, and a third deposit of the same material appears along the creek side 250 to 400 yards east of the springs. Hot water no doubt formerly issued at these places and built up the deposits.

The region east of the springs and apparently the higher slopes that surround them are granitic, but the slopes near by are of lava. Less than 50 yards northwest of the springs is a knoll of lava that is considered by E. S. Larsen, jr., to be quartz latite. Along the creek banks on each side of this material the rock has been so completely decomposed to a clay as to suggest that the lava is an intrusive mass or dike. If this is true, it is probable that the heat of the water and also its chemical contents are derived from the lava. The association of lava with lime carbonate deposits at hot springs has been mentioned in the descriptions of a few other springs, and seems worth calling attention to again in connection with the springs at Fales.

BUCKEYE HOT SPRING (MONO 2).

Buckeye Hot Spring is about 5½ miles south of west from Bridgeport and on the north bank of Buckeye Creek, a mile above the mouth of its canyon and 40 feet above the stream. The water issues with a temperature of 140°, and perhaps 25 gallons a minute flows down to the creek over a large domelike overhanging deposit of lime carbonate. In 1908 a part of the water was conducted across the creek in a small trough to a cabin in which there were two wooden bathtubs; but apparently the place was not often visited. The water has no appreciable taste or odor, but the large deposit of lime carbonate indicates that it carries notable amounts of the constituents of that material. The carbonate is deeply iron stained near the spring, so the water probably contains also a fairly high amount of iron in solution.

The formation near the spring seems to be a terrace composed of granitic bowlders and finer material. No direct evidence of the origin of the springs was obtained, but as they lie along the eastern front of the Sierra, where extensive faulting has taken place, it seems probable that at this place, as at so many others, faulting has provided a means of escape for heated water.

WARM SPRINGS NEAR BRIDGEPORT (MONO 4).

About 1½ miles south of Bridgeport are other hot springs that have formed noteworthy deposits of lime carbonate. At this locality there are about 20 pools, ranging in diameter from about 10 inches to 10 yards, that are scattered for a distance of 350 yards along a terrace that borders a small creek. Much gas, which is probably carbon dioxide, rises; but the total visible flow of the springs is only about 25 gallons a minute. Temperatures of 70° to 105° were observed in the various pools. In addition to the present pools there are a number of low mounds that are evidently extinct springs. In 1908 the springs at this place were unused, and apparently had not at any time been improved for bathing or other purposes.

The slopes that rise eastward are covered with lava that is probably andesite. In a canyon half a mile eastward cliffs of light-colored siliceous tuff are exposed.

HOT SPRINGS NEAR BRIDGEPORT (MONO 3).

A much more noteworthy group of hot springs, similar in character to those just described, is found about 1½ miles southeast from Bridgeport, on hilly slopes of andesitic lava, 200 to 300 feet above the valley. The locality of special interest is an area of gently sloping ground, approximately 350 yards in diameter, that lies at the base of steeper slopes and includes a number of prominent ridges of banded onyx marble or travertine,[1] 5 to 15 feet high and of somewhat greater thicknesses, that tend to radiate from a central point, as shown in figure 3 (p. 134). Each of the better-developed ridges is cut longitudinally by a vertical crevice, and the banding of the travertine, which is stained various shades of red and yellow, is seen at several places to be also vertical. On the outside of several of the ridges dull-brown lime carbonate has formed but in nearly horizontal layers. It has apparently been deposited where the water has flowed out over

[1] Specimens of this material have been examined microscopically by E. S. Larsen, jr., and identified as calcite.

the ridges. The deposition of the onyx marble has apparently ceased, and the lime carbonate that is now being deposited is in the form of dull-brown tufa.[1]

In 1893–1895 a quarry was opened in one of the ridges, and about 60 tons of the material was taken out and shipped in rough blocks to San Francisco. It was there cut into slabs and polished and used in the rotunda of the City Hall. In 1910 the deposit had not been worked since the San Francisco order was filled, as the nearest railroad point was 50 miles distant. The material has a pleasing mottled effect, is sufficiently translucent to give depth to the coloring, and takes a good polish.

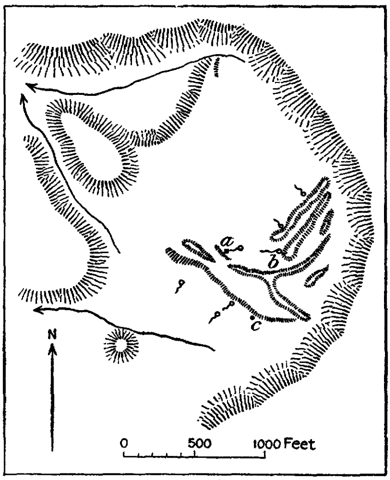

FIGURE 3.—Sketch map of travertine ridges near Bridgeport, Mono County, Cal. *a*, Bathhouse; *b*, main spring; *c*, derrick at quarry.

At two points near these ridges small springs, with temperatures of 121° and 148°, rise in pools about 3 and 10 feet in diameter. Water from the larger pool has been used to some extent for bathing in a small house near by. A third spring issues from a longitudinal crevice in the top of one of the ridges, which is shown in Plate IX, *A*. Its temperature is also 148° and its flow is perhaps one gallon a minute. It deposits lime carbonate on troughs and barrels that have been arranged so that the water can be used in preparing sheep dip. This deposit is said to form at the rate of nearly an inch a month. The water is noticeably carbonated, and the fol-

[1] The following notes concerning the formation of travertine are abstracted from an article by George P. Merrill, entitled "The onyx marbles; their origin, composition and uses, both ancient and modern" (Smithsonian Inst. Ann. Rept. for 1893, pp. 539–585, 1895).

Pure water dissolves only 1 part of calcium carbonate in 10,800 when cold, and 1 part in 8,875 when boiling; but when saturated with carbon dioxide at 10° C. (50° F.) it will dissolve nearly 1 part in 1,000 (0.88 grams per liter). The amount is increased by increased pressure, and under the most favorable circumstances the amount of calcium carbonate dissolved is 3 parts in 1,000. On cooling, and especially on relief of pressure and consequent escape of carbon dioxide, the excess of calcium carbonate is redeposited. Slow deposition tends to produce a crystalline structure; rapid deposition tends to produce a cellular one. The form of crystallization may also be determined by the character of the deposition, for G. Rose has shown (Fouqué and Lévy, Synthèse des minéraux et des roches) that by humid methods it is possible to produce out of the same solution crystals of both aragonite (orthorhombic, specific gravity 2.95) and calcite (hexagonal rhombohedral, specific gravity 2.72), the one or the other forming according to the temperature of the solution. Aragonite is formed exclusively by rapid evaporation of hot solutions, while calcite may be produced from similar solutions, both hot and cold. Most known deposits of onyx marble apparently were formed by hot water that was probably of a high degree of saturation and under some pressure. Rapid, cellular deposition is checked and a slower, compact, crystalline one is favored if the mineralized waters discharge in quiet pools; hence Merrill considers this condition of formation to have been a probable one at onyx marble deposits. Variations in the temperature of the water, the rate of cooling, and the amount and proportions of calcium, iron, and bicarbonates in solution, and the presence of impurities, such as clay, produce the numerous banded varieties of the stone.

A. TRAVERTINE RIDGES NEAR BRIDGEPORT, MONO COUNTY.

B. CARBONATE DEPOSIT BESIDE INDIAN CREEK, PLUMAS COUNTY.

lowing analysis shows that it is rather strongly primary alkaline and saline.

Analysis of water from spring from crevice in travertine ridge, Hot Springs near Bridgeport, Mono County, Cal.

[Analyst and authority, F. M. Eaton (1910). Constituents are in parts per million.]

Temperature	64° C. (148° F.)
Properties of reaction:	
Primary salinity	48
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	44
Secondary alkalinity	8
Tertiary alkalinity	6

Constituents.	By weight.	Reacting values.
Sodium (Na)	1,109	48.22
Potassium (K)	35	.90
Calcium (Ca)	60	3.01
Magnesium (Mg)	19	1.56
Iron (Fe), Aluminum (Al)	1.8	.06
Sulphate (SO_4)	939	19.55
Chloride (Cl)	214	6.04
Carbonate (CO_3)	844	28.14
Silica (SiO_2)	89	2.96
	3,310.8	....
Carbon dioxide (CO_2)	Present.	Present.

Although the water is strongly mineralized, water from one of the springs, which is said to contain 1 pound of solid matter in 17 gallons (about 7,000 parts per million), was used without causing serious trouble in the boiler of a hoisting engine at the quarry, by injecting about a gill of kerosene a day.

The ridges seem to have been formed by deposition along the sides of fissures, continuing until the opening was reduced to a mere crack or was closed entirely.

The lava from which the two groups of springs near Bridgeport rise possibly gives the water its thermal and also its chemical character. In regard to the latter character, the association of lava with hot springs that deposit lime carbonate is here again to be noted.

WARM SPRINGS BETWEEN BRIDGEPORT AND BODIE (MONO 5).

In the mountainous region between Bridgeport and Bodie thermal water rises in Warm Spring Flat, but no information is at hand concerning either its temperature or its discharge. The springs are thought to be relatively small and unimportant, however, and they are probably used only as watering places for range stock.

Another warm spring issues near Mormon Creek, 1½ miles southeast of Warm Spring Flat. It is worthy of note that Fales Hot Springs (Mono 1), the hot springs near Bridgeport (Mono 3), and the springs in Warm Spring Flat and on Mormon Creek lie in a direct line that, if extended southeastward, would pass 8 miles north of the Mono Basin Warm Springs (Mono 8, p. 145).

BENTON HOT SPRING (MONO 12).

About 300 yards northwest of the store and post office at Benton, at the base of slopes that border an area of meadowland, is a spring that forms a shallow pool approximately 10 feet in diameter in which the water has an observed temperature of 135°.[1] It has furnished a supply of water for the town for domestic and irrigation uses since the sixties, and in the early days it also furnished power for a small stamp mill. Its discharge is approximately 400 gallons a minute. The water as it rises effervesces with a gas that is probably carbon dioxide. A small amount of an efflorescent salt—probably Epsom salt—forms near the margin of the pool. A quantitative analysis of the water is not at hand, but the total amount of solids in solution has been given as 260 parts per million.[2]

The surrounding region is mainly granitic, but the slopes immediately north of the springs are of white volcanic ash or tuff that contains rounded lava gravel. This material lies nearly horizontal on weathered gray granite. In a canyon half a mile west of the spring are numerous bands of dark basaltic material, up to 2 feet in thickness, that are, however, considered to be inclusions and not intrusions in the granite. The intimate association of lava with the granite, both of the tuff and the inclusions, suggests that here again the lava offers an explanation for the existence of the spring and also for the quantities of carbon dioxide that rise with the water.

WARM SPRING IN SALINE VALLEY (INYO 12).

There are a few thermal springs of minor importance in the desert region of eastern California. One of these springs is at the northeast side of Saline Valley, about 25 miles in a direct line east of Independence. It yields a small flow, and its water is not of high temperature. There are several cool springs a short distance westward from it and also to the southeast that form watering places in this part of the desert.

WARM SPRING IN PANAMINT VALLEY (INYO 29).

About 4 miles north of Ballarat, on the eastern edge of Panamint Valley, is a spring similar to the one in Saline Valley. Its water is tepid and is noticeably sulphureted, and its yield is only about 40 barrels a day (1 gallon a minute). It forms a small watering place on a road leading northward from Ballarat.

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[1] A temperature of 138° was recorded in this spring in 1876 by the Wheeler Survey (U. S. Geog. Surveys W. 100th Mer., 1876, p. 196), where it is stated that the temperature is considered to vary 5°. In the Eighth Report of the California State Mining Bureau, 1888, pp. 356 and 357, temperatures of 135.5° in 1870 and 134.6° in 1888 are recorded.

[2] Wheeler, G. M., U. S. Geog. Surveys W. 100th Mer., 1876, p. 196.

HOT SPRINGS NEAR TECOPA (INYO 35).

About 2 miles north of Tecopa railroad station two hot springs issue on alkaline slopes that border the eastern side of an alkaline marsh along Amargosa River. The springs rise in pits that have been dug about 10 yards apart, and their combined flow is about 225 gallons a minute. The observed temperatures were 108° and 109°. Near the springs are heavy alkaline deposits of soda and common salt, and the water tastes noticeably, though not disagreeably, of the alkalies. In 1908 the water was piped to a railroad watering tank half a mile westward. It has also been used to some extent for bathing at a pool near the springs.

The water issues at the southwest base of a steep hill of quartzite that dips about 15° NE. The structure suggests that the hill forms part of a range that has been faulted and tilted in the manner characteristic of the Basin Ranges and that the springs rise along the zone of fracture. Other warm seepages rise in marsh land a mile southward and probably have the same origin.

SARATOGA SPRINGS (SAN BERNARDINO 3).

Saratoga Springs, situated at the eastern border of south Death Valley, at the base of the Black Mountains, have long been known to desert travelers, but they are hidden from view at a distance by a narrow rocky spur on the south and by sand dunes on the north and west. As there is plenty of water at the place and a considerable area overgrown with marsh grass, prospectors usually stop here for a few days to allow their animals to rest after excursions into the surrounding mountains, and in 1908 a stone cabin and other buildings were being erected by parties who had mining claims in the mountains near by.

The principal spring forms a pool about 25 by 35 feet in diameter and 3 feet deep, in whose sandy bottom the water can be seen rising at a dozen or more places. The temperature of the water is about 82°, and the pool is inhabited by many small fish, which have been identified by Prof. J. O. Snyder as *Cyprinodon macularius*, the species that live in other desert springs of similar character. At three other points along the base of the hills, 100 to 250 yards northeastward from the main spring, water has been obtained by excavating into the slopes. An area of marsh grass, tules, and open water extends 600 yards northward from the springs, but on account of the great evaporation the area of open water varies much with the season. The water tastes distinctly of alkali, but it has formed no noticeable alkaline deposits.

The mountains to the northeast consist of hard, altered limestones and sandstones that dip 25°–50° E. Some granitic rock is also exposed at places near the base of the slopes. The small ridge at whose end the main spring rises is of dioritic material.

Like many other ranges of this region, the Black Mountains appear to be a faulted block that dips eastward. Saratoga Springs rise at a point along this block where the intrusive dioritic rock has possibly produced conditions that permit the escape of water from a moderate depth. It does not seem probable that this spring is supplied either by water from the sink of Amargosa River or by deep alluvial water that may here be brought to the surface, for the surface slope, the temperature of the water, and its freshness compared with the water of Amargosa River do not favor either source.

MORGAN HOT SPRINGS (TEHAMA 2).

In the neighborhood of Lassen Peak, in the northeastern part of the State, there are some remarkable hot springs, whose positions with respect to each other and the peak are shown on Plate XI[1] (p. 140). The best-known group is at the southern base of the mountain on the Morgan ranch, where about 25 springs and pools are scattered for a distance of 600 yards in a meadow along Mill Creek. Most of them are quiet pools of small flow, less than 5 feet in diameter and relatively shallow. A number of them contain thick algous growths, and several deposit native sulphur. Others rise in areas where hard deposits of siliceous and of calcareous materials have formed. Three or four springs steam and sputter from vents on the banks of the creek. One of the northernmost of these springs seems to have a true geyser action, for it issues in a shallow basin 3 feet in diameter in which the water is said to come to a state of vigorous ebullition and then to subside about once a day. During a period of 41 hours the condition of this spring was noted five times as follows: At the beginning of the period, in active ebullition, discharge about 15 gallons a minute, temperature 200°+; two hours later quiet, no overflow, temperature 187°; at 16 hours and at 25 hours later in active ebullition, overflowing; at 41 hours, quietly overflowing, about 5 gallons a minute.

The place has been a camping resort for a number of years. In 1910 there were log bathhouses at three springs, a small shed over another pool, and a vapor bathhouse over a vent at the creek edge.

An analysis (tabulated on p. 142), of water from one of two pools, about 3 feet in diameter, in an area of hard siliceous deposit 45 yards west of the creek edge and 50 yards north of the eastern log bath-

[1] The descriptions of hot springs in the Lassen Peak region apply to conditions during 1909-10. The conditions vary from time to time and possibly were considerably changed by the renewed activity of the peak in 1914. The mountain, which had been considered an extinct volcano, broke forth on May 30, 1914, in eruptions that appear to have been volcanic, not geyser-like, and at intervals vapors, volcanic dust, and stones were cast out from two small craters developed near the summit.

house, shows that it is decidedly salty. The high content of silica shown by the analysis is also worthy of note. A few other hot springs, notably Arrowhead Hot Springs (p. 32), contain approximately as much silica, but the siliceous deposit at the Morgan springs is thought to be the largest spring deposit of this material in the State. In fact the only other hot spring locality where notable amounts of silica have been deposited is believed to be at Casa Diablo Hot Pool (p. 147). LeConte and Rising mention the deposition of silica at Sulphur Bank[1] (Lake 38) (p. 98), but it there takes place underground and is not noticeable to the casual observer.

It is possible that the water is magmatic and juvenile—that is, that it was originally contained in the underlying rock masses—and that it reaches the surface of the earth for the first time in the springs. The sodium, chlorine, and also the silica may therefore be derived from the deep-seated rock magma or semifluid mass. Diller[2] has shown, however, that a strait or arm of the ocean once occupied this area, which has since been uplifted and on which the mountain mass of Lassen Peak has been built up, and that the Chico formation, consisting of marine sediments, which outcrops 20 miles west and southwest of Morgan Hot Springs,[3] probably underlies the lava of Lassen Peak. The suggestion, based only on the chemical character of the water and the geologic structure that has been worked out by Diller, is therefore offered that the Chico beds furnish the saline constituents of the water at Morgan Hot Springs. The solvent action of this hot, saline water as it rises through the overlying lavas may account for the unusually high content of silica in the water, although literature concerning the solvent power of hot saline solutions on silicates has not been found.

The slopes on each side of the meadow at Morgan Hot Springs are covered with pyroxene andesite of Miocene or Pliocene age,[4] but a cemented conglomerate is exposed along the creek in the meadow where the springs rise. The cementing material is siliceous and probably has been deposited by the hot water.

Three-fourths of a mile northeastward, on a branch of Mill Creek, is another hot spring over which a bathhouse containing several compartments has been built. This spring also rises in a hard conglomerate similar to that at the springs in the meadow.

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[1] LeConte, Joseph, and Rising, W. B., The phenomena of metalliferous vein formation now in progress at Sulphur Bank, Cal.: Am. Jour. Sci., 3d ser., vol. 24, p. 33, 1882.

[2] Diller, J. S., Geology of the Lassen Peak district: U. S. Geol. Survey Eighth Ann. Rept., pt. 1, p. 413, 1889; Tertiary revolution in the topography of the Pacific Coast: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, p. 423, 1894.

[3] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Lassen Peak folio (No. 15), p. 1, 1895.

[4] Diller, J. S., idem, areal geology sheet.

BUMPASS HOT SPRINGS (SHASTA 16).

Bumpass Hot Springs (Pl. X, *C*) are situated on the side of Lassen Peak, about 9 miles by trail northward from Morgan Hot Springs (Tehama 2, p. 138). They consist of numerous pools of hot water, some of them in vigorous ebullition and rendered turbid by mud, and others less active but turbid with sulphur in suspension. Some pools contain acid or astringent water which is usually turbid with clay. The analysis given on page 142, with analyses of water from Devils Kitchen and Morgan Hot Springs, shows the composition of water from one of the principal springs, which is noticeably acid and sulphureted.

The position of the vents and the activity of the discharge change from time to time and seem to be influenced to a large extent by the surface supply of water, for the springs themselves yield a relatively small amount. In November, 1909, the stream running from them, which is a branch of Mill Creek, carried perhaps 200 gallons a minute at a time when the adjacent slopes were covered with snow. In the following July it carried perhaps half as much, though melting patches of snow still covered parts of the near-by slopes. On the earlier date there was a pond 20 yards across, at whose edge was a large vent, from which muddy water was being thrown to a height of 10 feet, but in the summer this pond was nearly drained and the active spring had subsided to a sputtering pool.

The area covered by the springs and vents of Bumpass Hot Springs—or Bumpass Hell, as it is locally called—is only about 200 yards long and 100 yards wide, but the rock for some distance surrounding the active area has been altered to a white, siliceous material by acid water and solfataric vapors. About 300 yards downstream from the main area there is an area perhaps 50 yards in diameter where also the rock has been greatly altered. When visited vapor still escaped from numerous small vents, and needles of sulphur crystallized at their orifices, but no water was flowing from them.

The locality has been mapped geologically by Diller[1] as a small area of basaltic lava at the lower border of dacite that overlies pyroxene andesite. The small basaltic area appears to have been intruded through these earlier lavas that form the greater part of Lassen Peak.

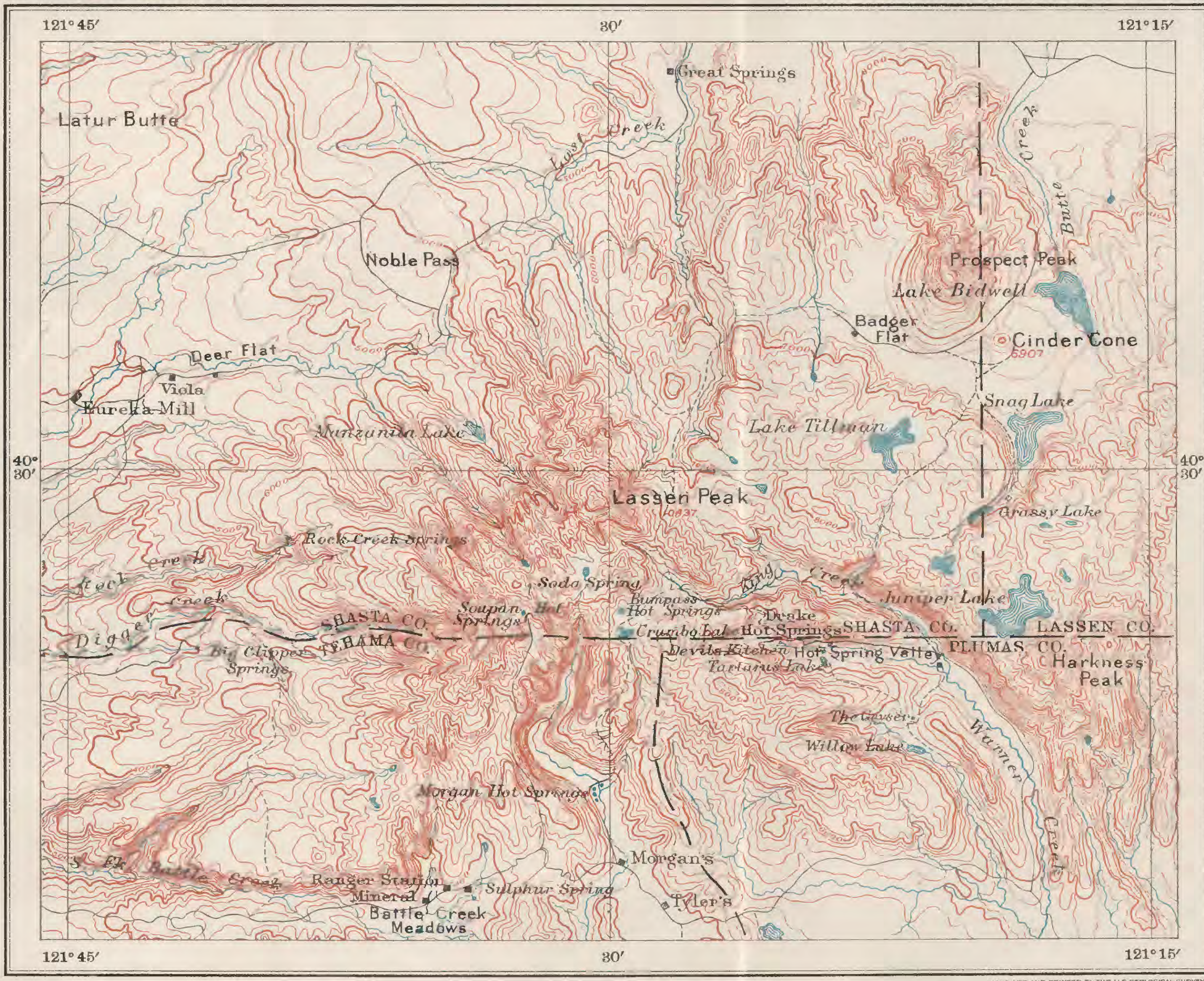
In 1910 the springs were occasionally visited as a natural curiosity, but the mineralized waters were not used for bathing or for other purposes. The Lassen Peak region is rapidly becoming a summer vacation ground, however, both because of the excellent fishing in its numerous streams and small lakes and because of its scenic features, and Bumpass Hot Springs will probably become a favorite objective

[1] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Lassen Peak folio (No. 15), 1895.

A. THE GEYSERS, SONOMA COUNTY.

B. CASA DIABLO HOT SPRINGS, MONO COUNTY.

C. BUMPASS HOT SPRINGS, SHASTA COUNTY.



ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY

From Lassen Peak atlas sheet
U. S. Geological Survey

MAP OF LASSEN PEAK REGION, CALIFORNIA

Scale $\frac{1}{250,000}$

2 0 2 4 6 8 10 Miles

Contour interval 200 feet

Datum is mean sea level

1914

point for outing parties from camps on the lower slopes. (See Pl. XI.) As these springs are only 3 miles from the craters formed in June, 1914, their character probably has also been changed.

SOUPAN HOT SPRINGS (SHASTA 15).

Soupan Hot Springs are about 2½ miles directly west of Bumpass Hot Springs, on the western side of the main canyon of Mill Creek, which is separated from the Bumpass springs by a divide only about 100 feet high. The springs yield a small amount of hot water similar in character to that of the Bumpass springs but are of interest chiefly because of the neighboring deposits of sulphur. These deposits were at one time prospected and the pits are still locally known as the "sulphur works," but they were never worked on a commercial scale and have long been abandoned.

Soupan Hot Springs, like the Bumpass springs, are in an area of altered lava, but apparently only the older Neocene lava of Lassen Peak is exposed. A carbonated spring (Shasta 14, p. 227) that issues about 1½ miles north of Soupan Hot Springs, is of geologic interest, for its presence indicates that much of the bubbling at the hot springs of the vicinity may be due to carbon dioxide instead of steam.

DEVILS KITCHEN (PLUMAS 1).

At the head of Hot Spring Valley is an area called the Devils Kitchen in which the lava has been extensively altered by solfataric action in a way similar to that observed at the Bumpass and the Soupan springs. The Kitchen differs somewhat in position from these other hot springs, however, as it is in the bottom of the stream canyon and is bordered by cliff-like walls. Numerous bubbling and sputtering pools form "paint pots" and mud cones over the bottom, which is about 200 yards across and is in many places floored by a treacherous crust that overlies scalding mud. Steam issues from many large vents around the border of the area, and in cool weather the clouds of vapor make an interesting and unusual sight. The analysis of water from a large pool near the center of the area shows that it is only moderately mineralized in regard to total content, but the large proportion of silica, sulphate, and of tertiary salinity makes it a very unusual water. The wide differences in character shown by the following chemical analyses of the three hot springs in the Lassen Peak region are of special interest.

Analyses of water from Devils Kitchen, Plumas County; Bumpass Hot Springs, Shasta County; and Morgan Hot Springs, Tehama County, Cal.

[Analyst and authority F. M. Eaton, 1909-10. Constituents are in parts per million.]

	1		2		3	
Properties of reaction:						
Primary salinity		10		36		94
Secondary salinity		10		29		5
Tertiary salinity		80		35		0
Primary alkalinity		0		0		0
Secondary alkalinity		0		0		1
Tertiary alkalinity		47		140		10
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	41	1.80	16	0.70	1,416	61.57
Potassium (K)	9.7	.25	14	.36	122	3.12
Calcium (Ca)	20	1.00	8.9	.44	90	4.48
Magnesium (Mg)	11	.92	5.1	.42	Trace.	Trace.
Iron (Fe)	11	.39	1.4	.05	2.2	.08
Aluminum (Al)	50	5.57	5.3	.59		
Hydrogen (H)	10	10.12	.37	.37		
Sulphate (SO_4)	963	20.05	141	2.93	102	2.12
Nitrate (NO_3)			Trace.	Trace.		
Chloride (Cl)	Trace.	Trace.	Trace.	Trace.	2,342	66.05
Carbonate (CO_3)	0	.00	0	.00	25	.83
Metaborate (BO_2)	0	.00			Present.	Present.
Phosphate (PO_4)	0	.00				
Silica (SiO_2)	286	9.50	124	4.11	200	6.64
	1,401.7		316.07		4,299.2	

1. Devils Kitchen springs.
2. Bumpass Hot Springs.
3. Morgan Hot Springs, the northwestern of two pools 75 yards northeast of log bathhouse.

In 1910 the water from springs in Devils Kitchen had not been made use of, but as the place is easily accessible from Hot Springs Valley it was visited by camping parties as a place of scenic interest.

DRAKE HOT SPRINGS (PLUMAS 4).

Drake Hot Springs issue along the side of Hot Springs Valley about 1½ miles east of Devils Kitchen. For many years the property has been a camping resort and within recent years accommodations for guests have been provided during the summer months.

The springs are scattered for a distance of 100 yards or more, mainly along the slope on the south side of Warner Creek, but one of the principal springs, which yields about 3 gallons a minute of water 128° in temperature, issues from a seam in rock at the south edge of the creek. In 1910 a small bathhouse and a wooden tank that was used as a plunge bath were supplied with hot water from three springs 40 or 50 yards south of the creek. These springs yield a total of perhaps 15 gallons a minute at temperatures of 123°, 146°, and 148°. The peculiar characteristic of this water is its apparently slight mineralization, for it has no noticeable taste and only a slight odor of hydrogen sulphide. At three or four places on the bank above the creek, however, are deposits of lime carbonate, indicating that the water carries some carbon dioxide and calcium, but the quantity of calcium in the water is not sufficient to make it appreciably hard.

TARTARUS LAKE (PLUMAS 5).

About 1 mile east of south from Drake Hot Springs (Plumas 4, p. 142) lies a shallow, oval pond, approximately 175 yards long and 100 yards wide, that is known as Tartarus Lake. An overflow channel leads northwestward from it, but in the summer of 1910 this channel carried no water. A number of mud pools or "paint pots" on its northern and northwestern border were in sluggish action, and at its southeastern end were sputtering and steaming vents with temperatures of 170°. Although the surface of the lake was apparently quiescent, the water was turbid and slightly yellow in color, probably from sulphur in suspension. It was said that two years previous the lake was vigorously bubbling throughout nearly its whole extent. During the season of greatest run-off the lake receives the drainage from the surrounding slopes and then overflows, but it ordinarily contains only a small amount of water. The water, like that of several other hot springs in areas of solfataric action in the region, tastes astringent and probably contains an unusually large amount of aluminum and sulphate.

The lake lies in a small depression surrounded by moderate slopes beside a trail that leads from Willow Lake northwestward to Drake Hot Springs. In several places close to the lake the lava of the Lassen Peak region has been altered to white siliceous material, but an area several yards wide on the western side of the lake consists largely of white and iron-stained kaolin. The locality presents features similar to those at Bumpass Hot Springs and Devils Kitchen, but the action of the springs, like that at Soupan Hot Springs, appears to be much less vigorous.

THE GEYSER (PLUMAS 6).

In a ravine about 2½ miles southeast of Tartarus Lake there is an actively boiling pool locally known as The Geyser (Pl. V, *C*, p. 50). A main pool, about 25 feet in diameter, is situated at the base of steep slopes, and in July, 1910, the water was continually thrown to a height of 1 to 3 feet from a vent in its northern part. From the main pool the water overflowed into another, somewhat smaller pool, in the center of which there was a distinct upward current and from which the overflow escaped down the ravine. In the center of a third pool or basin about 10 yards south of the main pool there was also a distinct upward current, and from this pool a stream of 2 or 3 gallons a minute overflowed. Although the main spring was in very active ebullition, it also discharged only 2 or 3 gallons a minute, and nearly all its water apparently came from two hot springs in the bowlder-strewn drainage channel on the slope 10 or 15 yards northwest of it. The slope immediately north of the springs is altered to white siliceous material, but the water has no distinctly mineralized taste.

It is said that during the seventies the main spring cast water to a height of 10 feet or more and was more truly geyser-like in action. Residents in the region say that its energy has been gradually diminishing and has noticeably decreased within the last few years. Information is not at hand, however, regarding the influence of the seasons on its action or the extent to which its vent has been choked by rocks thrown into the pool.

Lassen Peak and the country that surrounds it for a number of miles are composed of lavas of comparatively recent geologic age, being assigned to the Neocene epoch of geologic history. In at least one place, however, which is at Cinder Cone, there is evidence of an eruption that is believed to have taken place within two centuries.[1] The existence of numerous hot springs in this region therefore seems to be connected with the presence of the recent lava, and the water probably receives its heat from underlying masses of lava that have not yet cooled down to the normal temperature of the surrounding rocks at that depth. This condition is strongly indicated by the renewed activity of the peak in May and June, 1914.

HOT SPRINGS ON MOUNT SHASTA (SISKIYOU 14).

Vapor and small amounts of hot water rise at two localities near the summit of Mount Shasta. These localities are of relatively little importance as hot springs, but their presence at such an elevation and position is of geologic interest with respect to the mountain, which is a volcano that has become extinct within comparatively recent geologic time. The heat of the water, as at the springs near Lassen Peak, is probably derived from heated lava within the mountain.

HOT SPRINGS ON PAOHA ISLAND (MONO 7).

Along the eastern front of the Sierra there are other groups of hot springs whose existence seems to be closely related to lavas of recent geologic age. One of the northernmost of these groups is on the east side of Hot Spring Cove, on Paoha [2] Island in Mono Lake. The western part of the island is covered with lake sediments, but the eastern part is formed of black lava, and on its most southeastern point vapor and small amounts of hot water issue from numerous crevices.

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[1] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Lassen Peak folio (No. 15), p. 4, 1895.

[2] Because of the hot springs an Indian term (pa-ó-ha) meaning "spirits of the mist" was applied to the island by Prof. I. C. Russell in The Quaternary history of Mono Valley, California: U. S. Geol. Survey Eighth Ann. Rept., pt. 1, p. 279, 1889.

One spring, which has a temperature of 176° and discharges about 15 gallons a minute, was observed close to the water's edge. It is worthy of note that the maximum temperature in the thermal springs at this locality observed by Russell[1] at a time when the lake surface was several feet lower than it was in 1908, was 110°. Apparently the increased pressure due to a higher lake level has resulted in higher temperature of the water. This hot water is comparatively pure, and where it mingles with the cool, strongly alkaline water of the lake the convection currents produce an oily appearance. Much vapor rises for a considerable distance along the base of the lava bluffs that border this part of the island, and the oily appearance of the lake surface shows that considerable hot water rises beneath it. In 1908 the springs furnished a water supply for a goatherd who ranged his animals on the island.

MONO BASIN WARM SPRINGS (MONO 8).

In 1881 Russell visited Mono Basin Warm Springs, which then rose in Mono Lake a short distance from its eastern edge and were occasionally used for bathing. Springs also rise from tufa domes in the lake. The following analyses are of a warm spring on the eastern shore and of a spring issuing from a tufa dome near Black Point, on the western shore:

Analyses of water from springs in Mono Lake Basin.

[Analyst, T. M. Chatard (1884). Authority, U. S. Geol. Survey Bull. 9. Constituents are in parts per million.]

	1		2	
Temperature	27°-32° C. (80°-90° F.)			
Properties of reaction:				
Primary salinity		36		32
Secondary salinity		0		0
Tertiary salinity		0		0
Primary alkalinity		42		18
Secondary alkalinity		22		50
Tertiary alkalinity	(?)		(?)	
Constituents.	**By weight.**	**Reacting values.**	**By weight.**	**Reacting values.**
Sodium (Na)	612	26.59	51	2.23
Potassium (K)	63	1.61	8.8	.23
Lithium (Li)	Trace.	Trace.		
Calcium (Ca)	59	2.94	41	2.07
Magnesium (Mg)	60	4.97	4.4	.36
Aluminum (Al)	1.0	.11		
Sulphate (SO_4)	313	6.52	55	1.14
Chloride (Cl)	227	6.41	14	.41
Silica (SiO_2)	122	4.05	18	.59
	1,457		192.2	

1, Spring on eastern shore of Mono Lake.
2, Spring near Black Point, Mono Lake.

[1] Russell, I. C., op. cit., p. 288.

The analyses show that the waters are of the same general primary-saline and primary-alkaline type, though that of the warm spring is more concentrated and contains a less proportion of secondary bases than that of the spring near Black Point. The relatively greater proportion of silica and the higher magnesium-calcium and chloride-sulphate ratios of the warm spring are also noteworthy.

South of Mono Lake there is an area of prominent volcanic craters that are composed largely of fragmental material. These craters are considered to be of very recent geologic age. Their presence and the fact that the hot water on Paoha Island issues directly from lava furnish good evidence that the heat of the springs is derived from underlying lava that has not yet cooled to the normal temperature of the surrounding rocks.

CASA DIABLO HOT SPRINGS (MONO 15).

In the southwestern part of Mono County, near the base of the Sierra, hot water rises at several localities. The principal group, known as Casa Diablo Hot Springs (Pl. X, *B*, p. 140), is situated on lava slopes bordering Hot Creek, about 200 feet above open meadow land and at the base of steeper slopes of lava. One main spring here forms a pool about 15 feet in diameter, in which the water is in violent ebullition and is thrown to a height of 12 to 18 inches. The discharge is only about 15 gallons a minute, however, so the vigorous action is probably due largely to steam or other gas. Near the edge of the pool a temperature of 194° was recorded, which is only about 4° below the boiling point at this elevation (about 7,350 feet), and the water is probably at the boiling point in the center of the pool. The water is rendered very turbid by pink clay. Small amounts of vapor rise in half a dozen small pits that have been dug a few yards south of this pool. At a distance of 60 to 100 yards north of the main pool there are a dozen or more pools 2 or 3 feet in diameter in which observed temperatures range from 115° to 187°. They discharge from one-half gallon to 5 gallons a minute each, and the water forms a small marshy area, at the edge of which a small bathhouse has been erected. A log cabin has stood near by for a number of years, for the springs have long been visited by white people as well as by the Indians for relief in rheumatic and kindred troubles. Other small hot vents about 50 to 75 yards northeast of the bathhouse supply a shallow pool that discharges perhaps 5 gallons a minute. A quarter of a mile northeast of these springs there is still another group which supplies a pool measuring about 20 by 60 yards that discharges 15 gallons of scalding water a minute. In this pool the water rises mainly from a conical basin. A small pit in the bank near its margin forms a "paint pot" in which pink mud is kept in motion by bubbles of steam or other gas. In this material a temperature of 198° (probably the boiling point) was recorded.

At the base of hills a quarter of a mile northeastward is a shallow circular basin in the volcanic soil and gravel. In 1908 no water or noticeable amount of vapor issued here, but at four places the ground was hot. An Indian 50 or 60 years old, who was met at the springs, volunteered the information that this basin was formerly more active, and he described in graphic manner the rumbling that years ago was heard here. The rumbling of the present springs is occasionally heard at a distance of several miles, especially during cold weather.

CASA DIABLO HOT POOL (MONO 16).

About 3½ miles east of Casa Diablo Hot Springs there is a shallow pool, measuring about 30 by 35 yards, which may be called Casa Diablo Hot Pool. In November, 1908, this pool was not overflowing, though there was a small, well-defined outlet channel from it toward Hot Creek. Over nearly its entire bottom were numerous vents in which water bubbled and in several of which, near the margin, temperatures of 120° to 180° were recorded. Near the western border of the pool there are small amounts of soda alkali and also a little alum, and along part of the overflow channel there is a hard deposit, apparently of silica and lime carbonate, which also covers an area about 50 yards in diameter near the drainage channel. Its formation indicates that a portion of the bubbles that rise in the pool are of carbon dioxide rather than of steam. The pool is situated at the base of a small lava bluff that trends northward along the hillside and that has the appearance of a small fault scarp, but it may be only a small persistent scarp of erosion.

HOT SPRING NORTHEAST OF CASA DIABLO HOT SPRINGS (MONO 14).

About 5 miles northeast of Casa Diablo Hot Springs there is a pool, apparently of considerable depth, in which the water has a scalding temperature and is mildly sulphureted. It is not so active as the more southern springs, though it is similar to them in character. Like the Casa Diablo Hot Springs and Hot Pool, it is situated at the eastern front of the Sierra, in an area covered by comparatively recent lava, and both its position and its activity suggest that, like the springs in the Lassen Peak region, its heat is derived mainly from underlying lava and that places for the surface escape of the water may be furnished by faulting.

WARM SPRINGS IN LONG VALLEY (MONO 17).

In Long Valley, 3 miles west of Owens River and about 7 miles south of east of Casa Diablo Springs, there are two oblong pools a few feet apart and 40 feet long in which warm water rises and from which it flows to a shallow pond called Whitmore Tub. A maximum temperature of 100° was recorded in the pools, and the discharge measured was about 450 gallons a minute. The water rises quietly and has no distinct taste nor odor. Much dark-green algous growth lines the pools and the discharge channels, and small snails live in the water.

The springs rise in a flat, salt-grass area about 100 yards south of the base of lava hills and 15 or 20 yards west of a 6-foot terrace-like bank that drops eastward toward the river. At two places along the edge of this bank springs that have about equal flows of 8 gallons a minute issue with temperatures of 74° and 100°. The bank was not observed closely enough to be able to determine whether it is an old bank of Owens River or a small fault scarp. Like the Casa Diablo Springs, however, the position of the warm springs in a region of comparatively recent volcanic activity, where there has also been considerable minor faulting, affords suggestive evidence of the cause of their thermal character. Other similar springs rise about 3 miles farther north in the valley and form a small meadow.

HOT SPRING SOUTH OF BISHOP (INYO 1).

At the base of the Sierra about 8 miles south of Bishop a spring of considerable flow that is utilized for domestic supply and also for dipping sheep has a temperature of about 130°.[1] Like the springs farther north, in Long Valley, its water has no distinctive taste nor odor and is probably mineralized in only small amount.

Volcanic rocks are present a few miles north of Bishop, and lava cones border the valley several miles south of the spring; but its water issues from granitic rocks, and the unusually high temperature seems more probably to be caused by rising from a considerable depth along a fault zone than by contact with masses of lava that have not yet cooled.

WARM SPRING NEAR LITTLE LAKE (INYO 32).

A small amount of lukewarm, odorless water issues in a spring about 300 yards from Little Lake and near the base of a lava bluff 25 or 30 feet high. The spring has not been developed nor used to any extent during recent years and is known only locally. Perhaps the chief point of interest concerning it is its position with respect to the lava bluff. The primary alkaline and saline character of the water is shown by the following early analysis:

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[1] Reported by Adolph Knopf.

Analysis of water from Warm Spring near Little Lake, Inyo County, Cal.

[Analyst, Oscar Loew (1876). Authority, Wheeler report. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		34
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		51
Secondary alkalinity		15
Tertiary alkalinity	(?)	

Constituents.	By weight.	Reacting values.
Sodium (Na)	328	14.24
Potassium (K)	Trace.	Trace.
Calcium (Ca)	48	2.40
Magnesium (Mg)	Trace.	Trace.
Sulphate (SO_4)	54	1.13
Chloride (Cl)	163	4.60
Carbonate (CO_3)	327	10.91
Silica (SiO_2)	Trace.	Trace.
	920	....

COSO HOT SPRINGS (INYO 31).

Near the southwest corner of Inyo County there is a group of hot springs that are especially remarkable because of the acid character of their water. They have long been known as Coso Hot Springs, as they are on the eastern slope of the Coso range of mountains. The main group is about 12 miles east of Haiwee railroad station, and is beside a road that leads eastward to Coso and other mining camps. The rocks of the region are largely granitic, but this material is covered in some places by lava and by lava craters of a recent geologic period of eruption.

At the principal spring, which is in granitic material, in a pit about 50 by 100 feet in diameter and 10 feet deep, vapor and hot, sour water rise through a white mud that is apparently formed by the decomposition from the rock. In summer the water in this pit is low, but in winter, as a result of increased condensation and decreased evaporation due to cooler weather, it is nearly half full.

The following analyses of the water show that it contains unusually large amounts of sulphate and of iron, aluminum, and silica. The most remarkable feature, however, is the high tertiary salinity. The discordance of the two analyses is apparently due, in part at least, to a change in the character of the water. In connection with the large iron and sulphate content it is of interest to note that minute crystals, apparently of pyrite (iron sulphide), collect as a film on the water and also form on the clay at the side of the pool.

Analyses of water from Coso Hot Springs, Inyo County, Cal.

[Constituents are in parts per million.]

	1		2	
Properties of reaction:				
Primary salinity		5		13
Secondary salinity		5		18
Tertiary salinity		90		69
Primary alkalinity		0		0
Secondary alkalinity		0		0
Tertiary alkalinity	(?)			45
Constituents.	**By weight.**	**Reacting values.**	**By weight.**	**Reacting values.**
Sodium (Na)	49	2.13	81	3.52
Potassium (K)	11	.29	12	.31
Lithium (Li)	Trace.	Trace.	....	....
Ammonium (NH_4)	Trace.	Trace.	....	....
Calcium (Ca)	45	2.25	59	2.84
Magnesium (Mg)	2.4	.20	34	2.80
Iron (Fe)	122	4.98	83	2.97
Aluminum (Al)	201	22.22	56	6.20
Hydrogen (H)	16	15.98	12	11.67
Sulphate (SO_4)	2,308	48.05	1,400	29.18
Nitrate (NO_3)	Trace.	Trace.	0	.00
Chloride (Cl)	Trace.	Trace.	40	1.13
Carbonate (CO_3)	0	.00	0	.00
Metaborate (BO_2)	....	....	0	.00
Phosphate (PO_4)	Trace.	Trace.	Trace.	Trace.
Silica (SiO_2)	....	....	411	13.59
	2,754.4	....	2,188	....

1. Main spring. Analyst, Oscar Loew (1876). Authority, Wheeler report.
2. Main spring. Analyst and authority. F. M. Eaton (1910).

The place has become a camping resort for people afflicted with rheumatism, which is said to be relieved by baths in the hot mud. Bathing pits are dug in the cooler mud near the spring and the material is worked up to the desired consistency. Close to the main spring is an area of steam vents, about 25 by 50 yards across, which contains several pools that furnish clear water for washing and cooking. This area also furnishes sufficient heat for cooking, kettles containing food being placed in shallow pits, covered with sacks, and allowed to remain until the food is done.

Another area of hot vapors and mud in a ravine northwest of the main spring has been filed on as a placer claim for mining medicinal mud. The material at this place is somewhat finer in texture than that at the main spring.

VAPOR VENTS WEST OF COSO HOT SPRINGS (INYO 30).

Along the branches of a ravine 3 miles west of Coso Hot Springs there is an area several acres in extent in which much vapor issues and the ground is impregnated with sulphur and alum, but in 1908 no water was flowing. A temperature of 203°, which is probably the boiling point at this elevation (about 4,300 feet), was recorded in the vapor vents. These vents are in an area of lava where there are a number of small volcanic craters, and the surface is partly covered with fragments of pumice and obsidian. At the vapor vents the rock has been extensively altered by solfataric action and reduced to a siliceous sinter, but a mud similar to that at the Coso Springs was not observed. This difference is probably due partly to the fact that there is not sufficient water at the vapor vents to form a mud, and partly because they issue through lava, which does not become kaolinized as readily as does the granitic rock at Coso Hot Springs.

SUMMARY OF HOT SPRINGS.

The foregoing descriptions, comprising 149 springs or groups of springs, include 9 resorts at which there are no natural springs, so that the total number of hot-spring groups is 140. As several springs that have been described separately may be considered geographically to form only one group they have been gathered in the following list into 98 general localities, which have been arranged (1) according to the absence or presence of a notable spring deposit; (2) according to the absence or presence of lava near by, and (3) according to the character of the material from which the water issues, this arrangement having been adopted in order to show clearly the formation of deposits by hot springs, the relation of hot waters to lava areas, and their general geologic features.

Hot-spring localities.

A. No notable deposits (88 localities).

I. No lava near by.

In granitic rocks.

1. Arrowhead Hot Springs.
   Waterman Hot Springs.
   Harlem Hot Spring (in alluvial gravel).
2. Warm spring in Lytle Canyon.
3. Warm spring at Baldwin Lake.
4. Eden Hot Springs.
   San Jacinto Hot Springs.
   Ritchey Hot Springs.
5. Pilares Hot Spring (in alluvium).
6. Palm Springs.
7. Glen Ivy Hot Spring.
8. Elsinore Hot Springs (in alluvium).
   Bundys Elsinore Hot Spring (in alluvium).
9. Murrieta Hot Springs (in gravel).
10. Warner Hot Springs.
11. Agua Caliente Springs (San Diego County).
12. Agua Tibia Springs.
13. Deluz Warm Springs.
14. San Juan Capistrano Hot Springs.
15. California Hot Springs.
16. Hot springs near Kernville.
17. Neills Hot Spring (in alluvium).
18. Clear Creek Hot Springs.
    Delonegha Springs.
    Democrat Springs.
19. Williams Hot Springs.
20. Paradise Springs.
21. Blaney Meadows Hot Springs.
22. Lower springs on South Fork of San Joaquin River.
23. Hot springs at head of Fish Valley.
24. Hot springs on North Fork of Little Sur River.
25. Tassajara Hot Springs.
26. Sespe Hot Springs.
27. Warm springs in Elizabeth Lake canyon.
28. Kruger Spring (in alluvium in region of ancient effusives).
29. Hot spring south of Bishop.
30. Warm spring in Saline Valley.

In comparatively unaltered sedimentary rocks.

1. Fairview Hot Spring (in alluvium).
2. Paraiso Hot Springs.
3. Vickers Hot Springs.
   Stingleys Hot Springs.
   Matilija Hot Springs.
   Wheelers Hot Springs.
4. Montecito Hot Springs.
5. San Marcos Hot Springs.
6. Las Cruces Hot Springs.
7. Newsoms Arroyo Grande Warm Spring.
8. Pecho Hot Springs.
9. Paso Robles Mud Bath Springs (in alluvium).
   Santa Ysabel Springs.
10. Cameta Warm Spring.
11. Fresno Hot Springs.
12. Gilroy Hot Spring.
13. Warm Springs (Alameda County).
14. Byron Hot Springs (in alluvium).

In altered sedimentary rocks.

1. Slates Hot Springs.
2. Dolans Hot Spring.
3. Mercey Hot Springs.
4. Rocky Point Spring (on the beach).
5. Skaggs Hot Springs.
6. Hoods Hot Springs.
7. Orrs Hot Springs.
8. The Geysers (Sonoma County).
   Little Geysers.
9. Anderson Springs.
   Castle Hot Springs.
10. Harbin Springs.
11. Wilbur Hot Springs.
    Jones Hot Spring.
    Hot springs on Manzanita mining property.
    Blancks Hot Springs.
    Hot Springs at Elgin mine.
12. Crabtree Springs.
13. Warm spring in Panamint Valley.
14. Hot springs near Tecopa.
15. Saratoga Springs (intrusive rock near by).

II. Lava near by.

In granitic rocks.

1. Jacumba Springs.
2. Brockway Hot Springs.
3. Coso Hot Springs.

In altered sedimentary rocks.

1. Gordon Hot Spring.
   Howard Springs (in serpentine).
   Seigler Springs.
2. Bassett Hot Spring (in tuffaceous sandstone).
   Stonebreaker Hot Springs (in tuffaceous sandstone).

In lava.

1. Point Arena Hot Springs.
2. Hot springs at Sulphur Bank (carbonated).
3. Warm springs of State Home at Eldridge.
4. Los Guilicos Warm Springs.
   Warm springs on McEwan ranch.
5. Mark West Warm Springs.
6. Big Bend Hot Springs.
   Hot springs on Kosk Creek.
7. Hot springs in Little Hot Spring Valley.
8. Hot Springs on Hot Creek.
   Warm spring in Warm Spring Valley.
   Warm springs near Rattlesnake Creek.
   Warm springs near Canyon Creek.
9. Hot springs on Bidwell Creek.
10. Campbell Hot Springs.
11. Warm springs between Bridgeport and Bodie.

In lava—Continued.

12. Benton Hot Spring (carbonated).
13. Bumpass Hot Springs.
    Soupan Hot Springs.
    Devils Kitchen.
    Tartarus Lake.
    The Geyser (Plumas County).
14. Hot springs on Mount Shasta.
15. Hot springs on Paoha Island.
16. Warm spring near Little Lake.
    Vapor vents west of Coso Hot Springs.

In alluvium.

1. Mud Volcanoes.
2. Calistoga Hot Springs.
3. Kellys Hot Spring.
4. Klamath Hot Springs.
5. Hot springs near southwest side of Upper Lake.
   Hot springs on east side of Surprise Valley.
   Hot springs at east border of Surprise Valley.
   Hot spring near east side of Middle Lake.
   Hot springs near west side of Lower Lake.
   Hot springs near southwest side of Lower Lake.
   Warm springs at south end of Surprise Valley.
   Boyd Spring.
6. Marble Hot Wells (natural spring near by).
7. Mono Basin Warm Springs.
8. Warm springs in Long Valley.

B. Notable deposits (10 localities).

I. No lava near by.

In granitic rocks.

1. Jordan Hot Springs (calcareous deposit).
2. Buckeye Hot Springs (calcareous deposit).

II. Lava near by.

In granitic rocks.

1. Reds Meadows Hot Springs (calcareous deposit.
2. Grovers Hot Springs (calcareous deposit).

In lava.

1. Fales Hot Springs (calcareous deposit).
2. Warm springs near Bridgeport (calcareous deposit).
   Hot springs near Bridgeport (calcareous deposit).
3. Morgan Hot Springs (siliceous and calcareous deposit).
4. Drake Hot Springs (calcareous deposit).
5. Casa Diablo Hot Springs (siliceous and calcareous deposit).
   Casa Diablo Hot Pool (siliceous and calcareous deposit).
   Hot spring northeast of Casa Diablo Hot Springs (no deposit, but considered with the Casa Diablo group).

In alluvium.

1. Shaffer Hot Springs (calcareous deposit).
   Amedee Hot Springs (calcareous deposit).
   Highrock Spring (in alluvium at border of lava, calcareous deposit).

In a general way the list shows the character of the rocks at the various hot-spring localities, although, as in other groupings, the springs can not be rigidly classified in this respect. The number of localities is seen to be about the same in regions of granitic rocks, of sediments (including the unaltered and the altered rocks), and of lavas (including those issuing from alluvium near lava), being respectively 36, 32, and 30. If any significance can be attached to this fact, it indicates that the presence of thermal springs is due in most places to structural conditions in which the character of the rocks is not an important factor. It apparently emphasizes the evidence shown by the faults on the map (Pl. III, in pocket), that the existence of the thermal springs is due chiefly to crustal movements. Exception must be made, however, of a few thermal springs whose heat appears to be derived from lava that has not yet cooled to a normal temperature.

There are notable deposits at 10 hot-spring localities. At 2 of these, Morgan Hot Springs and Casa Diablo Hot Springs, the deposit is in large part siliceous and the silica seems probably to be derived from the lava; at the other 8 there are notable deposits of lime carbonate, and 6 of these are closely associated with lava. At 1 of the 2 remaining localities—Jordan Hot Springs—lava on the slopes to the north may possibly be in some way related to the deposit at the springs. Buckeye Hot Spring, the last of the 8, is only about 6 miles west of the springs near Bridgeport at which there are extensive lime carbonate deposits in a lava area, and there may be lava on the slopes near the Buckeye Spring, though it was not observed. The springs at Sulphur Bank, in Lake County, and Benton Hot Spring, in Mono County, are the only hot, notably carbonated springs observed that do not form deposits of considerable size.

The fact that most of the hot springs that issue in lava areas contain an excess of carbon dioxide and considerable sodium and magnesium with lesser amounts of calcium, suggests that the sodium and magnesium tend to deprive the calcium of bicarbonate and cause its deposition as lime carbonate. Thus the presence of notable amounts of carbon dioxide, derived presumably from the lava, and of the primary alkalies sodium and magnesium, apparently causes the deposition of the calcium present in the form of carbonate. The same fact seems also to be shown by the cool carbonated springs at which there are notable deposits, as is indicated by the tabulated list on pages 252–253. It is significant that relatively few of the carbonated springs that rise in sedimentary rocks form notable deposits, though some of them contain more calcium than do some of the hot springs that form extensive deposits. Most of the carbonated springs that do issue from sedimentary rocks and form deposits are noticeably thermal.

The conditions that were observed at the springs in California well bear out the facts that have been recorded of springs elsewhere at which there are notable deposits. They show that the temperature of the water and its rate of cooling, the amount of carbon dioxide that is present, and the concentration of the solution—in other constituents as well as calcium—all influence the deposition of calcium carbonate.

CARBONATED SPRINGS.

NUMBER AND LOCATION.

The number of carbonated springs—popularly known as soda springs—in California is larger than the number of hot springs, but few of the former class have been improved to greater extent than to form drinking springs at summer resorts. Most of them are of small flow, but they usually furnish good drinking waters.

The carbonated springs (see Pl. III, in pocket) are confined mainly to the coastal ranges north of San Francisco Bay and to a belt along the Cascade-Sierran uplift. The rocks of these regions have been briefly described (pp. 7–13) but are discussed in greater detail in connection with the description of the springs.

JACKSONS NAPA SODA SPRINGS (NAPA 12).

One of the best known and most extensively developed mineral-spring resorts of the State is at Jacksons Napa Soda Springs, on the mountain side 650 feet above Napa Valley. The principal buildings here, which were erected during the eighties, are made of a volcanic tuff quarried near the springs. A bathhouse and a pavilion are frame structures of more recent date. The property is open during the summer and provides accommodations for about 250 guests.

In 1892 Anderson[1] mentioned 27 springs at this place, but in 1910 only four were improved and made use of. Pagoda Spring, which rises in a hemispherical basin covered by a roof supported on stone pillars, is the principal drinking spring, but when visited its visible overflow was only about one-eighth of a gallon a minute. The water is strongly carbonated and has deeply iron stained its basin. Lemon Spring, which is similar in character to the Pagoda Spring, issues in a stone-roofed basin at the side of the driveway, 25 or 30 yards below the Pagoda Spring. Two other springs rise in a stone house and are covered by tanks that collect the carbon dioxide that is given off. This gas is used to more heavily carbonate the water, which is piped to a large bottling house near by. The water has not been extensively marketed east of the Pacific coast States, but has been shipped to Asiatic ports.

[1] Anderson, Winslow, Mineral springs and health resorts of California, p. 202, 1892.

The springs issue from slopes composed of tuff and rhyolitic lava. The following analyses show that the water of the two drinking springs is secondary alkaline in character and contains a relatively large proportion of magnesium and iron.

Analyses of water from Jacksons Napa Soda Springs, Napa County, Cal.

[Constituents are in parts per million.]

	1		2		3	
Temperature	20° C. (68° F.)		20° C. (68° F.)		19° C. (67° F.)	
Properties of reaction:						
Primary salinity		14		11		[illegible]
Secondary salinity		0		0		0
Tertiary salinity		0		0		0
Primary alkalinity		16		14		24
Secondary alkalinity		70		75		68
Tertiary alkalinity		316		14		206
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	126	5.48	107	4.65	143	6.22
Potassium (K)	Trace.	Trace.	....	....	Trace.	Trace.
Lithium (Li)	....	....	....	....	Trace.	Trace.
Calcium (Ca)	69	3.44	74	3.69	61	3.04
Magnesium (Mg)	116	9.54	129	10.58	124	10.22
Iron (Fe)	65	2.33	65	2.33	67	2.40
Aluminum (Al)	5.2	.58	5.4	.60	6.7	.74
Sulphate (SO_4)	19	.40	22	.46	8.8	.18
Chloride (Cl)	74	2.09	54	1.52	49	1.38
Carbonate (CO_3)	549	18.30	578	19.27	608	20.28
Metaborate (BO_2)	....	....	....	....	Trace.	Trace.
Silica (SiO_2)	13	.43	11	.36	14	.46
	1,036.2	....	1,045.4	....	1,081.5	....
Carbon dioxide (CO_2)	1,220	55.60	....	....	815	37.10

1. Pagoda Spring. Analyst and authority, Winslow Anderson (1888).
2. Pagoda Spring. Analyst, Lanzwurt (1870). Authority, U. S. Geol. Survey Bull. 32.
3. Lemon Spring. Analyst and authority, Winslow Anderson (1889).

CONGRESS SPRING (NAPA 14).

Congress Spring is situated at the base of a low hill of tuff, about 3½ miles southwest of Napa. It yields about one-half gallon a minute of carbonated saline water, and a considerable amount of alkaline material forms on the surface near by. The spring has been protected by a board curbing, and a small amount of the water has been sold locally, but it has been of little importance as a marketed water.

ÆTNA SPRINGS (NAPA 2).

Near the head of Pope Valley, about 20 miles in a direct line northwest of Jacksons Napa Soda Springs, a large resort has been built up at Ætna Springs (Lidell post office).

The property, which borders Pope Creek, formerly belonged to the Ætna Quicksilver Mining Co., and the locality once produced much of the metal. After mining was discontinued in one of the tunnels the water in it was observed to be mineralized, and as early as 1878 the locality was resorted to for use of this water. In 1887 it was put on the market for table use, and since that time the property has been extensively improved. There are extensive grounds in which are grouped several cottages, clubhouse, reception hall, and dining hall; and a bathhouse and a swimming plunge have been erected beside the creek. The place is within an easy ride from St. Helena by automobile stage, over a graveled and well-graded road.

The Tunnel Spring is no longer used, but on the southern bank of the creek two similar springs, known as the Summerhouse and the American Ems, have been surrounded by cemented basins and protected by a spring house. The two springs that furnish the water for bottling are situated in open land about 700 and 800 yards, respectively, northeast of those at the creek, at places that were formerly tule grown. The more distant is known as the Potassium Spring and is the one whose water is chiefly bottled; the other is called I-ador-a Spring.

The water of all five of the springs now used is carbonated, tastes distinctly mineralized, and is noticeably thermal, but as they are best known for their carbonated character they are more properly described under this heading. Summerhouse and American Ems springs are the warmest, their recorded temperature in 1909 being 92°. Analyses of all the springs, including the Tunnel Spring, have been made, and are here reproduced in standard form.

Analyses of water from Ætna Springs, Napa County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5		6		7	
Temperature	37° C. (98° F.)		37° C. (98° F.)		36° C. (96° F.)		....		31° C. (88° F.)		22° C. (72° F.)		19° C. (66° F.)	
Properties of reaction:														
Primary salinity	33		26		21		35		44		50		36	
Secondary salinity	0		0		0		0		0		0		0	
Tertiary salinity	0		0		0		0		0		0		0	
Primary alkalinity	49		66		70		47		31		48		49	
Secondary alkalinity	18		8		9		18		25		2		15	
Tertiary alkalinity	73		60		45		78		51		(?)		(?)	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	589	25.61	787	34.20	759	32.97	544	23.62	538	23.39	402	17.48	555	24.11
Potassium (K)	....	....	134	3.42	83	2.12	....	....	2.7	.07	290	7.42	....	....
Ammonium (NH_4)	....	....	....	....	....	....	....	....	....	....	.1	.01	....	....
Calcium (Ca)	44	2.20	61	3.05	22	1.10	43	2.15	59	2.94	6.6	.33	53	2.63
Magnesium (Mg)	39	3.24	1.5	.12	30	2.47	39	3.23	59	4.85	2.7	.22	22	1.76
Iron (Fe)	....	....	.4	.01	7.1	.25	.4	.01	60	2.15	3.0	.11	4.6	.16
Aluminum (Al)	....	....	....	....	.8	.09	....	....	Trace.	Trace.	19	2.10	....	....
Sulphate (SO_4)	89	1.86	115	2.40	12	.26	89	1.87	74	1.54	3.7	.08	95	1.99
Nitrate (NO_3)	....	....	....	....	....	....	....	....	....	....	6.9	.11	....	....
Chloride (Cl)	298	8.39	298	8.39	274	7.73	292	8.24	438	12.35	443	12.49	291	8.21
Carbonate (CO_3)	624	20.80	898	29.95	594	19.80	567	18.90	400	13.33	228	7.60	554	18.46
Metaborate (BO_2)	....	....	....	....	478	11.12	....	....	170	3.96	218	5.06	....	....
Silica (SiO_2)	11	.37	1.5	.05	95	3.15	6.0	.20	95	3.15	7.1	.29	14	.46
	1,694	....	2,296.4	....	2,354.9	....	1,580.4	....	1,895.7	....	1,630.1	....	1,588.6	....
Carbon dioxide (CO_2)	494	22.47	536	24.38	304	13.82	494	22.47	283	12.88	Present.	Present.	Present.	Present.

1. American Ems Spring. Analyst, J. A. Bauer (1878). Authority, U. S. Geol. Survey Bull. 32.
2. American Ems Spring. Analyst and authority, Winslow Anderson (1888).
3. Summerhouse Spring. Analyst, W. T. Wenzell. Authority, owner of springs.
4. Tunnel Spring. Analyst, J. A. Bauer (1878?). Authority, owner of springs.
5. Iron Spring. Analyst, W. T. Wenzell. Authority, owner of springs.
6. Potassium Spring. Analyst, W. T. Wenzell. Authority, owner of springs.
7. I-ador-a Spring. Analyst, J. A. Bauer (1878?). Authority, owner of springs.

The analyses indicate that the waters are all of the same general primary alkaline type, but they show minor differences in the relative proportions of calcium and magnesium and of sodium and potassium and in the content of silica, iron, and aluminum. The Wenzell analyses alone report borates, but it is not unlikely that tests for borates were not made by the other analysts and that borates are reported as carbonates. The great similarity of the three analyses by Bauer and the apparent change in composition of the American Ems Spring water are of interest.

The rocks about Ætna Springs are the altered sediments, opaline material, and associated serpentine of the Franciscan formation. A short distance northward, near some of the quicksilver workings, lava covers the surface.

WALTERS MINERAL SPRINGS (NAPA 3).

About 10 miles by road east of Ætna Springs, on the eastern side of the canyon of Pope Creek, there are two small carbonated springs that have long been known as Walters Mineral Springs. They issue about 150 yards apart and 350 feet above the creek, on the side of a ravine in an area of serpentine. The rock has decayed sufficiently to form a red clay soil, but many bowlders outcrop on the hillsides. The water has a distinctly sweet taste, and the analysis tabulated on page 160 shows that it contains a high proportion of magnesium, being secondary alkaline in character.

The magnesian character of the water is worthy of note in connection with the serpentine at this locality. The association with serpentine (a magnesium-bearing rock) of mineral springs having a high content of magnesium would be expected, however, and it has been already mentioned in the discussion of the relation of the mineral character of springs to the rocks through which they rise. (See p. 160.)

Walters Mineral Springs have been improved as a resort since about 1902. In 1910 there were two new frame buildings, having accommodations for 50 people, and a pavilion at the lower spring that provided a place for dances and other social gatherings. Water from this spring has been bottled and marketed to a small extent for table use.

SAMUEL SODA SPRINGS (NAPA 7).

About 6 miles southeast of Walters Mineral Springs, and also well above Pope Creek but on the other side of its canyon, Samuel Soda Springs form another group that has long been known. The place has been improved as a resort for a number of years, and the water has also been sold as a carbonated table water.

Four of the six mineral springs on this property rise close together, in cement basins near the bank of a small cascading stream, and a fifth spring issues at the opposite edge of the stream. These springs range in flow from about 1½ to 6 gallons a minute. The sixth spring, which is small and relatively unimportant, issues at the side of a ravine 250 yards northward. Small amounts of iron are deposited along all the overflow channels. The water of all the springs is carbonated and has a slightly sweet taste that is probably due to magnesium. The following analysis of water from one of the four main springs shows it to be similar in character to that of one of the Walters springs with which it is tabulated, but it is not so strongly mineralized.

Analyses of water from Samuel Soda Springs and Walters Mineral Springs, Napa County, Cal.

[Constituents are in parts per million.]

	1		2	
Temperature	....		14° C. (58° F.)	
Properties of reaction:				
Primary salinity	27		22	
Secondary salinity	0		0	
Tertiary salinity	0		0	
Primary alkalinity	12		15	
Secondary alkalinity	61		63	
Tertiary alkalinity	425		400	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	219	9.52	288	12.52
Potassium (K)	23	.59	2.5	.06
Lithium (Li)	Trace.	Trace.	Trace.	Trace.
Barium (Ba)	....	....	.7	.01
Strontium (Sr)	Trace.	Trace.	Trace.	Trace.
Calcium (Ca)	14	.70	50	2.49
Magnesium (Mg)	186	15.29	232	19.08
Iron (Fe)	7.9	.28	5.5	.20
Manganese (Mn)	....	....	.1	Trace.
Sulphate (SO_4)	31	.65	....	....
Chloride (Cl)	222	6.26	262	7.39
Carbonate (CO_3)	578	19.28	807	26.88
Metaborate (BO_2)	Trace.	Trace.	Trace.	Trace.
Phosphate (PO_4)	6.1	.19	2.7	.09
Silica (SiO_2)	82	2.72	114	3.78
	1,369	....	1,764.5	....
Carbon dioxide (CO_2)	2,370	107.80	2,920	134.70

1. Samuel Soda Springs; probably principal spring. Analyst, E. W. Hilgard. Authority, 12th Cal.
2. Walters Mineral Springs; probably lower sp ing. Analyst, G. E. Colby. Authority, advertising matter.

The high content of magnesium is to be expected, for the springs issue from serpentine in an area of altered sediments that form the principal rocks of this region. There are quicksilver prospects in a deep ravine a quarter of a mile to the southeast, but the deposition of the cinnabar probably has no close association with the existence of the mineral springs.

NAPA ROCK SODA SPRINGS (NAPA 9).

Napa Rock Soda Springs, known also as Priest Soda Springs, issue on the hillside that borders a small valley about 6 miles in a direct line south of Samuel Soda Springs. A spring that has a temperature of 79° and a discharge of about 15 gallons a minute here rises in a rock-walled basin 7 feet in diameter. Much gas rises with the water, which is moderately carbonated and also tastes distinctly of magnesium. The overflow channel is lined with iron-stained cemented gravel. In 1910 a smaller spring 40 yards southward was covered with boards, and a pipe line extended from it down the slope to a small bottling house. The following analysis shows that the water is secondary alkaline in character, magnesium being present in relatively large proportion.

Analysis of water from main spring, Napa Rock Soda Springs, Napa County, Cal.

[Analyst, W. B. Rising. Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		17
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		6
Secondary alkalinity		77
Tertiary alkalinity	(?)	

Constituents.	By weight.	Reacting values.
Sodium (Na)	736	32.00
Calcium (Ca)	401	19.98
Magnesium (Mg)	1,069	87.87
Aluminum (Al)	[a] 9.5	1.06
Sulphate (SO_4)	633	13.18
Chloride (Cl)	398	11.22
Carbonate (CO_3)	3,464	115.45
	6,710.5	....
Carbon dioxide (CO_2)	Present.	Present.

[a] Reported 95; probably a typographical error.

PHILLIPS SODA SPRINGS (NAPA 8).

About 350 yards north of Napa Rock Soda Springs and 100 feet higher up the slope are two carbonated springs that are known as Phillips Soda Springs. The principal spring rises in an oval, stone-walled basin about 4 by 10 feet across; the other forms a pool in the soil, 25 yards away. In 1910 an old bathhouse, a residence, and two other buildings stood near the springs, but the property had evidently been deserted for a number of years. The waters are carbonated and are apparently similar in character to those of the Napa Rock Springs, but they have formed a large deposit in which the cementing material is a carbonate of magnesia instead of the much more common carbonate of lime.

The following analysis of the material by Roger C. Wells indicates that at least a part of the deposit has come into a stable condition with regard to its content of moisture and may be the mineral hydrogiobertite ($MgCO_3.Mg(OH)_2+2H_2O$), though other parts of the specimen examined had a somewhat different composition.[1] A specimen that was examined microscopically by W. T. Schaller appeared to consist of two intergrown minerals.

Analysis of material from spring deposit at Phillips Soda Springs, Napa County, Cal.

[Analyst, R. C. Wells, 1910.]

Insoluble in hydrochloric acid[2]	25.37
Soluble in hydrochloric acid:	
Iron and alumina ($Fe_2O_3+Al_2O_3$)	1.88
Calcium oxide (CaO)	2.57
Magnesium oxide (MgO)	31.81
Carbon dioxide (CO_2)	18.07
Sulphate (SO_4)	None.
Water (H_2O)	19.94
	99.64

Along the front of this deposit, where it has been cut into by the surface water, there is a bluff that exposes a structure resembling a stockwork, in which veins and masses of the cementing material inclose fragments of dark shale.

Phillips and Napa Rock springs issue at the lower border of an area of serpentine that apparently overlies the shale forming the lower portion of the hills. The association of serpentine with magnesium waters is here again clearly shown, but the large spring deposit of a magnesium carbonate is believed to be an uncommon formation. The only other notable one of the kind that was observed in the State was near the Hot Springs at Elgin mine, in Colusa County, but the deposit at Phillips Springs differs from the hard compact material found there.

GAILLAUMES SODA SPRINGS (NAPA 6).

In a ravine about 6 miles northwestward across the hills from Phillips springs on the Gaillaume ranch are two or three small carbonated and sulphureted springs that have been occasionally visited by campers, but in 1910 they had not attained importance. The rocks at these springs are part of the sedimentary series that covers most of this region.

TOLENAS SPRINGS (SOLANO 1).

In the Coast Ranges there are two notable deposits of calcium carbonate in the form of onyx marble or Mexican onyx which seem to be essentially spring deposits and near which carbonated water

[1] Wells, R. C., A new occurrence of hydrogiobertite: Am. Jour. Sci., 4th ser., vol. 30, pp. 189–190, 1910.
[2] The insoluble portion had the appearance of soft grains resembling shale.

still issues. One of these is at Tolenas Springs, in Solano County, about 6 miles north of Fairfield. The material outcrops over an area about 100 yards in diameter, on slopes near the top of a range of hills composed of soft shale and sandstone, and carbonated saline water seeps from two shallow pools at the deposit. The principal spring, however, is on the hillside 300 yards westward and 50 feet higher, where a pit has been excavated a few feet deep in a small deposit of the onyx marble. In 1909 separate pipes conducted the water and the carbon dioxide to a bottling house a short distance away. Only sedimentary rocks were observed near these springs, but "a breccia of shale, sandstone and volcanic ash, cemented by lime and traversed by veins and bunches of aragonite (?)" has been mentioned by Day.[1] Considerable stone has been shipped from the deposit, but the material is too cavernous to be suitable for extensive use as a decorative stone, and quarrying was discontinued a number of years ago. Most of the stone is light colored and translucent, with white, cloudy mottling, but some darker material was noticed. Banded aragonite, several inches thick, has been deposited in some places on more compact calcite. The analysis of the material tabulated on page 165 with that of similar material from San Luis Obispo County represents a specimen of the calcite.

Another carbonated saline spring emerges in a ravine 300 yards southeast of the quarry and has been used as a watering place by range cattle and horses. It has built up a deposit of lime carbonate several yards in diameter.

Analyses of water from Tolenas Springs, Solano County, Cal.

[Constituents are in parts per million.]

	1		2	
Temperature	17° C. (62° F.)			
Properties of reaction:				
Primary salinity		59		61
Secondary salinity		0		0
Tertiary salinity		0		0
Primary alkalinity		19		19
Secondary alkalinity		22		20
Tertiary alkalinity		13		13
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	1,760	76.55	1,930	83.92
Potassium (K)	65	1.67	59	1.51
Calcium (Ca)	342	17.03	331	16.52
Magnesium (Mg)	57	4.70	54	4.42
Iron (Fe)	7.3	.26	5.3	.19
Aluminum (Al)	10	1.11	8.7	.96
Chloride (Cl)	2,068	58.34	2,288	64.51
Iodide (I)	23	.18	27	.21
Carbonate (CO_3)	1,154	38.45	1,151	38.36
Metaborate (BO_2)	139	3.24	150	3.48
Silica (SiO_2)	33	1.09	27	.91
	5,658.3		6,031.0	
Carbon dioxide (CO_2)	266	12.09	287	13.05

1. Main Spring. Analyst and authority, Winslow Anderson (1888).
2. Main Spring. Analyst, J. Hewston, jr. (prior to 1888). Authority, U. S. Geol. Survey Bull. 32.

[1] Day, W. C., Stone: U. S. Geol. Survey Twentieth Ann. Rept., pt. 6 (continued), p. 288, 1899.

KESSLER SPRINGS (SAN LUIS OBISPO 10).

The other group of springs at which onyx marble has been formed is at Kessler Springs—better known as the Kessler Mexican onyx quarries—in San Luis Obispo County, about 20 miles northeast of Arroyo Grande, among hills of sandstone and shale that are probably of Tertiary age. The principal outcrop of the onyx marble forms a ledge, several yards in height and extent, at the side of a small ravine; a smaller exposure of veins of the material, several inches in thickness, appears in a dark mud shale in a prospect trench a quarter of a mile northward. Between these two places are several outcrops of the stone, at three or four of which issue small amounts of slightly carbonated saline water. During the dry season the run-off channels are crusted with deposits that consist largely of common salt.

The property was filed on as a mineral claim in the early seventies, and a number of slabs of the stone were taken out by means of steel blades and emery, but the material contains too many cavities to enable it to compete as a merchantable stone with that from other quarries, and development ceased about 1895. The material at the prospect trench is almost pure white, but at the larger exposure, where most of it was obtained, it is more translucent, and has a mottled, cloudy appearance that is due to the inclusion of a small amount of clay.

Although the amount of water that now issues is very small, the fact that the onyx marble is essentially a spring deposit entitles the locality to description in this paper.

Two minor onyx marble deposits, probably formed by mineral springs, have been worked. One of these is near the western side of Sacramento River, near Shasta Springs, and was known as the Griffin quarry. Material large enough only for paper weights and similar small articles was obtained at this quarry. The other locality is near the Elgin quicksilver mine, about 30 miles west of Williams in Colusa County.[1]

The two analyses of Californian onyx marbles that are available are presented in the following table:

[1] In the description of the deposits at the hot springs near Bridgeport, Mono County (p. 134), Merrill has been quoted concerning the formation of onyx marble. He states that most of the onyx marbles are of calcite, not aragonite. Microscopic examination of material from the Bridgeport, Tolenas, and Kessler quarries, and determinations of the specific gravity of specimens show that nearly all of it is calcite, but a small specimen from the Tolenas quarry consists of two nearly equal bands of aragonite and calcite.

Analyses of onyx marbles from Kessler Springs and Tolenas Springs, Cal.[a]

[R. L. Packard, analyst.]

	Kessler Springs.	Tolenas Springs.
Color	White.	Dark amber.
Structure	Microcolumnar.	Granular and columnar.
Hardness	3.50	3.25
Specific gravity	2.72	2.70
Analysis as reported:		
Calcium carbonate ($CaCO_3$)	93.68	95.48
Magnesium carbonate ($MgCO_3$)	1.43	2.20
Iron carbonate ($FeCO_3$)	3.93	
Manganese carbonate ($MnCO_3$)	.06	
Strontium carbonate ($SrCO_3$)		1.59
Barium carbonate ($BaCO_3$)		0.11
Calcium phosphate ($Ca_3(PO_4)_2$)	.25	
Water (H_2O)		0.37
	99.35	99.75
Recalculated form:		
Iron (Fe)	1.897	
Manganese (Mn)	.029	
Calcium (Ca)	37.612	38.192
Magnesium (Mg)	.412	.634
Barium (Ba)		.077
Strontium (Sr)		.943
Carbonate (CO_3)	59.290	59.534
Phosphate (PO_4)	.110	
Water (H_2O)		.370
	99.350	99.750

[a] Merrill, G. P., The onyx marbles: Their origin, composition, and uses, both ancient and modern: U. S. Nat. Mus. Rept. for 1893, table facing p. 559.

LYTTON SPRINGS (SONOMA 9).

Lytton Springs are one-half mile west of Lytton station, in the hills that border the valley of Russian River, in Sonoma County. A number of years ago there was a resort at the springs, and the place was known as Geyser Spa. In 1910, however, the property was conducted as the Golden Gate Orphanage, under the auspices of the Salvation Army. The principal spring rises in the bed of a small stream at the northern side of the grounds. The water was formerly bottled in a house directly over the spring, and in 1910 it was still marketed, but the bottling house was not in repair and the water was piped a few yards below to a small shelter, where it formed a drinking fountain. The water tastes moderately carbonated and distinctly saline. Analysis 1 in the following table probably represents water from this spring and indicates that it is primary alkaline saline in character. Two other smaller carbonated springs that rise on the hillside half a mile northwestward have been unused for several years and when visited were of little importance. Analysis 2 in the table, which probably represents water from one of these springs, indicates that it is much less strongly mineralized than the main spring and that primary salinity, primary alkalinity, and secondary alkalinity are about equally prominent as properties.

Analyses of water from Lytton Springs, Sonoma County, Cal.

[Constituents are in parts per million.]

	1		2		3	
Temperature	17° C. (62° F.)					
Properties of reaction:						
Primary salinity		45		27		30
Secondary salinity		0		0		0
Tertiary salinity		0		0		0
Primary alkalinity		39		42		39
Secondary alkalinity		16		31		31
Tertiary alkalinity		507		High.	(?)	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	1,104	47.98	210	9.13	196	8.52
Potassium (K)	35	.89	Trace.	Trace.		
Lithium (Li)	Trace.	Trace.				
Ammonium (NH_4)	6.0	.33				
Calcium (Ca)	85	4.24	34	1.70	31	1.55
Magnesium (Mg)	63	5.17	30	2.47	28	2.30
Iron (Fe)	18	.63	17	.60	31	1.11
Aluminum (Al)	62	6.87				
Sulphate (SO_4)	153	3.19	46	.96	39	.81
Chloride (Cl)	822	23.21	93	2.62	103	2.90
Carbonate (CO_3)	975	32.51	310	10.32	293	9.77
Metaborate (BO_2)[a]	32	.75				
Silica (SiO_2)	138	4.58	64	2.12	31	1.03
	3,493		804		752	
Carbon dioxide (CO_2)	6,430	292.50	Excess.		Present.	Present.

[a] Reported as borates. Recalculated from $Na_2B_4O_7$.

1. Main spring. Analyst and authority, Winslow Anderson (1888).
2. Minor spring. Analyst and authority, Winslow Anderson (1888).
3. Minor spring. Analysts, Bauer and Price, date not given. Authority, Winslow Anderson.

Shale, overlain by quartzitic and cherty gravel, is exposed along the creek near the main spring, and sedimentary rocks apparently form the hills near by.

CARBONATED SPRING NEAR LITTLE SULPHUR CREEK (SONOMA 7).

A small carbonated spring issues at the side of a gully near Little Sulphur Creek, on the Nelson & Olsen ranch, 3 miles east of Geyserville. It has been used only as a local drinking spring, has not been improved, and is not specially noteworthy.

ALDER GLEN SPRINGS (SONOMA 2).

Alder Glen Springs form a resort in a small canyon 3 miles northwest of Cloverdale. In 1909 a two-story frame hotel, annex, and several cottages and tents furnished accommodations for about 75 guests, and a pavilion and hall were also provided. On the southern side of the stream channel the face of the bank has been cemented around four basins a yard apart that discharge into a common overflow channel. The springs differ somewhat in taste, but all are carbonated and are also faintly sulphureted. Small amounts of iron are deposited in the basins and along the overflow channel.

Besides its use on the grounds for drinking the water has been bottled and sold locally.

The rocks exposed along the canyon are crushed and altered sandstones and shales, with a little cherty material, the springs issuing from sandstone.

DUNCAN SPRINGS (MENDOCINO 31).

Duncan Springs are situated 2 miles west of south from Hopland, on slopes that overlook Russian River valley. The property has been run as a resort since the eighties. Several additional buildings have been erected during recent years, so that in 1909 a hotel, annex, and several cottages provided rooms for about 100 guests.

There are two principal springs, which are known as Magnesia Spring and Soda Spring, and two minor slightly used springs. The Magnesia Spring issues at the eastern end of a pavilion 175 yards south of the hotel. Two cemented basins have been constructed in this place on a sloping surface of serpentine. Their combined yield is perhaps one-half gallon per minute of water that is moderately carbonated and magnesic in taste. This water has for a number of years been shipped to San Francisco and carbonated and bottled for table use. The analysis (p. 168) shows that it is essentially a magnesic alkaline water. The unusually small content of sodium reported is a remarkable feature of the analysis.

The Soda Spring is higher up the slope, in a ravine 500 yards to the southwest. Like the Magnesia Spring, it also issues from serpentine and is protected by a rock-walled basin. Its water is strongly carbonated and tastes distinctly of iron, and considerable iron is also deposited in the spring and along its overflow channel. This constituent renders the water unsuitable for bottling and sale, as it stains the bottles, but the water is used on the grounds for drinking and is also piped to a bathhouse near the hotel and heated for bathing.

The following analyses of the water show noteworthy differences in the character of the two springs, the Soda Spring possessing both primary and secondary alkalinity, whereas the Magnesia Spring has no reported primary alkalinity but high secondary and tertiary alkalinity.

Analyses of water from Duncan Springs, Mendocino County, Cal.

[Constituents are in parts per million.]

	1		2		3	
Temperature			14° C. (57° F.)			
Properties of reaction:						
Primary salinity		9		9		2
Secondary salinity		0		0		2
Tertiary salinity		0		0		0
Primary alkalinity		18		18		0
Secondary alkalinity		73		73		96
Tertiary alkalinity	(?)			12		70
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	366	15.90	363	15.80	11	0.48
Calcium (Ca)	482	24.04	496	24.77	67	3.34
Magnesium (Mg)	223	18.33	220	18.11	268	22.02
Iron (Fe)	Trace.	Trace.	Trace.	Trace.		
Sulphate (SO_4)					22	.46
Chloride (Cl)	178	5.03	178	5.02	18	.51
Carbonate (CO_3)	1,597	53.24	1,610	53.66	746	24.87
Silica (SiO_2)	Trace.	Trace.	Trace.	Trace.	119	3.95
	2,846		2,867		1,251	
Carbon dioxide (CO_2)	Present.	Present.	153	6.96	311	14.14

1. Soda Spring. Analyst, J. A. Bauer (?). Authority, Bull. U. S. Geol. Survey No. 32.
2. Soda Spring. Analyst and authority, Winslow Anderson (1889).
3. Magnesia Spring. Analyst, A. W. Thatcher (?). Authority, 10th Cal.

There is a small sulphur spring a short distance above the Soda Spring, and a more alkaline spring farther down the ravine, but these two have been unimproved and seldom visited.

The country rock of the hillside on which this resort is situated seems to be mainly serpentine, but between the pavilion and the hotel there is a band of hornblende schist 20 yards wide, and a small amount of siliceous sandstone float was noted on the slopes near by.

McDOWELL SPRINGS (MENDOCINO 32).

McDowell Springs are situated at the southern edge of McDowell Valley, about 5 miles southeast of Hopland. Three principal springs issue at the northern edge of the main creek through the valley, at the base of a 30-foot bank. In 1909 one of the springs was improved by a brick curbing, which formed a pool about 4 feet in diameter and 2 feet deep. Much gas rises in large bubbles in the pool and is probably carbon dioxide, for it quickly extinguishes a flame and the water is strongly carbonated. The iron content has stained the surface of the ground near by and the water is said to precipitate too much iron to make it suitable for bottling. The following analysis shows the water to be of the secondary alkaline type, only moderately mineralized. The relative prominence of iron and silica makes the water of chemical interest.

Analysis of water from main spring at McDowell Springs, Mendocino County, Cal.

[Analysts, Curtis and Tompkins, 1908. Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	5
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	3
Secondary alkalinity	92
Tertiary alkalinity	394

Constituents.	By weight.	Reacting values.
Sodium (Na)	7.7	.34
Potassium (K)	2.9	.07
Lithium (Li)	Trace.	Trace.
Ammonium (NH_4)	Trace.	Trace.
Barium (Ba) and strontium (Sr)	Traces.	Traces.
Calcium (Ca)	40	2.01
Magnesium (Mg)	31	2.59
Iron (Fe)	53	1.90
Aluminum (Al)	2.8	.31
Manganese (Mn)	.1	Trace.
Sulphate (SO_4)	5.3	.11
Nitrate (NO_3) and nitrite (NO_2)	0.0	.00
Chloride (Cl)	5.5	.16
Carbonate (CO_3)	206	6.86
Metaborate (BO_2)	Trace.	Trace.
Phosphate (PO_4)	.7	.02
Silica (SiO_2)	69	2.28
	424	....
Carbon dioxide (CO_2)	336	15.30
Hydrogen sulphide (H_2S)	0	.00

Thirty yards below the main spring a similar spring has formed a small natural basin, and at about the same distance upstream carbonated water seeps from the bank and has heavily iron stained it. Other seepages that issue along the creek bed have stained it with iron for a distance of nearly a quarter of a mile above the main spring.

Soft shale that is overlain by gravel is exposed along the creek. At a few places several hundred yards eastward, upstream from the springs, inflammable gas is said to rise, making its presence known by bubbles when the ground is wet.

The property has been open as a resort since 1902 or 1903. In 1909 tent houses and a dining room provided accommodations for about 50 people.

CARBONATED SPRINGS NEAR FELIZ CREEK (MENDOCINO 28).

About 3 miles west of Hopland, in a ravine on the slopes above Feliz Creek, are two small springs. One of these springs is noticeably carbonated and deposits a little iron along its channel, whereas the other is less distinctly carbonated but tastes noticeably of hydrogen sulphide. The two springs are about 20 yards apart, on opposite sides of the ravine, and issue from banks of crushed sandstone and siliceous shale, near the side of a wagon road. In 1909 the carbonated spring formed a box-curbed drinking pool. A brick-lined basin 3 by 6 feet had been constructed at the sulphureted spring, and a pipe led from it to the roadside.

CARBONATED SPRINGS ON RUSSIAN RIVER (MENDOCINO 29).

Carbonated water issues from gravel at the western edge of Russian River, 2¼ miles north of Hopland, in springs locally known as Humanity Springs. In 1907 an excavation was made at the place so that the water was accessible, and it was considered to be of medicinal value. During the summer of 1910 the springs were again rendered accessible, and some of the water was bottled.

The following analyses represent water from two springs at this locality that issued a few yards apart in 1907:

Analyses of water from carbonated springs on Russian River, Mendocino County, Cal.

[Analyst, G. E Colby (1907). Authority, owner of springs. Constituents are in parts per million by weight.]

	1	2
Properties of reaction:		
Primary salinity	Large.	Probably dominant.
Secondary salinity	(?)	(?)
Tertiary salinity	0	0
Primary alkalinity	(?)	(?)
Secondary alkalinity	Dominant.	Large.
Tertiary alkalinity	Large.	Large.
Potassium sulphate (very small), sodium sulphate, etc	34	100
Sodium chloride	Trace.	2.9
Sodium carbonate	5.8	2.9
Calcium and magnesium carbonates (chiefly) and calcium sulphate (small)	77	70
Silica	45	38
Organic matter and combined water	24	20
	185.8	233.8
Carbon dioxide	Excess.	Excess.

1 and 2. Analyses of separate springs.

ORNBAUNS MINERAL SPRING (MENDOCINO 35).

Ornbauns Mineral Spring is located at the lower end of a small meadow valley, 20 miles northwest of Cloverdale. The spring issues near the southern side of the creek that runs through the meadow from soft, shaly sandstone that has been exposed by removing the thin layer of alluvium in order to obtain a rock drinking basin. The water is moderately carbonated and has noticeably iron stained the near-by surface.

In the summer of 1909 a hotel of about 20 rooms was built on the edge of the valley.

CARBONATED SPRINGS ON GARCIA RIVER (MENDOCINO 34).

About 3½ miles southwestward, downstream from Ornbauns spring, carbonated water seeps from the banks above Garcia River. One spring of appreciable flow also issues near the water's edge but is submerged during stormy periods. The springs are accessible by a trail but are seldom visited. A small alkaline deposit from the water makes the place a local deer lick. The rock from which the springs issue consists of the crushed sediments that cover a large part of the region.

CARBONATED SPRING NEAR BOONVILLE (MENDOCINO 26).

A small carbonated spring rises on the Hotel ranch, near Boonville, about 25 miles northwest of Cloverdale. It has not been improved, however, and has been used only occasionally for drinking.

SINGLEYS SODA SPRING (MENDOCINO 27).

Singleys Soda Spring is on the main road between Ukiah and Boonville, about 5 miles northeast of the latter place. There has been a roadhouse near the spring for a number of years and the place is well known to travelers through this region. The spring has been improved only for drinking.

VICHY SPRINGS (MENDOCINO 24).

Vichy Springs form a resort that has been established for many years on Sulphur Creek, 3 miles northeast of Ukiah. In 1909 a small hotel and several cottages provided accommodations for 50 guests, and tub baths were supplied by the two principal springs, which rise on the southern side of the creek, about 200 yards southeast of the hotel. One of them, known as Ardeche Spring, rises in a cemented basin about 5 by 15 feet in size and 2 feet deep and supplies half a dozen tubs in a bathhouse beside it. Many bubbles rise with the water, which is slightly clouded as if by a small precipitate of iron, and a slight deposit, probably of calcium carbonate, forms on its surface. The water is noticeably carbonated and slightly alkaline in taste. Its discharge is about 8 gallons a minute, and the temperature is 90°.

About 45 yards southeastward, upstream from Ardeche Spring, Vichy Spring rises in a pool of irregular shape, about 6 by 10 feet in size, in a natural grotto of lime carbonate. It is said to have formerly issued at a point 3 or 4 yards farther west but changed to its present outlet at the time of a small earthquake. The earthquake of April 18, 1906, is said not to have affected it, however. When visited, the water of Vichy Spring was somewhat clearer than that of Ardeche Spring, but a more noticeable deposit of iron was formed. Its recorded temperature was 88°, being slightly lower than that of Ardeche Spring, but its discharge was approximately twice as great. Because of the temperature of the waters of these main springs they are shown on the map (Pl. III, in pocket) as thermal-carbonated, but they are best known for their carbonated character.

The water of Vichy Spring is kept flowing through tubs in a bathhouse beside it, when they are in use. A tingling sensation that is caused by small bubbles of carbon dioxide which collect on the bather is locally ascribed to an electric property of the water. Two other carbonated springs rise in the gravel at the creek edge opposite Vichy Spring, but they have not been improved. They yield flows of about one-half gallon and 8 gallons a minute and have the same temperature as Vichy Spring. There is also a small seeping pool known as the Arsenic Spring on the bank 20 yards westward from Ardeche Spring, but it has been only slightly used. A quarter of a mile south of east from the main group, on the hillside 25 or 30 feet above the creek, a third spring of importance issues in a rock-walled basin that is protected by a roof, and yields perhaps a quarter of a gallon a minute. Like the other springs, it deposits iron and its water has a slightly alkaline taste. It is known as Crystal Spring and is a favorite for drinking, for its water is cool (59°) and pleasantly carbonated. Another small pool is formed by a seepage spring on the hillside 30 yards above Crystal Spring, but it has not been improved.

The following analyses of the three principal springs show their waters to be primary alkaline in character:

Analyses of water from Vichy Springs, Mendocino County, Cal.

[Constituents are in parts per million.]

	1		2		3		4	
Temperature	32° C. (90° F.)		34° C. (93° F.)		32° C. (90° F.)		15° C. (59° F.)	
Properties of reaction:								
Primary salinity		9		10		9		11
Secondary salinity		0		0		0		0
Tertiary salinity		0		0		0		0
Primary alkalinity		73		73		73		71
Secondary alkalinity		18		17		18		18
Tertiary alkalinity		115		107	(?)		(?)	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodinm (Na)	1,654	71.90	1,649	71.64	1,141	49.60	1,248	54.26
Potassium (K)	Trace.	Trace.	.8	.02	20	.51	19	.48
Calcium (Ca)	122	6.11	124	6.20	133	6.64	149	7.42
Magnesium (Mg)	112	9.19	97	7.98	48	3.95	58	4.74
Iron (Fe)	Trace.	Trace.	.6	.02	9.1	.33	7.9	.28
Aluminum (Al)	Trace	Trace.	Trace.	Trace.	....	....	....	....
Sulphate (SO_4)	Trace.	Trace.	4.2	.09	....	....	....	....
Chloride (Cl)	285	8.05	298	8.41	204	5.75	250	7.07
Carbonate (CO_3)	2,375	79.15	2,321	77.36	1,612	53.74	1,756	58.54
Metaborate (BO_2)	....	....	Trace.	Trace.	66	1.54	68	1.57
Silica (SiO_2)	117	3.88	101	3.35	54	1.79	32	1.06
	4,665	....	4,595.6	....	3,287.1	....	3,587.9	....
Carbon dioxide (CO_2)	2,128	96.70	1,962	88.18	....	....	....	....

1. Vichy Spring. Analyst, John Hewston. Authority, U. S. Geol. Survey Bull. 32.
2. Vichy Spring. Analyst and authority, Winslow Anderson (1889).
3. Ardeche Spring. Analyst, Price & Son. Authority, advertising matter.
4. Crystal Spring. Analyst, Price & Son. Authority, 12th Cal.

Water from these springs has not been bottled commercially, chiefly perhaps because the iron and calcium it contains stain the bottles and injure its sale.

The rocks of the locality are soft sandstones and clay shales. Along the creek for some distance below the springs there is a conglomerate that has probably been cemented by lime carbonate deposited from the spring water.

GOBBIS SODA SPRING (MENDOCINO 23).

A small carbonated spring, known as Gobbis Soda Spring, rises at the base of the hills a mile southwest of the business portion of Ukiah. A brick-lined, tunnel-like basin has been constructed in the bank, and in summer the spring is visited for drinking water. As is true at most of the other carbonated springs, there is considerable iron stain along its outflow channel, but the water does not seem to be strongly mineralized. The rock at the locality is soft, light-colored shale that yields a clay soil.

CARBONATED SPRINGS AT SHOEMAKER DELL (MENDOCINO 22).

At Shoemaker Dell, a mountain resort in the hills 6 miles northwest of Ukiah, there are a number of carbonated springs that are used for drinking. They are cool and of small flow, like most of the springs of the locality. One or two of the springs are said to be magnesic, and magnesium, derived from serpentinous material associated with the sedimentary series, may be present in unusual amount. Accommodations for about 50 guests were provided at the property in 1910.

CARBONATED SPRINGS AT HAZEL HILL (MENDOCINO 25).

Three small springs that are used for drinking are situated at Hazel Hill, a small mountain resort about 35 miles northwest of Cloverdale. Only one spring has been improved by a cement basin, but they all furnish cool drinking water. The principal spring is moderately carbonated; the other two are respectively sulphureted and ferruginous in character.

CARBONATED SPRINGS NEAR WENDLING (MENDOCINO 21).

Near Wendling, a lumbering settlement about 45 miles northwest of Cloverdale, there are two or three small carbonated springs. One of these was formerly visited by picnic parties, but in recent years it has become neglected and partly filled up. A 200-foot well that furnishes part of the water that supplies a mill pond in the neighborhood also yields water that is carbonated.

BAKER MINERAL SPRINGS (MENDOCINO 17).

Baker Mineral Springs are about 18 miles by road east of Willits, on the banks of a stream that is tributary to Tomki River. The place has been a small camping resort for several years, and there are five small mineral springs on the property. At the lowermost spring a collecting tank and a bathhouse containing two compartments have furnished means for bathing. The water issues from dark shale that is here exposed beside the creek and deposits considerable lime carbonate. The two principal drinking springs are at the camp grounds, which are a quarter of a mile southward up the ravine, and issue from seams in coarse-textured sandstone, one of them at the creek edge, the other about 25 yards farther upstream and 3 or 4 yards from the creek. Both are carbonated and deposit considerable iron. On the slopes within 100 yards of these springs there is a small area of mica schist and pyroxene rock associated with outcrops of cherty material, which is worthy of note in connection with the deposits of iron in the basins of the springs. A seeping carbonated spring issues in a branch gully about 150 yards above the principal drinking springs, and 50 yards farther up the main ravine the fifth spring issues from a bank of sandstone. Like the two principal springs, this spring deposits considerable iron, and, like the lowest one, it deposits also small amounts of lime carbonate. The water of all of the springs is cool, and the flows are only a quarter of a gallon to 2 gallons a minute.

SALMON CREEK MINERAL SPRINGS (MENDOCINO 18).

A small camping resort has been built up at Salmon Creek Mineral Springs about 12 miles east of Willits. Two small mineralized springs on the property are known, respectively, as Black Sulphur and Soda and Iron, and are used during the camping season as drinking springs. They are similar in mode of occurrence to Baker Mineral Springs, a few miles northward, but the sulphureted nature of one of the springs makes it similar in general character to springs farther west on a branch of Deep Creek, which are described with the sulphur springs (p. 258).

CARBONATED SPRINGS AT TRAVELERS HOME (MENDOCINO 13).

At Travelers Home (Hearst post office), which is a small mountain resort 14 miles by road northeast of Willits, there are about a dozen small carbonated springs. Several of them are used for drinking, but they have not been otherwise developed. The locality, like that of the other carbonated springs in the mountains eastward from Willits Valley, is one of disturbed sedimentary rocks.

KINSNER SODA SPRING (MENDOCINO 14).

Kinsner Soda Spring rises in a ravine 150 yards south of the wagon road and a mile west of Travelers Home. The water, which rises in a small basin excavated in soft sandstone, is strongly carbonated and probably contains considerable calcium, for lime carbonate and cemented gravel line portions of the bed of the ravine. At the roadside there is a lime-carbonate mound 20 feet in diameter that was also probably formed by deposition from a former carbonated spring. Water from Kinsner Spring has been bottled and sold in Willits for table use.

CARBONATED SPRING ON WHITE RANCH (MENDOCINO 16).

On the White ranch north of the road, about 1½ miles west of Kinsner Spring, there is another small carbonated spring. It has not been improved and is visited only by an occasional hunter or cattleman.

CARBONATED SPRING ON SNIDER RANCH (MENDOCINO 15).

A short distance west of the White ranch there is a similar spring on the Snider ranch south of the road. It has not been improved and is known only locally. The same kind of sedimentary rocks that were noted farther east seem to form the hills in this neighborhood.

CARBONATED SPRING SOUTHWEST OF WILLITS (MENDOCINO 19).

In the mountains west of Willits Valley there are several minor carbonated springs which form drinking pools that are known mainly to hunters. One of these is in a ravine well up on the slopes, about 10 miles by road and trail southwest of Willits. The water here rises in a small triangular basin in the rock. It forms a good drinking pool, but, like most of the springs of this kind, its yield is insignificant.

CARBONATED SPRING WEST OF WILLITS (MENDOCINO 10).

On the stage road to Mendocino, about 7 miles by road west of Willits, there is a carbonated spring that is known to travelers over the route. Its water is cool and pleasantly carbonated, but its flow is slight. A small amount of iron is deposited along the run-off channel.

CARBONATED SPRING IN BIG BASIN (MENDOCINO 9).

About 15 miles west of Willits, in a timbered valley that is known as the Big Basin, there is a carbonated spring that is known mainly to lumbermen. Considerable amounts of iron stain its channel, but the yield of water is small.

CARBONATED SPRINGS NEAR LONG VALLEY CREEK (MENDOCINO 8).

In the canyon and tributary ravines of Long Valley Creek, about 7 miles northward from Sherwood, there are a number of small mineralized springs. Several carbonated springs emerge within a space of 100 yards or more along the creek, two or three others are faintly sulphureted, and in one ravine carbonated water issues that deposits considerable iron. In 1910 none of the springs had been improved except as drinking pools, but two camping and fishing resorts, known as Roses Range and Llewellyn Springs Camp, had been established in the vicinity.

As in other portions of this region the rocks consist mainly of altered sediments. Near the iron-bearing springs, however, glaucophane schist and float fragments of mica-garnet schist and pyroxene were noticed.

JACKSON VALLEY MINERAL SPRINGS (MENDOCINO 6).

Three springs issue close together on the southern bank of Mud Springs Creek, about 18 miles northwest of Sherwood. They are about 2 miles northeast of Branscomb post office in Jackson Valley and hence are locally known as Jackson Valley Mineral Springs. They rise in rock-walled basins from sandstone. The principal spring is moderately carbonated and also tastes distinctly alkaline, probably of soda. Some iron is deposited in the pool, whose discharge is perhaps 2 gallons a minute. About three yards away there is a second basin of smaller discharge in which a greater amount of iron is deposited. The third spring, about 4 yards farther downstream, is apparently little mineralized and discharges about 5 gallons a minute of cold water.

Within recent years the property has been made a small camping resort, and water from the principal spring has been bottled and has found a local market.

JACKSON VALLEY MUD SPRINGS (MENDOCINO 7).

Three-fourths of a mile northeast of Jackson Valley Mineral Springs, on a knoll or bench on the northern side of the stream canyon, about 200 feet above the creek, a group of mud springs have built up the small, well-formed craters shown in Plate XIII, *A* (p. 242). The mud, which is light gray in color, covers a rudely circular area about 50 yards in diameter. In its southern half there are five craters, 2 to 4 feet high, but in 1909 only two of them had appreciable overflows. The largest one was about 5 feet in diameter and 4 feet high and discharged perhaps one-fourth of a gallon a minute of cool alkaline mud. In summer the mud is said to be covered by a deposit of efflorescent alkaline salts. The mud in the craters is kept in constant motion by bubbles of gas, which is probably carbon dioxide though its character was not definitely determined. The formation of the craters by mud which is probably brought up by a cool gas instead of by steam, as is usual in areas of mud volcanoes, is a unique feature of this locality. In a gully on the eastern side of the knoll water that is milky with suspended mud issues and forms a considerable stream. The rocks exposed in this gully indicate that the knoll is composed of crushed shale and sandstone, and this structure and topographic form of the knoll suggest that it is a landslide mass. The place is visited as a local curiosity, but no attempt has been made to develop the springs in any way.

CANTWELL SODA SPRING (MENDOCINO 5).

In a ravine about a quarter of a mile north of Branscomb post office, on property that formerly belonged to a Mr. Cantwell, there is a small carbonated spring which has not been improved but has been used slightly as a drinking spring. Its mineralization, like that of a number of similar springs, is greatly diluted by surface water in the rainy season, but in summer its water is said to be pleasantly carbonated.

PETERSONS MINERAL SPRING (MENDOCINO 2).

About 7 miles in a direct line east of north from Branscomb a small carbonated spring, that is known as Petersons Mineral Spring, rises at the edge of a small creek in an area of sandstone and conglomerate and has been protected by a rock wall and covered by a roof so as to form a drinking spring. When visited it was flooded by surface water, but in summer its water is said to be moderately carbonated. Only a small iron stain was noticed near it and no other evidence of mineral deposits was seen, so it is probably a fairly pure water.

The property has been a camping resort for several years. A small amount of the water was bottled and sold for table use during one summer.

WITTER MEDICAL SPRINGS (LAKE 15).

Witter Medical Springs are situated 20 miles north of east from Ukiah, on a hillside that overlooks the valley at the northern end of Clear Lake. The principal spring at this place was used for its medicinal value by the Indians long before the settlement of the region by white people, and it has been known to the latter for more than 60 years. About 40 years ago the property was filed on by Dr. Witter, and a medical resort was gradually built up at the place. In the fall of 1900 the Witter Medical Springs Co. was incorporated, and a four-story hotel was opened in May, 1906. Several cottages provide accommodations for guests during the winter season, when the hotel is closed.

The principal spring, which has long been known as Deadshot Spring, issues from crevices in massive rock at the creek edge in a ravine in front of the hotel and 250 yards from it by winding path. A small house protects the spring, which yields about five-eighths gallon a minute. The recorded temperature of the water is 53°. The water is strongly carbonated and noticeably saline in taste, and has been on the market as a medicinal water for a number of years. In 1910 the bottles were filled directly from the spring, corked, and conveyed by tramway to a warehouse a short distance down the ravine, where they were labeled and boxed, and thence taken by team to the railroad at Ukiah.

The following analysis shows the water to be highly concentrated and primary and secondary alkaline in character. The relatively large proportion of magnesium is of interest.[1]

Analysis of water from main spring at Witter Medical Springs, Lake County, Cal.

[Analysts, Curtis and Tompkins (1902). Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	8
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	53
Secondary alkalinity	39
Tertiary alkalinity	24

Constituents.	By weight.	Reacting values.
Sodium (Na)	3,095	134.53
Potassium (K)	84	2.14
Lithium (Li)	.04	.01
Ammonium (NH_4)	Trace.	Trace.
Barium (Ba) and strontium (Sr)	Traces.	Traces.
Calcium (Ca)	148	7.43
Magnesium (Mg)	950	78.12
Iron (Fe) and Aluminum (Al)	4.9	.21
Manganese (Mn)	1.5	.06
Sulphate (SO_4)	8.6	.18
Nitrate (NO_3)	Trace.	Trace.
Chloride (Cl)	651	18.36
Carbonate (CO_3)	6,032	201.07
Metaborate (BO_2)	1.4	.03
Phosphate (PO_4)	.2	.01
Silica (SiO_2)	84	2.77
	11,060.64	....
Carbon dioxide (CO_2)	1,166	53.00

About 25 yards upstream from Deadshot Spring another spring, which is known as the Magnesia Spring but has been used only to a small extent for drinking, forms a shallow pool a foot in diameter at the base of a small bank and yields perhaps one-eighth of a gallon a minute of distinctly alkaline water. About 100 yards farther upstream the small Iron Tonic Spring issues at the edge of the creek. A concrete basin has been constructed around it and it has been used for drinking. Considerable iron is deposited on the gravel near this basin. Two miles westward, near the headwaters of the same drainage channel, there is a small sulphur spring, which has been used only to supply a cattle watering trough, but the plan of piping its water to the hotel grounds for drinking purposes has been considered. A fifth spring, called Hummingbird Spring, near the

[1] Anderson (Mineral springs and health resorts of California, p. 266) gives an analysis of water from this spring which shows a solid content of only about 1,290 parts per million. The differences between his analysis and that more recently made, however, indicate that his analysis represents water from another spring.

warehouse, which is in the ravine 100 yards below Deadshot Spring, issues through a pipe that has been set into the bank, and yields perhaps 3 gallons a minute of cool, fresh water that is used for a table supply at the hotel.

The rocks of this locality seem to be the older sediments and associated metamorphics that compose the coastal ranges. Witter Hotel stands on shale and sandstone, and the usual more siliceous rocks that accompany these sediments are exposed eastward on the hillsides. Deadshot Spring emerges from a dark siliceous phase of the sandstone. About 30 yards southwest of the hotel, however, a ledge of serpentinous rock outcrops, and crosses the creek between the Iron Tonic and Magnesia springs. It forms the boundary between a small valley above it and the steep, narrow ravine below. Its relation to the Deadshot Spring and probably also to the Magnesia Spring suggests that it is the source of their unusually high magnesium contents.

SARATOGA SPRINGS (LAKE 18).

Saratoga Springs are on the side of a wide, brushy drainage ravine about 2 miles in a direct line southeast of Witter Medical Springs. The property has been a resort since the seventies, and in 1910, accommodations for 250 people were provided by a hotel, annex, and 16 cottages, in an oak grove in a small flat along the creek.

There are 12 small mineral springs on this property, 11 of them being on the slopes 100 to 150 yards east of the hotel. Six of these rise in cemented basins in a circular building 15 feet in diameter, known as the Roundhouse. They have been given such descriptive names as Appetizer and Digester. All are carbonated and deposit small amounts of calcium and iron, but they probably differ somewhat in the relative proportions of the solids in solution. Their combined flow is perhaps 1½ gallons a minute. Ten yards southwestward there are two other similar springs, and 20 yards to the west there is one known as the Magnesia Spring. The water of the Magnesia Spring is less noticeably carbonated than that of the others, but it has a ferruginous taste and deposits considerable iron in its basin. About 50 yards south of the Roundhouse there is also a carbonated iron spring whose water deposits notable amounts of iron. In the bank near it there is a small exposure of lime carbonate and of iron-stained ocherous earth. All of the 10 springs thus far mentioned rise in cemented basins at the bases of small banks that expose crushed shale and sandstone. Their discharge is collected in a tank and supplies water for bathing. About 75 yards north of the Roundhouse a sulphur spring issues at the base of a bank of dark crushed shale. It yields perhaps 1 gallon a minute of strongly sulphureted water and because of its presence the locality is shown on Plate III as containing sulphureted-carbonated springs. The twelfth spring seeps from massive sandstone two-fifths of a mile up the ravine from the hotel. Iron-stained lime carbonate is deposited by it on the rock face and indicates that the spring is similar in chemical character to the springs of the main group.

The following analyses of four springs at Saratoga show the water to be primary and secondary alkaline. The prominence of magnesium is an interesting chemical feature of the water.

Analyses of water from Saratoga Springs, Lake County, Cal.

[Analyst, Selby Smelting Co. Authority, advertising matter. Constituents are in parts per million.]

	1		2		3		4	
Properties of reaction:								
Primary salinity		3		3		3		2
Secondary salinity		0		0		0		0
Tertiary salinity		0		0		0		0
Primary alkalinity		11		7		11		12
Secondary alkalinity		86		90		86		86
Tertiary alkalinity		117		120		147		166
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	180	7.84	113	4.90	111	4.83	75	3.27
Potassium (K)	5.1	.13	4.3	.11	3.0	.08	3.3	.08
Calcium (Ca)	270	13.48	216	10.78	147	7.34	117	5.86
Magnesium (Mg)	458	37.68	421	34.63	291	23.94	180	14.82
Iron (Fe)	5.8	.21	5.1	.18	3.6	.13	3.6	.13
Aluminum (Al)	2.7	.30	2.8	.31	2.0	.22	1.6	.18
Sulphate (SO_4)	Trace.	Trace.	Trace.	Trace.	4.1	.09	5.3	.11
Chloride (Cl)	55	1.54	47	1.33	28	.79	16	.45
Carbonate (CO_3)	1,734	57.80	1,478	49.27	1,063	35.44	708	23.60
Silica (SiO_2)	105	3.48	101	3.34	93	3.10	84	2.79
	2,815.6	....	2,388.2	....	1,745.7	....	1,193.8	....
Carbon dioxide (CO_2)	1,439	65.40	1,250	56.80	1,101	50.00	812	36.91

1, 2, 3, 4. Separate springs, names not given.

CARBONATED SPRING NEAR NORTHWEST EDGE OF CLEAR LAKE (LAKE 21).

About 3 miles south of the town of Upper Lake a small carbonated spring rises in the alluvium near the lake edge, but it has not been improved and is little used. It forms a small, iron-stained pool that may be occasionally visited by a hunter or fisherman.

CARBONATED WELL NEAR UPPER LAKE (LAKE 19).

In connection with the existence of the carbonated spring just described, two flowing wells in the locality, which yield noticeably carbonated water, may be mentioned. One of these is near the northernmost extension of Clear Lake, north of the carbonated spring, and is one-half mile south of the town of Upper Lake. It is situated on the Taylor place, is 2¼ inches in diameter, and was sunk about 1905 to a depth of 108 feet. In 1910 it yielded about 5 gallons a minute of cool, slightly carbonated water. It was used only for domestic purposes.

CARBONATED WELL SOUTH OF UPPER LAKE (LAKE 20).

About half a mile south of the Taylor well (Lake 19, p. 180) there is another one, known as the Packwood well, which was sunk during the nineties to a depth of about 70 feet. It also yields carbonated water which may contain a notable amount of iron, for its run-off channel is deeply iron stained. It is more probable, however, that the iron comes from the well casing. Water from other wells at Upper Lake is said to contain mineral that quickly rusts tinned-iron vessels.

CARBONATED WELLS AT KELSEYVILLE (LAKE 35).

There is a group of carbonated wells in the eastern part of Kelseyville which may also be described in this connection. These wells were bored a number of years ago on a low mound a quarter of a mile east of the business portion of Kelseyville and yielded much gas and carbonated water. The gas was formerly piped to buildings in the town for heating and lighting, but its use has been discontinued. Considerable gas and water still rise, and the latter is used for irrigation. The following analysis shows the water to be primary saline and secondary alkaline in character and to contain iron, aluminum, and silica in unusually large amounts:

Analysis of water from artesian well at Kelseyville, Lake County, Cal.

[Analyst and authority, Winslow Anderson (1889). Constituents are in parts per million.]

Temperature	24° C. (76° F.)	
Properties of reaction:		
Primary salinity		50
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		11
Secondary alkalinity		39
Tertiary alkalinity		26
Constituents.	**By weight.**	**Reacting values.**
Sodium (Na)	484	21.04
Potassium (K)	36	.92
Lithium (Li)	Trace.	Trace.
Barium (Ba)	Trace.	Trace.
Calcium (Ca)	93	4.64
Magnesium (Mg)	111	9.13
Iron (Fe)	41	1.47
Aluminum (Al)	47	5.20
Manganese (Mn)	1.5	.05
Sulphate (SO_4)	639	13.31
Chloride (Cl)	164	4.63
Iodide (I)	10	.08
Carbonate (CO_3)	577	19.23
Metaborate (BO_2)[a]	23	.53
Silica (SiO_2)	110	3.65
	2,336.5	....
Carbon dioxide (CO_2)	82	3.71

[a] Reported as borates. Recalculated from $Na_2B_4O_7$.

LEE SODA SPRING (LAKE 31).

There is a small unimproved carbonated spring on the Lee ranch in the canyon of Scott Creek about 4 miles in a direct line southwest of Lakeport. Its water is cool and moderately carbonated, but the place is rather inaccessible and is seldom visited.

CARBONATED SPRING IN CANYON OF SCOTT CREEK (LAKE 30).

About 1½ miles west of the Lee spring there is another carbonated spring in the canyon of Scott Creek, also small in flow, unimproved, and seldom visited. Similar springs, which are known only to hunters, probably rise at other places in this region. The rock formations consist of the same series of sedimentary materials that was observed through the greater part of the coastal ranges in the north-central section of the State.

GLEN ALPINE SPRINGS (LAKE 33).

At Glen Alpine Springs, on the western bank of Scott Creek, 6 miles southwest of Lakeport and beside the wagon road between that town and Hopland, two small springs rise in bricked and cemented basins about 4 yards apart. A road house near the springs was formerly kept open, but of late years the place has been deserted. The water is moderately carbonated, but when visited in 1909 there was no overflow. Small amounts of iron have been deposited on the basin sides, and at the creek edge 5 yards away a very hard deposit of lime carbonate a foot thick is exposed for a few yards. The country rock, which is well shown along the road near by, consists of the usual series of shale and sandstone.

BYNUM SPRING (LAKE 34).

Bynum Spring is situated a mile south of Glen Alpine Springs, in a small ravine that is tributary to Scott Creek. Its water rises from crushed sandstone near the edge of the stream channel, in a cemented pool about the size of a barrel. When visited in 1909 there was no overflow. The water was strongly carbonated, and slight deposits of lime carbonate and iron had formed in the basin. The water has been bottled at the spring and marketed locally as a table water. The following analysis shows that it is essentially a secondary alkaline water.

Analysis of water from Bynum Spring, Lake County, Cal.

[Analyst, F. T. Green (1909). Authority, owner of spring. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		2
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		0
Secondary alkalinity		98
Tertiary alkalinity	(?)	

Constituents.	By weight.	Reacting values.
Sodium (Na)	16	.70
Calcium (Ca)	333	16.62
Magnesium (Mg)	173	14.23
Iron (Fe)	2.2	.08
Sulphate (SO_4)	30	.62
Chloride (Cl)	2.9	.08
Carbonate (CO_3)	928	30.93
Silica (SiO_2)	89	2.95
	1,574.1	....
Carbon dioxide (CO_2)	Present.	Present.

HIGHLAND SPRINGS (LAKE 39).

The property at Highland Springs has been improved as a resort for 25 years or more. It is situated on the stage road between Hopland and Kelseyville and 6 miles southwest of the latter place. In 1910 a large frame hotel and half a dozen cottages situated in a small flat along the course of Adobe Creek provided accommodations for 200 guests.

Eleven springs, or 10 individual springs and 1 group, may be recognized here. One of these, the Seltzer Spring, emerges at the base of a gentle slope about 150 yards southeast of the hotel. The others issue west to northwest of the hotel in a distance of about 225 yards along the western bank of the creek. Seltzer Spring, which is protected by a latticed spring house, rises in a cemented basin; the recorded temperature of the water is 59° and its discharge is perhaps 1 gallon a minute. The water is strongly carbonated and deposits considerable iron.

Neptune Spring, the southernmost of those along the creek, is about 100 yards west of the hotel. The spring rises in a small drinking pool in the center of an oval cemented basin, several feet across, on a gentle slope at the base of a low bank. The water has a recorded temperature of 66°. Its flow is slight, but it is piped to a small bathing plunge a few yards away. At the base of a small bank 50 or 60 yards northward and nearer the creek, Diana Spring and Magnesia Spring rise in cemented basins a few yards apart. Water from the former supplies a small bathing plunge near by, whereas the latter is used only for drinking. The recorded temperatures of these springs were 80° and 68°, and their flows were, respectively, about 4 gallons and one-fourth gallon a minute. From about 30 to nearly 55 yards beyond the Magnesia Spring much water rises beneath a platform. This water supplies an adjacent bathhouse and is also piped across the creek to a swimming plunge. Temperatures of 72° to 82° were recorded at different points beneath the platform. The discharge, as nearly as it could be estimated, is about 10 gallons a minute. There are two small pools with slight overflow along the creek bank a few yards north of the bathhouse and an iron-stained seepage area extends about 10 yards along the creek edge. Beyond this area there is a small board-curbed pool which discharges about 2 gallons a minute of water 73° in temperature. Ten yards beyond, at the northern end of the line of springs, Arsenic and Dutch springs rise in separate compartments of a circular, cemented basin near the creek edge. Their recorded temperatures were, respectively, 68° and 72°. Arsenic Spring yields approximately one-half gallon a minute and Dutch Spring perhaps twice as much.

All the springs are carbonated, and their basins are stained by iron. Small amounts of lime carbonate are deposited at several places, and south of the springs, along the road westward from the hotel, a deposit of lime carbonate several feet thick is exposed for 50 yards or more. The springs seem to issue mainly from crushed sandstone and shale, but along the northern part of the bank from which they come forth slickensided, apparently serpentinized material is exposed. The temperature of the water suggests that crushing and other movements have here taken place and have given rise to the springs. The locality is shown on the map (Pl. III, in pocket) as one of thermal carbonated springs, but the springs are known chiefly for their carbonated waters, which the following analyses show to be essentially secondary alkaline in character.

Analyses of water from Highland Springs, Lake County, Cal.

[Authority, Winslow Anderson. Constituents are in parts per million.]

	1		2		3		4		5		6		7		8		9		10	
Temperature	16° C.(60° F.)		18° C.(65° F.)		27° C.(80° F.)		28° C.(82° F.)		28° C.(83° F.)		29° C.(84° F.)		25° C.(77° F.)		21° C.(70° F.)		26° C.(79° F.)		28° C.(82° F.)	
Properties of reaction:																				
Primary salinity		1		1		1		1		1		1		2		2		1		1
Secondary salinity		0		0		0		0		0		0		0		0		0		0
Tertiary salinity		0		0		0		0		0		0		0		0		0		0
Primary alkalinity		15		12		13		11		14		14		13		12		17		14
Secondary alkalinity		84		87		86		88		85		85		85		86		82		85
Tertiary alkalinity		355		369		204		183		150		153		215		225		190		195
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	80	3.48	65	2.83	116	5.04	115	5.00	134	5.82	129	5.61	112	4.87	99	4.30	133	5.79	111	4.85
Potassium (K)	3.4	.09	3.2	.08	8.6	.22	5.3	.14	12	.31	9.8	.25	5.2	.13	5.1	.13	5.4	.14	3.6	.09
Lithium (Li)	......	......	......	......	......	......	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	......	......	......	......	......	......	......	......
Barium (Ba)	......	......	......	......	2.6	.04	16	.23	2.2	.03	1.8	.03	......	......	......	......	.8	.01	......	......
Calcium (Ca)	221	11.02	220	10.97	160	7.99	329	16.41	295	14.71	310	15.46	242	12.07	242	12.07	213	10.64	213	10.64
Magnesium (Mg)	96	7.90	99	8.14	300	24.69	255	20.98	231	19.00	224	18.43	197	16.21	192	15.79	201	16.56	199	16.41
Iron (Fe)	12	.43	6.8	.24	14	.50	7.4	.26	13	.47	7.6	.28	13	.47	7.2	.26	10	.36	6.0	.21
Aluminum (Al)	16	1.77	14	1.55	11	1.22	12	1.33	2.6	.29	2.1	.23	1.1	.12	1.1	.12	1.3	.14	1.5	.17
Manganese (Mn)	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	......	......	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Chloride (Cl)	7.0	.20	7.5	.21	17	.48	17	.48	19	.54	19	.54	18	.51	19	.54	16	.45	13	.37
Carbonate (CO_3)	682	22.72	662	22.05	1,140	38.00	1,276	42.54	1,194	39.80	1,186	39.52	997	33.24	960	32.01	990	33.00	955	31.83
Metaborate (BO_2)	......	......	......	......	[a] 3.9	.09	[b] 4.7	.11	[a] 4.1	.10	......	......	......	......	......	......	[a] 2.0	.05	......	......
Silica (SiO_2)	88	2.92	90	2.99	136	4.51	144	4.78	123	4.08	138	4.58	124	4.11	122	4.05	110	3.65	127	4.21
	1,205.4	......	1,167.5	......	1,909.1	......	2,181.4	......	2,029.9	......	2,027.3	......	1,709.3	......	1,647.4	......	1,682.5	......	1,629.1	......
Carbon dioxide (CO_2)	1,685	76.59	1,716	78.00	1,593	72.41	1,611	73.23	1,214	55.18	1,230	55.91	1,470	66.82	1,503	68.32	1,299	59.05	1,275	57.95

[a] Reported as borates. Recalculated from $Na_2B_4O_7$.
[b] Reported as boracic acid. Recalculated from H_3BO_3.

1. Seltzer Spring. Analyst, Winslow Anderson (1888).
2. Seltzer Spring. Analyst, W. B. Rising (1882).
3. Neptune Spring. Analyst, Winslow Anderson (1888).
4. Neptune Spring. Analyst, W. B. Rising (1882).
5. Diana Spring. Analyst, Winslow Anderson (1888).
6. Diana Spring. Analyst, W. B. Rising (1882).
7. Dutch Spring. Analyst, Winslow Anderson (1888).
8. Dutch Spring. Analyst, W. B. Rising (1882).
9. Magic Spring. Analyst, Winslow Anderson (1888).
10. Magic Spring. Analyst, W. B. Rising (1882).

ENGLAND SPRINGS (LAKE 40).

Eight miles south of Kelseyville a number of small carbonated springs issue near a road that was formerly the main road to Cloverdale by way of The Geysers (Sonoma 4, p. 83). This road follows up Adobe Creek for several miles, but it has been unused for a number of years. In 1910 the property near the springs was abandoned or used only as a goat range.

The springs are locally known as England Springs, after the name of the first locator or owner, though on some maps they are named Elliott Springs, after a later owner. One small carbonated spring issues from a bank of shale near the road and opposite the house on this property. A ravine enters Adobe Creek from the southeast at a point 150 yards down the road, northeast from this spring. Along the sides of this ravine and 250 to 300 yards from the road, are six other small springs that have been excavated to form drinking pools, two of which have been chiefly used by picnic parties. In one of the springs a temperature of 76° was measured, and as the water of the others is also noticeably above a normal temperature, the locality is indicated on Plate III as one of thermal carbonated springs. The flow of the springs ranges from about half a gallon to 1 gallon a minute. The waters are moderately carbonated and have deposited considerable iron as well as small amounts of lime carbonate.

There are numerous small iron-stained lime carbonate deposits at seepages from fissures in the rock along the edge of Adobe Creek, one-half to three-fourths mile below England Springs, but no flowing springs were noticed. The rocks of the locality comprise the usual series of crushed shales and sandstones and are well exposed along the canyon of Adobe Creek.

CARBONATED SPRINGS ON COLE CREEK (LAKE 42).

Near the road between Kelseyville and Middletown and 4½ miles south of the former place two carbonated springs rise near the channel of Cole Creek. Around one of these, which issues at the eastern edge of the creek, a cemented basin, 6 feet in diameter, has been constructed. Much gas rises in it, and the water deposits considerable iron. The spring had apparently been improved as a drinking basin in the grounds of a small residence that stood near by, but when seen the property was deserted. The second spring rises about 75 yards downstream from the main spring and on the opposite side of the creek, some distance from its bank. It has been protected by a small board curbing, and also deposits considerable iron. Both springs are of small flow and apparently have been used only for drinking.

The rock here seems to consist of a thin layer of obsidian gravel that overlies lake sediments. The gas that is given off from the main spring may be similar in composition to that of the gas wells at Kelseyville (p. 181).

CARLSBAD SPRINGS (LAKE 41).

Carlsbad Springs are also situated along Cole Creek, half a mile south of those that have just been described but farther upstream, where the creek flows in a brushy ravine. The property was conducted as a small resort for several years prior to 1905, but it has been deserted since about that year, and in the summer of 1908 a brush fire destroyed the hotel building.

Five springs on this property rise along the western side of the ravine within 100 yards of the hotel site. The principal one seems to have been that known as the Arsenic Spring, which rises in a semicircular, rock-walled place on the slope 50 yards southwest of the creek. The recorded temperature of the water in this spring is 74° and the yield is about one-fourth gallon a minute of carbonated water. Ten yards below it is a similar spring in which the water has nearly the same temperature, but which yields perhaps 2 gallons a minute. Water from this spring was formerly piped to a small bathhouse at the opposite side of the creek. A third spring rises near the creek in a rock-walled basin 8 feet in diameter, but it has no surface overflow. Another spring rises 60 yards farther downstream, at the edge of a small marshy area. It has a temperature of 66° and a flow of at least 2 gallons a minute. Iron-stained seepages issue beside the bathhouse and also 125 yards downstream from it, but the lower seepages do not appear to have been improved.

The following analyses of springs at this place have been published and are reproduced in standard form, but the spring to which each applies was not identified:

Analyses of water from Carlsbad Springs, Lake County, Cal.

[Analyst, W. D. Johnston. Authority, Register of Mines, California Min. Bur. Constituents are in parts per million.]

	1		2		3		4		5	
Temperature	30° C. (85° F.).		24° C. (75° F.).		27° C. (80° F.).		27° C. (81° F.).		25° C. (77° F.).	
Properties of reaction:										
Primary salinity		0		0		0		0		0
Secondary salinity		0		0		0		0		0
Tertiary salinity		0		0		0		0		0
Primary alkalinity		7		12		21		12		9
Secondary alkalinity		93		88		79		88		91
Tertiary alkalinity		763		788		1,532		946		736
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	14	0.61	23	1.00	15	0.65	20	0.87	17	0.74
Potassium (K)	4.7	.12	3.4	.09	5.9	.15	3.4	.09	3.6	.09
Lithium (Li)	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Calcium (Ca)	13	.65	24	1.20	11	.55	20	1.00	14	.70
Magnesium (Mg)	102	8.38	80	6.58	30	2.47	72	5.92	92	7.54
Iron (Fe)	1.5	.05	.1	Trace.	.1	Trace.	.9	.03	.1	Trace.
Aluminum (Al)	1.1	.12	1.4	.16	1.0	.11	1.1	.12	1.6	.18
Carbonate (CO_3)	294	9.79	266	8.87	115	3.82	237	7.91	272	9.07
Silica (SiO_2)	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	....	......
	430.3	....	397.9	....	178.0	....	354.4	....	400.3	....
Carbon dioxide (CO_2)	1,720	78.18	1,537	69.86	1,287	58.50	1,645	74.77	1,569	71.32

1, 2, 3, 4, 5. Separate springs, names not given.

The analyses indicate that the spring waters are secondary alkaline in character with very high tertiary alkalinity and a notable degree of primary alkalinity. The fact that sulphate and chlorine radicles are not included and that silica is reported as only a trace renders these analyses of doubtful reliability.

Like other springs yielding notably thermal carbonated water Carlsbad Springs are marked on Plate III (in pocket). The slopes at the springs are covered with lava that is probably andesite. For a short distance along the road grade, 1 or 2 miles southward and a few hundred feet higher, however, fine-bedded sediments that are similar to the lake beds near Kelseyville are exposed. At other places in this portion of the county the lava also appears to be present as a thin layer overlying sedimentary material.

ASTORG SPRING (LAKE 45).

A number of years ago a short prospect tunnel was run into the hillside three-quarters of a mile south of east from Glenbrook post office, which is 30 miles north of Calistoga. After the tunnel had been abandoned as a mining enterprise, the character of the water in it was noticed, and for a short time the water was shipped in tanks to San Francisco, carbonated, and bottled as a table water. When seen in 1910, however, the property was deserted. A reservoir had been formed in the tunnel by an earth and board dam across it. Although slightly carbonated, the overflow, perhaps one-eighth gallon a minute, seemed to be mainly of surface origin, and the relatively small mineral content of the spring water, as shown by the following analysis, tends to confirm the belief that it is essentially a surface water. The analysis, which is not complete and does not appear to be very reliable, indicates a secondary alkaline and primary saline water.

Analysis of water from Astorg Spring, Lake County, Cal.

[Analyst, M. E. Diebod. Authority, Register of Mines, California Min. Bur. Constituents are in parts per million.]

Temperature	10° C. (50° F.)
Properties of reaction:	
Primary salinity	32
Secondary salinity	17
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	51
Tertiary alkalinity	49

Constituents.	By weight.	Reacting values.
Sodium (Na)	9.9	0.43
Potassium (K)	16	.41
Calcium (Ca)	18	.92
Magnesium (Mg)	11	.89
Iron (Fe)	3.4	.12
Manganese (Mn)	3.4	.13
Sulphate (SO_4)	62	1.30
Carbonate (CO_3)	48	1.60
Silica (SiO_2)	32	1.05
	203.7	....

The tunnel is in an area of serpentine that is here associated with sedimentary rocks and is overlain on the hill slopes above by lava.

It is locally known as the Tunnel Spring, and its water is called a "chamise" water, as it is thought by some persons to taste of the chamiso brush roots. Another small carbonated spring of even less importance rises in Sulphur Valley, 1 or 2 miles north of Astorg Spring.

ADAMS SPRINGS (LAKE 44).

Adams Springs are situated in a deep ravine about 2 miles eastward across a divide from Astorg Spring. The springs are said to have been found and filed on by a Mr. Adams more than 40 years ago. The property has been improved as a resort for more than 20 years, but it has attained prominence chiefly since about 1900. A large drain pipe has been laid in the stream channel to carry off storm water, and the ravine has been widened and leveled to obtain space for buildings. In 1910 a large frame hotel and a number of cottages and tents furnished accommodations for about 400 people. A swimming plunge on the hillside above the springs is supplied by water piped from a stream. Though the water is used by some people for its medicinal value, the place is essentially a summer pleasure resort.

Analyses of water from Adams Springs, Lake County, Cal.

[Constituents are in parts per million.]

	1		2	
Properties of reaction:				
Primary salinity		2		2
Secondary salinity		0		0
Tertiary salinity		0		0
Primary alkalinity		26		26
Secondary alkalinity		72		72
Tertiary alkalinity		156		175
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	441	19.18	454	19.74
Potassium (K)	Trace.	Trace.	Trace.	Trace.
Calcium (Ca)	199	9.93	197	9.83
Magnesium (Mg)	483	39.73	488	40.15
Iron (Fe)	4.6	.16	4.3	.15
Aluminum (Al)	Trace.	Trace.	....	....
Sulphate (SO_4)	17	.35	....	....
Nitrate (NO_3)	....	....	Trace.	Trace.
Chloride (Cl)	48	1.35	44	1.24
Carbonate (CO_3)	2,019	67.30	2,059	68.63
Silica (SiO_2)	127	4.21	124	4.11
	3,338.6	....	3,370.3	....
Carbon dioxide (CO_2)	2,261	102.77	2,588	117.64

1. Main spring. Analyst and authority, Winslow Anderson (1888).
2. Main spring. Analyst, Price and Hewston. Authority, U. S. Geol. Survey Bull. 32.

The main spring, which is situated a few yards above the hotel and close to the former channel of the ravine, is inclosed by a frame buildiug, and the water is dipped from a small pool for drinking, but it is also piped to a bottling house below the hotel. It is used on the grounds only for drinking and is bottled for table use. The water is cool—a temperature of 46° being recorded in the spring in January, 1910, but it is probably about 55° in summer—and the yield is perhaps one-half gallon a minute. It is strongly carbonated and has a petroleum odor and taste similar to that which was noticed at Skaggs, Gordon, and Seigler springs. The analyses on page 189 show it is a secondary alkaline water with notable primary alkalinity and high tertiary alkalinity.

A smaller spring, the water of which is similar in character to that of the main one, issues from the bank opposite the latter but has not received much attention.

The rocks exposed along the ravine are sandstones and shales which dip steeply, but the structure shown is probably to a large extent of landslide character. On the higher slopes near the springs these sediments are overlain by basaltic or andesitic lava.

BONANZA SPRINGS (LAKE 50).

Bonanza Springs are situated in a grove on a gentle slope bordering a ravine, about 3 miles north of east from Adams Springs, and halfway between Seigler and Howard springs (described among the hot springs, pp. 95–98). The property has been a camping resort for a number of years. In 1910 there were 8 or 10 small cottages and grounds for tents near by.

Three springs, which are known as Sulphur, Soda, and Iron, are situated on the property. The Sulphur Spring is in a covered well, 9 feet deep, from which a pipe extends a few yards northeastward down the slope to a latticed house, where the water issues from a small jet. This water is cool and noticeably sulphureted and also has a slight oily odor and taste. An oily film is said to form on the water of a shallow well near by. The Soda and the Iron springs issue a few feet apart from crevices in a small exposure of sandstone 60 yards below the Sulphur Spring house. Both are cool and carbonated and have stained their basins with iron, though the Iron Spring has done so to the greater extent. All three springs are small, yielding only one-quarter to one-half gallon a minute each.

The rock at this locality seems to be sandstone, but on the slopes a short distance above it is overlain by lava.

SPIERS SPRINGS (LAKE 52).

Spiers Springs are situated about 3 miles in a direct line southeast of Bonanza Springs, in the canyon of the main branch of Putah Creek.

Two springs of similar character issue a few yards apart at this place and each discharges 7 or 8 gallons a minute. The water is moderately carbonated and is noticeably sweet, probably from magnesia. Their overflow channels are iron stained. One of the springs issues at the base of a serpentine bank on the eastern side of the creek channel and has been piped to the creek edge. Its water has been bottled for sale since about 1901. The other spring issues from crevices in serpentine at the eastern edge of the creek. The water seems to be similar in chemical character to that of the first, but in 1910 the spring was unimproved.

Although no analyses of these springs are available, the close relation of magnesia content to serpentine from which the water issues is thought to be well shown at these springs, as at other magnesia springs that have been described.

The canyon of this branch of Putah Creek seems to mark the western boundary of the serpentine near Spiers Springs, for though it covers an extensive area on the eastern side of the canyon, the banks on the opposite side are of sedimentary rocks.

Spiers Springs are noticeably thermal, temperatures of 74° and 78° having been recorded, so they are shown on Plate III (in pocket) as thermal-carbonated springs, but they seem to be more properly considered as carbonated springs. There is said to be another magnesia spring, though of only slight flow, known as Sweetwater Spring, 2 or 3 miles southeast of Spiers Springs, but it has been unused and was not found.

SODA BAY SPRINGS (LAKE 36).

Soda Bay Springs are situated at the western side of Clear Lake, near the north base of Mount Konocti, a lava peak that rises high above the lake. A boating and fishing resort has been established here for nearly 40 years, and in 1910 a hotel and cottages provided accommodations for about 150 people.

Numerous warm, bubbling springs rise along the border of the lake for a distance of half a mile on the east side of the bay, but five principal springs and groups may be recognized. Two of the springs are respectively about 200 and 235 yards east of the boat pier. They form carbonated drinking pools having temperatures of 90° and 82°. In January, 1910, they were at the lake edge, but as the lake surface fluctuates several feet during the year, the springs are sometimes submerged. All of the vents are said to be more active when the lake is high. From the two springs already mentioned, a line of bubbles extended northward about 300 yards, parallel with the lake edge but several yards out from shore, to a float that was used by bathers. A group of small vents here made the water warm and pleasant for bathing. At a low point 250 yards farther northwest, small flows of carbonated water 85° to 90° in temperature issued from iron-stained cemented gravel, both on the shore and for several yards into the lake. The largest and most important spring, however, rises in the lake 200 yards or more northwest of the springs last described and near the northern end of a small island. This spring is known as the Geyser Spring, or Omar-Ach-Hah-Bee, the Great Spring, and in July, 1910, it had a temperature of 87°. Its flow was not measurable but is probably several hundred gallons a minute, and much water also rises at other points near by. A dressing room has been built on the lake over this spring, which rises in a pit in an inclosure, and the place is used for bathing. The analysis shows the water to be distinctly ferruginous in character—a fact that is also evidenced by the iron stains on the adjacent rocks. It is a secondary-alkaline water with notable primary alkalinity.

Dr. Winslow Anderson[1] mentions a hot borate spring near the shore of Clear Lake, which in July, 1888, had a temperature of 124° and yielded 300 gallons a minute. The description given apparently refers to the Geyser Spring, but the difference in temperature is rather large, and the analyses he quotes vary so widely from the analyses made in 1910 that it seems probable that different springs were sampled. The Hot Borate Spring of Anderson is a primary alkaline water of high concentration with notable primary salinity. The prominence of ammonium and metaborate radicles is noteworthy. The analyses of both springs are reproduced herewith.

Analyses of water from Soda Bay Springs, Lake County, Cal.

[Constituents are in parts per million.]

	1	2	3	4
Temperature	31° C. (87° F.)	32° C. (88° F.)	51° C. (124° F.)	....
Properties of reaction:				
Primary salinity	9	9	26	27
Secondary salinity	0	0	0	0
Tertiary salinity	0	0	0	0
Primary alkalinity	20	17	74	73
Secondary alkalinity	71	74	Trace.	Trace.
Tertiary alkalinity	(?)	250	29	36

Constituents.	1 By weight.	1 Reacting values.	2 By weight.	2 Reacting values.	3 By weight.	3 Reacting values.	4 By weight.	4 Reacting values.
Sodium (Na)	115	5.00	104	4.52	1,722	74.84	1,547	67.26
Potassium (K)	9.5	.24	12	.32	29	.74	Trace.	Trace.
Lithium (Li)	....	....	.5	.08	....	....	....	....
Ammonium (NH_4)	4.8	.27	2.6	.14	376	20.83	421	23.36
Barium (Ba) and strontium (Sr)	....	....	.0	.00	....	....	....	....
Calcium (Ca)	85	4.24	92	4.60	Trace.	Trace.	Trace.	Trace.
Magnesium (Mg)	113	9.30	118	9.72	2.1	.17	.1	.01
Iron (Fe)	} 23	.82	{ 6.1	.22	....	....	....	....
Aluminum (Al)			.8	.08	19	2.05	11	1.27
Manganese (Mn)	....	....	1.0	.03	....	....	....	....
Sulphate (SO_4)	Trace.	Trace.	.2	Trace.	Trace.	Trace.	Trace.	Trace.
Nitrate (NO_3) and nitrite (NO_2)	....	....	.0	.00	....	....	....	....
Chloride (Cl)	60	1.70	60	1.68	897	25.30	879	24.80
Bromide (Br)	....	....	.0	.00	Trace.	Trace.	Trace.	Trace.
Iodide (I)	....	....	Trace.	Trace.	1.6	.01	1.4	.01
Carbonate (CO_3)	480	16.00	529	17.64	1,112	37.07	1,171	39.02
Metaborate (BO_2)	Present.	Present.	1.6	.04	1,471	34.20	1,152	26.80
Arsenate (AsO_4)	....	....	Trace.	Trace.	....	....	....	....
Phosphate (PO_4)	Trace.	Trace.	Trace.	Trace.	....	....	....	....
Silica (SiO_2)	132	4.38	142	4.70	136	4.52	141	4.67
	1,022.3	....	1,069.8	....	5,765.7	....	5,323.5	....
Carbon dioxide (CO_2)	....	....	963	43.77	527	23.96	622	28.28

1. Geyser Spring. Analyst and authority, F. M. Eaton (1910).
2. Geyser Spring. Analyst and authority, Curtis and Tompkins (1910).
3. Hot Borate Spring. Analyst and authority, Winslow Anderson (1888).
4. Hot Borate Spring. Analyst, Moore; authority, Winslow Anderson.

[1] Mineral springs and health resorts of California, p. 176.

CARBONATED SPRINGS AT SOUTHWEST EDGE OF CLEAR LAKE (LAKE 37).

About 5 miles southeastward around the west side of the lake from Soda Bay small warm carbonated springs issue for a distance of 25 yards along the lake margin. A quarter of a mile farther south numerous other springs rise within a stretch 200 yards long. One of the largest noted had a temperature of 100° and a flow of perhaps 1 gallon a minute. Its water was moderately carbonated and also had a noticeably "sharp" taste that was possibly due to free carbonic acid. At both of the localities mentioned there is considerable iron-stained cemented gravel and sand.

The rock that is exposed from about 2 miles west of Soda Bay, eastward and southward around the lake to and beyond the springs just described, is the andesite of Mount Konocti. There appears to be a close relation between the numerous warm carbonated springs and this comparatively recent lava. The thermal character of the springs at Soda Bay and farther southeast has been noted in the description of the springs at Sulphur Bank (p. 99). Their carbonated character is also noteworthy in connection with the presence of the lava. This association of lava with carbonated springs at several places has already been mentioned, and it is brought out in the tabulated arrangement of the carbonated springs (pp. 250–253).

BAKER SODA SPRING (LAKE 53).

A small carbonated spring, known as Baker Soda Spring, lies about halfway between Lower Lake and Reiff post office. Its water has been used to small extent for drinking, but in 1910 it had not been commercially developed and was of only local interest. Like most of the other carbonated springs in Lake County, it issues from sedimentary rocks, probably of pre-Cretaceous age.

GRIZZLY SPRINGS (LAKE 29).

Grizzly Springs (Pl. XIII, *B*, p. 242), which have also been known as Richardson Springs, issue on the northern side of Grizzly Canyon, about 2½ miles above its junction with Cache Creek. As the springs are beside a main road that leads up the canyon and across the divide into Colusa County, they have been known for many years, but they have been improved only since about 1908.

There are two springs on the property. The Main Spring has formed a prominent carbonate deposit that extends down to the creek and is crossed by the road. The water rises with continual bubbling in a cemented rock-walled pool beneath a shed roof and yields about 2 gallons a minute of moderately carbonated and noticeably sulphureted, salty water.[1] The pool is used as a drinking basin, and a pipe leads from it to a heating tank a few yards away and thence to a small bathhouse. Besides its use by campers for bathing, the water has been bottled and sold locally.

In two or three places a few hundred yards farther upstream there are small lime-carbonate deposits where carbonated water evidently issued at a former period. The second spring, which is called the Arsenic Spring, flows from a small pit dug in a grassy seepage area on the hillside about 175 yards northwest of the Main Spring. It yields perhaps one-half gallon a minute of salty magnesic water and has been used for drinking.

A small amount of serpentine is exposed near the Arsenic Spring and probably furnishes the magnesic contents of both springs. Well-bedded sandstones and shales that continue up the canyon beyond the spring probably furnish the other mineral constituents. Cemented gravels belonging to the beds described by Becker [2] as the Cache Lake beds, of late Pliocene age, extend up the canyon approximately to the springs. The springs apparently issue at the eastern limit of the gravels, though conclusive evidence of this was not seen.

OIL SPRING (COLUSA 8).

Prominent deposits of lime carbonate have been formed on the steep hillside that borders the western side of Bear Valley, about 1½ miles north of Wilbur Hot Springs (Colusa 9, p. 99). These deposits extend for about one-quarter of a mile along the hillside and 200 to 300 feet above Bear Creek. At three or four places there are seepages of salty, carbonated water, but the main flow is at the northern and largest deposit. Here a spring that is locally called the Oil Spring yields about 2 gallons a minute of water, 76° in temperature, that tastes salty and disagreeably of petroleum. A number of years ago a shed was built over the spring, a collecting tank for the oil was placed near by, and a pipe line was laid to two large storage tanks in a shed beside the creek. In 1910 these improvements still remained, but the attempt to collect oil in commercial quantity from the spring had proved unsuccessful. A well that was drilled for oil a few miles north of the spring was also unsuccessful in obtaining a supply.

The spring and associated seepages issue from shales and sandstones that here border Bear Valley and extend eastward to Sacramento Valley. These sediments are relatively unaltered, compared with the sediments of the Franciscan formation, but a portion of them may belong to the Knoxville formation (Lower Cretaceous).

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[1] An analysis of this water, indicating a mineral content of about 1,100 parts per million, with rather low sodium and magnesium and unusually high lithium, has probably been incorrectly reported.

[2] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, pp. 219-221, 1888.

DEADSHOT SPRINGS (COLUSA 6).

Deadshot Springs are situated along a ravine whose mouth is about one-half mile south of the buildings on the Stovall and Wilcox horse ranch in Bear Valley and about 5 miles southwest of Leesville. The principal spring issues from a short piece of pipe inserted near the base of a lime carbonate terrace on the south side of the ravine, about 1 mile above its mouth. The top of the terrace extends for about 50 feet along the ravine, and the material exposed in its front, which is perhaps 20 feet high, indicates that the terrace is composed largely of serpentine fragments cemented by lime carbonate.

The spring yields about 1½ gallons a minute of carbonated salty water, 65° in temperature, that is an active cathartic. About 150 yards eastward, below the main spring, a flow of perhaps 6 gallons a minute of mildly carbonated, salty water issues on the south bank of the ravine. The water here comes from one main spring and several seepages from carbonate-crusted patches in a small salt-grass area. On the north bank of the stream, 300 yards farther down the ravine, there is a carbonate terrace about 25 feet long and 10 feet wide. A small pool on its top yields about 1 gallon a minute of carbonated salty water, 78° in temperature. The material of part of the terrace is so deeply iron stained that it has an ocherous appearance. The lowest springs are about 150 yards farther downstream, on the north edge of the creek, and issue from two crevices about 6 yards apart. They yield flows of about a quarter of a gallon and 2 gallons a minute of water that is similar in character to that of the other springs.

All these springs issue from serpentine, which here forms a wide belt that extends from the valley land westward nearly or quite to the summit of the mountains and is possibly the northward extension of the serpentine area at Wilbur Hot Springs. It is worthy of note that though Deadshot Springs issue from serpentine, and Oil Spring (Colusa 8, p. 194) a few miles farther south, issues from shale, both groups of springs yield carbonated salty water and have formed large carbonate deposits.

QUIGLEY SODA SPRINGS (LAKE 27).

Three carbonated springs that emerge about a quarter of a mile from each other on the Quigley place, 14 miles by road north of the town of Lower Lake, have been surrounded by concrete basins so as to form drinking pools. One of them is near the western side of Long Valley Creek and apparently issues from siliceous shales that are overlain by basaltic lava which forms a low ridge. The second spring is farther northwest, on the wooded slope of the lava ridge but close to the northern edge of the lava. The third spring is still farther to the northwest and issues at the side of a small ravine from a seam in siliceous sandstone. Each spring yields one-half to 1 gallon a minute of moderately carbonated water, 60° to 65° in temperature, and heavily stains its overflow channel with iron. The water of the northernmost spring tastes noticeably of salt. The position of the springs near the northern border of the lava area is worthy of note and also their occurrence near cold fresh-water springs (Lake 28, p. 358), which are not common in this region.

DINSMORE SODA SPRING (LAKE 24).

A carbonated spring of seeping flow that issues on the Dinsmore ranch, at the west edge of Wolf Creek, has long been protected by a concrete curb and used for drinking. Its water is moderately carbonated and slightly salty but is pleasing in taste and is much used during the summer. On the eastern side of the creek, about 300 yards downstream from the main spring, a few seepages issue from a small deposit of lime carbonate on the steep bank. On the mountain side, about 2½ miles northward from Dinsmore's, there is a large carbonate deposit that is evidently a spring deposit, but little or no water now issues near it.

The rocks on the higher slopes north of Dinsmore's place consist mainly of shales and coarser sediments, with areas of serpentine, but near the spring the materials are siliceous, being apparently altered shales and sandstones and some chert.

CARBONATED SPRING NEAR NORTHEAST SIDE OF CLEAR LAKE (LAKE 23).

In a ravine about half a mile east of Bartlett Landing, which is on the northeast shore of Clear Lake, there is a small carbonated spring that, though known locally, has not been often visited and is of little importance. It lies in an area of altered sediments, mainly shales, that make up the mountains on the northeast side of the lake and are considered to belong to the Knoxville formation of Lower Cretaceous age.[1]

CARBONATED SPRINGS ON CHALK MOUNTAIN (LAKE 25).

Chalk Mountain lies about 11 miles in a direct line east of north from the town of Lower Lake, and in the bend of Cache Creek, where it swings from a westerly to a southerly course. The mountain is more properly the end of a ridge and received its name because altered lava, which partly composes it, forms white slopes that make it a prominent landmark from the north. The lava appears to have been altered by solfataric action similar to that which has taken place at Sulphur Bank (Lake 38). (See p. 98.) On the northwestern side of Chalk Mountain a spring deposit of lime carbonate extends for

[1] See Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, Sheet III of Atlas, 1888.

about 100 yards along the mountain side and down the slope to Cache Creek, 75 feet below. Water still issues along the upper edge of the deposit from a number of seepages and from three pools about a foot in diameter and 15 and 75 yards apart. These yield a total of perhaps 3 gallons a minute of water, 67° to 70° in temperature, which tastes strongly of hydrogen sulphide, carbon dioxide, and common salt. The taste of hydrogen sulphide is the most noticeable and the springs are locally known as sulphur springs, but they are here classed with the carbonated springs because of the prominent lime carbonate deposit that has been formed. Along the side of the mountain, about 250 yards west of south from the main deposit, another seepage area several yards wide is crusted with lime carbonate, but in July, 1910, no water was seen.

ALUM SPRING (LAKE 26).

Alum Spring seeps from a claylike layer in bedded gravel and volcanic ash, beneath a small bank on the side of a ravine at the southwest base of Chalk Mountain, and about one-third of a mile south of the carbonated springs just described. The water tastes sour and astringent, and considerable efflorescence of alum salts forms on the bank and on the slope below it. The flow of the spring is small and is probably supplied by surface water, but it appears to be continuous. Although it is not a noticeably carbonated spring, it is described with the other springs on Chalk Mountain, for in general character it appears to resemble them. At the main springs sulphides and hydrogen sulphide are apparently in solution in addition to carbon dioxide, whereas at Alum Spring acid sulphates and probably free sulphuric acid are formed. None of the springs on the mountain have been used, but they are known locally and are occasionally visited as points of interest.

HOUGH SPRINGS (LAKE 13).

Hough Springs (Pl. VI, *A*, p. 92) are situated in the canyon of North Fork of Cache Creek, on the stage road from Williams to Bartlett Springs (Lake 9, p. 200). The property has long been improved as a summer resort. In 1910 a hotel and about a dozen cottages, situated in a recess at the base of the hill slopes, furnished accommodations for 100 people, while camp grounds and a supply store allowed provision for many more.

There are two springs on the property, one being known as the Soda and Iron Spring, the other as the Magnesia Spring. The former is at the base of steep slopes about 125 yards south of the hotel. A basin has been formed at this spring by excavating beneath the base of a considerable deposit of lime carbonate. This basin is protected by a cement wall and by a roof, and yields a small flow of moderately carbonated water that is much appreciated for drinking. A small pool of only slightly carbonated water that collects in a basin on the side of the carbonate deposit, above the main pool, furnishes another drinking water of less mineralized character. The Magnesia Spring is about 75 yards farther to the southeast and issues at the base of the mountain slope, beside a small ravine. It is also protected by a roof and yields a small flow of carbonated water that is noticeably warmer than the main spring and has a different taste. A well 20 feet deep beside the store building, which is about 200 yards north of the springs, is artesian in character, and nearly overflows in winter. It yields water that is considered to be sulphureted but that tastes only mildly carbonated and slightly of iron. Another well 50 feet south of it was bored to a depth of 65 feet in search of fresh water, but it struck only salty water and was abandoned.

The rocks of this locality seem to be the crushed and altered sediments that are common in the Coast Ranges. Serpentine was not observed near the springs, but it may outcrop on the steep, brushy slopes above them.

CARBONATED SPRINGS ON WILEY RANCH (LAKE 12).

There are several carbonated springs on the Wiley ranch, in the canyon of a branch of North Fork of Cache Creek, about 2½ miles northwest of Hough Springs. In 1910 they were reached only by a steep and rocky trail and were not generally known. The springs issue in a long glade 100 to 300 yards wide. The water of two or three is slightly sulphureted, but carbon dioxide is the most noticeable constituent in the principal ones. The rocks of the locality are the usual altered sediments, being mainly siliceous sandstones that in some places have a schistose character.

ALLEN SPRINGS (LAKE 11).

Allen Springs are situated in the narrow canyon of Allen Creek, on the stage road about 4 miles west of Hough Springs (Lake 13, p. 197). The property was early improved as a resort, but high water a number of winters ago washed away some of the cottages, and for several years the place was closed. In the summer of 1910 it was reopened, however, and accommodations for guests were provided by a hotel building and several cottages.

A number of carbonated springs issue along the edge of the creek above (west of) the hotel, and strings of bubbles that rise at several places in the creek near them show that gas and probably water also issues in the stream bed. One spring, whose water was formerly bottled, issues from the steep canyon side south of the hotel, across the creek, and is piped to a drinking shed. A group of three or four principal and several minor springs is situated at the creek edge about 250 yards northwest of the hotel. One of these, which is known as the Chalybeate Spring, is surrounded by a cement basin and yields perhaps 5 gallons a minute of carbonated water, 63° in temperature. This water is rendered turbid by iron in suspension. The following analysis, believed to represent water from this spring, indicates that it is secondary alkaline in character:

Analysis of water from Chalybeate Spring, Allen Springs, Lake County, Cal.

[Analyst and authority, Winslow Anderson (1888). Constituents are in parts per million.]

Temperature	14° C. (58° F.)
Properties of reaction:	
Primary salinity	39
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	4
Secondary alkalinity	57
Tertiary alkalinity	73

Constituents.	By weight.	Reacting values.
Sodium (Na)	180	7.82
Potassium (K)	22	.57
Calcium (Ca)	89	4.44
Magnesium (Mg)	81	6.64
Iron (Fe)	7.5	.27
Sulphate (SO_4)	9.1	.19
Chloride (Cl)	263	7.42
Carbonate (CO_3)	359	11.95
Phosphate (PO_4)	5.7	.18
Silica (SiO_2)[a]	....	....
	1,016.3	....
Carbon dioxide (CO_2)	306	13.93

[a] Not reported.

About 20 yards eastward, across the creek from the Chalybeate Spring, there is a sulphur spring which yields about 1½ gallons a minute of slightly carbonated and distinctly sulphureted water which has a temperature of 56°. Another spring, known as the Sureshot, issues at the creek edge 150 yards upstream. It is the westernmost one that has been improved and is locally considered to be the most strongly mineralized. Like the Chalybeate Spring, it is turbid, but it yields only a slight flow. Half a mile west of the buildings at Allen Springs there is a small but vigorously bubbling and pleasantly carbonated spring at the roadside. A few small lime-carbonate deposits on the hillside show where carbonated water also formerly issued and perhaps still seeps out.

All of these springs emerge from siliceous altered sediments that are cherty in character on the slope south of Sureshot Spring but have a schistose appearance along the creek bed near the Chalybeate and Sulphur springs. A small amount of serpentine is exposed a few hundred yards east of the hotel, but none was seen near the springs.

BARTLETT SPRINGS (LAKE 9).

For several years Bartlett Springs (Pl. XII, *C*) have formed a summer resort in Lake County. The property is situated on the north side of a branch of North Fork of Cache Creek, and mainly on the slopes some distance above the stream. A number of small cottages were early built near the springs and others have been added from time to time. A commodious hotel, stores, pleasure buildings, and a large bottling house have aided in making a considerable settlement at the place.

The Main Spring is situated in the northern part of the grounds, at the base of steep slopes. It has been improved with a tin-lined cement basin elevated above a cement floor. This basin is used as a drinking fountain, and pipes lead from it to a small fountain at the hotel and to the bottling house. The water is cool (56°), is mildly carbonated, and is shown by the analysis to be secondary alkaline in character.

Analyses of water from Bartlett Springs, Lake County, Cal.

[Constituents are in parts per million.]

	1		2		3	
Temperature			12° C. (54° F.)			
Properties of reaction:						
Primary salinity		3		2		1
Secondary salinity		2		0		1
Tertiary salinity		0		0		0
Primary alkalinity		0		1		0
Secondary alkalinity		95		97		98
Tertiary alkalinity		620		695	(?)	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	9.4	.41	8.3	.36	22	.97
Potassium (K)	2.3	.06	2.7	.07		
Lithium (Li)	Trace.	Trace.	Trace.	Trace.		
Ammonium (NH_4)			Trace.	Trace.		
Barium (Ba)	Trace.	Trace.	.7	.01		
Calcium (Ca)	206	10.28	213	10.63	85	4.24
Magnesium (Mg)	44	3.61	33	2.69	478	39.32
Iron (Fe)	4.2	.15	Trace.	Trace.	35	.13
Aluminum (Al)						
Sulphate (SO_4)	30	.62	7.7	.16	6.1	.13
Chloride (Cl)	5.7	.16	5.3	.15	11	.31
Carbonate (CO_3)	407	13.56	399	13.29	1,323	44.09
Metaborate (BO_2)	Trace.	Trace.	Trace.	Trace.		
Phosphate (PO_4)	5.4	.17	5.1	.16		
Silica (SiO_2)	64	2.12	59	1.97	50	1.66
	778.0		733.8		2,010.1	
Carbon dioxide (CO_2)	1,911	86.86	2,060	93.64		

1. Main Spring. Analyst and authority, Winslow Anderson (1888).
2. Main Spring. Analyst, G. E. Colby (1880 ?). Authority, Winslow Anderson.
3. Soda-magnesia Spring. Analyst, Southern Pacific Co. (?) (1900). Authority, advertising matter.

Aperient Spring is on the hillside, about 200 yards by zigzag trail, northeast of the Main Spring. It issues in a small springhouse, and yields perhaps 2 gallons a minute of moderately carbonated water

A. COOKS SPRINGS, COLUSA COUNTY.

B. TUSCAN SPRINGS, TEHAMA COUNTY.

C. BARTLETT SPRINGS, LAKE COUNTY.

61° in temperature, which deposits considerable iron. Its water has been used for drinking and has also been piped to a swimming plunge.

The Soda-magnesia Spring is about 100 yards southeast of Aperient Spring at the base of a steep slope. It yields perhaps 3 gallons a minute of cool, mildly carbonated water that is piped to large storage tanks near by and thence to the grounds. Like the water of Aperient Spring, it deposits considerable iron along its overflow channel.

The analyses on page 200 show that Soda-magnesia Spring contains a considerably larger proportion of magnesium than the water of the Main Spring and is essentially secondary alkaline in character.

The Gas Spring is about three-fourths of a mile by trail northeast of the Main Spring and is across a divide on slopes that drain to North Fork of Cache Creek. The spring consists of a shallow pool 1 to 3 feet wide and about 10 feet long, partly beneath a small bank on the canyon side. There is only a seeping overflow in summer, but the pool is kept in vigorous ebullition by large bubbles of carbon dioxide that continually escape. The amount of this gas is so great that it extinguished a lighted newspaper held 8 inches above the surface of the pool.

The Main Spring at Bartlett Springs apparently issues from altered sandstone, but serpentine is exposed a few yards to the north. Aperient Spring also issues from altered sediments, but serpentine outcrops a few yards north and west of it. The steep slope back of the Soda-magnesia Spring is formed by a ledge of hard, altered sandstone. Shale forms the slopes near the Gas Spring, but there is a small exposure of decayed serpentine a few yards east of it. All of this region appears to be composed of the altered sediments and associated serpentine that are a characteristic rock formation in Lake County.

HOPPINS SPRINGS (LAKE 10).

The property of Hoppins Springs, which joins the eastern boundary of that of Bartlett Springs, has been improved to some extent as a resort by the erection of several cottages for light housekeeping.

Two small springs that issue on the property, about 100 and 150 yards east of the Bartlett Soda-magnesia Spring, are known respectively as the Magnesia Spring and the Iron Spring. Each forms a drinking pool that has been protected by a board cover and contains cool, carbonated water. That of the Iron Spring is the more strongly carbonated, and that of the Magnesia Spring has a more pronounced taste of iron or magnesia.

Serpentine is exposed at the roadside a short distance south of the springs, but like Bartlett Springs the mineral water apparently issues from altered sandstone.

NEWMAN SPRINGS (LAKE 8).

Newman Springs are about 1½ miles north of west from Bartlett Springs (Lake 9, p. 200), and issue along the channel of Soap Creek; hence they are sometimes referred to as the Soap Creek Springs. The spring farthest downstream—which is the principal one—emerges at the creek side at the base of a prominent ledge of serpentine that forms the eastern border of a belt of this rock and the contact zone between it and crumpled shales and siliceous sediments that continue eastward. The spring yields about 15 gallons a minute of mildly carbonated water 86° in temperature, that is turbid with iron. The water is conducted across the creek in a trough to a small plunge bathhouse. A spring in the creek bed about 75 yards above (southwest of) the main spring, forms the Borax Pool, which contains warm, turbid water that is considered to be of exceptional value for bathing. The serpentine belt continues for about 100 yards upstream (westward) from it and is then succeeded by schistose rock, from which seepages and slight flows of warm carbonated water issue in at least seven places along a distance of about 275 yards or to a point about a quarter of a mile above the main spring. Temperatures of 72° to 92° were noted in these small springs, and the locality is therefore indicated in Plate III (in pocket) as containing thermal carbonated springs. The position of the springs with respect to the serpentine dike is suggestive in considering their origin, for this dike may not only afford an upward passage of escape for heated water but may possibly also be the direct cause of its abnormal temperature.

HAZEL SPRINGS (LAKE 7).

About 8 miles northeast of Upper Lake, at Hazel Springs (formerly known as Dennison Springs), two small carbonated springs issue about 20 yards apart. The property has been used at times as a summer camping resort, but during July, 1910, it was closed to the public

ROYAL SPRING (LAKE 6).

Royal Spring is about 7 miles west of north from Bartlett Springs (Lake 9, p. 200), and 2 miles by a slightly used road running north from the dairy ranch in Twin Valley. The spring emerges on the side of a ravine that is tributary to North Fork of Cache Creek. It has been protected by a cement basin in which the water rises clear, but it deposits some iron along its overflow channel. It is cool, moderately carbonated, and tastes distinctly of iron or magnesia. In former years, when the property was occupied, the spring was better known, but it has been used for several summers as a private camping ground only.

The position of the spring is significant, for it is at the western border of a belt of serpentine that extends in a northerly direction through the usual altered sediments. Although the examination of the region was not sufficiently detailed to determine the positions of the springs with respect to the serpentine areas, it is thought that the occurrence of mineralized waters in the northern Coast Ranges is closely related to the serpentine areas. The relation seems to be especially well shown along the eastern side of Lake and western side of Colusa counties, where there is a wide zone of serpentine with minor, approximately parallel zones that trend in a general direction west of north. The hot springs of Sulphur Creek (Colusa 9 to 12, pp. 99–104) are in a serpentine area or near its western border; Oil Spring (Colusa 8, p. 194) is in a northern extension of apparently the same zone or dike; Complexion Spring (Lake 14, p. 297) is in serpentine; Bartlett Springs and Hoppins Springs (Lake 9 and 10, pp. 200–201) apparently issue at the borders of narrow serpentine dikes; Royal Spring (Lake 6) is at the west edge of a serpentine exposure whose course can be easily traced along the hillsides to the north and to the south; and Crabtree Springs (Lake 5, p. 106) are in siliceous rock that is closely associated with serpentine.

PARAMORE SPRING (LAKE 4).

Paramore Spring is situated on a branch of Rices Fork of Eel River, about 4 miles in a direct line northwest of Crabtree Springs (Lake 5, p. 106). The spring is in a deep, brushy ravine and is not easily accessible, but the place has been visited occasionally by campers. It yields cool, strongly carbonated water, but it issues at the creek edge and is hence available only during periods of low water.

CARBONATED SPRING NEAR RANGER CAMP (LAKE 3).

A small carbonated spring near the ridge west of Paramore Spring has been used in recent years by the Government forest rangers, who have established a camp near by. Like several other springs in the region, it yields a small amount of cool carbonated water that is appreciated for drinking.

CARBONATED SPRING ON BEAR CREEK (LAKE 2).

About 1½ miles above the mouth of Bear Creek and near the stream channel, there is a carbonated spring that is known to hunters in the region. It has not been improved, however, and is not easily found. There are probably other similar springs in the rugged parts of northern Lake County whose positions are known chiefly to residents of the region.

MORTON SODA SPRING (LAKE 1).

Morton Soda Spring is situated near the mouth of Soda Creek, which joins South Fork of Eel River about 2 miles south of west of Hullville. The spring yields a small flow of cool carbonated water that is very pleasant for drinking, but it has been known and used only locally.

COOKS SPRINGS (COLUSA 5).

Cooks Springs (Pl. XII, *A*, p. 200) have been a well-known summer resort for a number of years, and the water has long been marketed for table use. In 1910 accommodations were provided for 150 people by a well-appointed hotel and a number of cottages. The place is situated in the lower portion of the Coast Ranges west of Sacramento Valley, and the grounds extend along two ravines that unite near the hotel to form a tributary of Stony Creek.

There are three principal springs on the property, the main one being about 40 yards southeast of the hotel and beneath the roof that covers a bowling alley. A cemented, covered reservoir has been constructed at the spring. Over it a small hand pump supplies water for drinking, and a pipe leads from the reservoir to a bottling house about 125 yards northward, down the ravine. The spring yields perhaps 2 gallons a minute of moderately carbonated water, 64° in temperature, which tastes slightly saline.

The following analysis shows the water to be secondary alkaline in character with notable primary salinity and alkalinity. The large proportion of magnesia is also noteworthy.

Analysis of water from Main Spring, Cooks Springs, Colusa County, Cal.

[Analyst, R. E. Swain (1900). Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	14
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	21
Secondary alkalinity	65
Tertiary alkalinity	46

Constituents.	By weight.	Reacting values.
Sodium (Na)	624	27.14
Calcium (Ca)	26	1.29
Magnesium (Mg)	614	49.65
Iron (Fe)	5.6	.20
Aluminum (Al)	1.9	.21
Sulphate (SO_4)	6.0	.12
Chloride (Cl)	390	11.00
Carbonate (CO_3)	2,015	67.16
Silica (SiO_2)	80	2.65
	3,762.5	....
Carbon dioxide (CO_2)	731	33.22

Iron Spring issues on the hillside about 300 yards south of the Main Spring and 65 yards northeast of the dancing hall. A cemented basin at this spring, at the base of a small bank beneath a protecting roof, yields perhaps a quarter of a gallon a minute of water that tastes similar to that from the Main Spring but noticeably stains its run-off channel with iron. About 700 yards south of the dancing hall, at the creek side, there is an effervescing carbonated spring that is called the Sulphur Spring, as its water has a slight odor of hydrogen sulphide, but it is primarily a carbonated spring. A concrete wall along the creek protects the spring and forms a reservoir in which its flow of about 5 gallons a minute collects. Thence a pipe extends down the ravine to the swimming pool near the hotel. It is said that attempts to bottle the water have been unsuccessful because its large content of carbon dioxide breaks the bottles.

Among minor springs on the property are two or three vents in the creek bed a few yards above the Sulphur Spring, from which the water bubbles, and two noncarbonated springs of seeping flow at the creek side, behind the store and hotel annex building, which adjoins the main hotel. Small noncarbonated springs that are used for drinking also issue from the bank back of the bottling house and at the roadside about half a mile below the resort grounds.

Sedimentary rocks form the hills westward from Sacramento Valley to within about 1¼ miles of Cooks Springs. Serpentine thence extends westward and forms the slopes at and near the resort grounds. In some places this rock is altered so that it resembles siliceous material, but massive serpentine is exposed in the road bank 40 yards northeast of the hotel. Pyroxene rock that exhibits concentric weathering unusually well is shown in a roadside cut 100 yards west of the hotel. A few hundred yards farther west, up the ravine, the serpentine has been much broken and the fragments have been cemented by calcite into a breccia. Several tunnels have been driven into this material in search of copper ore.

The Main Spring and the Iron Spring issue from serpentine, but the Sulphur Spring, which is the largest and most strongly carbonated, issues from material that appears to be dark, altered sandstone containing veinlets of calcite. The exposure of this rock may indicate that it is present beneath the surface at the other springs, and the calcite in it may yield the carbon dioxide of the springs. Carbon dioxide that is given off by magnesite and other carbonates formed from the serpentine may, however, as plausibly account for the carbon dioxide.

FOUTS SPRINGS (COLUSA 3).

Fouts Springs have been resorted to during the summer for 40 years or more. In 1905 the property changed ownership and since then it has been greatly improved. The buildings are located on a gentle slope at the eastern base of a brushy mountain and are about 10 miles by road westward from Stonyford, across a mountain divide. In 1910 about 30 cottages, a dozen tents and a building containing an office and a dining hall, furnished accommodations for 150 guests.

There are four principal springs on the property. Champagne Spring, which is the one most used for drinking, rises in a pool beneath the floor of a spring house near a small creek and about 175 yards southwest of the dining hall. It yields a small flow of pleasantly carbonated water that is much appreciated for drinking. The analysis shows it to be a moderately mineralized water, secondary alkaline in character, markedly different from the waters of the other two springs that have been analyzed. In the creek bed, about 20 yards south of the spring, carbonated water issues with much bubbling, but in 1910 these springs had not been improved nor used.

The three other springs, or groups of springs, are in a ravine one-half to three-fourths mile northwest of the resort grounds. Redeye Spring receives its name from the rusty-red stain of iron along its overflow channel. The water issues from seams in the rock on the north bank of the creek, where two small basins yield about one-half gallon and 5 gallons a minute of carbonated saline water that has a temperature of 75°. This water was formerly bottled and marketed and is still used for drinking, but, as is shown by the analysis, it is too salty to be pleasant to the taste. Many bubbles that rise in the creek near Redeye Spring show that gas and probably also carbonated water issue from other seams in the rock at this place.

The Bath or New Life Spring is about 175 yards westward, upstream, from Redeye Spring and on the same side of the creek. The main flow comes from a pool 2 feet in diameter, which yields about 8 gallons a minute, and a small pool 3 yards away yields perhaps one-half gallon a minute more. The water has a temperature of 75° and tastes moderately carbonated and salty, like that of Redeye Spring, which analysis shows it to closely resemble, both being primary saline and secondary alkaline in character, but it has built up a terrace of gravel and lime carbonate about 5 yards wide and 20 yards long at the side of the creek. The water is conducted in a trough eastward to a bathhouse a short distance below Redeye Spring and heated for bathing. It deposits much calcium carbonate in the trough, though the following analyses show that it contains the least calcium of the three spring waters. Noteworthy features of the waters shown by the analyses are the amounts of iodine, ammonium, and nitrate.

Analyses of water from Fouts Springs, Colusa County, Cal.

[Analyst, U. S. Bureau of Chemistry (1906?). Authority, owner of springs. Constituents are in parts per million.]

	Champagne Spring.		Bath or New Life Spring.		Redeye Spring.	
Properties of reaction:						
Primary salinity	8		67		60	
Secondary salinity	0		0		0	
Tertiary salinity	0		0		0	
Primary alkalinity	8		23		26	
Secondary alkalinity	84		10		14	
Tertiary alkalinity	(?)		(?)		(?)	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	68	2.97	4,859	211.26	4,879	212.13
Potassium (K)	5.8	.15	34	.86	62	1.59
Ammonium (NH_4)	Trace.	Trace.	38	2.12	8.6	.48
Calcium (Ca)	139	6.93	132	6.59	162	8.11
Magnesium (Mg)	118	9.67	204	16.74	308	25.38
Iron (Fe)	1.4	.05	2.4	.09	3.5	.13
Sulphate (SO_4)	5.5	.12	13	.27	5.2	.11
Nitrate (NO_3)	15	.24	44	.71	88	1.43
Chloride (Cl)	40	1.13	5,591	157.67	5,221	147.24
Bromide (Br)	0	.00	Trace.	Trace.	Trace.	Trace.
Iodide (I)	0	.00	23	.18	41	.32
Carbonate (CO_3)	467	15.58	2,188	72.95	2,780	92.67
Metaborate (BO_2)	0	.00	Trace.	Trace.	Trace.	Trace.
Nitrite (NO_2)	0	.00	0	.00	0	.00
Phosphate (PO_4)	0	.00	0	.00	0	.00
Silica (SiO_2)	66	2.19	113	3.75	116	3.85
	925.7	....	13,241.4	....	13,674.3	....
Carbon dioxide (CO_2)	Present.	Present.	Present.	Present.	Present.	Present.

Sulphur Spring, which yields about 2 gallons a minute of pleasant-tasting, mildly sulphureted water, 60° in temperature, issues on the south side of the creek beneath an irrigating flume and 225 yards west of the Bath Spring. Like that of Redeye Spring, its water is used to some extent for drinking, but the spring is too far from the main grounds to be fully appreciated.

The carbonated springs—the Champagne, Redeye, and Bath springs—issue from serpentine, which at Redeye and Bath springs is weathered to a light-colored but hard material. The bowlders in the creek bed consist of altered sandstone veined with quartz and calcite, and the Sulphur Spring issues from a steep slope of crushed rock of this character. It is worthy of mention here that two other sulphur springs in this locality, one (Colusa 2, p. 267) southwest, and the other (Colusa 1, p. 267) west of Fouts Springs, also issue from the altered sediments. As elsewhere in the Coast Ranges, the serpentine is probably intrusive in the altered sediments, and the carbonated springs are apparently closely related to the presence of the serpentine. The salty character of the water of Redeye Spring and Bath Spring seems to be accounted for by the presence of the altered sediments.

FERNDALE SPRINGS (CONTRA COSTA 1).

Ferndale Springs are in Vaca Canyon, about 6 miles (by road) south of Martinez. Two springs of small flow issue from a steep bank on the southern side of the canyon, about 50 feet above the creek, and were formerly piped across it to bottling works on the opposite side of the canyon. In 1908, however, bottling had been discontinued for a year or more. A small tunnel has been excavated at the principal spring, which yields a flow of perhaps 1½ gallons a minute of noticeably carbonated water. The rocks consist of shale and soft fine-grained buff sandstone, the spring issuing from a bank of thick-bedded sandstone.

ALUM ROCK PARK SPRINGS (SANTA CLARA 3).

Alum Rock Park is in Alum Rock Canyon, about 7 miles northeast of San Jose. The property was purchased from the Spanish Government by the Pueblo de San Jose and still belongs to the city, being conducted as a recreation park. It received its name from an alum-coated bowlder that lies in the grounds. The improved part of the park extends for about 600 yards along the narrow canyon and has been partly laid out with walks and garden plots. Tub baths and a swimming plunge have been constructed, and a café, Japanese tea garden, candy booth, and a few other concessions have been granted in order to help defray the expense of maintenance. The place is easily reached by electric car from San Jose.

At least 16 mineral springs issue along the park at the bases of the canyon sides, their positions being shown on the sketch map (fig. 4). The springs differ notably in the chemical characteristics of their waters. All are distinctly sulphureted, four are moderately carbonated, and one deposits considerable amounts of iron. A seventeenth spring, which is noticeably saline and is known as the Salt-Condiment Spring, issues in a little ravine 600 yards west of the lower end of the park grounds. It is piped to a drinking basin at the roadside a few yards away.

Thirteen of the springs, including the Salt-Condiment Spring, have been improved by cement or rock-masonry basins to form drinking pools, and water from at least two of them is also piped to the baths. The other four—the one that deposits iron, a sulphur spring, and two carbonated springs that deposit lime carbonate—issue in tunnels that have been run into the canyon sides a few feet above the level of the other springs. They have been used in part to supply water for the baths.

Two drinking springs that issue from pipes side by side near the upper end of the park are worthy of special mention. One of them yields water that is milky from suspended sulphur, and the water

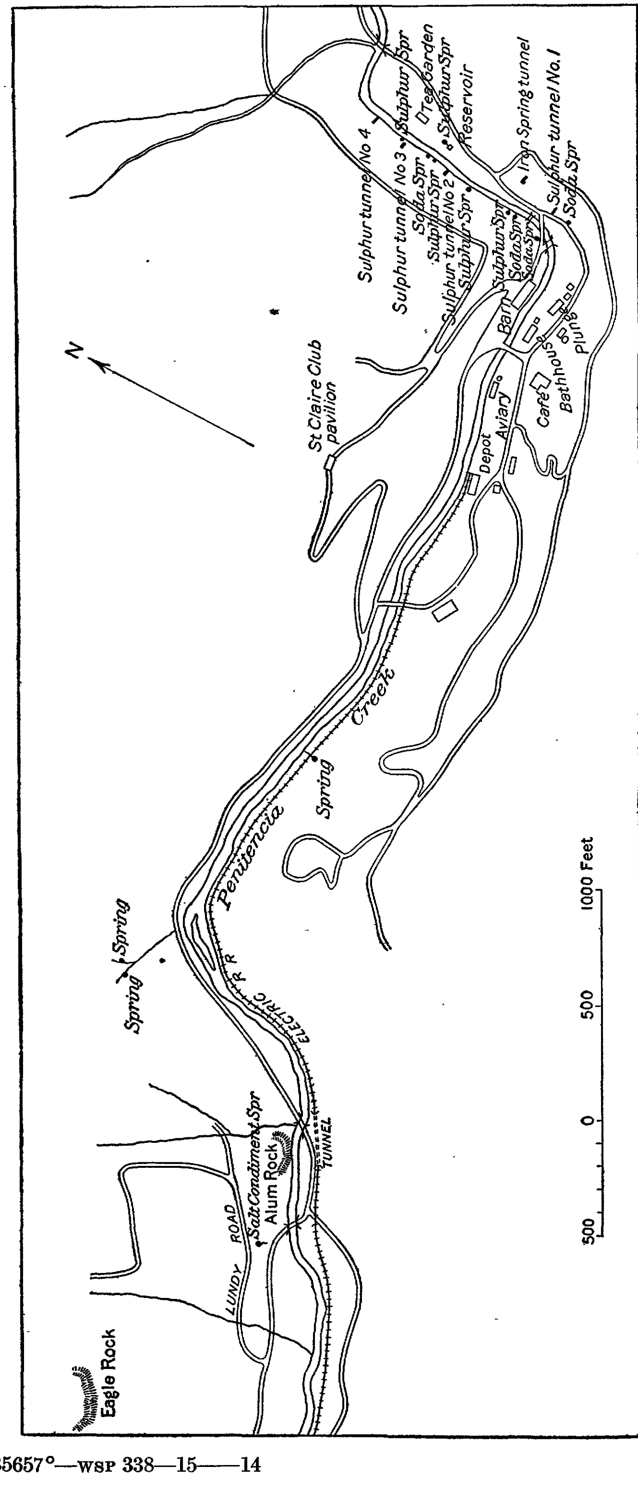

FIGURE 4.—Sketch map showing positions of springs in Alum Rock Park, Santa Clara County.

from the other is almost black from iron sulphide. The latter effect has, however, possibly been artificially produced by bringing together the flows of an iron and a sulphur spring.

As most of the springs are sulphureted, the locality might be properly described with the sulphur springs, but the carbonated springs are most used for drinking and are probably as characteristic of the place.

The following analyses show the chemical character of the principal springs. The Salt-Condiment Spring is characterized chiefly by primary salinity, but secondary salinity is notable; the Soda Spring is primary alkaline in character; and the other springs, though differing widely in concentration and exhibiting many minor differences in composition, are all of mixed type—primary alkalinity, secondary alkalinity, and primary salinity all being prominent.

All of the springs are of small flow. Only four of them discharge more than 1 gallon a minute, and each of these four yields less than 5 gallons a minute. The temperatures are above the normal, ranging from 69° to 87°.

The rocks at Alum Rock Park consist of beds of shale and sandstone of Tertiary age that have been highly tilted and folded. These sediments are probably the direct source of the main constituents in the spring waters.

Analyses of water from Alum Rock Park Springs, Santa Clara County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5		6		7		8	
Properties of reaction:																
Primary salinity		38		33		69		36		28		25		39		42
Secondary salinity		0		0		14		0		0		0		0		0
Tertiary salinity		0		0		0		0		0		0		0		0
Primary alkalinity		48		49		0		53		60		39		28		33
Secondary alkalinity		14		18		17		11		12		36		33		25
Tertiary alkalinity		104		91		10		80		61		2		2		42
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	1,320	57.40	879	38.22	1,751	76.16	2,110	91.77	1,652	71.80	583	25.35	657	28.59	856	37.24
Potassium (K)	25	.64	24	.61	45	1.16	77	1.96	25	.64	15	.39	13	.34	15	.38
Lithium (Li)	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Ammonium (NH_4)									0	.00	0	.00	0	.00	0	.00
Calcium (Ca)	142	7.11	101	5.02	423	21.10	164	8.16	127	6.33	198	9.86	161	8.02	152	7.60
Magnesium (Mg)	24	2.14	39	3.18	160	13.19	39	3.18	37	3.05	58	4.78	73	6.02	63	5.21
Iron (Fe) Aluminum (Al)	5.9	.21	3.5	.13	6.9	.25	4.2	.15	.6	.02	1.9	.07	30	1.06	5.4	.19
Manganese (Mn)									0	.00	0	.00	0	.00	0	.00
Sulphate (SO_4)	197	4.10	205	4.28	2,418	50.34	10	.21	18	.38	305	6.36	390	8.11	290	6.04
Nitrate (NO_3)									0	.00	0	.00	0	.00	0	.00
Chloride (Cl)	765	21.60	404	11.39	1,522	42.95	1,323	37.35	800	22.58	133	3.75	308	8.68	534	15.05
Bromide (Br)									0	.00	0	.00	0	.00	0	.00
Iodide (I)									Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Carbonate (CO_3)	1,236	41.20	934	31.12	546	18.21	1,995	66.50	689	22.96	908	30.27	785	26.18	880	29.34
Metaborate (BO_2)	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	0	.00	0	.00	Trace.	Trace.
Arsenate (AsO_4)									0	.00	0	.00	0	.00	0	.00
Phosphate (PO_4)	12	.39	10	.32	3.4	.11	32	1.01	Trace.	Trace.	0	.00	Trace.	Trace.	0	.00
Silica (SiO_2)	20	.66	22	.73	60	1.99	21	.70	31	1.03	26	.85	26	.87	25	.82
	3,746.9		2,621.5		6,935.3		5,775.2		3,379.6		2,227.9		2,443		2,820.4	
Carbon dioxide (CO_2)	1,483	67.41	838	38.09	192	8.73	1,835	83.41	1,093	49.66	16	.37	0	.00	447	20.34
Hydrogen sulphide (H_2S)	37	2.17	68	3.99					0	.00	10	.59	13	.77	13	.76

1. Blue Sulphur Spring. Analyst, William Irelan, jr. Authority, advertising matter.
2. White Sulphur (Sulphur tunnel No. 1). Analyst, William Irelan, jr. Authority, advertising matter.
3. Salt-Condiment Spring. Analyst, William Irelan, jr. Authority, advertising matter.
4. Soda Spring. Analyst, William Irelan, jr. Authority, advertising matter.
5. Soda Spring (on west side of creek, 100 yards north of baths). Analyst and authority, W. D. Forbes (1910). Possibly the same spring as that represented by the preceding analysis.
6. Sulphur Spring (75 yards northwest of tea garden). Analyst and authority, W. D. Forbes (1910).
7. Blackwater spring (west of tea garden). Analyst and authority, W. D. Forbes (1910).
8. Southernmost of three springs at Blackwater Spring house. Analyst and authority, W. D. Forbes (1910).

Chemical reactions that take place after the solution of the minerals may account in part for the abnormal temperatures of the springs; the intense movement that has tilted the beds at steep angles may also have produced a high thermal gradient, and thus partly account for them.

GRANT SPRING (SANTA CLARA 2).

About 5 miles above Alum Rock Park there is a small carbonated spring which is known as Grant Spring. Its water has been bottled and placed on the local market for table use.

The rocks at this locality appear to be the same as those lower down the canyon, and the spring seems otherwise to be similar in occurrence to the springs in Alum Rock Park.

CONGRESS SPRINGS (SANTA CLARA 5).

Congress Springs, which were formerly known as Pacific Congress Springs, are in a canyon near the edge of Santa Clara Valley, 12 miles southwest of San Jose. They were improved for many years as a resort, and the water formerly was in considerable demand for table use, but in 1903 or 1904 the hotel burned, and since that time the property has not been so well kept up.

Two small carbonated springs rise at the upper end of the grounds, on the north bank of Campbell Creek. A spring house has been erected over one of them, and a portion of its flow rises in a cemented brick drinking basin. The other spring is 30 yards farther upstream. A small house that inclosed a gas-collecting tank stood over it in 1908. Its gas (carbon dioxide) and water were formerly piped to bottling works a short distance below the lower spring. The analysis (p. 213) probably represents water from the upper spring and indicates that it is a primary alkaline and saline water containing a large proportion of iron and aluminum.

A considerable deposit of lime carbonate appears in the bed of Campbell Creek 200 or 300 yards below the springs. The position and character of this deposit suggests that it was formed at a time when carbonated water emerged at or near that place.

The springs issue in an area of dark-gray sandstone that belongs to the Franciscan formation. This material is cut by dikes of dark-gray diabase, and it is thought that a small dike of this rock crosses Campbell Creek a few yards above the upper spring. If this is true, the dike rock may have some influence on the rise of carbonated water at this place.

AZULE MINERAL SPRING (SANTA CLARA 4).

Azule Mineral Spring is situated in a ravine a mile northward across a divide from Congress Springs. It was first known as Mills Seltzer Spring, but the name was early changed to Azule, from the blue appearance of the mountains to the southwest. The water was formerly bottled for table use, but it has not been on the market since about 1890. The property has, however, been improved as a picnic resort.

The spring rises in a small concrete house, from a crevice in dark-colored sandstone. Water also issues beside the spring house, apparently from the same crevice as that within the house, and the combined flow of the two streams is perhaps a quarter of a gallon a minute. The water is strongly carbonated and also tastes slightly of hydrogen sulphide. A very small deposit of Epsom salt was noticed beside the spring, and the channel is iron stained for a few yards below it. There are small deposits of lime carbonate farther downstream.

Although the spring issues from sandstone, serpentine that appears to form a dike not much more than 10 yards thick is exposed on the slope immediately above it. This dike may determine the position of the spring at this point, and the considerable amount of magnesia in the water that is shown by the following analyses, tabulated with one from Congress Springs, is probably explained by the presence of the serpentine. The water may be classed as secondary alkaline and primary saline, but the unusually large content of magnesium is noteworthy.

Analyses of water from Azule Mineral Spring and Congress Springs, Santa Clara County, Cal.

[Constituents are in parts per million.]

	1				3	
Temperature	16° C. (60° F.)				10° C. (50° F.)	
Properties of reaction:						
Primary salinity	39		42		43	
Secondary salinity	0		0		0	
Tertiary salinity	0		0		0	
Primary alkalinity	13		11		36	
Secondary alkalinity	48		47		21	
Tertiary alkalinity	140		136		42	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	972	42.25	990	43.03	1,746	75.90
Potassium (K)	126	3.21	117	2.86	20	.51
Calcium (Ca)	69	3.44	62	3.08	181	9.05
Magnesium (Mg)	462	38.02	462	37.99	144	11.87
Iron (Fe)					115	4.10
Aluminum (Al)					41	4.52
Sulphate (SO_4)					378	7.87
Chloride (Cl)	1,212	34.17	1.280	36.10	1,201	33.89
Carbonate (CO_3)	1,582	52.75	1,526	50.86	1,790	59.67
Silica (SiO_2)	55	1.82			68	2.26
	4,478		4,437		5,684	
Carbon dioxide (CO_2)	2,632	119.64	2,606	118.46	756	34.36

1. Azule Mineral Spring. Analyst and authority, Winslow Anderson (1888).
2. Azule Mineral Spring (bottled water). Analyst, James Howden. Authority, U. S. Geol. Survey Bull. 32.
3. Upper spring, Congress Springs. Analyst and authority, Winslow Anderson (1888).

Congress and Azule springs form a rather isolated group of carbonated springs, for springs of this character are not common in this part of the Coast Ranges. There was formerly a carbonated spring about 200 yards east of the reduction works at the New Almaden quicksilver mine, 15 miles southward from San Jose, but the crevice or other source from which it received its carbon dioxide was cut through by mining operations, and the spring has been dry for many years. During the seventies its water was bottled and marketed as New Almaden Vichy Water, and in later years it was also pumped for bottling. An approximate analysis[1] showed that it contained considerable sodium, calcium, bicarbonate, sulphate, and free carbon dioxide.

MADRONE SPRING (SANTA CLARA 8).

Madrone Spring is situated on a tributary to Coyote Creek, 14 miles east of Madrone station. There were several cottages and a small hotel on the property as early as 1880, and in 1891 a larger hotel was erected. In 1908 the place was conducted mainly as a hunters' resort, with accommodations for about 50 people. A trail leads southeastward over the hills 6 miles to Gilroy Hot Springs.

The spring issues at the southern edge of the stream channel, beside a dancing pavilion that has been built over the creek. When visited the water issued in a cemented basin that had no appreciable overflow and was lifted to the level of the pavilion by a hand pump. In 1892, and for a few years following, the water was taken in barrels to San Jose and bottled. The analysis tabulated on page 215 shows that the water is essentially primary and secondary alkaline.

On the slopes south of the hotel are two unused seepages that are called "arsenic" and "iron" springs but do not appear to be notably mineralized. A quarter of a mile westward, up the creek, a faintly sulphureted spring that yields about one-half gallon a minute issues at the southern edge of the stream; it has been protected by a box curbing that forms a small drinking basin.

The carbonated spring rises from dark-colored shale which is exposed along the creek for 50 or 75 yards above and below it. A little farther downstream, thick-bedded sandstone is exposed, and eastward from it, the sediments are siliceous and cherty. The series dips nearly vertically northeast and strikes northwestward across the creek.

COES SPRING (SANTA CLARA 7).

In a ravine about $1\frac{1}{4}$ miles west of Madrone Spring, on the Coe ranch, carbonated water rises in a stream channel, amid bowlders of sandstone, and in 1908 a pipe conducted it from a small basin in the

[1] California State Mineralogist Sixth Rept., p. 73, 1886.

stream bed to a cattle-watering trough a few yards below. A small amount of iron-stained, lime-cemented gravel has been formed along the creek below the spring. The sandstone near by is much veined by secondary material, and some serpentine float was noticed. The formation, however, seems to be of sandstone and shales similar to those at Madrone Spring, but these materials dip less steeply toward the northeast than they do at the latter place. The following analysis, tabulated with one from Madrone Spring, shows that the water of the Coes Spring is the less strongly mineralized and that it is secondary alkaline in character, magnesium being present.

Analyses of water from Madrone and Coes springs, Santa Clara County, Cal.

[Authority, 13th Cal. Constituents are in parts per million.]

	1		2	
Properties of reaction:				
Primary salinity		1		3
Secondary salinity		0		0
Tertiary salinity		0		0
Primary alkalinity		29		8
Secondary alkalinity		70		89
Tertiary alkalinity		12		18
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	217	9.45	56	2.45
Potassium (K)	7.4	.19		
Lithium (Li)	Trace.	Trace.		
Barium (Ba)	1.2	.02		
Strontium (Sr)	Trace.	Trace.		
Calcium (Ca)	380	18.94	90	4.47
Magnesium (Mg)	37	3.04	182	14.94
Iron (Fe)	4.7	.17	21	.74
Aluminum (Al)			Trace.	Trace.
Manganese (Mn)	.8	.03		
Sulphate (SO_4)			27	.57
Chloride (Cl)	14	.40	6.4	.18
Carbonate (CO_3)	940	31.34	649	21.63
Metaborate (BO_2)	Trace.	Trace.		
Phosphate (PO_4)	3.2	.10	7.0	.22
Silica (SiO_2)	108	3.60	97	3.21
	1,713.3		1,135.4	
Carbon dioxide (CO_2)	Present.	Present.	Present.	Present.

1. Madrone Spring. Analyst, G. E. Colby. 2. Coes Spring. Analyst, M. E. Jaffa.

BANES SODA SPRINGS (MONTEREY 7).

Banes Soda Springs are situated on the coast about 6 miles southwest of the Cruikshank mines, in southern Monterey County. Carbonated water issues for a considerable distance along a bluff that here borders the ocean and has deposited notable amounts of lime carbonate. At the main spring a terrace several feet in height has been built by the iron-stained material that has been deposited from solution.

The water apparently derives its contents of calcium and of carbon dioxide from limestone masses that are associated with the other altered sediments along this portion of the coast.

HELMS SODA SPRINGS (MONTEREY 8).

Helms Soda Springs are about 3 miles east of Banes Soda Springs. Their water is strongly carbonated, but the flow is slight, and they have not formed a notable deposit such as is formed at the springs farther west.

GARRETSON SODA SPRINGS (SISKIYOU 1).

Near the northeastern border of the State there are a few carbonated springs along the branches of Beaver Creek, in a region that is composed mainly of altered rocks. Of these, the best known are Garretson Soda Springs, which lie on the northern side of the canyon of West Fork of Beaver Creek, about 500 feet above the stream. The place has been a camping resort for a number of years, and as many as 225 people have been there at one time. In 1909, however, it was reached by 9 miles of trail from the terminus of the wagon road, and few camping accommodations were provided.

There are two carbonated springs on the property. The principal one issues from crevices in mica schist on the side of a ravine 50 yards above Mr. Garretson's cabin. It yields perhaps 1 gallon a minute of cold carbonated water and has been protected by a spring house, beside which there are minor seepages of carbonated water. Other carbonated seepages rise beneath the floor of the spring house and yield nearly as much as the main drinking spring. Considerable iron stains the overflow channel.

The second spring is two-fifths of a mile westward and 50 yards from the bank of a creek that is tributary to the West Fork. The water rises in a board-curbed pool beneath a shed roof. It is about as strongly carbonated as the main spring and has nearly the same flow and temperature. Besides its use for drinking, water from this spring has been conducted in a wooden trough to a small tank 30 yards away and heated for bathing. The water deposits iron at the spring and also seems to contain considerable calcium, for it deposits lime carbonate in the trough and in the heating tank. The spring is locally designated the "salt spring," perhaps on account of its distinctly alkaline taste. Like the other spring, it issues from mica schist, which, however, is here covered with loamy soil. The schist, which is apparently associated with the sedimentary rocks of the region, is mineralized to some extent and has been prospected at a number of places. Half a mile northwest of the second of the Garretson springs two tunnels have been driven about 40 feet into the canyon side on quartz veins. In one of them there is a salt that seems to consist mainly of iron sulphate, associated with pyrite. Quantities of this material have been collected by campers and used for preparing solutions for bathing wounds and even as an eye wash and as a snuff for catarrh. Southward, across the canyon from the springs, there are abandoned quicksilver prospects. The Garretson springs are sometimes referred to as Cinnabar Springs, a name that is derived from these prospects, but this name is misleading.

KELLER SODA SPRING (SISKIYOU 2).

Keller Soda Spring, 4½ miles below Garretson Soda Springs, is on the north side of West Fork of Beaver Creek, 100 yards from and 100 feet above the stream. It is near the home of Mr. Alex. Keller, who has had a cabin and a small garden beside the creek since about 1902. A rock-walled basin makes a small drinking pool in which the water is cool and strongly carbonated. The discharge flows down an iron-stained channel and over a conspicuous deposit of lime carbonate 10 or 12 yards in diameter. A small amount of carbonated water also seeps from crevices in the rock at the creek edge, 150 yards downstream. The rock at this locality is a coarse-textured quartzitic material with some gneissic and hornblendic phases.

CARBONATED SPRINGS AT SODA BAR (SISKIYOU 3).

On the western side of the main fork of Beaver Creek, at Soda Bar, within 3 miles of the Oregon line, are two small cool carbonated springs that have not been improved but are occasionally visited by hunters.

CARBONATED SPRING AT EDGE OF BEAVER CREEK (SISKIYOU 4).

A small carbonated spring rises at the eastern edge of Beaver Creek, opposite the Curtis ranch, which is 2 miles above its mouth. A small basin has been made by drill and hammer in the gneiss from which the spring issues, and a spring house protects it. When it is not flooded by surface water, the spring water is moderately carbonated. The rock is iron stained along the overflow channel, but the water is apparently not highly mineralized. There is another small and unimproved carbonated spring on the same side of the channel a mile farther upstream.

CARBONATED SPRINGS NEAR LITTLE BOGUS CREEK (SISKIYOU 5).

In the western portion of the lava-covered region in northern California there are two areas of considerable extent in which there are a number of carbonated springs. The northern area is in the northern part of Siskiyou County; the southern is near the Siskiyou-Shasta county line. (See p. 220.)

The northernmost group in the first area is on the east side of Little Bogus Creek about 4½ miles northeast of Ager. The main springs here issue from basins in low carbonate mounds on a larger deposit of lime carbonate at the base of a hillside, near the county road between

Ager and Klamath Hot Springs (Siskiyou 7, p. 120). This deposit is about 75 yards in diameter and is built up prominently above the flat that borders the creek. Upon it there are six springs that yield small flows of carbonated saline water. The largest spring forms an oval pool 3 by 6 feet across and 2 feet deep, in which a temperature of 72° was recorded. Its discharge is about 2 gallons a minute. Another pool 10 inches in diameter also yields about the same amount of water, whose temperature is 76°. The other basins are small, of less discharge, and of lower temperatures. There are three other low mounds in this area of lime carbonate. One of these is entirely extinct; the other two have only seepage flows from basins 3 or 4 inches in diameter.

On the hillside about 300 yards northeast of the main carbonate deposit there is a prominent mound which is nearly 100 feet in diameter and 10 feet high on its upper side. A shallow pool 5 feet in diameter that is situated on its top yields perhaps 2 gallons a minute of carbonated saline water 74° in temperature. At the roadside, 50 yards below it, there is another low iron-stained mound from whose top there is a seepage flow of warm water similar to that of the other springs. White deposits on the hillside a short distance northward indicate that carbonated water formerly issued there also.

Material from the deposit that was first described has been used on an adjacent portion of the wagon road, for the carbonate is easily loosened by pick and forms a road material that soon packs to a firm surface.

The water has been used by range stock as a substitute for a salt lick, but it is too warm and too saline to be pleasant for drinking.

Lava, probably basaltic, covers the slopes and forms characteristic flat-topped hills near by. The association of lava with thermal carbonated water that deposits a notable amount of lime carbonate seems to be exceptionally well shown at these springs. Their temperatures have warranted their indication as thermal-carbonated springs on Plate III (in pocket), but they are more noticeably carbonated than thermal. The saline character of the water is also worthy of note.

Marine beds of Cretaceous age have been described by Diller[1] as probably underlying the lava of this region, and it seems probable that the salinity of the springs is derived from these sedimentary beds. This same suggestion was advanced to account for the saline character of Morgan Hot Springs, near Lassen Peak.

[1] Diller, J. S., Tertiary revolution in the topography of the Pacific coast: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, p. 423, 1894.

TABLE ROCK SPRING (SISKIYOU 9).

Three carbonated springs on the northeast side of Shasta Valley may be considered to be in the same general locality as those near Little Bogus Creek. The principal one is on the Terwilliger ranch, 12 miles east of Montague. It is situated a few hundred yards north of Little Shasta River and near the northern base of a flat-topped hill known as Table Rock. During 1909 the water was placed on the market under the label "Table Rock Water."

At this place there is a very low mound of lime carbonate about 100 yards in diameter, from near the center of which the spring rises, mainly from an irregular fissure 12 feet long and 1 inch to 30 inches wide, along which the water is continuously and vigorously bubbling. This fissure has been protected by a concrete wall 2½ feet high. In a bottling house beside it water for bottling has been obtained by a hand pump from a basin or well 1 foot in diameter and 10 feet deep. Near the bottling house there is also a shallow bubbling pond, 8 or 10 yards across. The water is not notably thermal, as it has a temperature of only 65°, but otherwise its occurrence is similar to that of the springs near Little Bogus Creek. It is more strongly carbonated, however, and much less salty, and it probably contains considerable iron, as it deeply stains its overflow channel.

CARBONATED SPRING AT EDGE OF LITTLE SHASTA RIVER (SISKIYOU 8).

Two miles downstream from Table Rock Spring, and half a mile east of Little Shasta post office, strongly carbonated water rises from lava gravel at the southern edge of Little Shasta River, 30 yards north of a low lava bluff. The spring yields about 8 gallons a minute of water, 57° in temperature. It rises clear but is said to become cloudy, probably from a small amount of precipitated iron, after being bottled for a short time. Considerable iron-stained, cemented gravel is exposed in a stream bank 50 to 100 yards above the spring, and indicates that carbonated water formerly issued farther upstream. The spring has been protected by a short piece of heavy galvanized-iron casing, but it is in pasture land some distance from the road and has not been much used.

MARTIN SODA SPRING (SISKIYOU 11).

The third of the carbonated springs near Shasta Valley issues on the ranch of Mrs. M. F. Martin, near the southern base of Table Rock, about a mile southward in a direct line from Table Rock Spring. The Martin spring rises in a cemented basin at the edge of a creek. Its water is clear, cool (55°), and strongly carbonated, but its yield is only about 1 gallon a minute. Like the water of the spring at the edge of Little Shasta River, it is said to become cloudy on standing and it has been used only locally for drinking.

A conical pile of lime carbonate that probably marks an old spring vent rises above a considerable deposit of the same material in a barnyard 75 yards east of the spring, and a few yards above the spring lime-cemented gravel is also exposed along the creek. Neither the Martin Spring nor the one on Little Shasta River is now depositing noticeable amounts of lime carbonate, but the deposit near the first-mentioned spring, and the lime-cemented gravel near each, suggest that they did so at a time when their waters were warmer than they are now.

Besides its location in the lava near Table Rock, the position of Martin Soda Spring is of interest because the stream at whose edge it rises issues in full volume 50 yards upstream from the spring. This stream is mentioned later among the large cold springs. Its position with respect to the carbonated spring may be accidental, but it at least suggests that the cold water found an outlet through old channels of the earlier, presumably thermal, carbonated spring.

SHASTA SPRINGS (SISKIYOU 22).

Nearly all of the carbonated springs in the southern of the two general localities that have been mentioned as lying along the western side of the lava area in northern California are close to Sacramento River. Shasta Springs, which are commercially the most important ones in this locality, are at Shasta Springs station, on the east side of Sacramento River. They were first brought to general notice in 1887, during the construction of the Southern Pacific Railroad along the river, and their commercial development was early begun. A cemented drinking fountain and a spring house have been built over the springs, so their direct source is no longer visible, but the following description of their improvement has been published:[1]

The ground immediately around the springs was cleared and the surface removed to bedrock. * * *

Numerous small springs were discovered in the exposed surface of the bedrock. All of these were carefully closed by the following method: The necks of bottles were broken off and placed over the points of gas and water leakage, and surrounded with cement, so that the gas and water could escape through the bottle necks and allow the cement to harden. After the cement had set, the mouths of the bottle necks were corked and a heavy layer of cement spread over them. The object of this was to force everything into the main fissure.

The main fissure of the Shasta Spring was arched over, with the exception of the principal vent, over which a concrete reservoir was built. This reservoir was divided into two compartments, the front being an open drinking basin for the use of the public, and the rear a hermetically sealed reservoir, the interior dimensions of which are

[1] Watts, W. L., Mineral springs in Siskiyou County: California State Mineralogist Eleventh Rept., pp. 449-450, 1893.

about 3 feet in diameter and 6 feet in height. * * * From this chamber a pipe leads directly to a small structure in which the bottling machinery has been erected. * * *

The following analysis shows that the water is characterized by primary and secondary alkalinity and primary salinity and contains a large proportion of magnesium:

Analysis of water from main spring, Shasta Springs, Siskiyou County, Cal.

[Analyst, W. S. Haines. Authority, 13th Cal. Constituents are in parts per million.]

Temperature	11° C. (51° F.)
Properties of reaction:	
Primary salinity	18
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	23
Secondary alkalinity	59
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Sodium (Na)	447	19.43
Potassium (K)	23	.59
Lithium (Li)	Trace.	Trace.
Calcium (Ca)	Trace.	Trace.
Magnesium (Mg)	349	28.70
Iron (Fe)	10	.36
Aluminum (Al)	2.5	.28
Manganese (Mn)	Trace.	Trace.
Sulphate (SO_4)	8.6	.18
Chloride (Cl)	312	8.79
Bromide (Br) and iodide (I)	Traces.	Traces.
Fluoride (F)	Trace.	Trace.
Carbonate (CO_3)	1,195	39.83
Metaborate (BO_2)	9.9	.23
Arsenate (AsO_4)	1.4	.03
Phosphate (PO_4)	.8	.03
	2,359.2	....
Carbon dioxide (CO_2)	Present.	Present.

The springs issue at the base of the steep canyon side. Eastward, 400 feet above the springs, the country opens to a gentle upward slope northward to Mount Shasta. A summer resort has been established on the plateau-like slope, directly above the springs. The grounds are reached by an inclined railway from the railroad station below, or by a zigzag path two-fifths of a mile long, up the canyon side. Much water rises in cold springs near the top of the canyon and cascades down the slope, near the path.

At the east bank of the river, 200 yards below Shasta Springs, and also on the west bank, 150 yards farther downstream, small carbonated springs have formed iron-stained deposits of lime carbonate. The Griffin onyx marble quarry, which has been mentioned in connection with the deposits at Tolenas and Kessler springs, consists of a vein of onyx marble about 5 inches wide, on the western side of the river a short distance below Shasta Springs. It has not been worked for a number of years.

OXONE SPRING (SISKIYOU 23).

Oxone Spring rises on the plateau-like slope nearly a mile east of the grounds of Shasta Springs resort and a few yards from a small creek channel. It forms a pool 10 feet in diameter and 18 inches deep, in quartz and lava gravel that covers the surface. Much gas continually rises in large bubbles in the pool. It is probably carbon dioxide, for it repeatedly extinguished a lighted newspaper held 14 inches above the open water surface. The spring has been known locally for many years as Poison Spring, for it is said that birds and small animals are occasionally found dead beside it, having probably been overcome by the carbon dioxide. This is probably the spring that has also been referred to as Scott Springs.[1]

The water is very strongly carbonated and has a pungent odor and a "sharp" taste, both of which characteristics are possibly derived from free carbonic acid. The spring has very little overflow directly, but it has been piped to the railroad station and there issues in a spring house 150 yards south of Shasta Springs. It flows quietly into a cement basin, but it there effervesces and tastes nearly as strongly carbonated as it does at the spring.

CASTLE SPRINGS (SISKIYOU 19).

About 300 yards west of Shasta Springs small carbonated springs rise near the southern bank of Sacramento River, which here makes a short eastward bend and then resumes its southerly course. These springs were early known as Castle Springs, and were at one time improved to slight extent as a resort. In 1909, however, the place had evidently been abandoned for many years. Four small carbonated springs were found, 5 to 15 yards apart, within a few yards of the river's edge. The northernmost one of these has a noticeably sulphureted as well as a carbonated taste, but another near it is only pleasantly carbonated. Each of these two springs yields perhaps 2 gallons a minute. The southern two springs have only seeping flows. One of them deposits considerable iron; the other has a strongly carbonated and slightly acidic taste. This is one of the three carbonated springs in the State that was observed to have an acidic taste, the other two being Oxone Spring and one at the southwest edge of Clear Lake. The taste is possibly due to the presence of free carbonic acid.

The springs rise in gravel and soil that border the river, but the bowlders along the stream and the rocks of the canyon side are of lava, probably andesitic, like that near Shasta Springs.

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[1] California State Mineralogist Eleventh Rept., p. 452, 1893.

WARMCASTLE SODA SPRINGS (SISKIYOU 28).

Six miles in a direct line east of Shasta Springs is another group of carbonated springs, known as Warmcastle Soda Springs. The place is $1\frac{3}{4}$ miles south of McCloud lumber mills and was formerly conducted as a resort, but it has been deserted since about 1903. In 1909 a 20-room frame hotel still stood on the grounds.

The principal spring, which is about 125 yards east of the hotel, rises in a concrete, dome-covered basin beneath a spring-house roof, and from a pipe at one side discharges about 10 gallons a minute of cool, strongly carbonated water. A small bubbling pool makes a marshy patch near this spring, and toward the hotel, beside a wagon road, another carbonated spring rises in a box-curbed basin. Its yield is perhaps one-half gallon a minute. Five hundred yards northward, beside a stream that rises from marshy land near by, a fourth carbonated spring issues through a joint of tile pipe and yields perhaps 4 gallons a minute of moderately carbonated water. All four of the carbonated springs deposit small amounts of iron, but they do not seem to be otherwise strongly mineralized. The main spring is much used by travelers along the road, and is also a favorite drinking place for the children from a schoolhouse 200 yards eastward.

The springs rise on the forested plateau surface near the southern base of Mount Shasta. The rock is lava, probably basaltic, which has weathered sufficiently to form red soil over most of the surface, but it is exposed at numerous places along stream channels and road cuts.

There are said to be other carbonated springs that are undeveloped on Bear Creek, which is a number of miles northward from the Warmcastle springs.

UPPER SODA SPRING (SISKIYOU 26).

Upper Soda Spring is three-fourths of a mile northward across Sacramento River from Dunsmuir, at the base of low lava hills, 150 or 200 yards from the river, which here makes a short eastward bend in its southerly course. The spring has been known for perhaps half a century by several names, of which Campbells Soda Spring and Freys Soda Spring are most common. The place has been conducted as a resort for a number of years, and the bottled water has a local market. The water rises in a cement basin in a small house and is thence piped to a bottling house near by, outside of which a faucet has been placed for public use. The water is cool, moderately carbonated, and is apparently not notably mineralized.

CAVE SPRING (SISKIYOU 25).

Cave Spring is near the eastern edge of Sacramento River and about one-half mile north of Upper Soda Spring. It issues from a crevice in the rock at the base of a 25-foot cliff of dark-colored lava, beneath which is the small cave from which the spring takes its name. It has been used only as a drinking spring. Like Upper Soda Spring it is cool and moderately carbonated, but it apparently contains more iron than the former, as it has deeply stained its overflow channel.

TWIN SPRINGS (SISKIYOU 24).

About 200 yards north of Cave Spring two small carbonated springs rise about 4 yards apart in joints of tile pipe. They are known as Twin Springs, and, like Cave Spring, are used only for drinking. The water deposits considerable iron, but it does not seem to be highly mineralized. Like Upper Soda and Cave springs, Twin Springs rise near the base of a low lava bank. The lava is also exposed across the river to the south and northward upstream, but on the western side of the canyon, opposite Twin and Cave springs and for some distance above and below them, light-colored dioritic rock is exposed.[1] This material may have had some influence in furnishing a place of upward escape for the carbonated water.

CASTLE CRAG SPRING (SHASTA 2).

Castle Crag Spring was formerly known as Lower Soda Spring and also as Hibbs Soda Spring, but during recent years the property has been improved as a resort under the name of Castle Crag Farm, and the spring has come to be best known by the newer name. It is situated at the base of a bank near the southern edge of Soda Creek, 5 miles south of Dunsmuir and a mile east of Sacramento River. A number of years ago a stone and concrete spring house was built over the spring, and the water formerly overflowed from a cement basin in its center. When the spring was visited, however, the water stood at about the ground level in this basin but rose vigorously in a small open pool 5 yards away, as if from a break in the supply pipe. The water is strongly carbonated and deposits considerable iron. It is said that it has never been placed on the market but has been used only at the spring. The following analysis shows that it is a strongly alkaline-saline water:

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[1] This rock has been examined microscopically by E. S. Larsen, jr., and found to contain granular augite and secondary hornblende, chlorite, biotite, calcite, and sericite.

Analysis of water from Castle Crag Spring, Shasta County, Cal.

[Analyst, Thomas Price & Son. Authority, Register of Mines, California Min. Bur. Constituents are in parts per million.]

Temperature	12° C. (53° F.)	
Properties of reaction:		
Primary salinity		41
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		21
Secondary alkalinity		38
Tertiary alkalinity		44

Constituents.	By weight.	Reacting values.
Sodium (Na)	1,155	50.20
Potassium (K)	28	.72
Lithium (Li)	.5	.07
Ammonium (NH_4)	15	.83
Barium (Ba)	.7	.01
Calcium (Ca)	207	10.30
Magnesium (Mg)	258	21.20
Iron (Fe)	7.8	.28
Aluminum (Al)	3.6	.40
Manganese (Mn)	.4	.01
Chloride (Cl)	1,198	33.82
Bromide (Br)	.9	.01
Iodide (I)	Trace.	Trace.
Carbonate (CO_3)	1,493	49.77
Metaborate (BO_2)	Trace.	Trace.
Arsenate (AsO_4)	.9	.02
Phosphate (PO_4)	Trace.	Trace.
Silica (SiO_2)	84	2.78
	4,452.8	....
Carbon dioxide (CO_2)	Present.	Present.

The rock that is exposed along the road from the river to a place 350 yards southeast of the spring is dark-colored lava, but at this place a green diabase is exposed, which forms a bank that extends below the road to the spring and for some distance beyond. At the roadside 200 yards southeast of the spring there are also small carbonated seepages from this rock.

CARBONATED SPRING ON SODA CREEK (SHASTA 3).

At the north side of Soda Creek, 1½ miles above Castle Crag Spring, a small carbonated spring issues in a little pool in the stream gravel, between two bowlders of the green diabase, which persists at least this far up the canyon.

The water is clear and moderately carbonated and deposits small amounts of lime carbonate and iron. Along the bank of the creek, about 150 yards below the spring, a lime carbonate deposit is exposed for a few yards.

The spring has not been improved, but it has been visited by picnic parties. It is also used as a roadside drinking spring, as it is only 50 yards from an automobile road that follows the canyon of Soda Creek.

There are said to be other small carbonated springs on a branch of McCloud River several miles eastward.

CASTLE ROCK SPRINGS (SHASTA 4).

Castle Rock Springs rise along the side of Sacramento River 5 miles west of south from Dunsmuir. One spring, which formerly rose in the eastern edge of the river, has been protected by a concrete wall, the ground about it has been filled in, and part of its flow now issues in a cemented drinking basin. The water is pleasantly carbonated and also has a distinct taste and odor of hydrogen sulphide. Bottled water from this spring has been marketed since about 1903. It is pumped by water power to a bottling house at the west side of the river, beside the railroad, and is passed over a series of slate plates to aerate it and thus remove the hydrogen sulphide before bottling. The following analysis shows the water to be primary alkaline saline and secondary alkaline, like that of the other principal springs in the locality:

Analysis of water from main spring, Castle Rock Springs, Shasta County, Cal.

[Analyst, Thomas Price & Son. Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		43
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		23
Secondary alkalinity		34
Tertiary alkalinity		3
Constituents.	**By weight.**	**Reacting values.**
Sodium (Na)	766	33.32
Potassium (K)	16	.41
Lithium (Li)	.1	.02
Barium (Ba)	.3	Trace.
Calcium (Ca)	127	6.34
Magnesium (Mg)	133	10.94
Iron (Fe)	.4	.01
Aluminum (Al)	12	1.35
Manganese (Mn)	.2	.01
Chloride (Cl)	771	21.74
Carbonate (CO_3)	870	29.32
Silica (SiO_2)	49	1.63
	2,745.0	....
Carbon dioxide (CO_2)	Present.	Present.
Hydrogen sulphide (H_2S)	Present.	Present.

Two other carbonated springs are situated on the western edge of the river 100 yards above the main spring. One of these has been protected by a joint of tile pipe and the other by a board curbing. Both are moderately carbonated and have been used as drinking springs.

Castle Rock Springs issue from dark-colored lava, probably basaltic, that here forms the bed of the river as well as its banks and is the extension down the river of a narrow lava flow from Mount Shasta.

This lava overlies slates that probably furnish the saline constituents of the several carbonated springs of the locality.

CARBONATED SPRING NEAR CASTLE CREEK (SHASTA 5).

A small carbonated spring rises near the west edge of Sacramento River about three-fourths of a mile south of Castle Rock Springs and 60 yards below the mouth of Castle Creek. It has been protected by a joint of tile pipe and forms a local drinking spring. Like the main spring at the Castle Rock group, its water tastes distinctly sulphureted as well as carbonated, and hence it is often spoken of as a sulphur spring.

CARBONATED SPRING IN HOT SPRING VALLEY (PLUMAS 2).

A carbonated spring issues in Hot Spring Valley about one-half mile west of Drake Hot Springs (Plumas 4, p. 142) that is of interest both because of its position and its amount of flow. The spring is in meadowland a few yards north of Warner Creek and yields about 8 gallons a minute of moderately carbonated water. It has been protected by a board curb and a log fence, and its water is occasionally used for drinking but is too warm (83°) to be palatable. Bubbles that are probably of carbon dioxide continually rise in the pool, and the water deposits considerable iron, but it does not taste very noticeably mineralized.

CARBONATED SPRING NORTH OF SOUPAN HOT SPRINGS (SHASTA 14).

About 1½ miles north of Soupan Hot Springs (Shasta 15, p. 141) there is a carbonated spring that was used as a drinking spring when the sulphur deposits at those springs were being prospected, but lately it has not been often visited. Like the carbonated spring in Hot Spring Valley (Plumas 2), it is of interest, however, in connection with the hot springs near by, and its presence indicates that much of the bubbling at Soupan Hot Springs and at Bumpass Hot Springs (Shasta 16, p. 140) is caused by carbon dioxide.[1]

CARBONATED SPRINGS ON SPANISH CREEK (PLUMAS 14).

At the north end of the Sierra Nevada, in Plumas County, there are a number of carbonated springs, those best known being beside the road between Quincy and Greenville, where lime carbonate has been extensively deposited at two localities. The southern locality is on the eastern side of the canyon of Spanish Creek, about 10 miles by

[1] A "cold soda lake" is indicated on some early maps of this locality, its position being shown about 1 mile north of Bumpass Hot Springs. Such a lake was not found when the locality was visited in 1910 and was not known to several people who are familiar with the locality. It is possible that conditions have changed since the early maps were made and that the carbonated spring north of Soupan Hot Springs is near the place indicated. The activity at Lassen Peak, beginning May 30, 1914, indicates that the positions of the springs on its slopes have varied in the past.

road northward from Quincy. One small carbonated spring here forms a drinking pool at the upper edge of the road, and 20 yards south of it, below the road, there is a second spring or group of springs. At the latter place three small board-curbed basins have been made, and the discharge was formerly piped to a bathhouse 30 yards farther down a steep slope. When visited in 1909 this house had evidently been unused for a considerable time, and a crumbly layer of lime carbonate one-fourth of an inch thick had been deposited on the floor by the overflow from the bath tub.

The carbonate deposit covers the surface from the springs westward to the creek, a distance of 125 yards down the steep slope, and forms a bluff for an equal distance along the stream. A few other deposits of much smaller extent were observed on the western side of the creek.

CARBONATED SPRINGS ON INDIAN CREEK (PLUMAS 13).

About $1\frac{1}{4}$ miles in a direct line northward from the springs on Spanish Creek that have just been described, carbonated springs issue on the southeastern side of Indian Creek, near a deposit of lime carbonate formed between the road and the creek. This deposit is larger than that at the other locality, for it covers an area of approximately 200 by 400 yards and forms a steep slope for a quarter of a mile along the creek. Plate IX, *B* (p. 134), shows a lower portion of this deposit. The carbonate deposit extends northward parallel to a bend of the creek at this locality and makes a low ridge that slopes northward to the stream. Along the crest of this ridge there are three depressions or sinks, 5 to 30 yards in diameter, in which a hard compact lime carbonate is exposed which resembles that of the "hoodoos" near Mammoth Hot Springs in Yellowstone Park. In the southernmost sink, which is the largest, two mounds of the more common white lime carbonate have been formed, and small pools of carbonated water of seeping flow still exist on their tops. Small veins of calcite and of banded onyx marble were also noticed in the darker, more massive carbonate in this sink. The more recent surficial deposits on the lower slopes are of the usual white carbonate. At the southern edge of the deposit, a few yards below the road, two pools form drinking springs, and the water has also been taken away in bottles for its supposed medicinal value. It is moderately carbonated, but it is too warm and too saline and calcic to be a pleasant drinking water. These pools are about 4 feet apart and are approximately a foot in diameter and a foot deep. When visited they did not overflow and contained only a few inches of water. On bailing out one the other was also emptied, indicating that they are connected underground.

A few small springs were noticed at the northern end of the deposit and also along its western side, bordering the creek, but only two of them had an appreciable flow. Each of these yielded perhaps 1 gallon a minute. One of them issued horizontally, with considerable force, among lime-cemented bowlders at the creek side. The small flow is worthy of remark in connection with the size of the deposit.

The rocks of this region are slates and sandstones, with some quartzitic material, that are very probably of the same series that has been mapped by Diller,[1] 3 or 4 miles westward, and by Turner,[2] 2 or 3 miles southward, as the Calaveras formation, of Carboniferous age.

Although no lava was observed near the springs, the southeastern border of the lava area that surrounds Lassen Peak is only about 10 miles to the west. The massive and hoodoo-like character of the underlying portion of the deposit makes it seem not improbable that the springs were thermal and accomplished most of their work of deposition during or shortly following the eruptions from Lassen Peak, and that they represent one phase of the results of volcanic activity when that mountain was in the making.

ARLINGTON SPRINGS (PLUMAS 12).

There are two carbonated springs near the Arlington Bridge, at the southeastern edge of Indian Valley, 3½ miles in a direct line northwest of the carbonated springs on Indian Creek. One of the Arlington Springs, as they are locally known (though the name Bach Springs has also been applied to them), rises in a barrel at the roadside; the other issues from a short piece of 1-inch pipe, on the gentle hill slope 25 yards to the southeast. Both yield cool, pleasantly carbonated water. The following partial analysis shows the water to be chiefly of secondary alkaline character:

Analysis of water from main spring, Arlington Springs, Plumas County, Cal.

[Analyst, G. E. Colby (1906). Authority, owner of springs. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	10
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	3
Secondary alkalinity	87
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Calcium (Ca), Magnesium (Mg)	235	11.77
Iron (Fe)	Small.	Small.
Sulphate (SO_4)	33	.69
Chloride (Cl)	23	.66
Carbonate (CO_3)	365	12.18
Combined water	100	....
Silica (SiO_2)	Small.	Small.
Total solids	799	....
Carbon dioxide (CO_2)	Present.	Present.

[1] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Lassen Peak folio (No. 15), 1895.
[2] Turner, H. W., U. S. Geol. Survey Geol. Atlas, Downieville folio (No. 37), 1897.

Although iron was not determined quantitatively in the analysis, the water probably contains a relatively large proportion of this element, for it has iron stained the soil in an area perhaps 75 yards in diameter to such an extent that it has been used locally as a paint pigment. Considerable lime carbonate has also been deposited in this area, but it is so deeply iron stained that it is not conspicuous.

CARBONATED SPRING IN HUMBUG VALLEY (PLUMAS 9).

A small carbonated spring rises in Humbug Valley a short distance from the little settlement of Longville. Although the spring is only locally known, its water is much appreciated during the summer, as it is pleasantly carbonated and makes a palatable drinking water. There is said to be another similar spring beside the road between Longville and Keddie station on the Western Pacific Railway.

CARBONATED SPRINGS ON CHIP CREEK (PLUMAS 10).

On Chip Creek, several miles farther south, there are carbonated springs similar to the one in Humbug Valley. As they are not on a main traveled road, they have been seldom visited and have been known only locally.

MOUNT IDA SPRING (BUTTE 3).

Mount Ida Spring is situated about 6 miles east of Oroville, in a wide ravine, at the base of slopes of schistose rock. The analysis below shows that the water is primary saline and secondary alkaline.

Analysis of water from Mount Ida Spring, Butte County, Cal.

[Analyst, G. E. Colby (1892). Authority, 13th Cal. and owner of spring. Constituents are in parts per million.]

Temperature	18° C. (65° F.)
Properties of reaction:	
Primary salinity	62
Secondary salinity	3
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	35
Tertiary alkalinity	94

Constituents.	By weight.	Reacting values.
Sodium (Na)	166	7.23
Potassium (K)	25	.64
Lithium (Li)	Trace.	Trace.
Strontium (Sr)	Trace.	Trace.
Calcium (Ca)	76	3.78
Magnesium (Mg)	14	1.16
Iron (Fe)	5.9	.21
Manganese (Mn)	Trace.	Trace.
Sulphate (SO_4)	279	5.80
Chloride (Cl)	88	2.49
Carbonate (CO_3)	138	4.60
Metaborate (BO_2)	Trace.	Trace.
Phosphate (PO_4)	4.1	.13
Silica (SiO_2)	35	1.17
	831.0	....
Carbon dioxide (CO_2)	233	10.59

The spring was well known to the Indians and later to white settlers, and formerly supplied a small drinking pool. As this pool easily became roiled, however, a number of years ago a shaft was sunk 13 feet deep to bedrock at the spring, and a joint of pipe was cemented into the fissure from which the water came. The water rises in this pipe to the surface clear and fresh and is used locally as a table water. It was at one time bottled at the Oroville soda works.

SUMMIT SODA SPRINGS (PLACER 5).

A number of groups of small carbonated springs lie in the Sierra west of Lake Tahoe. One of the northernmost of these groups has long been known as Summit Soda Springs, although the springs are about 13 miles by road south of Summit station, on the Southern Pacific Railroad. The springs are situated in a little flat beside North Fork of American River, and in the late eighties or early nineties a hotel was built, and the place was conducted as a resort for several years. The hotel burned in 1898, however, and since then the property has not been open to the public.

Four cool carbonated springs rise in the flat on the south side of North Fork, and a fifth rises at the edge of the stream. Three of them have been inclosed by spring houses and are used as drinking springs. All have small flows, but they are strongly carbonated and deposit noticeable amounts of iron. The following analyses of one of the principal springs shows the water to be moderately alkaline and saline:

Analyses of water from main spring, Summit Soda Springs, Placer County, Cal.

[Constituents are in parts per million.]

	1		2	
Properties of reaction:				
Primary salinity		34		36
Secondary salinity		0		0
Tertiary salinity		0		0
Primary alkalinity		13		14
Secondary alkalinity		53		50
Tertiary alkalinity		328		339
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	238	10.34	248	10.76
Potassium (K)	8.0	.20	Trace.	Trace.
Calcium (Ca)	210	10.48	183	9.14
Magnesium (Mg)	20	1.64	21	1.73
Iron (Fe)	22	.79	23	.82
Aluminum (Al)	10	1.11	16	1.77
Chloride (Cl)	272	7.69	272	7.69
Carbonate (CO_3)	201	15.76	143	13.94
Metaborate (BO_2)	Trace.	Trace.	....	....
Silica (SiO_2)	33	1.09	35	1.16
	1,014	....	941	....
Carbon dioxide (CO_2)	1,593	72.41	1,586	72.09

1. Analyst and authority, Winslow Anderson (1888).
2. Analyst, J. F. Rudolph (1878). Authority, U. S. Geol. Survey Bull. 32.

On the hillside 200 to 500 yards southward, there are four other carbonated springs which have been developed only to the extent of excavating small basins about them.

The main springs issue in an area of granitic rock; the minor ones, on the hillside to the southeast, issue from schists that are a result of contact metamorphism between the granitic rock and slates. A mile southward the slopes are covered with andesitic lava, and Tinker Knob, 3 miles to the east, is a volcanic mountain.[1]

Near the road, 2 miles westward, downstream from the Summit springs, there are considerable deposits of lime carbonate, and small quantities of carbonated water still seep from a few points. North of the railroad, on the wagon road to Truckee, there are also carbonate deposits that are the work of mineral springs.

FLORENCE SPRING (PLACER 6).

A quarter of a mile northeast of Summit Soda Springs, on the northern side of the stream, there is a carbonated spring that is locally called Florence Spring. It has a considerably larger flow than the springs of the Summit group and is not so strongly carbonated, but it tastes of iron and deposits much iron along its overflow channel. The spring has not been improved, but it has been used to some extent for drinking.

HEATH SODA SPRINGS (PLACER 4).

Carbonated springs, known as Heath Soda Springs, issue on the north side of the canyon of North Fork of American River, 5 miles in a direct line west of Summit Soda Springs. They yield considerably more water than the Summit Springs but are not so strongly carbonated. They have not been improved, and as the place is not easily accessible it is rarely visited. The springs issue in an area of granitic rock, within a quarter of a mile of the western border of an area of altered slates. Andesitic lava covers the slopes 2 miles northward and westward.

CARBONATED SPRING NEAR SERENO CREEK (PLACER 3).

About 3½ miles south of Soda Springs station, a short distance east of the road, is a small carbonated spring that forms a drinking pool. It is on the eastern side of the canyon of Sereno Creek, near the base of steep slopes of andesite overlying rhyolitic lava.

DEER PARK SPRINGS (PLACER 7).

In the canyon of Bear Creek, 8 miles in a direct line southeast of Summit Soda Springs, four small springs form drinking pools of cool, mildly carbonated water that deposits considerable iron. They were

[1] A detailed description of the geology of this region is given by Waldemar Lindgren, U. S. Geol. Survey Geol. Atlas, Truckee folio (No. 39), p. 5, 1897.

formerly known as Scott Springs but are now known as Deer Park Springs. The place has been conducted as a resort since the eighties. In 1909 a hotel, a dining hall, and seven cottages provided accommodations for 150 guests. The buildings are situated in a little flat on the northwestern side of Bear Creek, and the springs are on a hillside 150 to 200 yards eastward, across the stream. Small rustic houses have been erected over the springs, two of which are beneath one roof. Two of them are known as Soda springs, one as the Sulphur Spring, and one as the Iron Spring. Their waters have the distinctive tastes indicated by these designations and differ somewhat though not markedly in composition, as is shown by the following analyses of three of them, all secondary alkaline, primary saline waters.

Analyses of water from Deer Park Springs, Placer County, Cal.

[Analyst, G. E. Colby (1909). Authority, owner of springs. Constituents are in parts per million.]

	Soda No. 1.		Soda No. 2.		Sulphur.	
Properties of reaction:						
Primary salinity		33		19		31
Secondary salinity		0		0		0
Tertiary salinity		0		0		0
Primary alkalinity		13		13		13
Secondary alkalinity		54		68		56
Tertiary alkalinity		17		7		17
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Calcium (Ca) } Magnesium (Mg) }	160	7.99	205	10.29	114	5.69
Sulphate (SO_4)	174	3.62	84	1.75	111	2.31
Chloride (Cl)	45	1.27	39	1.09	32	.89
Carbonate (CO_3)	297	9.90	367	12.23	210	6.99
Silica (SiO_2)	76	2.52	31	1.03	53	1.76
Total solids	990	....	900	....	670	....
Carbon dioxide (CO_2)	Present.	Present.	Present.	Present.	Present.	Present.
Hydrogen sulphide (H_2S)	....	....	....	....	Present.	Present.

The springs rise in a small area of granitic rock which probably forms the core of the mountains to the west. At the springs the rock is decomposed to gravel and to kaolin-like clay. It is nearly surrounded by andesitic lava, which covers the slopes less than 100 yards east of the springs and the surrounding area for several miles.

CARBONATED SPRING NEAR MOUTH OF POWDERHORN CREEK (PLACER 11).

A small cool carbonated spring lies near the mouth of Powderhorn Creek, 5½ miles in a direct line southwest of Deer Park Springs, but it is unimproved and is known mainly to hunters and fishermen. Small carbonated springs of similar character probably issue at other places in this region, but they are of little note and are known chiefly to the local sportsmen.

RUBICON SPRINGS (ELDORADO 3).

Rubicon Springs form one of the oldest places of resort in the Lake Tahoe region, as they were visited in the sixties, when there was only a pack trail leading to them. The springs are in a little flat on the east side of Rubicon River, 12 miles by road westward from Lake Tahoe. In 1909 there was a small hotel and three log cabins on the property, and the place was open to guests during the summer months. A rustic spring house has been built over the principal spring, which rises at the base of a low granitic hummock or ridge at the edge of the flat. Like most other carbonated springs it is of small flow, the yield being only about half a gallon a minute. The water is cool, strongly carbonated, and is much prized for drinking. It tastes noticeably of iron and has deposited considerable iron along its overflow channel. As the following analysis shows, it is a primary and secondary alkaline water:

Analysis of water from main Rubicon Springs, Eldorado County, Cal.

[Analyst, N. E. Wilson. Authority, owner of springs. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		3
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		40
Secondary alkalinity		57
Tertiary alkalinity		2
Constituents.	**By weight.**	**Reacting values.**
Sodium (Na)	1,213	52.75
Lithium (Li)	Trace.	Trace.
Calcium (Ca)	726	36.21
Magnesium (Mg)	397	32.65
Iron (Fe) } Aluminum (Al) }	13	.47
Sulphate (SO_4)	24	.51
Chloride (Cl)	129	3.65
Carbonate (CO_3)	3,523	117.45
Silica (SiO_2)	84	2.77
	6,109	....
Carbon dioxide (CO_2)	Present.	Present.

Attempts to bottle the water on a small scale have been unsuccessful because many of the bottles were broken by the carbon dioxide and others were so stained by iron as to injure the sale.

About 100 yards north of the main spring, along the border of the granitic outcrop, a carbonated spring that yields perhaps twice as much water, rises in a rock-walled basin and is used to some extent for drinking. About 200 yards farther north, downstream, another small carbonated spring issues at the base of a pine tree near the river, but it has not been improved. A fourth carbonated spring, which has been known as Potter Spring, is three-quarters of a mile south of Rubicon Springs, at the southern edge of the meadow along the river. It issues from a crevice in massive granitic rock, 15 feet above the level of the meadow, and like the other springs it is strongly carbonated and has deeply iron stained its channel, but its yield is very small, being perhaps one-eighth of a gallon a minute. There is another seeping flow, of little importance, 50 yards northeast of Potter Spring, at the edge of the meadow.

For some distance south of this meadow the river flows northward toward it through a small, rocky gorge, in which, 100 yards above Potter Spring, there is a pothole in the massive granitic rock. A small amount of carbonated water apparently rises in this basin from a crevice beneath the rounded bowlder that it still contains, for the water in the pothole is rendered turbid by iron in suspension.

The distinctly ferruginous character of the water at Rubicon Springs is noteworthy in connection with the fact that they are surrounded for several miles by the massive iron-bearing granitic rock that is classed as a granodiorite.[1] The slopes on each side of the river are largely devoid of soil and present an unusually good example of the granitic slopes of the Sierra.

WENTWORTH SPRINGS (ELDORADO 2).

Wentworth Springs are 5 miles in a direct line (8 miles by road) westward from Rubicon Springs in a small area of open land near Gerle Creek. The property was at one time claimed by a settler, and in 1909 a house still stood in the flat, but for several years the place has been only a small campers' resort. It has been visited mainly by people from Auburn and other towns to the west.

At this locality two groups of small springs issue along a small wash that is tributary to Gerle Creek. At the lower group six natural basins in an outcrop of schistose rock receive seeping flows of carbonated water from crevices in the rock. Two of the basins—those chiefly used—have been protected by a fence railing and a board roof. The water in one of them is distinctly sulphureted, and all apparently contain considerable amounts but different proportions of salts in solution, as they differ noticeably from each other in taste. Chemical examination of water from the principal spring has shown the presence of abundant sodium, calcium, and magnesium and chloride and carbonate, as well as notable amounts of carbon dioxide and hydrogen sulphide. About 250 to 300 yards eastward, up the creek, eight other carbonated seepages discharge to small basins, in two of which sections of tile pipe have been sunk so as to form drinking pools. All of the springs of this group deposit considerable iron and noticeable amounts of lime carbonate. Like the lower springs they issue from schistose rock that is the result of contact

[1] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Truckee folio (No. 39), 1897.

metamorphism between the granitic rock on the east and the slate that is exposed for a couple of miles westward.

GLEN ALPINE SPRINGS (ELDORADO 4).

Glen Alpine Springs are reached by road 7 miles southward from Tallac, a resort at the south end of Lake Tahoe. The springs are said to have been discovered in 1867 by Mr. N. Gilmore, hence the place is sometimes known as Gilmores Glen Alpine Springs. The property has been conducted as a mountain resort since the eighties. In 1909 accommodations for 100 guests were provided in cottages and tents that were grouped beside Glen Alpine Creek, in a little flat that is bordered by steep, rocky slopes.

The main spring rises near the center of the flat, in a protecting spring house, and forms a convenient and valued drinking place. The water is cold and strongly carbonated and deposits some iron along its overflow channel. The following analysis shows it to be an alkaline water, with a rather high content of iron and aluminum:

Analysis of water from main spring, Glen Alpine Springs, Eldorado County, Cal.

[Analyst and authority, Winslow Anderson (1888). Constituents are in parts per million.]

Temperature	4° C. (40° F.)	
Properties of reaction:		
Primary salinity		19
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		26
Secondary alkalinity		55
Tertiary alkalinity		150

Constituents.	By weight.	Reacting values.
Sodium (Na)	382	16.61
Potassium (K)	Trace.	Trace.
Calcium (Ca)	329	16.44
Magnesium (Mg)	49	4.04
Iron (Fe)	15	.53
Aluminum (Al)	13	1.44
Sulphate (SO_4)	49	1.03
Chloride (Cl)	214	6.03
Carbonate (CO_3)	917	30.56
Metaborate (BO_2)	Trace.	Trace.
Silica (SiO_2)	43	1.42
	2,011	....
Carbon dioxide (CO_2)	1,177	53.50

The water was bottled in small amount for one or two summers, but it was not found suitable for the purpose, possibly because of the iron content.

Another carbonated spring, that is of somewhat greater flow than the main one, rises beside the spring house, but it has not been improved. Both it and the main spring apparently issue from a crevice in the granitic rock beneath the shallow alluvium of the flat. Seepages in the creek bed 150 yards eastward have iron stained the stream gravel, and carbonated water probably rises at that place also.

The springs rise near the eastern border of a small area of granitic rock in a rather complex region consisting of an igneous bedrock series that contains detached masses of slate and its accompanying schistose metamorphic phases.[1]

LAMBERT SODA SPRINGS (TUOLUMNE 1).

In the central part of the Sierra, near the crest of the range and about 100 miles south of the Lake Tahoe region, there is another region in which a number of carbonated springs rise. The northernmost of these that are worthy of note are the Lambert Soda Springs, near Tuolumne River, about 25 miles by trail and road northeast from Yosemite Valley.

The springs rise at the northern edge of Tuolumne Meadows, about 125 yards north of the river's edge, at the upper border of a grassy slope. There is only one spring of appreciable flow, but water bubbles from numerous vents near by. The spring rises in a funnel-shaped pool about 14 inches in diameter in a little log cabin that protects it. In August, 1909, it yielded about 1 gallon a minute, but its discharge is said to vary somewhat. The water is clear, strongly carbonated, and effervescing, but considerable iron is deposited in the pool. Within the cabin there are also two small vents of inappreciable discharge marked by bubbling. Six other similar pools, a few inches in diameter, lie on a low mound of iron-stained lime carbonate beside the cabin, and another group of eight small pools is located 15 to 25 yards northeast of the cabin. The water in all of the pools is carbonated, and small amounts of iron and of lime carbonate are deposited at nearly all of them. Efflorescent soda salts also appear in the adjoining grassy land. The following analysis shows the water to be primary and secondary alkaline in character:

Analysis of water from main spring, Lambert Soda Springs, Tuolumne County, Cal.

[Analyst and authority, F. M. Eaton (1909). Constituents are in parts per million.]

Temperature	8° C. (47° F.)	
Properties of reaction:		
Primary salinity		11
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		36
Secondary alkalinity		53
Tertiary alkalinity		7
Constituents.	**By weight.**	**Reacting values.**
Sodium (Na)	229	9.96
Potassium (K)	5.3	.14
Calcium (Ca)	196	9.81
Magnesium (Mg)	20	1.64
Iron (Fe), Aluminum (Al)	6.2	.22
Sulphate (SO_4)	24	.49
Chloride (Cl)	66	1.87
Carbonate (CO_3)	564	18.80
Silica (SiO_2)	58	1.93
	1,168.5	....
Carbon dioxide (CO_2)	Present.	Present.

[1] The rocks of this region have been described and mapped by Waldemar Lindgren, U. S. Geol. Survey Geol. Atlas, Pyramid Peak folio (No. 31), 1896.

The springs have been used mainly for drinking by campers and travelers through this portion of the mountains, but they form one of the best-known groups of carbonated springs in the Sierra. The water has occasionally been used in making biscuits without the use of baking powder, as the carbon dioxide in the water serves to lighten them.

The region is one of massive granitic rock, where domes and sharp spires are common weathering forms of the coarse-textured material.

CARBONATED SPRING AT HEAD OF AGNEW MEADOWS (MADERA 3).

A number of small carbonated springs are situated in the drainage basin of the northern branches of San Joaquin River, which lies southward across the divide from the headwaters of Tuolumne River. The springs are rather isolated from one another, but several of them are near trails through this rugged section of the mountains and are becoming well known as drinking springs to the rapidly increasing number of people who appreciate the grandeur of the high Sierra and visit them during the summer.

At the northern end of Agnew Meadows, about 20 miles in a direct line (or 28 miles by road and trail) southeast from Lambert Soda Springs, there is a low, iron-stained mound of lime carbonate near some prospect dumps. Very little water issues here now, but the alkaline deposits are said to be used by deer as a salt lick.

CARBONATED SPRING NEAR PUMICE FLAT (MADERA 4).

A carbonated spring that is often visited by travelers is situated about 4½ miles by trail southward from the spring at the head of Agnew Meadows and one-fifth of a mile from the main trail in Pumice Flat, northwestward up the eastern side of Middle Fork of San Joaquin River. A cool, rather stagnant pool, a yard in diameter, lies 30 yards from the stream, on a gentle slope that is covered with pumice gravel. Across the stream there is a bluff of dark lava agglomerate. The water is strongly carbonated, and considerable iron is deposited along its seepage overflow. Near the river's edge, 50 or 75 yards westward, there are several small pools that are slightly carbonated, but they seem to be supplied mainly by seepage water from the river. There is said to be another small carbonated spring a quarter of a mile farther upstream, however.

CARBONATED SPRING ON MINARET CREEK (MADERA 2).

A small but strongly carbonated spring lies in the canyon of Minaret Creek, about 5 miles westward by trail from the spring near Pumice Flat. In 1909 a well-traveled trail had not been opened along Minaret Creek, however, and the spring had been seldom visited.

CARBONATED SPRINGS IN SODA SPRING FLAT (MADERA 5).

Two miles south of the spring near Pumice Flat is a meadow known as Soda Spring Flat, which is a favorite camping place with fishermen because of its nearness to the river and the good camping facilities that it affords. On its western side, at the bank of a creek that joins the river a short distance farther down, there is a small carbonated spring that is well known to campers. It yields perhaps 2 gallons a minute of cool, strongly carbonated water. A small pool 12 yards farther downstream yields a seeping flow of distinctly carbonated water. About the same distance northwestward, upstream from the main spring, there is another small pool of slightly carbonated water. Two other larger pools, that are sunk below the turf of the meadow and are 100 and 150 yards northward from the main spring, also contain distinctly carbonated water, and the gravel in them is stained with iron.

The waters in the upper two of the small pools issue from soil and gravel along the stream bank, but that in the lower one issues directly from a bank of columnar lava that is exposed for some distance along the canyon, beneath higher slopes of granitic rock. The columnar character of the lava is exceptionally well shown half a mile south of the springs, at the Devils Post Pile, where it forms a bluff.

The association of the carbonated springs with lava was referred to in the description of Reds Meadows Hot Springs (Madera 6, p. 55), which are about 1¼ miles southeast of Soda Spring Flat. The association is worthy of mention again here, although the same close relation of lava to the existence of carbonated springs was not observed at all of the carbonated springs in the high Sierra.

CARBONATED SPRING IN FISH VALLEY (FRESNO 1).

At the eastern end of Fish Valley, 7 miles in a direct line (nearly 11 miles by trail) southward from Soda Spring Flat, a carbonated spring forms a pool 2½ feet in diameter about 20 yards east of the trail and 4 yards east of a large pine tree at the base of a granitic knoll. The water is cool, strongly carbonated, and deposits some iron, but there is only a seeping flow. A small amount of lime carbonate has been deposited around the basin, and 25 yards eastward on the side of the knoll there is a low mound of the material 10 yards across. No water now issues from the mound, but it was evidently deposited at a former outlet of the spring. The rock of this region is massive granite and forms a cliff south of the spring that compares favorably in height with the lesser cliffs of Yosemite Valley.

CARBONATED SPRINGS ON MIDDLE FORK OF SAN JOAQUIN RIVER (MADERA 10).

A number of iron-stained lime carbonate deposits and carbonated seeping springs are situated on the north side of Middle Fork of San Joaquin River above the mouth of Cargyle Creek, 7 miles westward, downstream from the spring in Fish Valley and 3 miles above the Miller Bridge. They are in a steep portion of the canyon, however, and are difficult to reach, so that they have been seldom visited.

CARBONATED SPRING ON NORTH FORK OF SAN JOAQUIN RIVER (MADERA 9).

Near Sheep Crossing, 2½ miles in a direct line northwest of the carbonated springs on Middle Fork of San Joaquin River, a short distance below the bridge that here crosses North Fork of the San Joaquin, on the western side of the stream and on the trail southwestward from Reds Meadows, is a spring that, like the others, is cool and strongly charged with carbon dioxide. Lava forms a prominent volcanic terrace along the eastern side of the stream and again suggests a relation between lava and carbonated water.

CARBONATED SPRINGS ON EAST FORK OF GRANITE CREEK (MADERA 7).

East Fork of Granite Creek is 3 or 4 miles west of North Fork of San Joaquin River and flows southward nearly parallel with it. A trail from the south follows up the northern part of the creek and thence swings westward across Isberg Pass and northward to Yosemite Valley. Near the head of the creek is Sadlier Lake, at which a small meadow affords good camp grounds. On the western side of the creek, between it and the trail, small carbonated springs issue at two places that are respectively three-fourths mile and 1½ miles south of the lake.

The upper spring issues from a crevice in massive granitic rock, 20 yards west of the creek. Its water is strongly carbonated and a noticeable film—probably of lime carbonate—forms on a small pool below the crevice. The rock surface over which the water flows is iron-stained, and considerable areas of rock higher up the slopes are conspicuously stained, as if by the same means at a former period of greater spring flow.

At the lower place the spring rises among the bowlders and gravel of a small stream course, 15 yards east of the trail. The water apparently issues from four small vents and forms a shallow pool over whose surface a white filmy crust, probably of lime carbonate, collects.

Like that of the upper spring, the water is strongly carbonated and has deeply iron stained its channel, but the flow is small.

CARBONATED SPRING NEAR FOERSTER PEAK (MADERA 1).

A small carbonated spring rises near the southeastern base of Foerster Peak, about 3½ miles in a direct line northward from Sadlier Lake. It is not near a main trail, however, and has been seldom visited.

CARBONATED SPRING NEAR BREEZE LAKE (MADERA 8).

Near the northwest side of Breeze Lake, which is about 7 miles in a direct line southwest of Sadlier Lake, there is a small spring of cool carbonated water. It is occasionally visited, as it is less than half a mile from a trail through this part of the mountains. Many other cool carbonated springs of similar character are scattered through the high Sierra, but they are not generally known nor of particular interest.

COBURN SODA SPRING (TULARE 9).

In the southern part of the Sierra, along the branches of Tule and Kern rivers, are many carbonated springs, a few of which lie near roads or trails and have become known and used as drinking springs. Probably the best-known spring in this region is the one situated at Springville, 18 miles north of east from Portersville, in a lumber yard on the property of Mr. A. M. Coburn, on the north side of North Fork of Tule River, 15 yards from the stream. The spring rises in a cement basin beneath a shed roof. It forms a greatly prized drinking spring, though the water is rather warm (68°). Much gas continually rises with the water, which is moderately carbonated and stains its run-off channel with iron. The following analysis shows that it is a rather strongly mineralized water, secondary alkaline and primary saline in character:

Analysis of water from Coburn Soda Spring, Tulare County, Cal.

[Analyst and authority, C. H. Stone (1906). Constituents are in parts per million.]

Temperature	20° C. (68° F.)	
Properties of reaction:		
Primary salinity		48
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		16
Secondary alkalinity		36
Tertiary alkalinity		10
Constituents.	**By weight.**	**Reacting values.**
Sodium (Na)	539	23.43
Potassium (K)	19	.49
Calcium (Ca)	179	8.94
Magnesium (Mg)	52	4.25
Iron (Fe) } Aluminum (Al) }	13	.48
Sulphate (SO_4)	21	.45
Nitrate (NO_3)	0	.00
Chloride (Cl)	618	17.45
Carbonate (CO_3)	618	20.60
Silica (SiO_2)	76	2.50
	2,135	....
Carbon dioxide (CO_2)	Present.	Present.

In 1909 the water had not been placed on the market.

The country rock of the region is granitic. The spring rises from a fissure in this rock, which was exposed when the bowldery gravel was cleared away, before constructing the present basin. Part of the fissure was closed by cement, in order to confine all of the discharge to one outlet.

CARBONATED SPRING ON MIDDLE FORK OF TULE RIVER (TULARE 10).

On the northern side of Middle Fork of Tule River, about 6 miles east of Springville and 1½ miles below the junction of the two main branches of the Middle Fork, is a small carbonated spring, to which a trail has been worn down the slope from the road a quarter of a mile above. The spring forms a small pool beneath a granitic bowlder 20 feet above the stream. Besides being moderately carbonated, the water tastes faintly of hydrogen sulphide. A considerable deposit, which is deeply iron stained, has been formed at the spring, and iron and a small amount of lime carbonate are also deposited along the overflow channel.

DOYLE SODA SPRINGS (TULARE 4).

Doyle Soda Springs are on North Fork of Middle Fork of Tule River, 13 miles northeast of Springville. A flat on the west side of the stream furnishes a good camping ground, and the place has long been used as a camping resort.

Two springs, each of which yields about 1 gallon a minute of moderately carbonated water, form pools 2 or 3 feet across, beside a gneissic bowlder near the western bank of the stream, within 15 yards of the water's edge. A third spring, nearer the stream, issues from a crevice in granitic gneiss. Its water is strongly carbonated and spurts out intermittently from the rock. There is considerable iron stain near the spring vents. A small amount of carbonate of lime or magnesia is also deposited by the spray from the main springs, but the water is probably not highly mineralized. All of the carbonated water probably issues from the gneiss, which seems to form a belt in the granitic rock.

CARBONATED SPRING ON SOUTH FORK OF MIDDLE FORK OF TULE RIVER (TULARE 11).

A carbonated spring of unusually large flow rises on the northern side of South Fork of Middle Fork of Tule River about 2 miles above its junction with North Fork of Middle Fork. The yield of this spring was estimated at about 25 gallons a minute. The water is warm (77°), strongly carbonated, and tastes faintly sweetish, probably of iron. A deposit of lime carbonate that is much iron stained extends to the river's edge, which is normally about 5 yards away.

A. JACKSON VALLEY MUD SPRINGS, MENDOCINO COUNTY.
White patches are fog, not vapor from springs.

B. GRIZZLY SPRINGS, LAKE COUNTY.

C. NELSON SODA SPRINGS, TULARE COUNTY.

Although a number of other carbonated springs in this region are also above a normal temperature, the unusually high temperature of this spring is especially worthy of note, and it is therefore indicated on Plate III (in pocket) as a thermal carbonated spring. The spring rises near the trail at the stream crossing, so it is used to some extent for drinking. The rock near it, as elsewhere along the canyon, is granitic.

CARBONATED SPRING ON SODA CREEK (TULARE 12).

About 1½ miles above the spring just described (Tulare 11) there is a carbonated spring on Soda Creek 150 yards above the trail. The spring issues among granitic bowlders at the eastern side of the stream channel. Like the springs farther downstream, it is strongly carbonated, tastes sweetish, and deposits iron, but a noticeable amount of lime carbonate was not seen. The spring is visited to some extent for drinking water.

NELSON SODA SPRINGS (TULARE 13).

Nelson Soda Springs, or Camp Nelson, as the place is better known, is a mountain resort 15 miles east of Springville and near South Fork of Middle Fork of Tule River, also called the East Fork of Middle Fork.

Four carbonated springs rise on the property. The lowest spring is on the southern bank of the stream, one-quarter of a mile west of south from the resort. It issues beneath an overhanging bank, in a small natural grotto of lime carbonate (Pl. XIII, *C*) and flows over an iron-stained terrace of the same material. The spring yields approximately 8 gallons a minute of strongly carbonated water, but it is too warm (69°) to be palatable. A second spring rises one-third of a mile southeast of the resort about 50 feet above and 50 yards from the north side of the river. It forms a small, rock-walled pool that yields about 4 gallons a minute of carbonated water 63° in temperature. It has deposited only a small amount of lime carbonate, but it has deeply iron stained its run-off channel. About 75 yards east of the spring just described another carbonated spring of nearly the same discharge issues on a low bank near the river in a deposit of lime carbonate that borders the stream for 200 yards. Two-fifths of a mile farther east a fourth spring rises in a little meadow. It yields about 8 gallons a minute of effervescing carbonated water that is fairly cool (62°) and is the most palatable of the four.

The springs rise in a region of granitic rock, but on the slopes above them are ledges of limestone that may account for the apparent high amount of calcium in their waters.

Limestone appears, possibly as included masses in the granitic rock, at a number of other places in this part of the Sierra. Although its outcrops were not observed to be so closely associated with the other carbonated springs as they are at Nelson Soda Springs, it seems plausible that masses which are not exposed furnish the calcium and carbonate constituents of some of the numerous other carbonated springs in the Sierra. There are many seeping carbonated springs and deposits of lime carbonate along the banks of the South Fork of Middle Fork of Tule River, but all the noteworthy carbonated springs are believed to be mentioned in the preceding descriptions.

TULE RIVER SODA SPRING (TULARE 15).

There is a carbonated spring on the Tule Indian Reservation, 16 miles east of Portersville, that is known as Tule River Soda Spring. It is situated about 200 yards southwest of an old schoolhouse, at the north edge of South Fork of Tule River. It is submerged during periods of high water, but in the summer it forms a drinking spring that has been occasionally resorted to by picnic parties. The spring issues beneath a large granitic bowlder, from crevices in gneiss that is similar to the rock at Doyle Soda Springs. The main spring rises in a rock-walled basin 2 feet square, but a number of vents in the gravel beside it are marked by bubbling. The water is moderately carbonated and deposits considerable iron.

CARBONATED SPRING NEAR MOUNTAINEER CREEK (TULARE 5).

A small carbonated spring issues on rocky slopes near Mountaineer Creek, close to its junction with Peck Creek, about 25 miles by trail northeast of Springville. It is not easily accessible, however, and has not been often visited.

CARBONATED SPRING IN LLOYD MEADOWS (TULARE 14).

A cool carbonated spring in Lloyd Meadows, about 9 miles by trail east of Nelsons, is well known to campers and fishermen in that part of the Kern River region and is used as a drinking spring, but like other springs in the Sierra, the yield of water is not large.

CARBONATED SPRING NEAR NORTH FORK OF KERN RIVER (TULARE 3).

North Fork of Kern River flows in a deep canyon that widens to a walled valley in which is a spring that, probably because of the character of the valley, has been referred to as Little Yosemite Soda Spring.[1] The spring is about 2¼ miles north of a small lake, known as Kern Lake, and 100 yards west of the river, at the lower edge of a meadow. The water rises in a rock-walled pool 3 feet below the normal ground surface, at the base of a bank in the meadow soil. It is cool (51°), strongly carbonated, and deposits considerable iron. The following analysis shows that the water contains only a very

[1] Wheeler, G. M., U. S. Geog. Surveys W. 100th Mer. Ann. Rept., 1876, p. 195.

moderate amount of solids in solution, being essentially primary and secondary alkaline in character:

Analysis of water from carbonated spring near North Fork of Kern River, Tulare County, Cal.

[Analyst, Oscar Loew (1876). Authority, Wheeler report. Constituents are in parts per million.]

Temperature	11° C. (52° F.)
Properties of reaction:	
Primary salinity	10
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	50
Secondary alkalinity	40
Tertiary alkalinity	32

Constituents.	By weight.	Reacting values.
Sodium (Na)	109	4.76
Calcium (Ca)	64	3.20
Iron (Fe)	4.5	.16
Sulphate (SO_4)	Trace.	Trace.
Chloride (Cl)	28	.80
Carbonate (CO_3)	220	7.32
Silica (SiO_2)	73	2.42
	498.5	....
Carbon dioxide (CO_2)	Excess.	....

The rock of the valley sides is mainly granitic, the spring probably rising from the granitic bedrock that underlies the stream gravel and meadow alluvium. A mile northeastward, along Golden Trout Creek, are cliffs of lava, and 2½ miles in a direct line northeastward, at Natural Bridge, there is a large deposit of lime carbonate which has been referred to in the description of Jordan Hot Springs (Tulare 7, p. 53). It may be that the carbonated water of the present isolated spring in the valley bears some relation to the former carbonated springs at Natural Bridge, 1,600 feet higher, but the relation is not apparent. A fault that is considered to extend along this part of the course of Kern River may, however, have determined the point at which the carbonated water now issues.

CARBONATED SPRING IN UPPER FUNSTON MEADOW (TULARE 1).

In Upper Funston Meadow, about 13 miles by trail northward from Kern Lake, on a plateau lying between two branches of Kern River, a small spring furnishes cool, moderately carbonated water, and seems to be similar in character to the one near Kern Lake. It is known to campers and cattlemen in the region.

CARBONATED SPRING NEAR QUINN HORSECAMP (TULARE 2).

Quinn Horsecamp is about 9 miles in a direct line west of Kern Lake but 16 miles by trail over Coyote Pass. Near Soda Creek, which heads near the camp, there is a carbonated spring of considerable flow that is known to travelers over the trails in this region.

CARBONATED SPRINGS IN MONACHE MEADOWS (TULARE 8).

Carbonated springs rise in Monache Meadows, near South Fork of Kern River, about 14 miles by trail southwest of Olancha—a small settlement at the eastern base of the Sierra. Several trails enter these meadows, so the springs are well known to travelers through this part of the mountains, though the water is too warm to be pleasant for drinking and is distinctly sulphureted as well as carbonated. It issues near the eastern base of Monache Mountain, a rhyolite mass [1] that towers above the meadow.

CARBONATED SPRING IN WELDON VALLEY (KERN 12).

A small carbonated spring rises in Weldon Valley, about 10 miles northeast of Onyx post office and a short distance from the road that leads southeastward through Walker Pass to the eastern front of the Sierra. The spring is not of importance for drinking, but like a number of others it is of geologic interest because of its carbonated water and its isolated position.

There are probably many other small carbonated springs in the region of the Sierra that is drained by Kern and Tule rivers, but those which have been mentioned are all that were learned of and are probably all that are known to any extent.

CARBONATED SPRINGS ON ENCINO RANCH (LOS ANGELES 8).

A carbonated spring that rises on the Encino ranch, 14 miles northwest of Los Angeles, was early improved and made use of for bathing and irrigation. In 1875 it supplied a stone reservoir and a bathing pool and yielded about 5 gallons a minute of water 85° in temperature.[2] The following analysis shows it to be a primary and secondary alkaline and primary saline water of moderate mineralization:

Analysis of water from main carbonated spring on Encino Ranch, Los Angeles County, Cal.

[Analyst, Oscar Loew (1876). Authority, Wheeler report. Constituents are in parts per million.]

Temperature	29° C. (85° F.)
Properties of reaction:	
Primary salinity	43
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	24
Secondary alkalinity	33
Tertiary alkalinity	20

Constituents.	By weight.	Reacting values.
Sodium (Na)	294	12.76
Potassium (K)	Trace.	Trace.
Lithium (Li)	Trace.	Trace.
Calcium (Ca)	129	6.43
Sulphate (SO_4)	368	7.67
Chloride (Cl)	18	.50
Carbonate (CO_3)	331	11.02
Phosphate (PO_4)	Trace.	Trace.
Silica (SiO_2)	115	3.81
	1,255	....
Carbon dioxide (CO_2)	Excess.	....
Hydrogen sulphide (H_2S)	Trace.	Trace.

[1] Reported by Adolph Knopf. [2] Wheeler, G. M., U. S. Geog. Surveys W. 100th Mer., 1876, p. 195.

In 1910 the spring still furnished the water supply for the ranch. Bubbles of inflammable gas rise with the water, which has a slight odor of hydrogen sulphide. A temperature of 84° was recorded in the reservoir. Another spring of weak flow rises about 30 feet west of the main one and is also inclosed by a small stone reservoir. Its water is similar in character to that of the main spring. The water rises from Miocene shale, which here dips about 25° N. toward San Fernando Valley.

BUCKMAN SPRINGS (SAN DIEGO 17).

In the southeastern part of San Diego County, 35 miles in a direct line but nearly 60 miles by road east of San Diego, is an isolated group of small carbonated springs, which were developed about 1876 and have been improved for a number of years. The water has been marketed for table use under the label "California Club Water." The group, which is known as Buckman Springs, comprises six small carbonated springs, lying 20 to 30 yards apart on a gentle slope on the eastern side of Tia Juana Creek. One of the springs issues from pegmatite at the creek edge; another, 40 yards farther upstream, rises in a box-curbed pool at the base of a bank in the soil. These two springs have not been used commercially. The other four springs are arranged in a square, 25 to 50 yards east of the creek, and have been developed by excavating small reservoirs in low mounds of lime carbonate. The gas and water from them have been collected by tanks and piped to a bottling house over the largest spring. All of the flows are small, probably less than 1 gallon a minute, but the water is strongly carbonated and is pleasing for table use. The considerable amount of iron in the water has been detrimental to its sale for table use, for a portion is deposited as a slight coating in the bottles after they have been filled for a few weeks.

The rock near the springs is granitic and is cut by pegmatite dikes, but half a mile northeastward hills of a dark-colored diabase that contains much hornblende and is cut by quartz ledges extend into the creek valley. The pegmatite in the granitic area and the hornblende rock near by furnish conditions that differ somewhat from those observed at other carbonated springs. The presence of both rocks is at least worthy of note in connection with the unusually high contents of iron and silica that are indicated by an old analysis of the water. The high relative salinity and unreasonably high "combined water" in this analysis, however, cast doubt on its reliability as reported.

MAGNESIA SPRING (RIVERSIDE 13).

In the southeastern desert section of California there [illegible] springs that are noticeably carbonated as well as bein[illegible] saline like many of the other desert springs.

Magnesia Spring, which is situated in a canyon on the western side of Colorado Desert, about 15 miles west of Indio, yields a small amount of water that effervesces with carbon dioxide and is also locally believed to contain a notable amount of magnesium. As the spring is about 2 miles from the main road along the west side of the desert and is reached only by a dim trail, it has not been often visited.

McCAIN SPRINGS (IMPERIAL 4).

McCain Springs are about 4½ miles southward from another group known as Soda Springs (Imperial 3), which are described among the saline springs (p. 303). The springs lie in a broad wash in an area whose surface is cut by many gulches, and issue on a low mound that has probably been built up by material blown upon it and retained by the moist soil. They discharge a small amount of slightly carbonated water.

The following analysis shows the character of water from a small carbonated spring near McCain Springs and probably also indicates the general chemical features of the water from the McCain group. The high content of total solids, which are chiefly primary saline and secondary alkaline in character, is probably typical of several other springs in the southwestern part of Colorado Desert.

Analysis of water from carbonated spring in Colorado Desert, Imperial County, Cal.

[Analyst, W. O. Robinson (1909). Authority, United States Bureau of Soils. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	52
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	12
Secondary alkalinity	36
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Sodium (Na)	1,628	70.78
Potassium (K)	4	.10
Calcium (Ca)	436	21.75
Magnesium (Mg)	224	18.43
Sulphate (SO_4)	68	1.42
Nitrate (NO_3)	0	.00
Chloride (Cl)	2,028	56.50
Carbonate (CO_3)	1,549	51.65
Metaborate (BO_2)	Trace.	Trace.
Phosphate (PO_4)	0	.00
	5,937	....
Carbon dioxide (CO_2)	Present.	Present.

SUMMARY OF CARBONATED SPRINGS.

[illegible]easons for the existence of most of the hot springs of the State [illegible]ed by the geology or topography of the surrounding coun- [illegible] little apparent cause for the rise of carbonated water [illegible] it does issue.

Nearly all the carbonated springs are found in the sedimentary and metamorphic rocks of the Coast Ranges north of San Francisco Bay, in the lava area in the northern part of the State, and in the granitic and metamorphic rocks of the Sierra, but the character of the rocks appears to have little influence on the carbonated character of the springs. In the tabulated summary, therefore, they are grouped, as were the thermal springs, as impartially as possible, into general localities, with respect, first, to the formation of notable carbonate deposits; second, to the presence of lava near by; and third, to the rock from which they issue, in order to show what evidence they furnish as to the effect of lava on the formation of spring deposits.

The water of several of the springs at which there are deposits is cool, but the maximum temperature of most of them is noticeably above the normal. In the tabulated list of carbonated springs the 10 localities at which hot springs have formed deposits are included (in italics) in order to bring together those springs at which there are notable deposits. As noted in the summary of the hot springs (pp. 151–153), most of these carbonate-depositing thermal springs issue from or near lava.

In the descriptions of the hot springs it has been suggested that the gas at a few of the carbonated hot springs may possibly be derived from the deeper layers of the lava, for carbon dioxide is a large constituent of the vapors that are given off during volcanic eruptions, and it may plausibly be considered to be occluded in the lower portions of the lava flows. The same suggestion is offered to account for the carbon dioxide in several of the larger cool carbonated springs, but it is based only on the evidence that is furnished by the most vigorously effervescing springs, especially Oxone Spring and Table Rock Spring, both of which issue from lava. This evidence is, however, partly counterbalanced by that furnished by the Gas Spring, on the Bartlett Springs property (Lake 9, p. 200), which issues from altered sediments.

The list shows 29 general localities having no deposit and 31 having a deposit but offers little suggestive evidence as to the cause of deposition. The seemingly approximate equality in the number of localities in each group disappears if the individual springs are counted, as the totals are 119 springs without deposits and 45 springs with deposits. Of these 45 springs 21 issue from sedimentary or metamorphic rocks, 10 from granitic material, and 14 from or near lava.

With the carbonated springs are tabulated the localities learned of at which there are notable carbonate deposits that are probably of spring origin, for some of them are of interest in connection with existing springs.

Carbonated-spring localities.

A. No notable deposit (29 localities).

I. No lava near by.

In sedimentary and metamorphic rocks.

1. Walters Mineral Springs.
   Samuel Soda Springs.
   Gaillaumes Soda Springs.
2. Lytton Springs.
   Carbonated spring near Little Sulphur Creek.
   Alder Glen Springs.
   Duncan Springs.
   McDowell Springs.
   Carbonated springs near Feliz Creek.
   Carbonated springs on Russian River.
   Ornbauns Mineral Spring.
   Carbonated springs on Garcia River.
   Carbonated spring near Boonville.
   Singleys Soda Spring.
   Gobbis Soda Spring.
   Carbonated springs at Shoemaker Dell.
   Carbonated springs at Hazel Hill.
   Carbonated springs near Wendling.
3. Baker Mineral Springs.
   Salmon Creek Mineral Springs.
   Carbonated springs at Travelers Home.
   Carbonated spring on White ranch.
   Carbonated spring on Snider ranch.
   Carbonated spring southwest of Willits.
   Carbonated spring west of Willits.
   Carbonated spring in Big Basin.
   Carbonated springs near Long Valley Creek.
4. Jackson Valley Mineral Springs.
   Jackson Valley Mud Springs.
   Cantwell Soda Spring.
   Petersons Mineral Spring.
5. Witter Medical Springs.
   Saratoga Springs.
   Carbonated spring near northwest edge of Clear Lake.
   Lee Soda Spring.
   Carbonated spring in canyon of Scott Creek.
   Bynum Spring.
   England Springs.
   Adams Springs.
   Spiers Springs.
6. Baker Soda Spring.
   Quigley Soda Springs.
   Carbonated spring near northeast side of Clear Lake.
   Carbonated springs on Wiley ranch.
   Allen Springs.
   Bartlett Springs.
   Hoppins Springs.

Newman Springs.
Hazel Springs.
Royal Spring.
Paramore Spring.
Carbonated spring near ranger camp.
Carbonated spring on Bear Creek.
Morton Soda Spring.
7. Cooks Springs.
8. Ferndale Springs.
Alum Rock Park Springs.
Grant Spring.
9. Madrone Spring.
Coes Spring.
10. Garretson Soda Springs.
Carbonated springs at Soda Bar.
Carbonated springs at edge of Beaver Creek.
11. Mount Ida Spring.

In granitic rocks.

12. Rubicon Springs.
Wentworth Springs.
Glen Alpine Springs (Eldorado County).
13. Lambert Soda Springs.
Carbonated spring at head of Agnew Meadows.
Carbonated spring on Minaret Creek.
Carbonated springs on East Fork of Granite Creek.
Carbonated spring near Foerster Peak.
Carbonated spring near Breeze Lake.
14. Coburn Soda Spring.
Carbonated spring on Middle Fork of Tule River.
Doyle Soda Springs.
Carbonated spring on Soda Creek (Tulare County).
Tule River Soda Spring.
Carbonated spring near Mountaineer Creek.
Carbonated spring in Lloyd Meadows.
Carbonated spring near North Fork of Kern River.
Carbonated spring in Upper Funston Meadow.
Carbonated spring near Quinn Horsecamp.
Carbonated spring in Weldon Valley.
15. Carbonated springs on Encino ranch.
16. Magnesia Spring.
McCain Springs.

II. Lava near by.

In sediments.

1. Carbonated springs on Cole Creek.
Carlsbad Springs.
Bonanza Springs.

In lava.

2. Jacksons Napa Soda Springs.
Congress Spring.
3. Soda Bay Springs (small cemented-gravel formation).
Carbonated springs at southwest edge of Clear Lake (small cemented-gravel formation).
4. Shasta Springs.

Oxone Spring.
Castle Springs.
Warmcastle Soda Springs.
Upper Soda Spring.
Cave Spring.
Twin Springs.
Castle Crag Spring.
Carbonated spring on Soda Creek (Shasta County) (deposit a short distance downstream).

5. Castle Rock Springs.
Carbonated spring near Castle Creek.
6. Carbonated spring in Hot Spring Valley.
Carbonated spring north of Soupan Hot Springs.
7. Carbonated spring near Sereno Creek.

In metamorphic rocks.

8. Ætna Springs.
9. Astorg Spring.

In granitic and metamorphic rocks.

10. Carbonated spring in Humbug Valley.
Carbonated springs on Chip Creek.
11. Heath Soda Springs.
Deer Park Springs.
Carbonated spring near mouth of Powderhorn Creek.
12. Carbonated spring near Pumice Flat (covered by thin layer of pumice).
Carbonated springs in Soda Spring Flat.
Carbonated spring on North Fork of San Joaquin River.
13. Carbonated springs in Monache Meadows.

B. Notable deposits (31 localities).

I. No lava near by.

In sedimentary and metamorphic rocks.

1. Napa Rock Soda Springs; 79° F.
Phillips Soda Springs; 68° to 76°.
2. Tolenas Springs; 57°.
3. Kessler Springs; 60°±.
4. Vichy Springs; 88° to 90°.
5. Kinsner Soda Spring; 47° (deposit a short distance below).
6. Glen Alpine Springs (Lake County); 50°±.
Highland Springs; 52° to 82°.
7. Grizzly Springs; 70°.
8. Oil Spring; 76°.
Deadshot Springs; 65° to 79°.
9. Dinsmore Soda Spring; 63°+.
10. Hough Springs; 66°.
11. Fouts Springs; 75°.
12. Congress Springs; 60°.
Azule Mineral Spring; 60°.
13. Banes Soda Springs; 60°±.
Helms Soda Springs; 60°±.
14. Carbonated springs on Spanish Creek; 62° to 68°.
Carbonated springs on Indian Creek, 57° to 68°.
Arlington Springs; 53°.

In granitic rocks.

15. Keller Soda Spring; 53°.
16. Summit Soda Springs; 44° to 65° (deposit farther downstream).
    Florence Spring; 52° (deposit farther downstream).
17. Carbonated spring in Fish Valley; 54°.
    Carbonated springs on Middle Fork of San Joaquin River; 55°+.
18. Carbonated spring on South Fork of Middle Fork of Tule River; 77°.
    Nelson Soda Springs; 62° to 69°.
19. Buckman Springs; 60° to 65°.
20. *Jordan Hot Springs;* 95° to 123°.
21. *Buckeye Hot Springs;* 140°.

II. Lava near by.

In granitic rocks.

1. *Reds Meadows Hot Springs;* 90° to 120°.
2. *Grovers Hot Springs;* 50° to 146°.

In lava.

3. Carbonated springs on Chalk Mountain; 70°.
   Alum Spring; 60°.
4. Carbonated springs near Little Bogus Creek; 54° to 76°.
   Table Rock Spring; 65°.
   Carbonated spring at edge of Little Shasta River; 57° (cemented gravel near by).
   Martin Soda Spring; 55° (carbonate deposit near by).
5. *Fales Hot Springs;* 97° to 141°.
6. *Hot and warm springs near Bridgeport;* 100° to 148°.
7. *Morgan Hot Springs;* 90° to 200°.
8. *Drake Hot Springs;* 123° to 148°.
9. *Casa Diablo Hot Springs and pool;* 115° to 194°.
10. *Shaffer, Amedee, and Highrock springs;* 86° to 204°.

Carbonate deposits that are probably spring formations.

In canyon of Kern River 25 miles north of Kernville, Kern County.
At Natural Bridge, 7 miles east of north of Kern Lake, Tulare County.
Two miles west of Summit Soda Springs, Placer County.
South of Euers Valley, 10 miles northwest of Truckee, Nevada County.
Alabaster Cave, 5 miles southeast of Auburn, Placer County.

SULPHUR SPRINGS.

DISTRIBUTION.

The following descriptions of sulphur springs include chiefly those that are not markedly thermal. Many thermal springs that are noticeably sulphureted have been described among the hot springs. The distribution of all the sulphur springs is, however, shown on Plate III (in pocket), which shows that they are found mainly through the Coast Ranges, being more plentiful in the region north of San Francisco Bay than in that to the south. They occur at only a few scattered points in the Sierra and in the deserts of the southeastern part of the State.

ST. HELENA WHITE SULPHUR SPRINGS (NAPA 10).

St. Helena White Sulphur Springs are situated in the canyon of Sulphur Creek, 2 miles southwest of the town of St. Helena. They form the nucleus of an old and formerly a well-known resort, but about 1904 the hotel was destroyed by fire, and in 1909 the improvements had not been extensively rebuilt. There were, however, cottages and an open screened dining room, furnishing accommodations for about 25 people, and a small bathhouse near one of the springs.

Analyses of water from St. Helena White Sulphur Springs, Napa County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5	
Temperature	25° C. (77° F.)		21° C. (69° F.)		32° C. (90° F.)		30° C. (86° F.)		21° C. (70° F.)	
Properties of reaction:										
Primary salinity	83		59		82		80		63	
Secondary salinity	4		0		1		5		1	
Tertiary salinity	0		0		0		0		0	
Primary alkalinity	0		5		0		0		0	
Secondary alkalinity	13		36		17		15		36	
Tertiary alkalinity	21		9		22		13		(?)	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	218	9.48	136	5.91	207	8.99	232	10.05	177	7.70
Calcium (Ca)	23	1.15	42	2.10	28	1.40	29	1.45	49	2.45
Magnesium (Mg)	10	.82	15	1.23	6.8	.56	13	1.03	24	2.00
Aluminum (Al)	2.0	.22	5.6	.62	......	......	......	......	......	......
Sulphate (SO_4)	123	2.56	83	1.73	96	2.00	131	2.73	149	3.10
Chloride (Cl)	260	7.33	133	3.75	251	7.08	280	7.90	164	4.63
Sulphide (S)	9.4	.59	Trace.	Trace.	a 19	1.20	a 13	.84	a 12	.75
Carbonate (CO_3)	29	.97	113	3.76	20	.67	32	1.06	110	3.67
Silica (SiO_2)	11	.36	25	.83	......	......	......	......	......	......
	685.4	......	552.6	......	627.8	......	730	......	685	......
Hydrogen sulphide (H_2S)	34	2.01	Trace.	Trace.	41	2.38	28	1.64	Trace.	Trace.

a Reported as sodium and calcium sulphides. Recalculated on assumption that 41 per cent is CaS and 59 per cent Na_2S by comparison with analysis of spring No. 5.

1. Spring No. 5. Analyst and authority, Winslow Anderson (1888).
2. Spring No. 9. Analyst and authority, Winslow Anderson (1888).
3. Spring No. 2. Analyst, J. Le Conte (1871). Authority, U. S. Geol. Survey Bull. 32.
4. Spring No. 6. Analyst, J. Le Conte (1871). Authority, U. S. Geol. Survey Bull. 32.
5. Spring No. 7. Analyst, J. Le Conte (1871). Authority, U. S. Geol. Survey Bull. 32.

The group includes five noteworthy springs which issue within a space of 150 yards near the foot of the slope on the northeast side of Sulphur Creek. All these springs were formerly improved with brick basins, but when visited the northern two were the ones chiefly used. One of these formed a drinking pool that yielded about one-half gallon a minute of mildly sulphureted water. The northernmost spring, which is about 25 yards beyond the drinking spring, was surrounded by a cement reservoir and yielded warm, mildly sulphureted water, which supplied the bathhouse below it. The central spring was formerly used as a bathing pool, but it had become filled with mud and grown with tules. The two southern springs filled slightly used brick drinking basins. The southernmost spring appeared to be the largest of the five, as a stream of about 4 gallons a minute, which apparently came from it, issued at the creek edge a few yards away. A temperature of 83° was recorded at this spring. The water of the other springs is also noticeably warm, so the springs are marked on Plate III (in pocket) as thermal sulphur, but they are best known as sulphur springs.

The analyses on page 254 show that the waters are essentially primary saline. The presence of sulphide sulphur is of interest, as this form of sulphur is considered to be the most efficient medicinally.

The springs issue from crushed sandstone of the Franciscan formation,[1] which forms the hills of the locality.

NAPA VICHY SPRING (NAPA 13).

A small spring, whose water is moderately sulphureted, issues about 3 miles east of north from Napa, on low slopes of tuffaceous lava that border the valley. The water rises in a cemented basin within a circular, latticed spring house. It is piped directly to a bottling house near by, where it is carbonated and bottled in siphons for local sale. It has been on the market since about 1898 as Napa Vichy Water.

VALLEJO WHITE SULPHUR SPRING (SOLANO 2).

Vallejo White Sulphur Spring is situated in the hills 4 miles north of east from Vallejo. The property has been conducted as a resort for a number of years, the improvements in 1909 including a hotel, several cottages, and a small artificial lake.

The spring rises in a shallow pool about 12 feet in diameter, at the base of a steep, craggy slope of siliceous rock that has been mapped as being a portion of the Franciscan formation.[1] The water is distinctly sulphureted, but is not otherwise noticeably mineralized. A partial analysis, published in advertising matter, indicates that sodium and magnesium are the two principal constituents and that they are present in the ratio of 1 to 1.6. It is rather warm for drinking, as its temperature is 68°, but it is heated for bathing. It has also been bottled to some extent and marketed locally for table use.

EL TORO SPRING (MARIN 1).

Mildly sulphureted water issues at El Toro Spring on the eastern side of a basaltic hill 2½ miles northwest of Novato. This water was formerly bottled and sold for table use, but for a number of years it

[1] Weaver, Charles, U. S. Geol. Survey Geol. Atlas, Napa folio (unpublished).

has been used only for domestic purposes. The spring rises in a stone basin, and its yield, which is about 4 gallons a minute, is piped to a storage tank 100 yards away, near the house. The following analysis indicates that the water is essentially primary alkaline and carbonated:

Analysis of water from El Toro Spring, Marin County, Cal.

[Analyst, W. T. Wenzel. Authority, 11th Cal. Constituents are in part per million.]

Properties of reaction:	
Primary salinity	28
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	54
Secondary alkalinity	18
Tertiary alkalinity	367

Constituents.	By weight.	Reacting values.
Sodium (Na)	67	2.92
Potassium (K)	11	.29
Calcium (Ca)	4.4	.22
Magnesium (Mg)	5.7	.47
Iron (Fe)	1.4	.05
Aluminum (Al)	.4	.04
Sulphate (SO_4)	8.6	.18
Chloride (Cl)	32	.91
Carbonate (CO_3)	84	2.81
	214.5	....
Carbon dioxide (CO_2)	315	14.31
Hydrogen sulphide (H_2S)	Present.	Present.

O'DONNELL'S SPRINGS (SONOMA 17).

Two sulphur springs of relatively small flow that issue in a ravine on the west side of Sonoma Valley have been used for drinking for a number of years, and of late a small sanitarium has been established at the place. The water is not strongly mineralized, however, and the occurrence of the springs is not of unusual interest.

TAYLOR SULPHUR SPRING (SONOMA 13).

A small sulphur spring, that is known as Taylor Sulphur Spring, lies at the base of the hills 2 miles southeast of Santa Rosa. A hotel was built on the property in 1870 and the place was opened as a resort, but the building burned within a few years. It was later rebuilt, with accommodations for sixty people, and was conducted intermittently as a resort until the time of the earthquake of April 18, 1906. It was again reopened as a resort in the summer of 1910, as Kawana Sulphur Springs but is probably best known by its original name. The water rises in a cement basin beneath a small spring house and yields perhaps 1 gallon a minute of faintly sulphureted water. The hillside back of the spring is soil covered, but it apparently consists of lava, such as is exposed in the hills farther to the southeast. The following analysis shows the chief properties to be primary and secondary salinity:

Analysis of water from Taylor Sulphur Spring, Sonoma County, Cal.

[Analyst and authority, Winslow Anderson (1886). Constituents are in parts per million.]

Temperature	16° C. (60° F.)
Properties of reaction:	
Primary salinity	56
Secondary salinity	28
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	16
Tertiary alkalinity	35

Constituents.	By weight.	Reacting values.
Sodium (Na)	93	4.04
Potassium (K)	6.3	.16
Calcium (Ca)	7.0	.35
Magnesium (Mg)	35	2.88
Iron (Fe)	Trace.	Trace.
Aluminum (Al)	8.4	.93
Sulphate (SO_4)	220	4.59
Chloride (Cl)	59	1.67
Carbonate (CO_3)	35	1.17
Metaborate (BO_2)	Trace.	Trace.
Silica (SiO_2)	20	.66
	483.7	....
Carbon dioxide (CO_2)	35	1.61
Hydrogen sulphide (H_2S)	43	2.50

WALL SPRINGS (SONOMA 10).

Wall Springs are situated on the side of a large ravine near the northern border of the valley of Russian River, 14 miles northwest of Santa Rosa. The property has been improved for a number of years as a resort, accommodations being provided in 1909 by a small hotel and three cottages.

Five springs issue near the buildings, in cemented basins 10 to 30 yards apart, at the bases of small banks on the slope. They are designated, respectively, as Potash, Sulphur, Magnesia, Clearwater, and Iron springs. When they were seen all were probably diluted with surface water, but the Potash Spring tasted distinctly alkaline and the Sulphur and the Magnesia springs were noticeably sulphureted; the other two had no distinctive taste. Water from the Sulphur Spring has been piped to a tank near by and has been heated for bathing. The other springs have been used only for drinking. All apparently yield flows of less than 1 gallon a minute. Their recorded temperatures ranged from 47° in the Clearwater Spring to 63° in the Sulphur Spring. Although their flows were so slight and their basins were about equally exposed to the weather, the noticeably higher temperatures of the distinctly mineralized springs indicate that the chemical changes that cause their mineralization also produce observable amounts of heat.

The rocks of the region are shales and sandstones, which are in some places considerably silicified, but the springs apparently issue from soft sandstone that overlies a bed of harder sedimentary material. Their small flows indicate that they are supplied by water of essentially surface origin, which becomes slightly mineralized from the shales and sandstones and is brought to the surface on the side of the ravine by a bed of relatively impervious material.

SULPHUR SPRINGS IN FRANZ VALLEY (SONOMA 12).

Franz Valley lies about 15 miles north of Santa Rosa, between that place and Calistoga. Two small sulphur springs in it are occasionally used as drinking springs by outing parties to the Petrified Forest, a small group of silicified tree trunks a few miles distant. The springs are probably similar in character to those at Mark West Warm Springs (Sonoma 11, p. 115), which are a few miles westward. Small undeveloped sulphur springs issue at a number of other places in the counties north of San Francisco and San Pablo bays. Among them is one in Lucas Valley, a few miles northwest of San Rafael, but it has been known only locally and is seldom visited.

SULPHUR SPRING NEAR LITTLE SULPHUR CREEK (SONOMA 6).

Near Little Sulphur Creek, about 7 miles northeast of Geyserville, on property that has been open for a few years as a summer resort under the name of Geyser Peak Ranch, is a spring that yields a small flow of cool, distinctly sulphureted water. It has been used only for drinking.

The rocks at this locality are the shales and coarser sediments that constitute the greater part of the coastal ranges of the region.

SULPHUR SPRING NEAR SULPHUR CREEK (SONOMA 3).

A small cool sulphur spring which is about 3 miles northeast of Cloverdale, on the road to The Geysers (Sonoma 4, p. 83), rises in the bottom of a ravine tributary to Sulphur Creek and a few yards above the road. The spring has not been improved and is sometimes covered by landslide material, but when open it yields moderately sulphureted water and forms a roadside drinking spring.

The rocks of the locality consist of serpentine and of dark altered sandstone which probably belongs to the Franciscan formation. The spring apparently issues from crevices in a crushed zone in the sandstone.

SULPHUR SPRINGS ON BRANCH OF DEEP CREEK (MENDOCINO 12).

Mildly sulphureted water issues from several vents in the bed and along the bank of a branch of Deep Creek, on the eastern side of Willits Valley about 4 miles east of Willits. The yield is apparently slight, but small amounts of white algous growths on the banks and strings of bubbles that rise in the creek make the locality easily noticeable. Sandstone and shale that dip about 10° N. are exposed at this place.

MUIR SPRINGS (MENDOCINO 11).

On the edge of the valley about 4 miles northeast of Willits natural gas and a small flow of water have been obtained on the property of Mr. A. J. Muir. A collecting tank covers a small pit in which gas rises and is used for heating and lighting the residence a few hundred yards away, and a natural spring rises near by that yields about 5 gallons a minute of mildly sulphureted water with a slight oily taste. A well was drilled 150 feet deep, close to the gas tank, in search of oil or a greater supply of gas, but obtained only a flow of cool water.

This part of the valley is underlain by dark shales from which natural gas is said to escape at several other places along the eastern side of the meadow land.

SULPHUR SPRING NEAR LAYTONVILLE (MENDOCINO 4).

A spring that yields about 200 gallons a minute rises near the barnyard of Mr. Samuel Pinches, half a mile north of Laytonville. The water issues on a gentle slope at the base of a steeper hillside, from several vents in a small depression. It is locally called a sulphur spring, and a small amount of the algous growth that is common in sulphur springs grows along the outflow channel, but the water is only faintly sulphureted. It has a distinctly mineralized taste as of sulphates, however, and inflammable gas rises with the water. A small bathhouse is supplied by the spring, but little other use has been made of the water. The rock from which it rises appears to be a crushed quartzitic sandstone, and the topography suggests that the spring rises along a slight fault.

SULPHUR SPRING NEAR BRANCH OF EEL RIVER (MENDOCINO 3).

A small spring of distinctly sulphureted water rises in the barnyard of Mr. Mitchell's ranch, on the southern side of a branch of South Fork of Eel River, about 13 miles by road and trail northwest of Laytonville and 1 mile northwest of Petersons Mineral Spring (Mendocino 2, p. 177). The spring has not been used for drinking or for other purposes, but it is of interest from the fact that its water was rendered milky by clay for a week following the earthquake of April 18, 1906. It issues in a marshy patch near the base of dark-colored sedimentary rocks.

SULPHUR SPRINGS NEAR CUMMINGS (MENDOCINO 1).

Near Cummings post office, on the stage road 30 miles northward from Sherwood, are two sulphur springs which have not been improved but which yield flows of about 5 and 10 gallons a minute of cool, mildly sulphureted water that is used to some extent for drinking.

SULPHUR SPRING NEAR HOAGLIN (TRINITY 4).

Near Hoaglin post office, in the southern part of Trinity County, there is a spring which yields inflammable gas. The water is mildly sulphureted and has formed a watering place for cattle, but otherwise the spring has been little used.

A few other sulphur springs issue in the rugged slopes of western Trinity County, but they have not been improved and are known to only a few residents. One such spring that has a considerable flow is said to issue on the side of South Fork Mountains a number of miles southwest of Weaverville, and others are reported at Wildwood and at Coxs Bar.

SULPHUR SPRING IN EUREKA (HUMBOLDT 1).

A spring of moderately sulphureted water is situated at the foot of H Street, in the city of Eureka. It has been known for a long time, but in 1910 its water had not been used for two or three years. The spring is about 50 feet from the shore of Humboldt Bay, and when examined the water stood 5½ feet below the surface, in an iron pipe 2 feet in diameter, within a shallow, board-curbed pit. This is possibly the spring mentioned by Anderson,[1] who gives an analysis showing that the water is a strong brine, containing 30,815 parts per million of solids in solution and that it is saturated with hydrogen sulphide.

Another sulphureted water at Eureka, which is obtained from the Humboldt artesian mineral well, is mentioned among the saline mineral waters.

MOUNTAIN VIEW SPRING (HUMBOLDT 3).

Mountain View Spring is at a small resort on Mad River, about 28 miles by road southeast of Eureka. In 1910 a hotel of 10 rooms and a small cottage afforded accommodations for 15 or 20 people. A small spring of strongly sulphureted water issues on the hillside 600 yards west of the hotel, near a creek that is tributary to Mad River. Its water has been used occasionally by some ailing guest, but otherwise little attention has been given to the spring.

Unaltered sandstone is exposed for about 10 miles along the road eastward from Eureka toward Mountain View Spring. A schist,

[1] Anderson, Winslow, Mineral springs and health resorts of California, p. 133, 1892.

most of which contains glaucophane, then appears as the road is followed southeastward up a steep grade nearly to Kneeland post office, which is about 20 miles from Eureka. Chert is exposed at this place and extends, interspersed with a few areas of serpentine, southeastward nearly to Mountain View Spring. The spring issues in an area of andesitic lava, which is exposed on the lower slopes near the resort. Serpentine appears above the andesite, on the slopes across the creek and a short distance southeast of the spring, and tremolite schist was observed still higher up the hillside.

COOK SPRING (HUMBOLDT 4).

Cook Spring is about 7 miles south of Mountain View Spring (Humboldt 3, p. 160), or 35 miles by road southeast of Eureka. It is situated near the north bank of North Yager Creek and 10 yards below the road, near the point at which the road crosses the stream a quarter of a mile east of Iaqua. A pool 14 inches in diameter here forms a drinking basin that is used occasionally by travelers and by the cattle of the surrounding range.

Several other sulphur springs of small flow issue in the upper portions of the basin of North Yager Creek, but they are unimproved and are even less important than Cook Spring. A small sulphur spring at Felts Springs (Humboldt 5, p. 300) is mentioned in the description of the saline springs at that place.

The southern boundary of the andesite along the road from Mountain View Spring to Cook Spring is about 2 miles south of the former place. Mica schist that contains glaucophane extends from that point to and beyond Cook Spring and also westward along the road to a point about 6 miles in a direct line east of Fortuna. Unaltered sediments extend from this point northwestward to the coast. In the schist there are lenses of limestone, and many small sink holes have been formed by the partial solution and removal of this material.

DEERLICK SPRINGS (TRINITY 3).

Deerlick Springs are situated in the deep, rugged canyon of Browns Creek, 28 miles by road and trail south of Weaverville. They are also reached by 9 miles of trail northward from the Midas mine in Harrison Gulch (Knob post office). They have long been known as Coumbs Springs and have been a local camping resort. A supply store was formerly conducted during the summer in a cabin that was built near the springs more than 20 years ago. During 1909 the property changed hands, and the present name was adopted.

There are five strongly sulphureted springs on the property, all on the west side of the creek. Two of them, known as the Blue

Sulphur and White Sulphur springs, from the tint of the water in their basins, rise about 8 yards apart, at the base of an earth and gravel bank beside the creek, yield respectively about 1 gallon and 4 gallons a minute, and have deposited small amounts of sulphur along their overflow channels.

About 225 yards downstream from the Blue Sulphur and White Sulphur springs two other strongly sulphureted springs issue from crevices in a light-colored siliceous rock that seems to form a ledge about 50 feet wide, which trends northeastward and crosses the creek at a small angle. One of these springs is the most important of the group and yields about half a gallon a minute of clear cold water that has a pronounced greenish-yellow tint and tastes strongly of hydrogen sulphide. The other spring, 3 or 4 yards farther north, yields perhaps 1 gallon a minute of water that is also strongly sulphureted but is colorless. The mixed water of the two springs, named Nipicuro by the new owner but formerly known as Deadshot, has been conducted by a small trough into a wooden tank and heated in tubs for bathing. During 1909 small amounts were bottled and used experimentally in the treatment of diseases of the blood, preparatory to putting it on the market as a medicinal water.

Mr. F. M. Eaton has suggested that the yellow color of the principal spring may be due to the presence of polysulphides, and it seems probable that they are alkaline sulphides like those that have been determined in the waters of Blue Lick Springs, Ky.[1] The following analyses of the waters have been made. The sample of Nipicuro analyzed by Mr. Dinsmore was collected from the tank into which both springs discharge and during the summer, when there was probably very little dilution by surface water. The sample analyzed by Mr. Eaton was collected from the first-described spring of the two forming Nipicuro, in November, during a stormy period, but at a time when the ground was partly frozen, so that there was little surface water in evidence. The difference shown by these two analyses is not greater than would be expected in such highly mineralized water, considering the different proportions of surface water that may have diluted the springs, and especially the fact that they were not collected at the same point. It seems probable that the carbonate reported in the three Dinsmore analyses represents alkalinity due to sulphide as well as carbonate. All of the analyses indicate secondary saline waters with differing proportions of primary salinity and secondary alkalinity. The differences in concentration are considerable.

[1] Matson, G. C., Water resources of the blue-grass region, Kentucky, with a chapter on the quality of the waters by Chase Palmer: U. S. Geol. Survey Water-Supply Paper 233, p. 209, 1909.

Analyses of water from Deerlick Springs, Trinity County, Cal.

[Constituents are in parts per million.]

	1		2		3		4		5	
Temperature	10° C.(50° F.)									
Properties of reaction:										
Primary salinity		41				44		27		22
Secondary salinity		51				48		55		71
Tertiary salinity		0				0		0		0
Primary alkalinity		0				0		0		0
Secondary alkalinity		8				8		18		7
Tertiary alkalinity		45				43		14		11
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	1,118	48.60			1,332	57.90	50	2.18	47	2.05
Potassium (K)	28	.71			163	4.17	8.2	.21	5.7	.15
Ammonium (NH_4)			Tr.	Tr.						
Calcium (Ca)	1,419	70.79	1,520	75.90	1,522	75.95	108	5.38	132	6.62
Magnesium (Mg)	11	.93			21	1.76	11	.93	12	.99
Iron (Fe), Aluminum (Al)	5.1	.18	.2	.01	9.5	.34	0.3	.01	2.0	.07
Sulphate (SO_4)	1,067	22.23			1,504	31.33	94	1.95	85	1.77
Nitrate (NO_3) and nitrite (NO_2)			0	.00						
Chloride (Cl)	3,141	88.64	3,750	105.80	3,463	97.70	184	5.19	262	7.38
Bromide (Br)	0	.00								
Iodide (I)	0	.00			5.2	.04				
Sulphide (S)	159	9.34								
Carbonate (CO_3)	25	.82		9.89	268	8.94	47	1.56	19.8	.66
Metaborate (BO_2)	Tr.	Tr.			Tr.	Tr.				
Arsenate (AsO_4)	0	.00								
Silica (SiO_2)	11	.37			25	.84	36	1.18	32	1.05
	6,984.1		a9,480		8,312.7		538.5		597.5	
Carbon dioxide (CO_2)					0	0	(b)	(b)	(b)	(b)
Hydrogen sulphide (H_2S)	86	5.06	398	23.37	118	6.91	Trace.	Trace.	(b)	(b)

a Total solids. b Present.

1. Nipicuro Spring. Analyst and authority, F. M. Eaton (1909). Sample from spring having the greater flow.
2. Nipicuro Spring. Analyst, T. W. Melia (1911). Authority, owner of springs. Taken from a sanitary analysis of water bottled direct from spring.
3. Nipicuro Spring. Analyst, S. C. Dinsmore (1909). Authority, owner of springs. Sample bottled after standing.
4. Blue Sulphur Spring. Analyst, S. C. Dinsmore (1909?). Authority, owner of springs.
5. White Sulphur Spring. Analyst, S. C. Dinsmore (1909?). Authority, owner of springs.

A fifth spring, known as the Highshot Spring, issues on the side of a ravine about 125 yards northwest of the Nipicuro Spring and about the same distance from the creek. Like the others, it is strongly sulphureted and of slight flow, but it has been comparatively little used.

The rocks of the region consist of the series of altered sediments and of serpentine that forms the greater part of the northern Coast Ranges. Near the springs there is considerable impure limestone or calcitic sandstone, which probably accounts for the large amount of calcium in the spring water. Quartz porphyry was observed on the mountain ridge a mile south of the spring, and float of the same material was found along the creek.

SULPHUR SPRINGS ON BROWNS CREEK (TRINITY 2).

Sulphur water issues at several places along the course of Browns Creek, notably at points about four-fifths mile, $1\frac{1}{5}$ miles, and $1\frac{1}{4}$ miles below Deerlick Springs (Trinity 3, p. 261), appearing in places on the western bank of the creek and also in its bed. These lower springs have not been improved, but they are near the trail and are noticeable because of the sulphur-coated algous growths along their run-off channels. On the eastern side of the creek, nearly opposite the spring farthest downstream, a strongly sulphureted spring that yields perhaps 1 gallon a minute, issues from crevices in a dark, schistose rock beside the trail. Bubbles of inflammable gas that is probably hydrogen sulphide rise in the small pool that is formed in a natural basin in the rock. These springs are doubtless similar in origin and character to Deerlick Springs.

NEYS SPRINGS (SISKIYOU 18).

The sulphur springs that have thus far been described are on the western slopes of the northern Coast Ranges. There are also a few sulphur springs on the eastern slopes that are drained by tributaries of Sacramento River. The northernmost of these springs that are worthy of note are Neys Springs, in the canyon of Little Castle Lake Creek, 5 miles southwest of Sisson. They were discovered in 1887 by Mr. John Ney, who has improved them and established a small resort for the medicinal use of the waters. At this place there are three mineralized springs, the two less important being sulphureted and the principal one of less usual character.

The principal spring rises at the northern side of the creek and was formerly submerged during periods of high water. It has been protected by rockwork and the channel has been filled in, however, so as to form a pool about 7 feet in diameter a few feet from the creek edge. The outflow (Aqua de Ney) is piped to a tank and heated for use in a bathhouse near by. Bubbles constantly rise in the pool, in which the water is clear but slightly amber in tint. It is a water of very unusual character, inasmuch as it smells and tastes strongly of ammonia and appears to have caustic alkalinity. This fact was commented on by the analyst, who states that after making a number of confirmatory tests he is unable to account for the alkalinity in any other way than by assuming the presence of the hydroxide radicle. It is not unlikely that a part of the alkalinity is due to silicate.

The water apparently rises from a seam of claylike decayed serpentine, a few inches wide, in a dark schistose rock that is exposed for a number of yards along the bed and sides of the creek. It has been suggested by Mr. Eaton that the remarkable ammoniacal character of the water may result from the action of ferrous iron derived from the decayed serpentine on nitrates derived from buried organic material.

About 75 yards eastward downstream a cold, mildly sulphureted spring, called Milton Spring, issues from a crevice in a ledge of the schist on the opposite side of the creek and several feet above it. Water from this spring has been used for drinking. A few yards farther north there is a small seepage pool of sulphureted ammoniacal water, which has been used only slightly for drinking and for shampooing. The following analyses represent water from the two principal springs:

Analyses of water from Neys Springs, Siskiyou County, Cal.

[Analyst and authority, F. M. Eaton (1910). Constituents are in parts per million.]

	Aqua de Ney.		Milton Spring.	
Properties of reaction:				
Primary salinity		43		22
Secondary salinity		0		0
Tertiary salinity		0		0
Primary alkalinity		57		61
Secondary alkalinity		Trace.		17
Tertiary alkalinity		3		15
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	11,090	482.4	151	6.57
Potassium (K)	72	1.8	8.9	.23
Ammonium (NH_4)	152	8.4	....	....
Calcium (Ca)	Trace.	Trace.	20	1.00
Magnesium (Mg)	7.2	.6	5.5	.45
Iron (Fe), Aluminum (Al)	Trace.	Trace.	1.7	.06
Sulphate (SO_4)	272	5.7	18	.37
Chloride (Cl)	7,310	206.2	51	1.44
Hydroxide (OH)	1,720	101.1	....	....
Sulphide (S)	264	16.5	....	....
Carbonate (CO_3)	4,872	162.4	139	4.64
Metaborate (BO_2)	Trace.	Trace.	....	....
Phosphate (PO_4)	Trace.	Trace.	....	....
Silica (SiO_2)	420	13.9	92	3.05
	26,179.2	....	487.1	....
Carbon dioxide (CO_2)	0	.00	Present.	Present.
Hydrogen sulphide (H_2S)	....	....	Present.	Present.

Both springs are essentially primary alkaline and saline in character. The deficiency in acid radicles commonly found in water is especially noteworthy. The water of the Milton Spring, though differing in several particulars from that of the main spring, appears to have the same origin. It is a water such as would be produced by diluting water from the main spring with surface water.

There are benches of gravel along the canyon sides for half a mile or more above and below the springs. Farther down the canyon some gabbroid rock was noticed, but nearly to Cantara railroad station, 2 miles away, the canyon walls are mainly of light-colored lava, probably andesitic, which at one place forms prominent cliffs.

SULPHUR SPRING ON CASTLE CREEK (SHASTA 1).

A small sulphur spring issues in the canyon of Castle Creek about 4 miles west of Castella railroad station. The spring is not easily accessible, however, as it is in a steep and brushy region and has not been improved nor often visited. In connection with its occurrence, a small, faintly sulphureted spring (Shasta 5) may be mentioned, which issues at the edge of Sacramento River near the mouth of Castle Creek. This latter spring is more noticeably carbonated, however, so it has been described with the carbonated springs (p. 227). The water of Castle Rock Springs (Shasta 4, p. 226), which are at the edge of Sacramento River about one-half mile above the mouth of Castle Creek, is also slightly sulphureted as well as carbonated in character.

COLYEAR SPRINGS (TEHAMA 10).

Colyear Springs are situated high on the mountain side, 35 miles by road westward from Red Bluff. Six springs here rise in basins in a cemented place about 5 yards in diameter, among the pine trees on a moderate slope. All yield flows of cool water varying in amount from mere seepages to about 2 gallons a minute. One of the largest is noticeably sulphureted, but the others are only faintly so. On the slopes about 8 yards above them there is a clear-water spring that yields 4 or 5 gallons a minute.

An attempt was early made to establish a resort at Colyear Springs, but it met with little success. Within recent years, however, several cabins have been built, a road of easier grade has been constructed up the mountain, and the place has been used to some extent as a mountain resort.

HENSLEY SPRING (TEHAMA 9).

Hensley Spring is about 4 miles by trail west of north from Colyear Springs and about 450 feet lower down the mountain side. It rises at the edge of a clump of black oaks, on a low ridge between two ravines, in an area that is covered with dense brush. It furnishes sufficient water for plant growth, forming a small green patch within which there are a few willow trees. The spring rises partly as seepage and partly from a shallow basin in the soil. Its water is noticeably sulphureted and deposits a small amount of iron. The spring has long been known, but the place has been abandoned since the early nineties, and a cabin that stood near the spring was destroyed by a brush fire several years ago. A much smaller spring, similar in character to Hensley Spring, issues in the bed of a ravine a mile southward.

Dark shales that dip steeply eastward are well exposed in the ravines and canyons of the lower slopes of this region.[1] Near both the Colyear and Hensley springs, however, the rocks are altered, and schists were observed associated with siliceous sediments veined with quartz. Serpentine is exposed for most of the distance between the localities of the two springs and apparently forms a dike that trends west of north across the slopes.

SULPHUR SPRING ON SOUTH FORK OF COTTONWOOD CREEK (TEHAMA 8).

There is a sulphur spring in the canyon of South Fork of Cottonwood Creek, about 4 miles west of Toms Head Mountains and 10 miles in a direct line northwest of Colyear Springs, but it is in a brushy region, is difficult of access, and has been seldom visited. The rocks in the vicinity are the sedimentary and metamorphic rocks of the Coast Ranges, such as were noted at Colyear Springs and Hensley Spring.

SULPHUR SPRING SOUTHWEST OF FOUTS SPRINGS (COLUSA 2).

A spring about 1 mile by trail south and west of Fouts Springs (Colusa 3, p. 205), in the upper end of a little glade on the brushy slopes, forms a small pool, from which there is a flow of about 5 gallons a minute of water that tastes mildly sulphureted and slightly salty. A deposit of lime carbonate that crusts the surface for several yards below the spring indicates that the water also contains calcium and carbon dioxide in considerable amounts. The spring has been occasionally visited by guests from Fouts Springs, but it has not been permanently improved as a drinking spring.

SULPHUR SPRING WEST OF FOUTS SPRINGS (COLUSA 1).

A sulphur spring that is similar in character and mode of occurrence to that southwest of Fouts Springs (Colusa 3) issues on "Old Joe's" place, about 1½ miles west of Fouts Springs. It yields perhaps 10 gallons a minute of mildly sulphureted water and was formerly used in irrigating a garden. During recent years, however, it has been unused, and as it lies on a steep mountain side it has been seldom visited.

The rocks near both of the sulphur springs described in the foregoing paragraphs consist of the series of altered sediments and associated serpentine that is common in this region. The springs apparently issue from altered sandstone.

[1] These deposits have been described by J. S. Diller (Tertiary revolution in the topography of the Pacific coast: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, p. 406, 1894).

SULPHUR SPRING NEAR BLUE LAKES (LAKE 17).

A small flow of mildly sulphureted water issues in a ravine one-third of a mile south of Blue Lakes resort, which is 19 miles by road north of east from Ukiah. The water emerges at the base of a bank of gray sandstone into a cemented drinking pool. It was at one time piped down the ravine to the resort, but in 1909 it was apparently used only at the spring. A partial analysis of the water, published in advertising matter, shows it to be mildly mineralized, with sodium and sulphate predominating.

HAYVILLA SULPHUR SPRING (LAKE 16).

In an open drainage course 5 miles northwest of the town of Upper Lake there is a sulphur spring whose water has been used to some extent for bathing and drinking. It has become known as Hayvilla Sulphur Spring, from the name of the ranch on which it is situated. When the place was visited the water rose from buff-colored sandstone near the drainage wash into a small rock-walled drinking pool, and was piped to a bathtub a few yards away. The water is noticeably sulphureted and has a slightly alkaline or saline taste.

In connection with the Hayvilla Spring, two other sulphur springs in the same region, which have already been described, may be mentioned here. One of these is about 3 miles westward, on the property of the Witter Medical Springs Co. (p. 177); the other is at Saratoga Springs (Lake 18, p. 179), about 3 miles southward in a direct line.

SULPHUR SPRINGS IN SULPHUR VALLEY (LAKE 43).

Two small unimproved springs that are noticeably sulphureted lie in Sulphur Valley, in southern Lake County, 2 or 3 miles northeast of Glenbrook post office. One of these springs is on the Ogden ranch, and rises near a small spring of distinctly carbonated water; the other, which is some distance westward and is known locally as the Deadshot Spring, is alkaline and saline, as well as sulphureted, and its water is said to have been used for curing deer hides by putting them to soak in the spring.

ZEM ZEM SPRING (NAPA 1).

A small spring of strongly sulphureted water is situated near the road between Knoxville and Monticello, about 5 miles southeast of Knoxville. The spring was of more importance during the days of active mining in the Knoxville district than it is now, but it is still a camping place for teamsters. The water is too highly mineralized, however, to be palatable, an early analysis[1] indicating a content of 21,000 parts per million of total solids.

[1] Crook, J. K., The mineral waters of the United States and their therapeutic uses, p. 176, 1899.

PIEDMONT SPRINGS (ALAMEDA 1).

Piedmont Springs are in a recreation park on the hillside 3 miles north of Oakland.

Two mineralized springs, which are known, respectively, as Sulphur and Magnesia springs, rise in a ravine that extends through the property. The springs have been curbed and covered, and the ravine has been graded for a walk. The waters are piped about 100 yards downstream into two drinking basins in a grotto-like spring house that is built against a rock face at the side of the ravine. A third basin in the spring house is supplied from the municipal water main. The water of both springs is noticeably sulphureted, and that of the Magnesia Spring also tastes distinctly alkaline. The following analyses show the characters of the waters. Both have noteworthy primary salinity and secondary alkalinity, but although the sulphur spring is characterized by secondary salinity, the magnesia spring has high primary salinity.

Analyses of water from Piedmont Springs, Alameda County, Cal.

[Analyst and authority, Winslow Anderson (1889). Constituents are in parts per million.]

	Sulphur Spring.		Magnesia Spring.	
Temperature	16° C. (60° F.)		14° C. (58° F.)	
Properties of reaction:				
Primary salinity		42		23
Secondary salinity		15		0
Tertiary salinity		0		0
Primary alkalinity		0		36
Secondary alkalinity		43		41
Tertiary alkalinity		29		59
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	151	6.55	113	4.93
Potassium (K)	7.4	.19	31	.78
Calcium (Ca)	58	2.92	23	1.13
Magnesium (Mg)	77	6.35	35	2.88
Iron (Fe)	Trace.	Trace.	14	.51
Aluminum (Al)	Trace.	Trace.	4.1	.45
Sulphate (SO_4)	329	6.84	33	.69
Chloride (Cl)	82	2.32	53	1.49
Iodide (I)	Trace.	Trace.	Trace.	Trace.
Carbonate (CO_3)	196	6.53	215	7.16
Metaborate (BO_2) [a]	14	.32	38	.89
Silica (SiO_2) [b]	87	2.87	72	2.38
	1,001.4	....	631.1	....
Carbon dioxide (CO_2)	39	1.78	62	2.80
Hydrogen sulphide (H_2S)	61	3.58	Trace.	Trace.

[a] Reported as "borates;" recalculated from $Na_2B_4O_7$.
[b] Reported as "silicates;" assumed to be SiO_2.

The second analysis is given by Anderson[1] as from an "iron spring," but this is believed to be the same spring that is now known as the Magnesia Spring.

[1] Anderson, Winslow, Mineral springs and health resorts of California, p. 223, 1892.

Sandstone associated with serpentine exposed near the springs probably belongs to the Franciscan formation of old sediments and metamorphic rocks, which occupies considerable areas in the central portion of the coastal region.

SULPHUR SPRINGS NEAR WALNUT CREEK (CONTRA COSTA 3).

A group of sulphur springs lies near the northeastern base of a low ridge about 2 miles northeast of the town of Walnut Creek. The largest spring is on the ridge, about 100 yards from its eastern base and 25 yards north of the county road. When the place was visited, the water rose in a board-curbed pool protected by a latticed house and was piped to a cattle trough a few yards away. It yielded about 3 gallons a minute of mildly sulphureted water, 81° in temperature On account of this noticeably high temperature the springs are indicated on Plate III (in pocket) as thermal sulphureted. Five other smaller sulphur springs issue in a belt extending 350 yards along the base of the ridge, in and near the barnyard of Sulphur Springs farm. Two of them have been piped to watering troughs near by. The other three are of seeping flow and form only small marshy places.

The ridge is composed of sandstone that appears to dip nearly vertically and strike S. 30° E. (magnetic) along the trend of the ridge. The steep inclination of the beds shows that intense movement has taken place here, and a fault that is indicated on Plate III extends along the border of the valley land. This structural break probably accounts for the rise of the springs and also for their thermal character.

SULPHUR SPRING IN PINE CANYON (CONTRA COSTA 4).

A moderately sulphureted spring emerges about 4 miles in a direct line northward from Danville, in Pine Canyon, which is at the western base of Mount Diablo. The water forms a clear pool, about 15 inches wide and 4 feet long, in thick-bedded sandstone at the southern side of the creek. The yield is larger than is usual for springs of this class, being estimated at 5 gallons a minute, and the temperature of the water (67°) is also somewhat above the normal. The spring has not been improved, but it has been visited by occasional picnic parties. There are three seepages within 5 yards of the spring, and 1½ miles farther eastward, upstream, sulphureted water seeps from a bluff on the northern side of the creek. Only the one spring of appreciable flow was observed along the canyon, however.

MAYHEW SPRING (ALAMEDA 2).

Mayhew Spring is about 200 yards north of Niles depot. It is situated in an orange orchard and is surrounded by a cemented stone curbing which forms a reservoir about 4 feet in diameter and 10 feet deep. A small pipe and faucet furnish an outlet from a point about 3 feet below the surface, but the yield is only about 1 gallon a minute of water that had an observed temperature of 67° in the reservoir.

The spring was known to the Spaniards in the early days and is still used to slight extent for drinking. Bubbles of gas continually rise in the reservoir, but the water is only faintly sulphureted. The spring is situated on a gentle alluvial slope at the mouth of a drainage wash, between hills of sedimentary rocks that are probably of Tertiary age.

In connection with the Mayhew Spring, Warm Springs (Alameda 3, p. 80), which have been described among the hot springs, may be mentioned, as they are along the same range of hills although about 6 miles southeastward. They are also faintly sulphureted but are named and best known as Warm Springs. There are other sulphur springs, described already (see p. 208), in Alum Rock Park, about 18 miles southeast of Mayhew Spring. At these three localities the warm sulphur water emerges along the front of hilly slopes where a fault has been traced, and the springs seem therefore to be closely related to this structural break.

SULPHUR SPRING ON CROW CREEK (STANISLAUS 1).

A few sulphur springs of small flow issue along the stream channels on the northeastern border of San Joaquin Valley. One of these is situated on Crow Creek, about 10 miles west of Newman, but it has not been developed and is of little importance.

SULPHUR SPRINGS ON ORESTIMBA CREEK (STANISLAUS 2).

About 8 miles southwest of the sulphur spring on Crow Creek (Stanislaus 1) two other sulphur springs that have only a slight flow issue from the banks of Orestimba Creek. Like the one farther northeast, they have not been used and are unimportant.

The rocks that border this portion of San Joaquin Valley consist of gravels and finer sediments, probably of Tertiary age.

HILLYDALE SULPHUR SPRING (SANTA CLARA 6).

A small sulphur spring is situated on property known as Hillydale, about 4½ miles south of the reduction works of the New Almaden quicksilver mine, or 20 miles by road southward from San Jose. The spring is on the western bank of a stream, 200 yards from the house on the place, and yields about one-half gallon a minute of moderately sulphureted water. The following analysis indicates a primary-saline, secondary-alkaline water whose total mineral content is small.

Analysis of water from Hillydale Sulphur Spring, Santa Clara County, Cal.

[Analyst, F. T. Green (1904). Authority, owner of spring. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	57
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	6
Secondary alkalinity	37
Tertiary alkalinity	6

Constituents.	By weight.	Reacting values.
Sodium (Na)	95	4.12
Calcium (Ca)	32	1.60
Magnesium (Mg)	9.5	.78
Iron (Fe) } Aluminum (Al) }	1.0	.04
Sulphate (SO_4)	39	.81
Chloride (Cl)	104	2.93
Carbonate (CO_3)	83	2.76
Silica (SiO_2)	11	.37
	374.5	....
Hydrogen sulphide (H_2S)	Present.	Present.

The water is used locally for drinking and is considered useful medicinally.

The spring is situated at the base of a basaltic slope, in an area of sedimentary rocks that may belong to the Franciscan formation. The rock near the spring contains much calcite and is stained with metallic sulphides, from which the sulphide constituents of the water are possibly derived.

HINNS SULPHUR SPRING (SANTA CRUZ 2).

About 4 miles south of Hillydale Sulphur Spring, across a mountain divide, is a small spring known as Hinns Sulphur Spring. It has been used to some extent for drinking, but has not been greatly improved and has only local interest.

OLIVE SPRING (SANTA CRUZ 1).

Olive Spring is about 1 mile west of Hinns Sulphur Spring. Like the latter it has been of only local importance, as it yields but a small flow of moderately sulphureted water and is remote from well-traveled roads.

Analyses of "Nicholas Springs," published by Anderson, are probably of water from either Olive or Hinns springs. They show a solid content of about 3,100 parts per million, with calcium, magnesium, and sulphate as the prominent constituents.

SULPHUR SPRING ON BODFISH CREEK (SANTA CLARA 11).

Several mineralized springs issue along Bodfish Creek and its tributaries west of Gilroy. Not all of these springs are sulphureted, but as hydrogen sulphide is the most prominent constituent of some of them, the group is described among the sulphur springs.

A strongly sulphureted spring is situated on the northern bank of Bodfish Creek, about 7 miles west of Gilroy and 75 yards above the point where the wagon road crosses the stream and both road and stream make a sharp bend from an easterly to a northerly direction. The water issues in a pool about 1 by 3 feet across that has been dug in the bank 5 yards from the stream. The pool is usually covered with a scum of sulphur and there is a strong odor of hydrogen sulphide near it. The water is used to a slight extent for drinking by campers and teamsters.

BLODGETT MAGIC SPRING (SANTA CLARA 12).

About a quarter of a mile below the sulphur spring on Bodfish Creek (Santa Clara 11, p. 272) there is a spring that has been known as Blodgett Magic Spring and visited by campers during many summers. The water issues in a board-curbed and inclosed pool near camp grounds, at the base of the canyon side 25 yards east of the stream. It is not strongly mineralized, but tastes slightly saline and is mildly sulphureted and carbonated. The second of the two analyses on page 274 is thought to represent water from this spring. The analysis shows a primary and secondary alkaline water with notable tertiary alkalinity and primary salinity. In former years it was bottled and sold locally to small extent. The water issues from soft white sandstones.

Other noticeably sulphureted and carbonated seepages issue along the course of the stream at short distances above and below this spring, and there is said to be a more distinctly carbonated spring several miles southeastward.

BLODGETT MINERAL SPRING (SANTA CLARA 10).

A spring that is known as the Blodgett Mineral Spring or Magnesia Spring is situated on the hillside above a branch of Bodfish Creek and several miles north of Blodgett Magic Spring. It issues from serpentine and its water is piped from a small covered and rock-walled basin 1 mile eastward to a tank near a farm house. The following analysis of the water shows that besides containing a large proportion of magnesia, the water of Mineral Spring is primary and secondary saline in character.

Analyses of water from Blodgett Mineral Spring and Blodgett Magic Spring, Santa Clara County, Cal.

[Analyst and authority, Winslow Anderson (1889). Constituents are in parts per million.]

	Mineral.		Magic.	
Properties of reaction:				
Primary salinity	45		28	
Secondary salinity	16		0	
Tertiary salinity	0		0	
Primary alkalinity	0		21	
Secondary alkalinity	39		51	
Tertiary alkalinity	57		50	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	111	4.83	129	5.61
Potassium (K)	34	.88	4.7	.12
Calcium (Ca)	30	1.48	61	3.05
Magnesium (Mg)	68	5.62	37	3.03
Iron (Fe)	Trace.	Trace.	Trace.	Trace.
Aluminum (Al)	Trace.	Trace.	37	4.15
Sulphate (SO_4)	222	4.63	42	.88
Chloride (Cl)	112	3.15	85	2.40
Iodide (I)	Trace.	Trace.	....	....
Carbonate (CO_3)	151	5.03	256	8.53
Metaborate (BO_2)	Trace.	Trace.	Trace.	Trace.
Silica (SiO_2)	93	3.08	70	2.33
	821	....	721.7	....
Carbon dioxide (CO_2)	32	1.45	79	3.58
Hydrogen sulphide (H_2S)	48	2.81	Trace.	Trace.

EL PAJARO SPRINGS (SANTA CRUZ 3).

El Pajaro Springs are situated near the northern bank of Pajaro River and about a quarter of a mile eastward upstream from the Southern Pacific Railroad bridge near Chittenden station. At least 12 cool, strongly sulphureted springs issue at this place along a sloping bank about 20 feet high that borders a flat willow-grown area along the river. The springs rise at intervals of a few yards for a distance of about 120 yards along the bank, being 25 to 50 yards from the edge of the river during normal stages of the water. Three of the springs, each of which yields 1 or 2 gallons a minute, have been used locally for many years for drinking. One of these has been known as the Railroad Spring, as it has been a favorite with some of the railroad men. The other two, which are about 75 yards northwest of it, are known as White Sulphur Springs. The water of the Railroad Spring has the dark appearance that is characteristic of so-called black sulphur springs, but it becomes milky from suspended sulphur when it stands in an open vessel for a short time. The water of the White Sulphur Springs becomes milky and deposits native sulphur after flowing a few yards from the sources. The difference between the Black Sulphur or Railroad Spring and the White Sulphur Springs is possibly due to different degrees of oxidation of the sulphide constituents in the water as it reaches the surface. The same feature is shown in several minor springs of the group.

The springs were long known locally as Chittenden Sulphur Springs, but were not improved until 1909, when concrete basins were constructed around the springs and the property opened to the public as Shale Sulphur Springs. Later the name was changed to El Pajaro.

The following analyses of water from the Railroad Spring and the larger of the White Sulphur Springs show them to be secondary alkaline, primary saline waters:

Analyses of water from El Pajaro Springs, Santa Cruz County, Cal.

[Constituents are in parts per million.]

	1		2		3	
Properties of reaction:						
Primary salinity		37		31		
Secondary salinity		0		4		
Tertiary salinity		0		0		
Primary alkalinity		1		0		
Secondary alkalinity		62		65		
Tertiary alkalinity	(?)		(?)			
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	199	8.63	159	6.94		
Potassium (K)	4.3	.11	4.5	.12		
Lithium (Li)	0	.00	0	.00		
Barium (Ba) and strontium (Sr)	0	.00	0	.00		
Calcium (Ca)	154	7.66	182	9.08		
Magnesium (Mg)	83	6.81	84	6.88		
Iron (Fe) } Aluminum (Al) }	6.2	.22	2.8	.10		
Sulphate (SO_4)	150	3.12	234	4.85	85	1.77
Chloride (Cl)	193	5.45	109	3.08		
Sulphur (S) [a]	.4	.02	.8	.05		
Carbonate (CO_3)	402	13.41	392	13.07		
Metaborate (BO_2)	0	.00	0	.00		
Phosphate (PO_4)	0	.00	0	.00		
Silica (SiO_2)	58	1.92	57	1.88		
	1,249.9		1,225.1			
Carbon dioxide (CO_2)	Present.	Present.	Present.	Present.		
Hydrogen sulphide (H_2S)	4.8	.28	8.6	.50	28	1.67
Methane (CH_4)			Present.	Present.		

[a] In suspension.

1. Railroad Spring. Analyst, Riddell and McCreary (1908). Authority, owner of springs.
2. White Sulphur Spring. Analyst, Riddell and McCreary (1908). Authority, owner of springs.
3. White Sulphur Spring. Analyst and authority, F. M. Eaton (1909).

The first two samples were analyzed several weeks after they were collected. In order to determine, if possible, to what extent change had taken place in the unstable sulphur compounds between the times of collection and analysis, a sample from the White Sulphur Spring was later collected in a bottle containing iodine solution, so that the sulphide constituent was at once precipitated as sulphur according to the reaction $H_2S + 2I = 2HI + S$ and could be determined independently of the sulphate radicle. The sulphide and sulphate constituents were then determined within a few days of the time of collection, with the results shown in the analysis by F. M. Eaton. These results are not very satisfactory, however, for although the content of hydrogen sulphide is much greater in the sample treated with iodine than in the other, the much smaller amount of sulphate indicates that there was a marked change in the concentration of the water during the year that intervened between the collection of the two samples. However, in the first samples there appears to have been a considerable increase in the amount of sulphate in the water on standing, and a decrease in the sulphides, a change that probably somewhat alters the medicinal properties of the water. Although sulphides were not reported in the analyses, the change that takes place in the sulphur compounds when the water stands for a time is believed to show that sulphides are present.

Considerable inflammable gas rises in several of the springs. Analysis [1] of a sample of this gas indicates that it consists principally of methane (marsh gas, CH_4), with carbon dioxide (CO_2), and hydrogen sulphide (H_2S).

A third of a mile north of El Pajaro Springs are two other springs, or wells. One issues at the base of a steep hillside through a 12-inch casing. A few bubbles of gas rise with the water and the surface of the pool that surrounds the casing is covered with a film of oil. The spring yields about 1½ gallons a minute of sulphureted water that becomes milky by the time it reaches a watering trough 10 yards away. The other spring is situated in meadowland, 300 yards northwest of the first. It yields perhaps 8 gallons a minute of clear water that is not noticeably sulphureted. It has been piped to a near-by storage tank for supplying cattle troughs.

The rock of this area is light-colored shale of Tertiary age. Oil is obtained from wells a few miles to the northeast. The fault zone along which the earthquake of April 18, 1906, took place passes through the locality. The shale along the fault zone has been crushed by the earth movements, and landslides have been caused by the shocks. The issuance of gas and sulphur water along this zone of shattered material, where escape for them has been furnished, is noteworthy.

SULPHUR SPRING ON MISSION CREEK (MONTEREY 6).

About 12 miles west of north from Jolon post office, or 10 miles from San Antonio Mission, there is a cool sulphur spring that has been used to a slight extent as a drinking spring. It is not near a main traveled road, however, and is not widely known. The spring apparently issues from sedimentary materials, probably of Tertiary age, that form the hills bordering the west side of Salinas Valley.

[1] Analysts, Riddell and McCreary, 1908.

HUER HUERO SPRINGS (SAN LUIS OBISPO 4).

Two groups of mineralized springs, that are known as the Huer Huero Springs, rise on the ranch of the same name, 13 to 15 miles southeast of Paso Robles. The northernmost, which is known as the Old Spring, is on the eastern side of the road and about 1½ miles south of Creston post office. The water issues in the stream channel at the head of a creek, and yields a small flow of cool sulphureted iron water. The locality is well shaded by oaks and willows and has been used as a summer camp ground for more than 20 years. It is the site of the Keunard German settlement, which was started a number of years ago. The New Springs, which are across a drainage divide and about 2 miles farther south, are locally known as iron springs, though their water is strongly sulphureted. They rise for a distance of about 100 yards along a stream channel and yield about 2 gallons a minute. Like the Old Spring, the New Springs are used by campers. At both localities the water issues from the light-colored granitic material that forms a considerable portion of the hills southeast of Paso Robles.

SULPHUR SPRING IN CARRIZO PLAIN (SAN LUIS OBISPO 12).

A number of small springs in the region between Paso Robles and the San Joaquin Valley are sulphureted, but few of them are of particular interest, and very few are of greater use than as cattle-watering holes. One spring that is in the southern portion of Carrizo Plain has been developed to the extent of piping its water about a mile northward to a 10,000-gallon iron tank which supplies two cattle troughs. It yields about 3 gallons a minute of strongly sulphureted water.

The hydrogen sulphide of most of the springs in this region is probably derived from sulphide minerals in the sediments of Tertiary age, which form the greater part of the hills that border the plains.[1]

SULPHUR SPRINGS ON BURTON MOUND (SANTA BARBARA 6).

A number of sulphur springs of small flow formerly issued near the beach in Santa Barbara, from the slight elevation known as Burton Mound, on which the Potter Hotel has been built. Since the construction of the hotel, about 1901, the water of the springs has been pumped to a small drinking fountain in the hotel office and another at the southeastern border of the grounds. The springs rise in a small basin in the basement of the hotel. Although considerable difficulty

[1] "Bitterwater Spring" is shown on some early maps, about 15 miles northwest of the sulphur spring in Carrizo Plain. In 1910, however, it was not found, and information concerning it was unsuccessfully sought. It is probably a minor sulphureted spring near the channel of Bitterwater Creek.

was experienced in controlling the flow during construction of the hotel, the springs now yield only a slight amount of moderately sulphureted water.

LYONS SPRING (VENTURA 6).

Lyons Spring has been mentioned incidentally in speaking of Stingleys Hot Springs (Ventura 5, p. 63). It is situated in Matilija Canyon, about halfway between Vickers and Matilija hot springs, and about 1 mile northwest of the latter place. The property has been open as a small resort since 1888, accommodations being provided in 1908, by tent houses, for about 50 people.

The spring rises in a ravine to the south, and the water is piped 1,100 feet to a small stone reservoir on the grounds. It is thence piped to a boiler and heated for bathing. It is soft and mildly sulphureted, being known as a white-sulphur water from the slight milkiness that is produced by sulphur in suspension.

SULPHUR SPRING IN MATILIJA CANYON (VENTURA 4).

One other cool sulphur spring in Matilija Canyon has been mentioned in the description of Vickers Hot Springs. It rises at the base of the canyon side, about a quarter of a mile southeast of the Vickers Hot Springs and supplies a cool, strongly sulphureted pool of small discharge that was formerly used as a drinking basin. When visited, however, it had apparently been unused for several years.

The region is composed of shales and sandstones that are probably of Tertiary age. They are steeply inclined, showing that intense folding has taken place. The sulphur constituents of the mineral springs in the canyon, as in many other places, are probably derived from sulphide and sulphate minerals in the sediments.

SULPHUR SPRING NORTHEAST OF NORDHOFF (VENTURA 8).

A small sulphur spring on the hillside about 2¾ miles by road northeast of Nordhoff is probably the one that has been sometimes referred to as Ojai Sulphur Spring. It is situated in private grounds on a gentle open slope about 100 yards north of a ravine and rises in a board-curbed pool 5 feet square and 3 feet deep. Bubbles of gas intermittently rise in it. The water has a distinctly sulphureted odor and taste and the dark color of "black sulphur" waters. Small amounts of sulphur are deposited on leaves and other objects that expose the sulphide constituents to oxidation by the air. The water has been used mainly for laundry purposes at the spring. There is said to be a similar spring a mile eastward, and small sulphur springs probably issue at other places in this region of Tertiary sediments. The rocks of the locality consist of marine sediments, mainly sandstones, that are of the same character as those in Matilija Canyon 5 or 6 miles westward.

SULPHUR MOUNTAIN SPRINGS (VENTURA 9).

Sulphur Mountain Springs are in the canyon of Sisar Creek, a quarter of a mile above (west of) its junction with Santa Paula Creek and 6 miles north of Santa Paula. The property has been conducted as a summer resort since the late nineties, accommodations being provided mainly by tents and tent cottages. The buildings are situated in a grove of black walnuts in a flat on the south side of the creek.

The main spring is on the hillside a few hundred yards southward from the grounds and 150 feet above them. It issues from a drift and tunnel in a small ravine and yields about 15 gallons a minute of mildly sulphureted water. The water is conducted in an open trough to a storage tank about 50 yards away and is thence piped to the grounds to supply a swimming plunge and also tub baths, for which it is heated. It issues clear but becomes milky from suspended sulphur before reaching the storage tank. The following analysis shows it to be a secondary saline water with notable sulphide content:

Analysis of water from main spring, Sulphur Mountain Springs, Ventura County, Cal.

[Analyst, Frederick Salathe. Authority, advertising matter. Constituents are in parts per million.]

Temperature	18° C. (65° F.)
Properties of reaction:	
Primary salinity	14
Secondary salinity	70
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	16
Tertiary alkalinity	2

Constituents.	By weight.	Reacting values.
Sodium (Na)	47	2.04
Lithium (Li)	Trace.	Trace.
Calcium (Ca)	163	8.12
Magnesium (Mg)	55	4.55
Iron (Fe)	1.1	.04
Aluminum (Al)	0.4	.04
Sulphate (SO_4)	584	12.16
Chloride (Cl)	4.6	.13
Sulphide (S)	3.8	.24
Carbonate (CO_3)	67	2.22
Silica (SiO_2)	.2	.01
	926.1	......
Hydrogen sulphide (H_2S)	2.2	.13

A second spring, which yields perhaps 1 gallon a minute, issues near the side of the creek on the resort grounds. An excavation 6 feet below the ground surface has been cemented, and the water rises in a joint of tile pipe that forms a drinking basin. This water is not so strongly sulphureted as is that of the larger spring. At the springs there is a small anticline or upward fold [1] in the Tertiary sediments that predominate in this part of the State. At the larger spring shaly sandstone is exposed in the tunnel, the walls of which are impregnated with alum salts. Small amounts of lime carbonate appear in the cut in front of the tunnel and more noticeable deposits of the same material on the hillside below it.

SULPHUR SPRING IN SANTA SUSANA MOUNTAINS (LOS ANGELES 3).

A spring that is strongly charged with hydrogen sulphide issues on the southern side of Santa Susana Mountains, on the Sparks ranch, about 5 miles north of Chatsworth. In the early days it was visited by the padres of Mission San Fernando, a few miles away, and by the Indians of the locality. The following partial analysis of its water made a number of years ago shows it to be secondary alkaline and primary saline in character:

Partial analysis of water from sulphur spring in Santa Susana Mountains, Los Angeles County, Cal.

[Analyst, Oscar Loew (1876). Authority, Wheeler report. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	23
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	8
Secondary alkalinity	69
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Sodium (Na)	104	4.53
Potassium (K)	Trace.	Trace.
Lithium (Li)	Trace.	Trace.
Calcium (Ca) } Magnesium (Mg) }	203	10.10
Iron (Fe)	Trace.	Trace.
Aluminum (Al)	Trace.	Trace.
Manganese (Mn)	Trace.	Trace.
Sulphate (SO_4)	161	3.36
Chloride (Cl)	Trace.	Trace.
Carbonate (CO_3)	338	11.27
Phosphate (PO_4)	Trace.	Trace.
Silica (SiO_2)	Trace.	Trace.
	806	....
Carbon dioxide (CO_2)	Excess.	....
Hydrogen sulphide (H_2S)	50	2.93

The spring is still locally known, but its water has not been used as much during recent years for medicinal purposes as it was formerly. It has strongly impregnated the adjacent soil with sulphur. Another seepage of strongly sulphureted water also issues near by.

[1] Eldridge, G. H., and Arnold, Ralph, The Santa Clara Valley, Puente Hills, and Los Angeles oil districts, southern California: U. S. Geol. Survey Bull. 309, Pl. I, 1907.

SULPHUR SPRING NORTH OF CHATSWORTH (LOS ANGELES 4).

A sulphur spring whose water is noticeably above a normal temperature issues about 1½ miles north of Chatsworth and 200 or 300 yards east of the southern mouth of the Southern Pacific railroad tunnel. Its water has not been used except for drinking, but its flow is perhaps 8 gallons a minute. It issues from the thick-bedded sandstone of this portion of the mountains.

SULPHUR SPRING AT MOUTH OF BELL CANYON (LOS ANGELES 5).

At Bell's ranch, at the mouth of Bell Canyon, which enters San Fernando Valley from the west, there is a sulphur spring of considerable flow. The spring is inclosed by a stone-walled reservoir about 8 by 12 feet across and 6 feet deep and yields strongly sulphureted water that is rendered milky by sulphur in suspension. The water is piped to a summer bathhouse near by. It is very soft and good for bathing and laundry use. A similar spring that has not been improved issues some distance westward up the canyon. Both springs apparently emerge from a calcareous bed near the contact between beds of lower Miocene sandstone and middle Miocene shale.

SULPHUR SPRING SOUTH OF BELL CANYON (LOS ANGELES 6).

A small spring whose water is noticeably sulphureted is situated about 2½ miles south of the one at the mouth of Bell Canyon. It yields a soft water but has been used only for watering cattle.

SULPHUR SPRING NEAR CARBERRY STORE (LOS ANGELES 7).

In a ravine near the Carberry store, which is beside the county road along the southern border of San Fernando Valley, there is a small spring whose water is strongly sulphureted and noticeably above a normal temperture. The spring has not been developed and has been used only as a watering place by cattle.

SULPHUR SPRING ON TUCKER RANCH (LOS ANGELES 9).

A spring on the Tucker ranch, beside the wagon road between Calabasas and Santa Monica, yields water that is rather strongly sulphureted but is soft and otherwise of good quality, and as water is scarce in this part of the Santa Monica Mountains the spring has been used for a number of years as a domestic supply. This spring and the sulphur springs south of Bell Canyon and near the Carberry Store (Los Angeles 6 and 7) issue from middle Miocene shale that dips northeastward toward San Fernando Valley. The sulphur contents of the spring waters are evidently derived from this shale, as it contains noticeable amounts of sulphur compounds.

SANTA FE SPRINGS (LOS ANGELES 14).

Three wells that were put down in the coastal plain 15 miles southeast of Los Angeles by Dr. J. E. Fulton, during the seventies, obtained sulphur water, and as the locality was favorable a hotel was built, a swimming plunge was constructed, and the property was early made a resort, under the name of Santa Fe Springs, or Fulton Wells. The hotel burned a number of years ago, and the plunge has been filled up, but when visited in 1908 the place was still conducted in a small way as a resort, there being three small cottages and a bathhouse on the property. Windmills over two of the wells 100 yards or more from the cottages pumped the water into a tank, whence it was piped to a heating boiler and to the baths. The third and innermost well, which is near the cottages, was equipped with a hand pump. Water from this well was formerly bottled for table and medicinal use. The following analysis shows it to be a secondary alkaline and primary and secondary saline water that contains a large proportion of iron:

Analyses of water from east well, Santa Fe Springs, Los Angeles County, Cal.

[Constituents are in parts per million.]

	1		2	
Properties of reaction:				
Primary salinity		20		24
Secondary salinity		30		31
Tertiary salinity		0		0
Primary alkalinity		0		0
Secondary alkalinity		50		45
Tertiary alkalinity		High.		High.
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	84	3.63	90	3.89
Calcium (Ca)	205	10.21	167	8.31
Magnesium (Mg)	50	4.08	47	3.86
Iron (Fe)	97	3.47	107	3.84
Sulphate (SO_4)	294	6.12	[a] 278	5.78
Chloride (Cl)	100	2.81	108	3.05
Sulphide (S)	....	....	6.3	.39
Carbonate (CO_3)	374	12.46	320	10.68
Silica (SiO_2)	42	1.39	....	....
	1,246	....	1,123.3	....
Carbon dioxide (CO_2)	Excess.	....	Excess.	....
Hydrogen sulphide (H_2S)	Excess.	....	Excess.	....

[a] Reported as "sulphur;" recalculated from $CaSO_4$ by comparison with the other analysis.

1. Analyst and authority, Winslow Anderson (1888).
2. Analyst, Price and Hewston. Authority, U. S. Geol. Survey Bull. 32.

A number of other wells in this coastal plain area of southern California yield water that is noticeably sulphureted but not so strongly mineralized as is the water of Santa Fe Springs. Seepages of sulphureted water also issue from shales at a few places along the coast. One strongly sulphureted spring of this character issues from the

Cretaceous shales of Point Loma, but as it is exposed only at low tide its existence is known to very few people.

SULPHUR SPRING SOUTHEAST OF CARBON (SHASTA 10).

There are a few isolated cold sulphur springs in the Cascade-Sierran ranges of the State. Among them is a small cool sulphur spring that issues about 1 mile southeast of Carbon post office in Shasta County, a short distance east of Hat Creek. The water flows only a few yards from its source and is seldom used for drinking, but the spring is of interest because noticeably sulphureted waters are uncommon in this part of the State, where the surface rocks consist almost entirely of lavas.

SULPHUR SPRING NEAR HEAD OF BATTLE CREEK MEADOWS (TEHAMA 3).

Near the head of Battle Creek Meadows and about 1½ miles northeast of Mineral post office, which is near the southern base of Lassen Peak, is a small cool sulphur spring. It issues in a ravine, 15 yards from the eastern bank of the creek and 150 yards east of the stage road. In 1910 there was a house between the creek and the road, and the spring had been cleaned out and was used for drinking. It yields about 8 gallons a minute of cold, noticeably sulphureted water which deposits small amounts of sulphur.

The rock that is exposed along the creek is the basaltic lava of Lassen Peak. It is worthy of mention that this is the only cold sulphur spring that was seen in the Lassen Peak region, the other sulphur springs being of notably thermal character.

McLEAR SULPHUR SPRINGS (PLUMAS 15).

On the southeast side of Mohawk Valley, near the southern border of Plumas County, is a group of sulphur springs that might as properly be described with the hot springs, for five of the eight springs that rise here are warm, but they are best known as sulphur springs, though they are also indicated as thermal on Plate III (in pocket).

The principal springs are situated a short distance back of the buildings on the McLear ranch, rising for a space of about 500 yards along the eastern border of the valley from lake sediments that have been described by Turner.[1] The southernmost of these springs issues from two vents about 4 yards apart in a bank of sandstone, and yields about 8 gallons a minute of water 84° in temperature. A second warm spring that rises 100 yards northward in a cut in the bank yields about the same amount of water whose observed temperature was 85°. About 85 yards farther to the northeast a spring that yields approximately 30 gallons a minute, of water with a tem-

[1] Turner, H. W., Philos. Soc. Washington Bull., vol. 11, pp. 385-410, 1891.

perature of 86°, issues from another adit or cut in the lake sandstone. In a small drainage ravine 150 or 200 yards farther northward a small sulphureted spring emerges at the base of tuffaceous agglomerate that borders the valley at this point. Near it a cooler spring that is not noticeably mineralized rises in a ditch that discharges perhaps 5 gallons a minute. The largest spring is 50 yards farther up the ravine, where approximately 75 gallons a minute of non-mineral water 62° in temperature rises in a small box-curbed pool and is piped to the house. The northernmost spring rises from a small fissure in the lake sediments and yields perhaps 15 gallons a minute of water 85° in temperature. It is mildly sulphureted and is distinctly mineralized, probably mainly with sodium salts. In 1890 Turner[1] noted a uniform temperature of 75° in the springs but mentions the reported increase of temperature of other thermal springs in the region at the time of a slight earthquake. He considers the consolidation of the lake sediments to a sandstone near the springs to be due to the cementing action of their waters. The water from the several warm springs is collected in a ditch that runs below them and is used for irrigation.

In the meadowland half a mile west of the sulphur springs there is a marshy area 20 yards in diameter. A keg that has been sunk near its margin affords a drinking pool containing distinctly sulphureted water that had an observed temperature of 48° (in September). The sulphur contents of this spring and of the warm springs seem to be derived from the lake sediments through which they rise.

SULPHUR SPRINGS NEAR SOUTH FORK OF YUBA RIVER (PLACER 2).

In the canyon of South Fork of Yuba River, less than a mile north of Cisco railroad station, are two small springs, one of which forms a drinking spring near the wagon road on the southern side of the river. The other is some distance farther upstream, on the northern side of the river, and has been little used. Their waters are only faintly sulphureted. The rocks of the locality consist of slates, in part altered by contact metamorphism,[2] that are of Jurassic and Triassic age.

SULPHUR SPRING ON BEAR RIVER (NEVADA 1).

A sulphur spring that is similar to the springs near Cisco rises on the northwest bank of Bear River, a quarter of a mile below the wagon bridge 3 miles north of Colfax. The spring rises below flood-water mark, at the base of a bowlder of gabbro, which is the country

[1] Op. cit., p. 396.

[2] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), 1900.

rock at this locality,[1] and forms a pool of distinctly sulphureted water. The spring is known locally, but as it is not near the road it has been seldom visited.

SULPHUR SPRING ON MIDDLE FORK OF AMERICAN RIVER (PLACER 10).

A small spring of strongly sulphureted water is situated in the canyon of Middle Fork of American River, about 20 miles west of Tahoe. The water issues at the base of a bluff of morainal material, on the southeast side of the stream. It has been visited by fishermen and others who penetrate this portion of the Sierra, but it is not well known.

SULPHUR SPRINGS ON RUBICON RIVER (ELDORADO 1).

On the southern side of the canyon of Rubicon River, below the mouth of Five Lakes Creek and about 13 miles in a direct line southwest of Tahoe, there is a spring that yields perhaps 1 gallon a minute of strongly sulphureted, saline water. Two other similar springs issue at points about 1 mile and 3 miles farther downstream. An analysis of water from one of them shows that it contains large amounts of sodium, calcium, and chloride. As the canyon is rugged and is not easily accessible, the springs are not well known.

The canyon sides near the springs are of granitic rock, but slate and quartzite are exposed on the higher slopes, and it seems probable that the chemical constituents of the water are derived mainly from these altered sedimentary rocks.

SULPHUR SPRING NEAR AMERICAN RIVER (ELDORADO 5).

Near Kyburz station, which is on the stage road between Placerville and Lake Tahoe and near the junction of the Silver and South forks of American River, there is a small, strongly sulphureted spring, which is known only locally. It is situated in an area of slates and granitic rocks that are overlain by lava of relatively recent age, and the water probably rises in altered slates near the zone of contact with the granitic material.

SULPHUR SPRING ON PAOHA ISLAND (MONO 6).

On the western shore of Hot Spring Cove on Paoha Island, in Mono Lake, opposite the hot springs that have been previously described (Mono 7, p. 144), there is a spring of mildly sulphureted water that has also a slight odor and taste of petroleum. On account of the intensely alkaline character of the lake water, this spring has at times furnished a welcome supply, and during the fall of 1908 it was used by men who were drilling for oil on the western border of the island. It is worthy of note that a slight artesian flow of warm water, which, like the spring water, tasted mildly of hydrogen sulphide and of

[1] Lindgren, Waldemar, op. cit.

petroleum, was struck at a considerable depth in the well. Both the water of the well and that of the spring issue from lake sediments which cover the western part of the island.

SULPHUR SPRING IN SULPHUR MEADOWS (FRESNO 6).

A spring of faintly sulphureted water rises in Sulphur Meadows, one-half mile south of Shaver lumber mills, in the mountains of northeastern Fresno County. It is situated at the border of a pine grove in which there is a group of cabins, and it has been curbed and inclosed to form a drinking pool. It yields a small amount of clear cool potable water. The region is one of granitic rocks, in which at least one other sulphur spring rises in the ravine above the meadow, but this latter spring is of slight flow and has not been improved.

SULPHUR SPRINGS NEAR GLENNVILLE (KERN 6).

Two mildly sulphureted springs that yield a combined flow of about 10 gallons a minute issue one-half mile east of Glennville post office on the slopes of the southern Sierra. The springs have been used for irrigating a garden, as their water is not strongly mineralized. A few other mildly sulphureted springs of small flow issue in the same locality, one of them being near the post office. The rocks of the region consist of the granitic material that composes most of this portion of the Sierra, and on account of the scarcity of other mineralized springs in the vicinity the sulphur springs near Glennville are worthy of special note.

SULPHUR SPRINGS NEAR BULLION MOUNTAINS (SAN BERNARDINO 43).

Several springs of strongly sulphureted water issue near the southern end of Bullion Mountains, in flat land on the road that leads southeastward from Victorville to Dale mining camp. The yield of water is considerable, but it tastes too strongly of hydrogen sulphide to be palatable. It is seldom used for watering, as there is better water about 2 miles farther north.

SUMMARY OF SULPHUR SPRINGS.

In the following list the sulphur springs, numbering 72, have been tabulated, as were the hot springs and the carbonated springs, with respect to the character of the rock in which they rise. Many of the hot springs are sulphureted, and those which are notably so have been included in the list in italics. A few sulphur springs at groups that have been described under other headings are also included in the list, in which they are marked by parentheses.

The list shows that most of the sulphur springs are in areas of sedimentary rocks, possibly because the sulphide constituent, which is usually hydrogen sulphide, is more readily taken into solution from sediments, for they usually contain organic matter and metallic sulphides from which the hydrogen sulphide is derived, and the metallic sulphides are probably more readily decomposed in the relatively pervious shales and sandstones than they are in the relatively impervious crystalline rocks.

Sulphur-spring localities.[1]

In alluvium.

Byron Hot Springs.
Sulphur springs on Burton Mound.
Santa Fe Springs (wells).
Sulphur spring on Paoha Island.
Sulphur springs near Bullion Mountains.

In sandstone or shale.

St. Helena White Sulphur Springs.
O'Donnells Springs.
Wall Springs.
Sulphur springs in Franz Valley.
Sulphur spring near Little Sulphur Creek.
Sulphur spring near Sulphur Creek.
The Geysers.
Little Geysers.
Sulphur springs on branch of Deep Creek.
Muir Springs.
Sulphur spring near branch of Eel River.
Sulphur springs near Cummings.
Sulphur spring near Hoaglin.
Sulphur spring in Eureka.
Mountain View Spring.
Cook Spring.
Sulphur spring southwest of Fouts Springs.
Sulphur spring west of Fouts Springs.
Wilbur Hot Springs.
Jones Hot Springs.
Sulphur spring near Blue Lakes.
Hayvilla Sulphur Spring.
(Saratoga Springs, one sulphur spring.)
(Tuscan Springs, sulphureted saline springs.)
(Richardson Springs, sulphureted saline springs, from tuffs.)
Sulphur springs in Sulphur Valley.
Harbin Springs.
Anderson Springs.
Zem Zem Spring.
Sulphur springs near Walnut Creek.
Sulphur spring in Pine Canyon.
Mayhew Spring.
(Alum Rock Park Springs, several sulphur springs.)
Paraiso Hot Springs.
Sulphur spring on Crow Creek.
Sulphur springs on Orestimba Creek.
Hinns Sulphur Spring.

[1] Thermal springs are in italics; those described in other groups are in parentheses.

Olive Spring.
Sulphur spring on Bodfish Creek.
Blodgett Magic Spring.
El Pajaro Springs.
Sulphur spring on Mission Creek.
Sulphur spring in Carrizo Plain.
Pecho Warm Springs.
San Luis Hot Springs.
San Marcos Hot Springs.
Montecito Hot Springs.
Vickers Hot Springs.
Stingleys Hot Springs.
Lyons Spring.
Sulphur spring in Matilija Canyon.
Matilija Hot Springs.
Wheelers Hot Springs.
Sulphur spring northeast of Nordhoff.
Sulphur Mountain Springs.
Sulphur spring in Santa Susana Mountains.
Sulphur spring north of Chatsworth.
Sulphur spring at mouth of Bell Canyon.
Sulphur spring south of Bell Canyon.
Sulphur spring near Carberry store.
Sulphur spring on Tucker ranch.
McLear Sulphur Springs.

In metamorphic rocks.

Vallejo White Sulphur Spring.
Sulphur spring near Laytonville.
Deerlick Springs.
Sulphur springs on Browns Creek.
Neys Springs.
Sulphur spring on Castle Creek
Colyear Springs.
Hensley Spring.
Sulphur spring on South Fork of Cottonwood Creek.
Piedmont Springs.
Blodgett Mineral Spring.
Sulphur springs near South Fork of Yuba River.

In lava.

Napa Vichy Spring.
El Toro Spring.
Taylor Sulphur Spring.
Hillydale Sulphur Spring.
Sulphur spring southeast of Carbon.
Sulphur spring near head of Battle Creek Meadows.
Hot springs on Bidwell Creek.

In granitic rocks.

Huer Huero Springs.
Sulphur spring on Bear River.
Sulphur spring on Middle Fork of American River.
Sulphur springs on Rubicon River.
Sulphur spring near American River.

Sulphur spring in Sulphur Meadows.
Sulphur springs near Glennville.
Warm spring in Panamint Valley.
Tassajara Hot Springs.
San Jacinto Hot Springs

SALINE SPRINGS.

NUMBER AND DISTRIBUTION.

California contains no large saline springs nor wells that yield brine which furnishes a commercial supply of common salt, but a number of small, notably saline springs issue in the northern part of the Coast Ranges, most of them in areas of unaltered sediments of Tertiary and Cretaceous age. In the earlier slates of the northern Sierra there are a few salt licks, or deer licks, and a few strongly saline and alkaline springs also rise in the deserts of the southeastern part of the State, where great evaporation has concentrated the salts that have probably been leached from ancient sedimentary rocks. Several of the springs have been commercially developed, either as resorts or for the purpose of bottling the water. In the following pages the developed springs are first described, beginning with those in the northern part of the State.

TUSCAN SPRINGS (TEHAMA 5).

Tuscan Springs (Pl. XII, *B*, p. 200) are 10 miles northeastof Red Bluff near the head of the canyon of Salt Creek. They are said to have received their name because when they were first noticed a salt that coated the surface resembled that at Tuscan, Italy. It is also said that the first borax in the State was found here and that borax has been found in the spring waters,[1] but borates are not reported in the available analyses. The property was early improved as a resort for the medicinal use of the water, and a three-story hotel and a bathhouse were erected. In 1909 a large cottage and several smaller ones furnished additional accommodations; gas from one of the springs was used for lighting, and water from another was evaporated in shallow troughs and the salt was sold for medicinal use. The water was formerly bottled and marketed, but the sale of the salt has replaced the trade in the water.

The canyon of Salt Creek widens at its head to a small valley or amphitheater, surrounded by rugged cliffs,[2] and the springs issue along the main creek and its branches in this open area. As many as 52 springs have been claimed for the locality, but the writer

[1] California State Mineralogist Tenth Rept., p. 694, 1890.

[2] On account of its shape and its walls of tuffaceous lava, the locality has been described (California State Mineralogist Tenth Rept., pp. 693–694, 1890) as a volcanic crater, but the shales in the bottom of the amphitheater discountenance this hypothesis.

counted only 18 appreciable springs. Spring houses protect the three that are most used for drinking. Water from another spring supplies the evaporating trays. Two other springs rise in cemented reservoirs about 15 and 20 feet in diameter. Gas from one of these, which is called the Natural Gas Spring, is piped to a tank higher on the hillside for use at the hotel, and water from the other, which is named Fountain Spring, supplies the baths. The other springs rise in bricked and cemented basins along the banks of the drainage channels. All of the springs are within 250 yards south to east of the hotel, which is on higher ground overlooking them. Most of them are of inappreciable flow, but all are strongly mineralized. Some are strongly sulphureted as well as saline, and for this reason the locality is marked on Plate III (in pocket) as one of sulphur springs. The following analyses indicate that they are primary saline waters remarkably uniform in composition for springs of such high mineral content, the chief difference being in the high sulphate content of spring No. 1. The remarkably high potassium content in all but the Natural Gas Spring is notable. It is not unlikely that the proportion of potassium is about the same for all the springs and that the apparent difference is due to differences in analytical methods or calculation.

Analyses of water from Tuscan Springs, Tehama County, Cal.

[Authority, advertising matter. Constituents are in parts per million.]

	1		2		3		4		5	
Properties of reaction:										
Primary salinity		96		99		99		99		99
Secondary salinity		2		0		0		0		0
Tertiary salinity		0		0		0		0		0
Primary alkalinity		0		0		0		0		0
Secondary alkalinity		2		1		1		1		1
Tertiary alkalinity		7		4		2		1		4
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	8,096	352.0	8,349	363.0	8,241	358.3	7,944	345.4	8,386	364.6
Potassium (K)	29	.75	2,448	62.6	3,353	85.8	2,705	69.2	2,851	72.9
Lithium (Li)	.3	.05	1.7	.24	2.0	.29	1.9	.27	1.9	.27
Barium (Ba)	3.7	.05	......	......	......	......	......	......	......	......
Calcinm (Ca)	144	7.20	67	3.34	66	3.28	68	3.37	68	3.41
Magnesium (Mg)	92	7.59	23	1.86	28	2.27	27	2.21	21	1.71
Iron (Fe)	13	.47	.9	.03	Trace.	Tr.	Trace.	Tr.	0	.00
Sulphate (SO_4)	351	7.30	2,108	43.9	420	8.76	448	9.33	680	14.15
Chloride (Cl)	12,460	351.4	13,540	381.9	15,440	435.6	14,380	405.6	15,020	423.6
Carbonate (CO_3)	281	9.38	156	5.20	166	5.55	167	5.58	154	5.12
Silica (SiO_2)	35	1.17	13	.43	13	.43	5.6	.19	.5	.02
	21,505.0	......	26,706.6	......	27,729.0	......	25,746.5	......	27,182.4	......
Hydrogen sulphide (H_2S)	383	22.54	320	18.77	122	7.16	84	4.94	294	17.23

1. Natural Gas Spring. Analyst, Price & Son.
2. Spring No. 1. Analyst, N. Lehnen (1905).
3. Spring No. 10. Analyst, N. Lehnen (1905).
4. Spring No. 11. Analyst, N. Lehnen (1905).
5. Spring No. 15. Analyst, N. Lehnen (1905).

The following analysis of the marketed salt indicates that the water from which it is derived has a somewhat different composition from that of the other springs, and the absence of calcium and magnesium from it seems questionable. The average proportion of the soluble materials in ocean water is tabulated with it, for comparison.

Analyses of Tuscan Springs salts and soluble matter in ocean water.

	Tuscan Springs salts.[a]	Ocean water.[b]
Sodium (Na)	28.05	30.65
Potassium (K)	15.50	1.11
Lithium (Li)	.02	....
Calcium (Ca)	....	1.20
Magnesium (Mg)	....	3.75
Sulphate (SO_4)	.62	7.68
Chloride (Cl)	55.77	55.20
Bromide (Br)	....	.20
Carbonate (CO_3)	.14	.21
	100.10	100.00

[a] Analyst, N. Lehnen (1905). Authority, advertising matter.
[b] Recalculated from average composition of ocean water: Dittmar, Challenger Reports, Physics and chemistry, vol. 1, p. 204, 1884.

The springs rise in dark-colored shale and sandstone, the latter material being veined in places with calcite. The structure shows that the beds have been folded into a small arch or anticline at this locality. Dips of 50° on the western side of the fold were observed. The occurrence of usable quantities of illuminating gas is worthy of mention in connection with this anticlinal structure, as is also the presence of a large mound, shown in Plate XII, *B* (p. 200). This mound has the appearance of a spring formation, although the material on its surface was not noticeably different from that of the adjacent slopes. The sediments are overlain by volcanic agglommerate or tuff, which forms the cliffs of the canyon walls. The marine sediments have been described by Diller[1] as part of the Chico formation, of Upper Cretaceous age, and the fresh-water deposit of tuffaceous material that overlies them has been named the Tuscan tuff and is of Pliocene age.[2]

RICHARDSON SPRINGS (BUTTE 2).

Richardson Springs are situated in the canyon of Mud Creek, 12 miles north of Chico. The property has been developed as a medicinal and vacation resort since 1898. In 1909 the improvements included a main hotel, three large rooming cottages, a number of small ones, and a bathhouse. The buildings are on the slope on the northern side

[1] Diller, J. S., Geology of the Lassen Peak district: U. S. Geol. Survey Eighth Ann. Rept., pt. 1, p. 411, 1889; Tertiary revolution in the topography of the Pacific coast: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, pp. 405–406, 1894.

[2] Diller, J. S., Geology of the Lassen Peak district: U. S. Geol. Survey Eighth Ann. Rept., pt. 1, pp. 422–424, 1889.

of the creek, and the springs issue along the northern edge of its natural channel. A wall directs the stream to the opposite side of its channel, however, and protects the springs from being flooded.

Three of the four principal springs on the property rise within 30 yards of each other, between the hotel and the bathhouse. Two of these form cemented drinking pools of slight discharge in which the water is strongly saline and sulphureted. The analysis of the water of the western of these two (No. 1 below) indicates that it is a highly concentrated saline water. The central spring of the three rises in a concrete standpipe to a height of several feet above the ground, and its water is thence conducted by a small flume to a heating boiler at the bathhouse. Small quantities of sulphur and gypsum are deposited along the sides of the flume. The yield is about 2½ gallons a minute. The fourth spring, which is known as Montgomery Spring, rises in a cemented drinking pool about 300 yards farther eastward, upstream, and yields perhaps 2 gallons a minute of mildly sulphureted water that does not taste noticeably saline. Analysis shows that it is a moderately concentrated water of primary and secondary alkaline character but containing also notable primary salinity. Because of the sulphureted character they are indicated on Plate III (in pocket).

Analyses of water from Richardson Springs, Butte County, Cal.

[Analyst, Maxwell. Authority, advertising matter. Constituents are in parts per million.]

	Spring No. 1.		Montgomery Spring.	
Temperature	16° C. (61° F.).		15° C. (59° F.).	
Properties of reaction:				
Primary salinity	90		30	
Secondary salinity	10		0	
Tertiary salinity	Trace.		0	
Primary alkalinity	0		25	
Secondary alkalinity	0		45	
Tertiary alkalinity	9		45	
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	6,431	279.2	89	3.87
Potassium (K)	766	19.6	18	.46
Lithium (Li)	Trace.	Trace.	Trace.	Trace.
Ammonium (NH_4)	Trace.	Trace.	....	....
Barium (Ba)	....	....	Trace.	Trace.
Calcium (Ca)	622	31.05	48	2.39
Magnesium (Mg)	11	.92	14	1.15
Iron (Fe)	Trace.	Trace.	Trace.	Trace.
Aluminum (Al)	6.3	.71	3.7	.41
Sulphate (SO_4)	2,730	56.9	66	1.37
Chloride (Cl)	9,729	274.6	36	1.01
Carbonate (CO_3)	....	....	165	5.50
Silica (SiO_2)	18	.60	61	2.02
	20,313.3	....	500.7	....
Carbon dioxide (CO_2)	96	4.36	11	.50
Hydrogen sulphide (H_2S)	417	24.48	17	1.02

A cemented drinking basin surrounds a fifth spring, known as the Iron Spring, on the side of a ravine about 400 yards north of the main springs. The overflow is slight and the water has no distinctly mineralized taste.

In several respects conditions at Richardson Springs are similar to those at Tuscan Springs, about 35 miles farther north. As at Tuscan Springs, cliffs of lava agglomerate form the upper portion of the canyon side, but the springs issue from tuffaceous sediments (the Tuscan tuff) that overlie the Cretaceous shales and sandstones which are exposed at Tuscan Springs and which probably underlie the tuff at a shallow depth at Richardson Springs. About three-quarters of a mile southwest, downstream from the springs, inflammable gas rises near the creek, probably from these Cretaceous beds. In December, 1909, an attempt was being made to confine the gas and render it available for use.

SALINE SPRINGS AT BYRON HOT SPRINGS (CONTRA COSTA 8).

Byron Hot Springs have been described among the thermal springs, but they are mentioned here because the waters of two of them—the Liver and Kidney and the Hot Salt springs—are notably saline, and that of Surprise Spring is a strong brine. Comment on the saline character of these springs was made in describing the group. (See p. 109.)

ALHAMBRA SPRINGS (CONTRA COSTA 2).

At two localities in the State there are small saline and sulphated springs whose waters have been bottled for medicinal use. Although not all of the springs at these localities are notably saline, the principal springs contain large amounts of sodium and chlorine, and the localities may properly be considered with the saline springs.

The northern locality is at Alhambra Springs, which are situated in a ravine about 6 miles by road south of Martinez. Of the three principal springs on the property, one which is known as No. 1, fills a housed-in pool 6 feet square and a foot deep, on the eastern bank of the ravine; its water tastes strongly saline and sulphated. About 400 yards southward, up the ravine from it, a mildly sulphureted spring rises in a small spring house. The third spring, which is known as Spring No. 2, rises in a cement-covered joint of tile pipe on the western edge of the stream channel, 75 yards above this sulphur spring. Water from the two numbered springs is piped to tanks and thence to bottling works beside the railroad at Martinez. A fourth spring has a flow of a little over half a gallon a minute and is designated in the table of analyses as "Alhambra." The following analyses show that the waters of the Alhambra and Spring No. 1 are primary and secondary saline in character, but the water of Spring

No. 2 is less strongly mineralized than that of the others and is characterized chiefly by secondary alkalinity.

Analyses of water from Alhambra Springs, Contra Costa County, Cal.

[Authority, advertising matter. Constituents are in parts per million.]

	1		2		3	
Temperature	14° C. (57° F.)		....		9° C. (48° F.)	
Properties of reaction:						
Primary salinity		73		38		63
Secondary salinity		26		0		36
Tertiary salinity		0		0		0
Primary alkalinity		0		0		0
Secondary alkalinity		1		62		1
Tertiary alkalinity		3		4		Trace.
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	3,416	148.52	100	4.34	2,727	118.57
Potassium (K)	68	1.74	13	.32	7.6	.19
Lithium (Li)	....	....	....	....	.8	.01
Ammonium (NH_4)	....	....	....	....	1.3	.07
Barium (Ba) and strontium (Sr)	....	....	....	....	0	.00
Calcium (Ca)	972	48.49	82	4.07	1,278	63.78
Magnesium (Mg)	106	8.72	42	3.43	81	6.77
Iron (Fe)	9.5	.34	....	....	.6	.02
Aluminum (Al)	5.8	.64	2.2	.24		
Manganese (Mn)	....	....	....	....	1.1	.04
Sulphate (SO_4)	60	1.24	180	3.75	35	.73
Nitrate (NO_3) and nitrite (NO_2)	....	....	....	....	Trace.	Trace.
Chloride (Cl)	7,205	203.19	32	.91	6,595	185.98
Bromide (Br)	....	....	....	....	21	.26
Iodide (I)	....	....	....	....	13	.10
Sulphide (S)	59	3.68	....	....	....	....
Carbonate (CO_3)	10	.34	225	7.50	51	1.70
Metaborate (BO_2)	....	....	....	....	26	.61
Arsenate (AsO_4)	....	....	....	....	0	.00
Phosphate (PO_4)	....	....	....	....	Trace.	Trace.
Silica (SiO_2)	21	.69	13	.43	20	.66
	11,932.3	....	689.2	....	10,858.4	....
Carbon dioxide (CO_2)	....	....	Present.	Present.	5.5	.25
Hydrogen sulphide (H_2S)	63	3.68	....	....	0	.00

1. Spring No. 1. Analyst, Thomas Price & Son.
2. Spring No. 2. Analyst, Thomas Price & Son.
3. Alhambra Spring. Analyst, Curtis and Tompkins.

The waters have been on the market since about 1898, and have been bottled, both carbonated and still (natural). A "tonic water," consisting of 25 per cent of No. 1 and 75 per cent of No. 2, has also been marketed.

The rocks near Alhambra Springs are of the same character as those at Ferndale Springs (Contra Costa 1, p. 208) half a mile to the northwest, which have been described among the carbonated springs. They consist of soft shales and sandstones that are apparently tilted about 30° W.

VERONICA SPRINGS (SANTA BARBARA 3).

The southern locality of saline or sulphated springs whose waters are bottled is in the hills near the coast, 2 or 3 miles west of Santa Barbara. The most important of these—Veronica Springs—are situated on the sides of the wide drainage channel of San Roque Creek, about three-quarters of a mile northward from the ocean. The principal springs are on the western side of the creek, but water from about 12 springs, half of which are on each slope of the drainage channel, has been piped to collecting tanks in a warehouse at the principal springs. As the yield of the springs is small and the bottled product consists of the combined flow from a number of springs whose composition probably varies with the season, differences in any two analyses of the water would be expected. The remarkably high content of magnesia shown by the analysis on page 296 seems to have been produced by concentration of the material from the ocean water by some means which is not clearly understood but which probably involved the evaporation of the water of lagoons to a bittern.

BYTHINIA SPRINGS (SANTA BARBARA 4).

Bythinia Springs issue in a gully on the hillside, half a mile northwest of Veronica Springs. The water has been piped to a bottling house below them and marketed as a medicinal water, but the commercial value of the springs has not been so great as that of the others to the southeast.

SANTA BARBARA SPRINGS (SANTA BARBARA 5).

Santa Barbara Springs are about three-fourths of a mile northeast of Veronica Springs, near the top of the mesa land overlooking Santa Barbara. Their water, like that of the other strongly mineralized springs in the locality, has been marketed to some extent for medicinal use. Pipes from several small springs supply a bottling plant.

The following analyses of waters from the three groups of springs last described show that they all are primary and secondary saline waters, secondary salinity being dominant in Veronica and Bythinia springs.

The flat-topped hills on whose flanks the springs issue are composed of shales of late Tertiary age that probably belong to the Fernando formation, which has been described by Arnold.[1] The mineralized water is said to seep from a yellow clay of the consistency of cheese.

[1] Arnold, Ralph, Geology and oil resources of the Summerland district, California: U. S. Geol. Survey Bull. 321, pp. 30-33, 1907.

Analyses of water from Veronica, Bythinia, and Santa Barbara springs, Santa Barbara County, Cal.

[Constituents are in parts per million.]

	1		2		3	
Properties of reaction:						
Primary salinity		27		24		63
Secondary salinity		68		73		23
Tertiary salinity		0		0		0
Primary alkalinity		0		0		0
Secondary alkalinity		5		3		14
Tertiary alkalinity		Trace.		Trace.		Trace.
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	2,153	93.6	3,210	139.6	4,043	175.8
Potassium (K)	89	2.27	21	.53	296	7.58
Lithium (Li)	....	....	....	....	.6	.09
Ammonium (NH_4)	.1	Trace.	....	....	....	....
Calcium (Ca)	564	28.13	561	28.0	856	42.7
Magnesium (Mg)	2,858	235.0	4,920	404.7	773	63.6
Iron (Fe)	2.6	.09	18	.63	8.4	.30
Aluminum (Al)					....	....
Manganese (Mn)	0	.00	....	....	....	....
Sulphate (SO_4)	12,361	257.5	20,880	434.8	9,120	189.8
Nitrate (NO_3)	1,740	28.1	3,988	64.2	....	....
Nitrite (NO_2)	0	.00	....	....	....	....
Chloride (Cl)	2,004	56.5	2,021	57.0	2,107	59.4
Bromide (Br)	0	.00	....	....	Trace.	Trace.
Iodide (I)	Trace.	Trace.	....	....	Trace.	Trace.
Carbonate (CO_3)	522	17.41	504	16.8	1,206	40.2
Metaborate (BO_2)	0	.00	....	....	1.6	.04
Arsenate (AsO_4)	0	.00	....	....	....	....
Phosphate (PO_4)	Trace.	Trace.	....	....	21	.65
Silica (SiO_2)	18	.60	28	.93	15	.49
	22,311.7	....	36,151	....	18,447.6	....
Carbon dioxide (CO_2)	0	.00	....	....	....	....

1. Veronica Spring. Analyst, U. S. Bureau of Chemistry (1903-1904). Authority, U. S. Bureau of Chemistry Bull. No. 91.
2. Bythinia No. 3 (bottled). Analysts, Hilgard, Jaffa and Colby. Authority, advertising matter.
3. Santa Barbara (bottled). Analyst, Curtis and Tompkins. Authority, advertising matter.

EPSOM SPRING (LAKE 32).

A small flow of sulphated water, known as Epsom Spring, formerly issued in a ravine about 2½ miles south of west from Lakeport. Within recent years range animals have trampled the place so that there has been little or no flow, but during the summer a considerable efflorescence of Epsom salt forms on the surface of the moist ground, and a small flow of water could probably be again developed at the place. The locality is near the western border of a belt of serpentine that extends northward along the western side of Clear Lake. It seems probable that this magnesian rock furnishes the basic portion of the efflorescent salt, which may be formed by chemical reaction of the minerals dissolved in water that passes through both the serpentine and the adjacent altered sedimentary materials.

COMPLEXION SPRINGS (LAKE 14).

In Lake County and more northern portions of the Coast Ranges there are several springs that contain unusually large amounts of ammonium salts. It has not been considered advisable to group them for discussion according to this characteristic, however, as they have other and different qualities.

Complexion Springs are perhaps remarkable chiefly because of their high content of ammonium, but they are also strongly salty and hence are described with the salt springs. They include three pools, which are situated on the slope 50 yards east of the bed of a ravine about 325 yards north of the road between Leesville and Hough Springs (Lake 13, p. 197), and 2 miles west of the divide at the boundary between Lake and Colusa counties. The northernmost pool, which is the principal one, is about 4 feet in diameter and 2 or 3 feet deep. A few bubbles of gas rise at its back edge, beneath a small bank, and the discharge is perhaps a quarter of a gallon a minute of clear water that tastes strongly of salt and ammonia and that deposits on the sides and bottom of the pool a white curdy precipitate that is easily roiled. The analysis shows that this precipitate consists chiefly of calcium and magnesium compounds, and its similarity to the hard deposit at the hot springs at the Elgin mine (Colusa 7, p. 104) and at Phillips Soda Spring (Napa 8, p. 161) is worthy of note. The water contains an unusually large proportion of ammonium and hydroxide, but analysis shows that it is really a brine, the other constituents being in very minor amounts compared with the sodium and chloride contents:

Analysis of insoluble deposit in Complexion Springs, Lake County.

[Analyst and authority, F. M. Eaton, 1910.]

Silica (SiO_2)	18.67
Iron and alumina ($Fe_2O_3+Al_2O_3$)	3.08
Lime (CaO)	31.90
Magnesia (MgO)	17.15
Sulphate (SO_4)	0
Undetermined (H_2O+CO_2)	29.20
	100.00

Analysis of water from main spring, Complexion Springs, Lake County, Cal.

[Analyst and authority, F. M. Eaton (1910). Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	94
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	6
Secondary alkalinity	Trace.
Tertiary alkalinity	Trace.

Constituents.	By weight.	Reacting values.
Sodium (Na)	10,295	447.61
Potassium (K)	223	5.70
Ammonium (NH_4)	150	8.31
Calcium (Ca)	6.9	.34
Magnesium (Mg)	Trace.	Trace.
Iron (Fe) / Aluminum (Al)	Trace.	Trace.
Sulphate (SO_4)	47	.99
Chloride (Cl)	15,400	434.29
Hydroxide (OH)	178	10.47
Carbonate (CO_3)	456	15.20
Metaborate (BO_2)	Trace.	Trace.
Arsenate (AsO_4)	0	.00
Phosphate (PO_4)	0	.00
Silica (SiO_2)	2.8	.09
	26,758.7	....
Carbon dioxide (CO_2)	0	.00
Hydrogen sulphide (H_2S)	0	.00

The second pool, which is 5 or 6 yards southwest of the main one and is somewhat smaller, also yields a slight flow of clear salty ammoniacal water, but a precipitate does not form in it. The third pool, about 5 yards farther south, was not overflowing when visited in July, 1910. It contained brown-stained water that tasted strongly of salt but not of ammonia. Water from the principal spring has been used locally as a nasal douche and as a wash for sores.

The water issues from decomposed serpentine, but altered sediments are exposed in the ravine near by. Although the yield of Complexion Springs is small, their continual flow and strong mineralization indicate that their source is deeper and more permanent than would be furnished by surface seepage. The chemical character of the water indicates that it receives its salt content from the sedimentary beds, whereas the ammonia is possibly formed by chemical reactions of the minerals of the decomposed serpentine, perhaps by the action of ferrous sulphate on organic matter.

SALT SPRING NORTH OF SITES (COLUSA 4).

On the Peterson ranch, 3½ miles north of Sites, there is a salt spring whose water has been used for many years to supply stock salt for the use of the ranch by evaporating the brine in shallow troughs. The spring has no surface overflow, as it forms a pool in a salt flat where the discharge seeps away, but the quantity of water is sufficient to supply several evaporating troughs. The rocks of the locality are unaltered sediments, mainly sandstone, in which there are apparently beds that contain an unusually large amount of salt.

SALT SPRING IN SALT SPRING VALLEY (GLENN 3).

A spring that is similar in character to the one north of Sites is situated in Salt Spring Valley about 4 miles north of Stonyford or 27 miles north of west from Sites. The water issues on the slope above the valley land and flows down through a barren salty patch perhaps 2 acres in extent. No attempt has been made to collect the salt in commercial amount, although the spring yields several gallons a minute of salty water. The crust that forms naturally is, however, occasionally scraped up and used as stock salt. The salt of this spring, like that of the spring near Sites, is apparently derived from salt-bearing layers in the unaltered sedimentary rocks that compose the hills along the western side of Sacramento Valley.

SALT SPRINGS WEST OF ELK CREEK (GLENN 2).

Salt springs issue about 3 miles west of Elk Creek post office, in western Glenn County, but they are of small flow and have been used mainly as salt licks by range cattle. As seems probable at the salt spring farther south, in Salt Spring Valley, those west of Elk Creek apparently derive their salt from beds in the unaltered sedimentary rocks that form this portion of the Coast Ranges.

SALT SPRINGS ON NORTH FORK OF ELDER CREEK (TEHAMA 11).

A few seepage springs of salty water issue on North Fork of Elder Creek, about 32 miles by road south of west from Red Bluff. A number of years ago a small amount of the water was bottled and found a local sale for medicinal use. The springs have not been improved nor used in recent years, though they have been considered valuable because of their mineral character. The water issues from dark-colored shales of the Chico formation of Upper Cretaceous age, which has been described by Diller.[1]

SALT SPRINGS ON STEWARTS FORK OF TRINITY RIVER (TRINITY 1).

A few small springs of salty water that are similar in character to those on Elder Creek (Tehama 11) issue along Stewarts Fork of Trinity River, in northern Trinity County. They are remote from other than mining settlements, however, and have been little used. Schists and dark altered shales cover a large part of the area in this portion of the Coast Ranges, and it is from such material—probably altered sediments—that the saline water issues.

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[1] Diller, J. S., Tertiary revolution in the topography of the Pacific coast: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, pp. 405–406, 1894.

FELTS SPRINGS (HUMBOLDT 5).

Felts Springs are situated 5½ miles by road and trail northeast of Fortuna. The property was formerly used as a resort, but one hotel burned in 1878 and another in 1894, and since that time the place has been abandoned.

The group includes three springs that lie close together near the top of a hill from which the timber has been cut. The largest spring rises in a reservoir or well 24 feet deep and 6 feet in diameter and yields about half a gallon a minute of saline water. One of the other springs is also saline, and the third is mildly sulphureted. A small amount of gas rises in each spring.

Soft sandstone that contains fossil shells is exposed near the springs and to the south and west there are sand dunes. The saline and sulphureted constituents of the waters are evidently derived from the marine sediments from which the springs issue.

SALT SPRINGS ON NORTH FORK OF AMERICAN RIVER (PLACER 9).

On the western bank of North Fork of American River, about 2 miles east of Colfax, there are a few saline and alkaline seepages that are known to local hunters as salt licks or deer licks. Springs that yield perhaps 10 gallons a minute issue 25 or 30 feet above the river from the canyon side. There is said to be a considerable saline deposit along their courses in summer, but when the locality was visited the small deposit that was seen consisted mainly of soda and alum. The surrounding rock is slate of Carboniferous age, which has been described by Lindgren.[1] The saline material is apparently derived from these old sediments.

VALLEY SPRINGS (CALAVERAS 1).

Two small saline springs issue about one-half mile east of Valley Springs station on the branch railroad from Lodi eastward into the mountains bordering Sacramento Valley. One spring is a mere seepage, but the other yields about 1 gallon a minute of water having a temperature of 75°. In the summer of 1909 this water was being bottled for use as a mineral table water. The following partial analysis shows that the water is primary and secondary saline in character.

[1] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), pp. 1-2, 1900.

Partial analysis of water from main spring, Valley Springs, Calaveras County, Cal.

[Analyst, G. E. Colby (1909). Authority, owner of springs. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	Large.
Secondary salinity	Large.
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	Moderate.
Tertiary alkalinity	Small.

Constituents.	By weight.
Residue soluble in water	1,687
Sodium (Na)	Large.
Potassium (K)	Small.
Magnesium (Mg)	Considerable.
Sulphate (SO_4)	Large.
Chloride (Cl)	Large.
Carbonate (CO_3)	Small.
Residue insoluble in water	843
Calcium (Ca)	Large.
Magnesium (Mg)	Large.
Sulphate (SO_4)	Large.
Carbonate (CO_3)	Large.
Silica (SiO_2)	Large
Loss on ignition (organic matter and chemically combined water)	324
Total residue	2,854

Several other saline springs that are very probably similar in mode of occurrence and chemical character issue at points farther south in the Sierra, notably on the west slope of Miami Mountain, about 15 miles east of Mariposa, and near the small settlement of Salt Springs, 10 miles farther southeast.

SALT SPRING NEAR ANTELOPE VALLEY (KERN 1).

A few saline springs and seepages issue from the marine sediments that border the southwest side of San Joaquin Valley. One of them is at the edge of the valley, about 4 miles south of the northern border of Kern County and 15 miles northeast of Annette post office. The yield of the spring is small, and the water has not been used, as it is too saline to be suitable for drinking.

SALT SPRINGS NEAR KESSLER ONYX MARBLE QUARRY (SAN LUIS OBISPO 11).

Salt Creek, near Kessler onyx marble quarry, has been mentioned in the description of the carbonated springs (p. 164). It is here referred to again because of the notable amounts of salt that are deposited along its bed and in several other ravines near by. The quantity is sufficient to render the stream channels white during the summer, and the small amount of water that flows is strongly saline.

The hills of the locality are composed of shales and sandstones of probable Tertiary age. The salt is evidently leached from them by water that issues as surface springs.

SALT SPRINGS NORTH OF FURNACE CREEK RANCH (INYO 19).

The sink or lowest portion of Death Valley, in the eastern part of the State, is crusted with impure salt, and at several places along its borders small springs issue whose waters are strongly saline. One group of springs of this character is situated about 10 miles north of the Furnace Creek [1] ranch at the northeast border of Death Valley, where a slight amount of salty water issues.

SALT SPRINGS SOUTH OF FURNACE CREEK RANCH (INYO 21).

About 4 miles south of the Furnace Creek ranch saline water forms a small wet area at the east edge of Death Valley. The flow is slight and the water is too salty to be drinkable.

POISON SPRING (INYO 18).

Poison Spring is on the western border of Death Valley, 7 miles northwest of the Furnace Creek ranch. It yields salty water that probably also contains sulphates, whose sickening effect on thirsty travelers has given the spring its name.

VALLEY SPRING (SAN BERNARDINO 2).

A few strongly saline springs issue in the southern extension of Death Valley proper, in the portion that is known as South Death Valley. Valley Spring, which rises in a marshy area on the western side of South Death Valley, is probably the largest of these. The water forms a clear stream that flows for a short distance, but it is strongly saline.[2] The source of the water is believed to be Amargosa River, which normally sinks a few miles to the southeast. A portion of its flow is apparently brought to the surface at the spring by a ledge of rock that is there exposed above the valley floor.

SALT SPRING (SAN BERNARDINO 4).

Salt Spring, at the southeast end of South Death Valley and about 5 miles southwest of Dumont railroad station, is probably better known than the saline springs farther north in the valley (San Bernardino 2). It was mentioned many years ago by Frémont, who camped there in April, 1844, and described the springs as being "a very poor camping ground; a swampy, salty spot, with a little long, unwholesome grass; and the water which rose in the springs being useful only to wet the mouth but entirely too salt to drink." [3] The springs are in the canyon of South Branch of Amargosa River. This canyon

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[1] The name Furnace was applied to this creek not because of the climate of the region but because a small furnace for the reduction of ore was built near its mouth in 1862.

[2] An analysis purporting to represent this water (U. S. Geol. Survey Water-Supply Paper 224, p. 46) is believed to be that of water from Owens Lake.

[3] Frémont, J. C., Report of the exploring expedition to the Rocky Mountains, p. 264, 1845.

forms a pass between the Kingston Range and the Avawatz Mountains, but desert travel has been mainly north of it, through the canyon of the main branch of the river. It has been said that the water contains arsenic, as several people have perished from drinking it, but the fatalities have probably been due rather to the effect of such a strong solution of Epsom and Glauber salts on persons who were nearly delirious with thirst.

GARLIC SPRING (SAN BERNARDINO 10).

There are a few other saline or alkaline springs in the southeastern portion of the State that may here be mentioned because of their notably mineralized character. One of these is Garlic Spring, which is on the road between Daggett and Death Valley, about 35 miles northeast of the former place. It yields a small supply and has been used as a camping place, but its water contains a large amount of sodium, magnesium, and sulphates.

BITTER SPRING (SAN BERNARDINO 11).

Bitter Spring is about 12 miles east of Garlic Spring and near the southeast side of a small intermittent lake. It formed a watering place on the emigrant road between Salt Lake City and San Bernardino as early as 1852 and has been a camping place since that time, but the water contains large amounts of sodium and sulphates.

DEADMANS HOLES (SAN BERNARDINO 41).

There are small pools, known as Deadmans Holes, in the playa surface at the northwest side of Mesquite Dry Lake, near the road between Victorville and Dale mining camp. These pools or springs are sometimes used as watering places, but their water contains large amounts of alkaline material, probably sodium, magnesium, and sulphates.

SODA SPRINGS (IMPERIAL 3).

Soda Springs are about 25 miles south of Mecca, on a road along the western side of Colorado Desert. They yield a small amount of water that is too strongly saline to be suitable for drinking, but travelers are sometimes obliged to use it.

The springs are situated at the base of a low barren knoll of Tertiary sediments, and the saline constituents of the water are probably obtained directly from these marine deposits. An analysis that is given among the carbonated springs under the heading of McCain Springs (p. 248) shows the general character of the alkaline saline springs of this part of the State.

KANE SPRING (IMPERIAL 6).

Kane Spring issues from a low knoll in a patch of cane and salt grass, 2 or 3 miles south of the channel of Carrizo Creek, on the southwest side of Salton Sink. Its water is strongly charged with soda salts. The spring is below sea level and rises in lake sediments whose content of alkaline salts has been concentrated at the spring by the great evaporation that takes place in this region.

YUHA SPRING (IMPERIAL 8).

Yuha Spring is about 20 miles west of El Centro and 2 miles south of the road between Imperial Valley and the settlements of eastern San Diego County. The water rises in a wash and has little if any flow, but in 1905 a pump and a trough furnished means for watering horses. The water is notably saline and alkaline, but it is drinkable.

CASTALIAN MINERAL WATER (INYO 15).

A few saline waters that are obtained from wells and lakes have become known as mineral-spring waters and therefore may be mentioned among the saline springs.

Analyses of Castalian Mineral Water and water from Owens Lake, Inyo County, Cal.

[Constituents are in parts per million.]

	1	2	3	4
Properties of reaction:				
Primary salinity	56	57	55	54
Secondary salinity	0	0	0	0
Tertiary salinity	0	0	0	0
Primary alkalinity	44	43	45	46
Secondary alkalinity	Trace.	Trace.	Trace.	Trace.
Tertiary alkalinity	(?)	(?)	(?)	(?)

Constituents.	1 By weight.	1 Reacting values.	2 By weight.	2 Reacting values.	3 By weight.	3 Reacting values.	4 By weight.	4 Reacting values.
Sodium (Na)	29,300	1,273.5	21,660	941.7	26,840	1,167.0	81,180	3,530.0
Potassium (K)	1,188	30.4	2,750	70.4	1,548	39.6	3,448	88.2
Lithium (Li)	....	....	Trace.	Trace.	....	....	57	8.2
Rubidium (Rb) and cæsium (Cs)	....	....	.0	.0	....	....	Traces.	Traces.
Thorium (Th)	....	....	....	....	....	....	Trace.	Trace.
Calcium (Ca)	Trace.	Trace.	Trace.	Trace.	13	.7	34	1.7
Magnesium (Mg)	Trace.	Trace.	Trace.	Trace.	4.7	.4	15	1.2
Iron (Fe)	Trace.	Trace.	....	....	9.2	.3	....	....
Aluminum (Al)	....	....	Trace.	Trace.	12	1.3	[a] 48	5.3
Sulphate (SO_4)	7,530	156.9	9,360	194.8	7,065	147.2	21,170	440.7
Nitrate (NO_3)	....	....	Trace.	Trace.	....	....	948	15.3
Chloride (Cl)	20,200	569.7	13,440	378.9	18,220	514.0	52,900	1,492.0
Bromide (Br) and iodide (I)	Traces.	Traces.	....	....	....	....	....	....
Sulphide (S)	325	20.3	....	....	....	....	....	....
Carbonate (CO_3)	16,710	557.0	13,152	438.4	16,500	549.9	[b]48,880	1,667.0
Metaborate (BO_2)	Trace.	Trace.	Trace.	Trace.	190	4.4	329	7.8
Arsenate (AsO_4)	....	....	....	....	....	....	156	3.4
Phosphate (PO_4)	Trace.	Trace.	Trace.	Trace.	....	....	238	7.5
Silica (SiO_2)	245	8.1	164	5.4	207	6.9	297	9.7
	75,498	....	60,526	....	70,608.9	....	209,700	....

[a] Iron and aluminum oxides expressed as aluminum. [b] Calculated.

1. Castalian Mineral Water. Analyst, Thomas Price (1880). Authority, U. S. Geol. Survey Bull. 32.
2. Owens Lake. Analyst, Oscar Loew (1876). Authority, Wheeler report.
3. Owens Lake. Analyst, T. M. Chatard (1886). Authority, U. S. Geol. Survey Bull. 60.
4. Owens Lake. Analysts, C. H. Stone and F. M. Eaton. Authority, Am. Chem. Soc. Jour., p. 1169, 1906.

Castalian Mineral Water, which has been sold for medicinal use, has been obtained either directly from Owens Lake, in Inyo County, or from springs close to its shore. An analysis that is thought to represent the bottled water is here tabulated with analyses of water from Owens Lake. The analyses on page 304 indicate that the waters are similar in character, if not identical, being primary saline and alkaline.

LAKESIDE MINERAL WELLS (SAN DIEGO 12).

Lakeside Mineral Wells are situated on property belonging to the Lakeside Inn, which is 22 miles by railroad northeast of San Diego. Three wells that were here sunk about 1906 in the valley of San Diego River yield mineralized waters that are known, respectively, as Soda, Iron-soda, and Saline. Water from the first two wells has been piped to hydrants in a small house near the inn and is used for drinking. The following analysis of the Iron-soda water shows that it is primary saline and secondary alkaline in character. The content of iron is not unusually high.

Analysis of water from Iron-soda well, Lakeside Mineral Wells, San Diego County, Cal.

[Analyst, Smith, Emery & Co. (1907). Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	59
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	2
Secondary alkalinity	39
Tertiary alkalinity	10

Constituents.	By weight.	Reacting values.
Sodium (Na)	190	8.25
Potassium (K)	Trace.	Trace.
Calcium (Ca)	62	3.10
Magnesium (Mg)	27	2.22
Iron (Fe)	2.4	.09
Sulphate (SO_4)	78	1.61
Nitrate (NO_3)	.6	.01
Chloride (Cl)	226	6.38
Carbonate (CO_3)	169	5.63
Phosphate (PO_4)	Trace.	Trace.
Silica (SiO_2)	37	1.23
	792.0	....
Carbon dioxide (CO_2)	0	.00

A mildly saline water, similar to the Lakeside water, was formerly obtained from a well on the grounds of Coronado Hotel, on the sand spit or peninsula that forms a protecting arm of San Diego Bay. The water had a local sale for table use and was also used at the hotel, but an attempt to increase the supply by deepening the well resulted in obtaining a strongly saline, unusable water, and the well has long been abandoned.

AQUA VITÆ MINERAL WELL (LOS ANGELES 13).

Aqua Vitæ Mineral Water is obtained from a well in the northeastern part of the city of Los Angeles. The well is about 400 feet deep and the mineralized water rises to within about 40 feet of the surface. The water, which is pumped into cement reservoirs and thence piped to an adjacent bottling house, has been on the local market since 1901 or 1902 and has been sold both natural and carbonated. The following analyses show that the water is primary and secondary saline in character. These analyses were made several years apart and indicate a considerable change in the character of the water that is probably accounted for largely by the decay of the casing and admission of other than the lower mineralized water into the well.

Analyses of Aqua Vitæ Mineral Water, Los Angeles County, Cal.

[Authority, advertising matter. Constituents are in parts per million.]

	1		2	
Properties of reaction:				
Primary salinity		57		32
Secondary salinity		29		34
Tertiary salinity		0		0
Primary alkalinity		0		0
Secondary alkalinity		14		34
Tertiary alkalinity		93		29
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	399	17.36	232	10.09
Calcium (Ca)	264	13.17	252	12.58
Magnesium (Mg)	....	....	109	8.97
Iron (Fe)	20	.71	....	....
Sulphate (SO_4)	1,174	24.45	876	18.24
Chloride (Cl)	69	1.95	91	2.57
Carbonate (CO_3)	145	4.84	325	10.83
Silica (SiO_2)	20	.66	36	1.19
	2,091	....	1,921	....
Carbon dioxide (CO_2)	593	26.96	178	8.09

1. Analysts, Childs and Hansen, several years prior to 1909.
2. Analyst not given; made in 1909.

SAN BENITO MINERAL WELL (SAN BENITO 1).

San Benito Mineral Water has been obtained for a number of years from Mr. A. F. Anderson's well, about 4 miles southeast of Hollister, in San Benito County, and has been carbonated and bottled by the local soda works. The following analysis shows that the water is rather concentrated and is primary saline in character:

Analysis of San Benito Mineral Water, San Benito County, Cal.

[Analyst, M. E. Jaffa. Authority, 13th Cal. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		85
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		7
Secondary alkalinity		8
Tertiary alkalinity	(?)	
Constituents.	**By weight.**	**Reacting values.**
Sodium (Na) Potassium (K)	780	33.94
Calcium (Ca)	29	1.46
Magnesium (Mg)	18	1.50
Iron (Fe)	8.9	.32
Sulphate (SO_4)	736	15.32
Chloride (Cl)	566	15.97
Carbonate (CO_3)	178	5.93
Silica (SiO_2), organic matter, and combined water	188	....
	2,503.9	....

The well was put down in the early nineties. Water was first struck at a depth of 100 feet, and drilling was stopped at 167 feet in blue clay, but a sufficient supply of water was not obtained and the well was deepened a year later. The mineralized water was struck at a depth of 286 feet, where drilling was discontinued. The water stands about 100 feet below the surface and is pumped by a windmill for domestic use. Its strongly sulphated character renders it laxative and prevents its free use for drinking at first, but those who use it daily gradually become accustomed to it and it ceases to have notably medicinal effect.

Clays and coarser sediments of Tertiary age form low rolling hills that border San Benito Valley in this locality. The mineral constituents of the water are evidently derived from these marine sediments.

TAMALPAIS MINERAL WELL (MARIN 2).

Tamalpais Mineral Well is situated in the town of San Rafael, in Marin County. A mildly saline water that is obtained from it has been carbonated and bottled for a number of years as Tamalpais Natural Mineral Water and is also used with sirups in the preparation of carbonated beverages. The well is in the southern part of the town, at the base of a tuffaceous hill, and has been sometimes referred to as San Rafael Spring. The water rises in a stone-curbed well 6 feet in diameter and 25 feet deep in the basement of the building of the Buffalo Soda Works.

The following analysis shows it to be a secondary alkaline and primary saline water:

Partial analysis of Tamalpais Natural Mineral Water, Marin County, Cal.

[Analyst, Price & Son. Authority, owner of well. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	33
Secondary salinity	Small.
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	67
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Sodium (Na)	79	3.42
Calcium (Ca) Magnesium (Mg)	138	6.90
Sulphate (SO_4)	Small.	Small.
Chloride (Cl)	121	3.42
Carbonate (CO_3)	207	6.90
	545	....

HUMBOLDT ARTESIAN MINERAL WELL (HUMBOLDT 2).

Humboldt Mineral Water was carbonated and bottled for many years as a table water. The following analysis indicates that the water is secondary alkaline and primary saline in character:

Analysis of Humboldt Mineral Water, Humboldt County, Cal.

[Analyst, W. D. Johnson (1894?). Authority, 12th Cal. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	47
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	4
Secondary alkalinity	49
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Sodium (Na)	200	8.70
Calcium (Ca)	94	4.67
Magnesium (Mg)	44	3.59
Iron (Fe)	.6	.02
Aluminum (Al)	1.7	.17
Sulphate (SO_4)	Trace.	Trace.
Chloride (Cl)	285	8.04
Carbonate (CO_3)	268	8.92
Silica (SiO_2)	19	.62
	912.3	....
Carbon dioxide (CO_2)	Excess.	....

The water was obtained from the Humboldt Artesian Mineral Well, which is situated near the edge of the bay, at high-tide level, about a mile south of Eureka, and is now within the boiler room of Flannagan's lumber mill. The well is 6 inches in diameter and 175 feet deep, and water is pumped from it to supply the water boxes of the lumber company. The pump is run constantly during working hours and lifts 30,000 gallons a day, but 5 minutes after pumping is stopped the well overflows. Much gas rises with the water, and in order to prevent its interference with pumping the well has been capped and a 2½-inch pipe extends down the well a considerable distance.

The well is sunk into the alluvium and more consolidated sediments that border the bay, and its water evidently obtains its saline and other constituents directly from the marine beds.

MAGNESIC SPRINGS.

SPRINGS PREVIOUSLY DESCRIBED.

Most of the magnesic springs in the State have been described under headings suggested by other more pronounced characteristics, but it has been thought advisable to give them brief mention under one heading. The springs at Duncan (Mendocino 31, p. 167), Howard (Lake 51, p. 95), Spiers (Lake 52, p. 190), Napa Rock (Napa 9, p. 161), and Phillips (Napa 8, p. 161) springs and at The Geysers (Sonoma 4, p. 83), as has already been noted, issue from serpentinous rock from which they evidently derive their magnesium contents. A few other springs contain large amounts of magnesium that is apparently derived from sources other than serpentine. Several of the desert alkaline springs are of this character, but perhaps the most notable are Alhambra Springs (Contra Costa 2, p. 293) and the group near Santa Barbara, including Veronica Springs (Santa Barbara 3, p. 294). These waters contain large amounts of magnesium, which is probably derived from ocean water, although it has been concentrated by some process that is not clearly understood.

MENDENHALL SPRINGS (ALAMEDA 5).

Mendenhall Springs are 11 miles by road southeast of Livermore on the steep southwestern side of the canyon of Arroyo Mocho, 500 feet above the stream. Two springs here seep from short prospect tunnels 50 yards apart that were driven many years ago in search of gold. The water was early noticed to be perceptibly mineralized, the perceptible taste apparently being due to magnesia, and a number of years ago it was bottled as Agua de Vida (Water of Life) Springs Water.

The water of the southern spring is piped to a tank and furnishes a domestic supply; the other spring supplies a watering trough in the barnyard. Their flows are respectively about 1 gallon and half a gallon a minute.

The following analyses show that they are essentially primary saline and secondary alkaline waters, the upper spring having the higher salinity:

Analyses of water from Mendenhall Springs, Alameda County, Cal.

[Constituents are in parts per million.]

	1		2		3	
Temperature					14° C. (58° F.).	
Properties of reaction:						
Primary salinity		35		31		42
Secondary salinity		0		0		18
Tertiary salinity		0		0		0
Primary alkalinity		8		1		0
Secondary alkalinity		57		68		40
Tertiary alkalinity		54	(?)			32
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	136	5.91	96	4.16	148	6.43
Potassium (K)	5.5	.14			Trace.	Trace.
Calcium (Ca)	95	4.72	106	5.30	104	5.17
Magnesium (Mg)	41	3.36	44	3.61	46	3.77
Aluminum (Al)	3.3	.37			3.6	.40
Manganese (Mn)					Trace.	Trace.
Sulphate (SO_4)	178	3.70	144	3.00	374	7.78
Chloride (Cl)	42	1.18	38	1.08	52	1.48
Carbonate (CO_3)	278	9.25	270	8.99	183	6.11
Silica (SiO_2)	7.2	.24	7.2	.24	9.4	.32
	786.0		705.2		920.0	
Carbon dioxide (CO_2)	164	7.45	Present.	Present.	79	3.58
Hydrogen sulphide (H_2S)					18	1.06

1. Lower Spring. Analyst and authority, Winslow Anderson (1888).
2. Lower Spring. Analyst, Falkenau and Reese. Authority, 8th Cal.
3. Upper Spring. Analyst and authority, Winslow Anderson (1889).

The water is apparently of surface origin and has become somewhat mineralized from the materials through which it percolates. The tunnels are driven into thin-bedded cherts and crushed shales that belong to the Franciscan group.

The property has been improved as a mountain resort for a number of years. In 1909 accommodations for 75 people were provided by several cottages and by a dining room in the main building.

SWEET SPRINGS (ALAMEDA 6).

Another group of magnesic springs that are associated with serpentinous rock rise at the border of a small meadow on a low saddle between two ravines 18 miles southeast of Livermore. The group, which is known as Sweet Springs, includes 10 that issue for a space of 200 yards along the southern side of the meadow and 4 others that issue on its eastern side. They range in size from mere seepages to flows of 6 or 8 gallons a minute, the total yield being perhaps 30 gallons a minute. The water has a distinctly sweet taste. The locality has been used by range stock as a watering place.

The principal springs rise from the northern border of an area of pyroxene rock and serpentine which cover the slopes to the south, the slopes north of the springs being of siliceous sandstone. The sandstone probably belongs to the Franciscan group of altered sediments, which occupies considerable areas in the Coast Ranges, and the serpentine bears its usual intrusive relation to the sediments.

ISHAM SPRING (SAN DIEGO 15).

In the granitic ranges northeast of San Diego there are a number of small springs whose waters have been developed commercially for table and medicinal use. Isham Spring is probably the best known of these, as its water has been on the market for many years. It was formerly known locally as Baldhead Spring, as the use of its water was thought to aid in preventing baldness. The spring is situated in a swale near the head of a small tributary of Sweetwater River, 12 miles by road north of east from San Diego. The water issues in a small cemented and inclosed basin at the side of the drainage channel, from two crevices in the bedrock. It is piped thence to a small reservoir and to a bottling house.

The water is noticeably mineralized, magnesia apparently being the constituent most evident to the taste, and the analysis, which is tabulated on page 312 with that of another commercially developed spring in the same locality, shows that the water is primary and secondary saline and secondary alkaline in character.

The rock of the locality is considerably decomposed and evidently furnishes the main soluble constituents of the water. A small amount of lime carbonate has been deposited along the side of the ravine near the spring and also on the hillside a few hundred yards eastward.

NUVIDA SPRING (SAN DIEGO 16).

Nuvida Spring is a few miles southeast of Isham Spring, being 8 miles by road from La Presa railroad station. Its water has been placed on the market for table and medicinal use. The following analysis shows that it is essentially secondary saline in character, with magnesia fairly well represented though not very noticeable to the taste.

Analyses of water from Isham and Nuvida springs, San Diego County, Cal.

[Authority, advertising matter. Constituents are in parts per million.]

	1		2	
Properties of reaction:				
Primary salinity		36		5
Secondary salinity		38		79
Tertiary salinity		0		0
Primary alkalinity		0		0
Secondary alkalinity		26		16
Tertiary alkalinity		12		25
Constituents.	By weight.	Reacting values.	By weight.	Reacting values.
Sodium (Na)	110	4.78	19	.84
Potassium (K)	18	.45	Trace.	Trace.
Calcium (Ca)	95	4.73	139	6.93
Magnesium (Mg)	57	4.71	108	8.91
Iron (Fe)	.3	.01	2.0	.07
Aluminum (Al)	.8	.09	7.9	.87
Manganese (Mn)	1.4	.05	20	.73
Sulphate (SO_4)	52	1.08	55	1.15
Chloride (Cl)	346	9.76	454	12.79
Bromide (Br)	Trace.	Trace.	....	....
Iodide (I)	.1	Trace.	9.1	.07
Carbonate (CO_3)	117	3.89	104	3.47
Arsenate (AsO_4)	Trace.	Trace.	....	....
Phosphate (PO_4)	Trace.	Trace.	....	....
Silica (SiO_2)	53	1.76	102	3.37
	850.6	....	1,020.0	....

1. Isham Spring. Analysts, Price & Son.
2. Nuvida Spring. Analyst, C. E. Munroe.

IRON SPRINGS.

SPRINGS PREVIOUSLY DESCRIBED.

A few of the springs of California deserve separate consideration because of the exceptionally large quantities of iron deposited by their waters. Among those that have already been described probably the most noteworthy in this respect are Arlington Springs (Plumas 12, p. 229), which have been mentioned among the carbonated springs, though they might as properly be described as iron springs, for their waters have deposited so much of the mineral that the surrounding soil has been used locally as an ocher for the preparation of paint.

IRON SPRINGS IN YOSEMITE VALLEY (MARIPOSA 4).

Probably one of the most frequently visited groups of iron springs in the State is half a mile southwest of Mirror Lake in Yosemite Valley, on the western side of the outlet of the lake. Two springs rise at this place. At the lower one the water issues around the edge of an oval depression a few yards in diameter, 2 or 3 feet below the normal surface of the valley soil. A keg that has been sunk near the center of the depression forms a drinking pool which yields about 10 gallons a minute of cold excellent water. The second spring rises about 50 yards farther upstream, in an area of marshy ground a few yards in diameter. Its immediate yield is perhaps 15 gallons a minute, but this is increased by other seepages, so that the combined flow of the two springs and the seepages forms a stream of perhaps 30 gallons a minute. Much soft brown deposit along the course of the overflow and in the marshy land possibly consists to large extent of Crenothrix, a vegetable organism that secretes iron.

IRON SPRINGS NEAR LAKE TAHOE (PLACER 12).

A mile northwest of McKinney, on the western side of Lake Tahoe, two small iron springs rise in the woods on a gentle slope about 350 yards above the main wagon road and form pools about a foot in diameter and a foot in depth, 4 yards apart, which are used for drinking. The water tastes distinctly ferruginous and has deeply iron stained the soil for about 75 yards below the springs. The staining is probably caused by the fact that the water contains a small amount of carbon dioxide, which holds the iron in solution until this gas has escaped, when the iron is precipitated and deposited along the overflow course.

The springs issue from lake deposits of sand and gravel near the base of steep slopes of andesitic lava.

IRON SPRING NEAR CISCO (PLACER 1).

A cold iron spring that yields perhaps 8 gallons a minute is situated in a small depression in a patch of alders on a gentle slope on the southern side of the canyon of South Fork of Yuba River, half a mile north of Cisco railroad station and 100 yards south of the wagon road. The soil is deeply iron stained for a number of yards along the overflow channel. The spring is well known locally, as it furnishes excellent cold drinking water. The surrounding rocks are the slates and schists derived from them that have been mentioned in speaking of the sulphur springs near South Fork of Yuba River (Placer 2, p. 284), a mile or two upstream from the iron spring.

ARTESIAN SPRINGS.

SPRINGS PREVIOUSLY DESCRIBED.

Many of the springs that rise in the alluvial valleys of the State yield considerable good water that is noticeably above a normal temperature and that is apparently forced to the surface through the deep alluvial deposits by artesian pressure. Several springs in Sonoma County, notably those on McEwan ranch (Sonoma 14, p. 114), Los Guilicos Warm Springs (Sonoma 15, p. 114), and the Warm Springs of the State Home at Eldridge (Sonoma 16, p. 114), which have been described among thermal springs, may also be mentioned in connection with artesian springs, as they rise in tuffaceous lava, the structure of which is apparently adapted to carry and yield water under artesian pressure. The artesian wells at Agua Caliente, Fetters, and Boyes hot springs (Sonoma 18, 19, and 20, pp. 112–114) also furnish evidence in support of the theory that the natural warm springs are of artesian origin. Boyd Spring (Modoc 12, p. 124) has characteristics which suggest that it is supplied by alluvial artesian water, but the fact that all the other notable springs in Surprise Valley are too hot to be of artesian origin favors the opinion that the source of Boyd Spring also is deep-seated, its water rising along a structural break.

The warm springs at south end of Surprise Valley (Modoc 18, p. 124), like Boyd Spring, may possibly be supplied by alluvial artesian water, but a more probable source is heated water that may rise along a fault or structural break.

TORO SPRINGS (RIVERSIDE 14).

Near the northern end of Salton Sink in the Colorado Desert the artesian water that underlies this portion of the desert rises to the surface, forming several "ciénagas" or marshy areas. The northernmost of these ciénagas that is worthy of note is at Toro Springs, on the Toro Indian Reservation, about 9 miles south of Indio. There has been an Indian settlement at the springs for many years, and the water has been used by the Indians to irrigate garden patches.

ALAMO BONITO SPRINGS (RIVERSIDE 15).

Alamo Bonito Springs are about 5 miles southwest of Mecca and 8 miles southeast of the Toro Springs, to which they are similar. The name, which is Spanish and means "beautiful poplar," refers to the trees that are numerous in the vicinity of the springs. Like Toro Springs there has been an Indian settlement at them for many years.

AGUA DULCE SPRINGS (RIVERSIDE 16).

Agua Dulce (sweet water) Springs are about 7 miles south of Mecca and were close to the margin of Salton Sea at its highest stage in 1907. Several springs in the group have long been used by the Indians. They were formerly an important watering place on the road along the western side of the desert, but within recent years their value has been lessened by the fact that other supplies of water have been obtained from a number of flowing wells in the neighborhood.

FIGTREE JOHNS SPRINGS (RIVERSIDE 17).

A small group of springs about 3 miles southeast of Agua Dulce Springs has long been known by the name of an Indian, Figtree John, who, with his family, has lived near the springs and cultivated a small garden and orchard. In 1907 the springs were submerged to a depth of a few feet by the rising water of Salton Sea, but they have doubtless been exposed again as the level of the sea has been lowered.

FISH SPRINGS (IMPERIAL 1).

Fish Springs, which are about 3 miles southeast of those of Figtree John, were submerged to a depth of about 25 feet in 1907 by the water of Salton Sea. They yielded a considerable flow of tepid, slightly saline water and formerly constituted an important watering place on the western side of the desert, for they furnished the southernmost potable water for a number of miles. They will again be of value to travelers when they are exposed by the subsidence of the lake water.

DOS PALMAS SPRINGS (RIVERSIDE 18).

A group of tepid, rather salty springs that seem to be of artesian origin is situated about 6 miles east of Salton railroad station, on the northeastern side of Salton Sink. The locality was formerly a well-known camping place on the road between San Bernardino and Yuma, but it has not been much used for this purpose since the construction of the railroad through the region. The following analysis of the water of the springs shows that it is primary and secondary saline in character:

Analysis of water from main spring, Dos Palmas Springs, Riverside County, Cal.

[Analyst, Oscar Loew (1876). Authority, Wheeler report. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	80
Secondary salinity	20
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	Trace.
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Sodium (Na)	908	39.50
Calcium (Ca)	96	4.79
Magnesium (Mg)	63	5.15
Manganese (Mn)	Trace.	Trace.
Sulphate (SO_4)	477	9.94
Chloride (Cl)	1,400	39.50
Carbonate (CO_3)	Trace.	Trace.
Phosphate (PO_4)	Trace.	Trace.
Silica (SiO_2)	Trace.	Trace.
	2,944	....

OROCOPIA SPRINGS (RIVERSIDE 19).

Orocopia Springs, which are half a mile east of Dos Palmas Springs, rise in a marshy area several acres in extent. A plentiful supply of mildly saline water is obtained from several large holes cut in the sod. The Orocopia Mining Co. has established a pumping plant at the springs, and the water is pumped to the mine, several miles northward.

TWENTY-NINE PALMS SPRINGS (SAN BERNARDINO 44).

In the region north of the Colorado Desert there are a number of springs and groups of springs that are probably supplied by alluvial artesian water. Twenty-nine Palms Springs, which form a camping place for prospectors and also furnish a water supply for mining camps in the near-by mountains, are scattered for a mile along the southwest edge of a dry lake, about 45 miles by road northward from Indio. They receive their name from groups of palm trees that grow near them.

OLD WOMAN SPRINGS (SAN BERNARDINO 27).

On the southern border of Mohave Desert, about 40 miles by road south of east from Victorville, two springs issue from the northern base of a hill of basic lava. The larger spring, which is known as Old Woman Spring proper, flows from a 30-foot tunnel in the hillside. In June, 1910, it yielded about 150 gallons a minute, but its flow is said to vary considerably with the season. The water is collected in an earthen reservoir and is thence used to irrigate an alfalfa field. The second spring, which is known as Pommer Spring, issues from a hole beneath a cottonwood tree about 50 yards northwest of the main spring. It yields about 12 gallons a minute of water that has been used to irrigate an orchard near by.

COTTONWOOD SPRING (SAN BERNARDINO 26).

Cottonwood Spring, which is 1 mile northwest of Old Woman Springs, issues from a 50-foot tunnel in coarse gravel or conglomerate near lava slopes. It yields about 3 gallons a minute of water that is collected in a small reservoir and used to irrigate a garden.

The three springs last described—Old Woman, Pommer, and Cottonwood—are apparently situated at places where alluvial water from the slopes of San Bernardino Mountains, which lie to the south, is forced to the surface by rock obstruction. In this respect they are thought to be similar in origin to Newberry Spring, described on page 317. The waters of all three are slightly alkaline.

RABBIT SPRINGS (SAN BERNARDINO 25).

Rabbit Springs, which are situated about 25 miles east of Victorville, issue from a marshy bank near a group of cottonwood trees. The group includes two principal springs, one of which slightly overflows from a box-curbed pool and is used by campers and travelers;

the other spring is a quarter of a mile farther westward and yields about 1 gallon a minute, which supplies a cattle trough. Since well water has been obtained at the Box S ranch, a mile to the southeast, the springs have not been so much used, for the water at the ranch is of better quality.

NEWBERRY SPRING (SAN BERNARDINO 20).

Newberry Spring rises at the north base of hills of tuffaceous lava that border a desert flat 600 yards south of Newberry pumping station, on the Santa Fe Railway. The spring is surrounded by a circular masonry reservoir about 20 feet in diameter, from which an 8-inch pipe line leads to the pumping station at the railroad. The water is used for locomotive supply at this station and is also hauled in tank cars for railroad supply at Ludlow and Bagdad, two stations farther east. The water is of good quality for boiler use, the following partial analysis showing its character for this purpose:

Partial analysis of water from Newberry Spring, San Bernardino County, Cal.

[Analyst and authority, Atchison, Topeka & Santa Fe Railway Co. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	Present.
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	Present.
Secondary alkalinity	About 30
Tertiary alkalinity	(?)

Constituents.	By weight.
Temporary hardness	91
Permanent hardness	0
Dissolved solids	324

The temperature of the water, 77°, indicates that it is of essentially alluvial artesian origin, although the position of the spring at the north base of Kane Mountain suggests that it may be related to faulting that probably has taken place here. There are a few mesquite trees at the spring, which has long formed a camping place for desert travelers.

BUCKHORN SPRINGS (KERN 26).

Buckhorn Springs form a group on the west side of Rodriguez Dry Lake and about 7 miles south of Muroc railroad station. The springs rise in low grassy mounds in the lake flat and yield small quantities of slightly alkaline water, forming a watering place that has been used for many years by prospectors. The cabin of a prospector has stood near the principal spring for several years and marked its location. Several springs of similar character rise at other points around the border of this dry lake. All appear to be supplied by the upward leakage of alluvial artesian water.[1]

INDIAN SPRING (KERN 25).

Indian Spring is situated near the northern border of Rosamond Dry Lake, 3 miles east of the station of the same name on the Southern Pacific Railroad, about 200 yards south of the base of steep hills. The spring, which has only a slight flow, has been curbed to form a cattle-watering pool about 12 feet square, and deeply worn trails lead to it. A small box-curbed pool in the center furnishes a water supply to prospectors and travelers. The property has been filed upon and two or three cabins have been built near the spring. Another spring of similar character but of only seeping flow issues near the southern border of the valley, about 13 miles southward or 2 miles southwest of the town of Lancaster.

WILLOW SPRINGS (KERN 22).

Willow Springs are on the ranch of Mr. E. M. Hamilton, at the northern border of Antelope Valley, 8 miles west of Rosamond. The ranch forms a small settlement where supplies and accommodations for the night may be obtained.

Several springs and seepages issue for a distance of a quarter of a mile along the base of hills that border the valley, and farther westward, beyond the Willow Springs group, others of similar character issue, the principal one being known as Bean Spring.

In the Willow Springs group 7 springs may be recognized, of which the southernmost yields much the greatest supply, its discharge being (in July, 1909) 15 or 20 gallons a minute. It rises in a bricked and cemented chamber, about 15 feet in diameter and 10 feet high, that has been constructed in an excavation in the bank. The water is piped to a cement reservoir about 50 feet in diameter and 6 feet deep and is used for irrigation. Water from two or three of the other springs is collected in a smaller reservoir and is also used for irrigation. About 35 acres of vegetables, alfalfa, and orchard are watered by these springs. The following analysis of water from the main spring shows it to be a primary saline secondary alkaline water of low concentration.

[1] The origin of these springs is discussed by H. R. Johnson, in Water resources of Antelope Valley, California: U. S. Geol. Survey Water-Supply Paper 278, pp. 47–48, 1911.

Analysis of water from main springs, Willow Springs, Kern County, Cal.

[Analyst, Walton Van Winkle (1909). Authority, U. S. Geol. Survey Water-Supply Paper 278. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		44
Secondary salinity		6
Tertiary salinity		0
Primary alkalinity		0
Secondary alkalinity		50
Tertiary alkalinity	(?)	
Constituents.	By weight.	Reacting values.
Sodium (Na)	54	2.35
Potassium (K)		
Calcium (Ca)	44	2.20
Magnesium (Mg)	9.1	.75
Iron (Fe)	.2	.01
Aluminum (Al)		
Sulphate (SO_4)	101	2.10
Chloride (Cl)	19	.54
Carbonate (CO_3)	76	2.54
Silica (SiO_2)	25	.83
	328.3	....
Carbon dioxide (CO_2)	Present.	Present.

The water issues along a terrace-like bank whose position indicates that it may be a small fault. The springs may therefore be supplied by alluvial artesian water that here escapes upward along the faulted zone.[1]

RESTING SPRINGS (INYO 34).

Resting Springs rise at the southern end of a mountain range, about 5 miles east of the Tonopah & Tidewater Railroad, in southeastern Inyo County. Frémont camped at them in 1844, when returning eastward from his exploring expedition, and they early became a stopping place on the road between Salt Lake City and San Bernardino. They are still well known to desert travelers, and Mr. Philander Lee, who has lived there since 1882, has made a real oasis of the place. About 25 acres of alfalfa, corn, and garden vegetables are irrigated by the main spring, which is said to yield 29 miner's inches (260 gallons a minute).[2] The springs are situated in a small marshy area at the base of a terrace-like bank, 25 yards south of the steep slope of Resting Springs Mountain. The water rises in this marshy area mainly at four points around the edge of a natural basin about 8 yards in diameter, which is sunk several feet below the normal surface. The temperature of the water (80°) and its constant flow indicate that it is essentially of deep-seated or artesian character, but the mountain slope at whose base it issues is composed of quartzite that dips

[1] For discussion of these springs, with diagrams, see Johnson, H. R., Water resources of Antelope Valley, California: U. S. Geol. Survey Water-Supply Paper 278, pp. 49-51, 1911.

[2] The old California miner's inch is approximately equivalent to a flow of 9 gallons a minute.

60° NE., and the rise of the water may be determined largely by a fault along the western face of the ridge. About 200 yards west of the main springs a flow of perhaps half a gallon a minute has been developed in a small bank and piped to a watering trough beside the road.

Considerable agricultural land extends southwestward from the springs, but the higher land eastward and the slopes to the west are composed largely of barren knolls and dry washes.

TEXAS SPRINGS (INYO 20).

A large amount of slightly saline water rises in Texas Springs, near the mouth of Furnace Creek, at the northeast edge of Death Valley. The water has been used for irrigation on Furnace Creek ranch for a number of years, and the springs have long formed a camping place for desert travelers. The water apparently has an alluvial artesian source, though it may be related to the rock structure along the eastern side of Death Valley.

BLACKROCK SPRING (INYO 8).

Several large springs that rise along the western side of Owens Valley are probably supplied by alluvial artesian water, which is apparently forced to the surface by lava of relatively recent geologic age that has flowed down into the valley from craters near by. Blackrock Spring, which is the southernmost and largest, is 10 miles by road north of Independence. The water rises in a pool 10 or 15 yards in diameter, at the southern base of a low lava ridge, and flows eastward across the flat alluvial valley. The water has been used for irrigating meadowland, but it is now a portion of the supply for the Los Angeles aqueduct.[1] Its temperature (56°) is said to be the same as the mean annual temperature that is indicated by records covering a period of 12 years at Independence. The normal flow of the spring has been measured as 21 second-feet[2] (9,425 gallons a minute), but it is said to decrease notably when the water level is raised by an irrigation head gate. The following three analyses show wide variations in the apparent proportions of certain constituents but in general indicate that the water contains little mineral matter in solution:

[1] A gravity canal that conveys the water of Owens River 250 miles southward as a municipal supply for the city of Los Angeles.

[2] Second-foot = 1 cubic foot a second. It is the unit that is commonly employed in measuring the discharge of streams.

Analyses of water from Blackrock Spring, Inyo County, Cal.

[Authority, records of Los Angeles aqueduct. Constituents are in parts per million.]

	1		2		3	
Properties of reaction:						
Primary salinity	31		21		34	
Secondary salinity	0		13		31	
Tertiary salinity	0		0		0	
Primary alkalinity	41		0		0	
Secondary alkalinity	28		66		35	
Tertiary alkalinity	11		12		74	
Constituents.	**By weight.**	**Reacting values.**	**By weight.**	**Reacting values.**	**By weight.**	**Reacting values.**
Sodium (Na)	36	1.55	9.3	.40	11	.46
Potassium (K)			Trace.	Trace.	Trace.	Trace.
Calcium (Ca)	7.2	.36	20	1.04	18	.90
Magnesium (Mg)	3.0	.24	5.4	.45		
Iron (Fe) / Aluminum (Al)	3.0	.11	Trace.	Trace.		
Sulphate (SO_4)	21	.44	20	.42	40	.83
Chloride (Cl)	7.8	.22	8.3	.23	1.8	.05
Carbonate (CO_3)	45	1.49	37	1.24	14	.48
Silica (SiO_2)	7.0	.23	6.8	.23	30	1.00
	130.0		106.8		114.8	

1. Analyst, L. J. Stabler (1906).
2. Analyst, G. E. Colby (1905).
3. Analyst, Wade & Wade (1905).

LITTLE BLACKROCK SPRING (INYO 7).

Little Blackrock Spring, which rises at the valley edge half a mile west of north from Blackrock Spring, forms a pool a few yards in diameter at the edge of a lava flow and also forms part of the supply for the Los Angeles aqueduct. Its normal discharge is about 7 second-feet (3,140 gallons a minute), but its flow is said to increase when that of Blackrock Spring is decreased by the closing of an irrigation head gate.

HINES SPRING (INYO 5).

Hines Spring rises in a marshy and tule-grown area at the southern base of a lava ridge 8 or 10 feet high that is 3½ miles north of Blackrock Spring. Its water had not been made use of when the spring was visited in 1908, and it formed a sluggish stream about 3 feet wide.

SEELYS SPRING (INYO 4).

Seelys Spring is about 2½ miles north of Hines Spring. It rises at the south base of a low lava ridge 75 yards from the west bank of Owens River, into which it flows directly. It yields 1⅓ second-feet (600 gallons a minute)[1] of good water that has a temperature of 61°.

[1] Measurement made with current meter Nov. 15, 1908, by A. T. Barrows, jr.

FISH SPRINGS (INYO 3).

Fish Springs are at the west edge of Owens Valley, about 3½ miles south of Big Pine or 27 miles north of Independence. They form a large pond at the northern side of a lava ridge that extends for some distance into the valley. The water has not been efficiently used, but it irrigates a small amount of meadow along its course eastward to Owens River.

DEEP SPRINGS (INYO 2).

At the southern end of Deep Spring Valley, in the northeastern part of Inyo County, are several large artesian springs that have been used for a number of years for irrigation, and their supply is said to be sufficient to water 600 acres. The springs are about 18 miles by road northeast of Alvord railroad station and form a stopping place on the road to Nevada. The largest group of springs is sometimes known as Buckhorn Springs. Water issues at numerous places, however, for a distance of a mile along the upper border of a meadow area.

ARTESIAN SPRINGS AT OASIS (MONO 20).

Oasis is a small settlement lying northward from Deep Spring Valley, on the road from Owens Valley to Nevada. Springs of considerable size, whose yield is augmented by wells, furnish water for irrigating a number of acres. As at the springs in the valley a few miles southward, the artesian water of Oasis apparently rises from alluvium that deeply buries the bedrock and is probably supplied from layers of gravel that act as storage reservoirs for the run-off from the surrounding mountains.

BERTRAND RANCH SPRINGS (MONO 10).

Tepid springs that rise on the Bertrand ranch in Spring Valley, about 6 miles north of Benton, are used to irrigate a considerable area of meadowland. The water apparently rises under artesian pressure at the base of alluvial slopes, which are remarkably well developed along the flanks of the mountains that border the valley.

RIVER SPRING (MONO 9).

River Spring, about 10 miles in a direct line west of north from Benton, yields a considerable flow of water that is probably of alluvial artesian origin, and is otherwise similar in character to that of the springs a few miles to the southeast on the Bertrand ranch. It furnishes part of the supply of a small narrow lake around whose borders is a little meadowland.

BLIND SPRING (MONO 13).

Blind Spring, which is situated about 3 miles east of south from Benton, was formerly of some importance as a watering place, but of late years its flow, always slight, is reported to have nearly ceased. It is in open valley land and is said to have received its name because there was little growth near it to indicate the presence of water.

ARTESIAN SPRING NEAR HOPLAND (MENDOCINO 30).

A spring which is apparently of artesian origin issues on the Horst ranch, 1 mile north of Hopland. The water rises in a grove of willows at the mouth of a small ravine on the western edge of valley land along Russian River. The spring is protected by a board curbing, which forms a shallow pool 8 by 10 feet across, and the discharge—about 5 gallons a minute of faintly sulphureted water—is used to irrigate a vegetable garden.

The adjacent hills are composed of the older sandstones and shales that form so large a portion of the Coast Ranges. Their structure, however, is not favorable to the occurrence of water under artesian pressure, and the spring is probably supplied by alluvial water that rises at this place. At the time of the earthquake of April 18, 1906, the spring ceased flowing for a short time but gradually returned to its normal discharge.

ARTESIAN SPRINGS IN SHASTA VALLEY (SISKIYOU 13).

A number of springs which rise in the northeastern part of the State are probably of alluvial artesian origin. Two of these that yield considerable water rise in Shasta Valley at points about 10 and 11 miles southeast of Montague, one being known as Big Spring and the other as Little Spring. The former yields a large flow of water that is noticeably above the normal temperature; the latter, a mile farther south, yields a smaller flow of similar character. Both springs are used to irrigate tracts of meadowland but are capable of much more extensive development.

ARTESIAN SPRING NEAR ALTURAS (MODOC 9).

At the southern base of a low but extensive mound in meadowland 1½ miles southeast of Alturas is a spring of small flow at which a hydraulic ram has been installed that pumps the water to troughs in a corral on the mound. The observed discharge from the spring was only about 1 gallon a minute, but there was much seepage near it. The temperature of the water (72°) indicates that it is of deep-seated origin rather than of essentially surface flow. It may rise from rock beds that underlie the valley alluvium and be similar in origin to the warm springs near Rattlesnake Creek (Modoc 8) and near

Canyon Creek (Modoc 7), to the northwest and to the southwest, which have been mentioned among the thermal springs. (See p. 120.)

CABIN SPRINGS (LASSEN 18).

Cabin Springs form a small roadside watering place on the border of Honey Lake Valley, about 4½ miles east of Amedee. There are five shallow depressions at the locality, 10 or 15 yards apart, and a quarter of a mile south of the lava slope that borders the valley. The western two are the largest, and when visited they contained small amounts of water of good quality, but there was no overflow. This water is thought to be essentially alluvial artesian in character. A number of years ago a small well three-quarters of a mile westward obtained flowing water, and three other wells which were sunk during the nineties about 3 miles westward also obtained small flows.

In 1909 these four wells were still flowing, and each yielded from 1 to 3 gallons a minute of water 71° to 78° in temperature.

SELLICKS SPRINGS (LASSEN 9).

Besides those springs in the lava-covered northeastern section of the State that have been mentioned as probably of alluvial artesian origin, there are a number of others which are thought to be in structural artesian basins.[1] Several large springs of constant flow rise on the borders of Secret Valley, in eastern Lassen County. Sellicks Springs, which form one of the largest groups, rise in a strip of meadowland on the northern edge of the valley, about 1¼ miles northwest of Karlo railroad station. A careful float measurement of the stream flowing into the valley indicates that the discharge is about 1,050 gallons a minute. The water is of good quality and has a temperature of 72°. The original belt of meadowland formed by it in the open valley south of the springs has been greatly increased by distributing the water through ditches, so that nearly 300 acres of meadowland have been produced. A pipe also leads from the springs to a railroad watering tank at the station.

TIPTONS SPRINGS (LASSEN 10).

Tiptons Springs, at Secret post office, issue from the basaltic lava slope at the northern edge of the valley, 3½ miles east of Sellicks Springs. The water rises mainly in a marshy strip 150 or 200 yards long and flows at a rate measured at 925 gallons a minute (103 miner's inches). The water flows southward and irrigates meadowland, from which quantities of hay are cut.

[1] A structural artesian basin is formed where bedded rocks that make a series of alternating relatively pervious and impervious layers are folded into a trough-shaped or saucer-shaped valley. Water collects in the lower portions of the more pervious beds under pressure of the water in the higher portions of the same beds around the borders of the valley.

Springs similar to those near the Tipton ranch house rise at three places between Sellicks and Tiptons springs, along the edge of meadowland on the south side of the road. One of these, which is about 1 mile southwest of Tiptons, does not form a noticeable stream, but it makes a considerable meadow area. Two other springs rise at points about one-third of a mile and 1¼ miles west of it. Each of these western springs yields about 50 gallons a minute of water 60° to 64° in temperature. They form small areas of meadowland and also serve as watering places for cattle.

SECRET SPRINGS (LASSEN 12).

Secret Springs are on the southern border of the valley land, about 4 miles east of Tiptons Springs. They yield a flow of perhaps 50 or 60 gallons a minute that forms the usual meadow area, but their water has not been efficiently used.

SHEEP SPRINGS (LASSEN 11).

Sheep Springs, 4½ miles northeast of Tiptons Springs, form a watering place for range cattle and have also been used to some extent for irrigating garden and meadow tracts.

SPANISH SPRING (LASSEN 5).

Spanish Spring issues on the slope 14 miles north of the Tipton ranch, near the home of a settler in the region. The spring yields a considerable amount of water that has been used for domestic and garden supply.

ARTESIAN SPRINGS ON SOUTH SIDE OF SHINNS PEAK (LASSEN 6).

Springs that yield perhaps 100 gallons a minute of water noticeably above the normal temperature of this region (about 55°) issue on the southern side of Shinns Peak. Although they are at a considerable elevation above the valley land, it seems probable that, like others in the region, they issue from porous, tuffaceous beds and are of structural artesian character.

ARTESIAN SPRINGS NEAR SMOKE CREEK (LASSEN 7).

Near the eastern border of the State water in considerable quantity issues from the slopes near Smoke Creek and forms a tributary of this stream. The rocks, as in most parts of Lassen County, consist of lava with interbedded tuffaceous layers that form excellent water carriers.

ARTESIAN SPRINGS NEAR HEAD OF RUSH CREEK (LASSEN 13).

Springs that strongly resemble those near Smoke Creek issue a few miles away on slopes near the head of Rush Creek and render it perennial in its upper course. They are too remote, however, to have become of use other than as a watering place for range stock.

ARTESIAN SPRINGS ON EAST SIDE OF HORSE LAKE VALLEY (LASSEN 8).

In the western part of Lassen County there are a number of springs that are similar in character to those in the neighborhood of Secret Valley, which lies farther east. On the east side of Horse Lake Valley are springs that yield water of good quality and noticeably above the normal temperature of the region. These springs have been developed somewhat and are used by settlers on the valley land.

ARTESIAN SPRINGS NEAR BAILEY CREEK (LASSEN 4).

Near Bailey Creek, which is on the western side of Madeline Plains, there are springs of considerable flow that have been used mainly as watering places for cattle, but within recent years portions of the Madeline Plains (or Madeline Meadows) have been brought under irrigation and cultivation, and it is probable that all the minor available flows of water will soon be utilized by settlers.

ARTESIAN SPRINGS NEAR SOUTH END OF EAGLE LAKE (LASSEN 14).

At the south end of Eagle Lake there is a considerable area of meadow that has been used for winter range and natural hay land for many years. A portion of it is irrigated by springs that are apparently of artesian origin, and other smaller springs of similar character issue on the lower slopes above the meadowland.

Many other springs than those which have been individually referred to issue on the mountain slopes and along the valley borders in Lassen County, but most of them have been used only as watering places on the stock range. As the region becomes more thickly populated, however, and the valley lands are brought under cultivation, the springs will become of much greater economic value and can be used to irrigate many acres.

LARGE COLD SPRINGS.

DISTRIBUTION.

Cold springs of notable flow are found almost entirely in the northeastern, lava-covered section of the State. They seem to be supplied by water of essentially surface origin, which sinks into the fissured lavas and porous tuffs and emerges at favorable localities.

SPRINGS AT HEAD OF FALL RIVER (SHASTA 6).

The largest of the cold springs—and probably the largest springs in the State—rise at the head of Fall River, one-fourth to three-fourths of a mile north of Dana post office, which is 56 miles by railroad and stage east of Sisson. About six large springs rise on the borders of a meadow at the head of the river. Two of these rise about 250 yards apart on the southwest side of the meadow and flow eastward, uniting to form a stream that is perhaps 10 feet wide and 2 feet deep. The water of two other springs which rise 100 yards apart at the base of a gentle lava slope at the northwest edge of the meadow is distributed by ditches to irrigate the natural hay land. A large amount of water also issues at the northeast edge of the meadow about 500 yards east of these springs, where a pond is formed by an earthen dam, so that the level of the water is raised to a height that renders it available for use on the meadow. Below this dam a stream 100 to 200 feet wide and 2 or 3 feet deep flows southward along the western base of a lava bank that borders the meadow. At several places along the margin of the stream and in its channel there are other springs of considerable flow. The most remarkable is about one-fifth mile below the dam at the head of the stream. This spring rises in an oval pool about 50 by 60 feet across and 16 feet deep in a depression in the lava nearly 100 yards east of the main stream. The water in this pool is very clear. It rises quietly but with a strong flow and joins the main stream 250 yards southward. The combined flow of the springs, or of Fall River, which they form, is 1,500 second-feet (675,000 gallons a minute).[1] As the grade of the stream is low, water is not easily available for irrigation by gravity canals and has been used to relatively little extent.

The springs rise at the southern border of an extensive lava field. They are locally considered to be the outlet of Tule or Rhett Lake at the northern border of the State. The water may, however, be furnished by the precipitation on the lava fields to the north, for much the greater part of the water that falls on these fields sinks into the crevices and caverns in the rock, and there is very little direct surface run-off. A continual flow of 1,500 second-feet would be furnished by an annual run-off of 1 second-foot from 1,700 square miles. This amount, 1 second-foot, is not excessive for the region under consideration, where the annual precipitation is 20 to 40 inches, for it represents both a normal run-off and the amount that usually sinks into the ground. There is an area of nearly 2,000 square miles of lava beds extending from northeast to northwest of Dana, and the topography of this area is favorable to the hypothesis that it may furnish the water of the springs at the head of Fall River.

The temperature of the water, 53° to 54°, indicates that it is of essentially surface origin.

LARGE COLD SPRING SOUTHEAST OF PITTVILLE (LASSEN 3).

On Mr. George Guthrie's ranch, 3 miles southeast of Pittville, or 16 miles in a direct line southeast of the big springs at the head of Fall River, there is a spring whose water is probably essentially of

[1] Clapp, W. B., and Hoyt, J. C., Report of progress of stream measurements for the calendar year 1905: U. S. Geol. Survey Water-Supply Paper 177, p. 133, 1906.

surface origin, though its temperature (64°) indicates that it may rise from a depth of a few hundred feet. The spring was opened by Mr. Guthrie at the base of a slope of loose material and has been developed so that it yields about 900 gallons a minute of water of very good quality. It is used for domestic purposes and for irrigation on valley land that borders the course of Pit River.

LARGE COLD SPRINGS ON BURNEY CREEK (SHASTA 9).

During periods of normal and low water Burney Creek sinks at a point 5 or 6 miles north of Burney Valley, but a short distance above Burney Falls, which are about 1½ miles above the junction of the creek with Pit River, the water issues again as large springs. The greater part of the water goes over the falls, but a large part also issues from fissures in the lava cliff, some distance below the crest of the falls. Although the water is apparently only that of the creek which sinks below Burney Valley and rises again farther down the course of the stream, it may be properly considered to issue as springs, whose chief difference from similar springs in the lava region is that the immediate source of the water seems to be evident.

RISING RIVER (SHASTA 11).

Rising River is a stream that flows from a small lake about 10 miles east of Burney Valley, westward a distance of 2 or 3 miles to Hat Creek. The water rises in the lake and adjacent meadow, and its flow, which in July, 1910, was approximately 250 second-feet (112,500 gallons a minute), is nearly uniform. The water has been used to some extent for irrigating meadow hay land, and by means of current wheels a small amount of water is lifted for dairy and domestic supplies. The source of the springs of Rising River is not so evident as is that of the springs on Burney Creek, but the water is locally (and plausibly) believed to be derived from Butte or Lost Creek, which flows from Lake Bidwell or Butte Lake to Porcupine Flat, where it sinks about 12 miles southeast of the head of Rising River.

GREAT SPRINGS (SHASTA 12).

Great Springs issue for a distance of about a quarter of a mile along the southwestern bank of Hat Creek, at the northern base of the mountain mass that culminates in Lassen Peak (Pl. XI). The greater part of the headwaters of Hat Creek is conducted westward by a power ditch, so that in July, 1910, there was a flow of only about 2 second-feet (900 gallons a minute) in its channel above Great Springs. Below the springs the stream was 50 to 75 feet wide and 2 or 3 feet deep, and a float measurement indicated a discharge of 280 second-feet (126,000 gallons a minute). A portion of the water has been used for a number of years on the small ranches of Indians and white settlers along the lower course of the stream, but only a small part of the supply has been employed. The water of Lost Creek[1] normally sinks at a distance of about a mile above its junction with Hat Creek, or about 2½ miles in a direct line west of south from Great Springs, and it is locally believed that the creek reappears in the springs. The position of the springs at the northern base of slopes that rise to Lassen Peak and the fact that the water issues almost entirely on that bank of Hat Creek which is toward the mountains indicate, however, that the supply comes mainly from melting snow on the slopes to the south, though a part is perhaps derived from Lost Creek. The yield of the springs is said to vary somewhat with the season, a characteristic of springs that have near-by sources of supply.

ROCK CREEK SPRINGS (SHASTA 13).

Several cold springs of large flow issue on the western slopes of Lassen Peak. Among them are Rock Creek Springs, which are near the headwaters of the stream of the same name. The water issues from a hard lava agglomerate at a rate of about 11 cubic feet per second (4,950 gallons a minute). This water has been appropriated by the Northern California Power Co. for use in generating electric power in their plant near Manton, several miles west of the springs.

BIG CLIPPER SPRINGS (TEHAMA 1).

Big Clipper Springs are similar in character and mode of occurrence to Rock Creek Springs. They issue about 4 miles in a direct line southeast of the latter, beside a tributary of Digger Creek, and yield a flow of about 5 second-feet (2,250 gallons a minute). Their water, like that of Rock Creek Springs to the northeast, has been appropriated for electric power generation by the Northern California Power Co. The positions of both Big Clipper and Rock Creek springs and their large and nearly uniform flows indicate that, like other large cold springs in the region, their source of supply is the melting snow of Lassen Peak. The springs issue from layers of tuffaceous lava or lava agglomerate through which the water very probably percolates westward from the higher slopes until it finds surface escape in the creek canyons.

LARGE COLD SPRINGS ON GERBER RANCH (TEHAMA 4).

On the Gerber ranch, which is beside the stage road between Red Bluff and Paynes Creek post office and about 20 miles east of the former place, springs of considerable flow issue in a small meadow along the course of Paynes Creek. The water has supplied a small pond and has been used to some extent for irrigation. It is evi-

[1] This stream is 10 or 15 miles west of Butte Creek, which is also locally known as Lost Creek.

dently derived from the melting snow of the higher slopes to the east. The porous tuffaceous lava, which is known as the Tuscan tuff and which covers the slopes for some distance surrounding the springs, affords good storage for the water and renders the flow of the springs fairly uniform.

LARGE COLD SPRINGS IN HOT SPRING VALLEY (PLUMAS 3).

Large perennial springs of cold water issue from lava bluffs that form the north side of Hot Spring Valley, on the southeastern slope of Lassen Peak. The water issues about one-half mile west of Drake Hot Springs (Plumas 4, p. 142) at numerous places for a distance of 200 or 300 yards along the steep slope. The various streams flow down among small quaking aspens and unite to form a stream of fairly uniform flow that discharges approximately 1,500 gallons a minute. A small part of the water has been used in irrigating adjacent meadowland, but the main part of it flows directly into Warner Creek, of which it forms a tributary.

In connection with these cold springs several minor ones in the same region may be mentioned. One that furnishes a domestic supply at Drake Hot Springs issues 300 yards east of the house, from beneath a large lava bowlder on a steep slope below a bluff that borders the north side of Hot Spring Valley. This spring has a nearly uniform flow of about 75 gallons a minute and is of interest because of its low temperature, which was 39° in July, 1910. Another unusually cold spring but of less flow issues in meadowland at the head of Warner Valley, about 4 miles east of Drake Hot Springs. When visited this spring had a temperature of 44°, but its water was probably warmed somewhat by irrigation water from the creek. Its yield was only about 2 gallons a minute. Other cold springs that yield 5 to 20 or 30 gallons a minute issue in small meadow patches along tributaries of King and Warner creeks. On the barren slopes near the summit of Lassen Peak springs that discharge several second-feet issue along the sides of drainage channels during the season of melting snow. Their sources can often be recognized in melting snow banks a few hundred yards away, and their mode of occurrence helps to explain the existence of large springs on the lower slopes, where the source of supply is not so evident.

LARGE COLD SPRINGS IN BIG MEADOWS (PLUMAS 8).

Large springs issue at the northeast edge of Big Meadows, about 5 miles by road northeast of Prattville. The water issues from basaltic lava, a few feet above the meadow level, in an area of willows and quaking aspens about 100 yards in diameter. After flowing down over riffles of coarse lava gravel it forms a sluggish stream 100 yards or more in width in the meadow. A very rough float measurement at the riffles indicates that the discharge is about 56 second-feet (29,000 gallons a minute). The water is cold (46°) and of very good quality. It has been used to some extent for irrigating the meadow and forms a tributary of North Fork of Feather River.

LARGE COLD SPRINGS ON BRANCH OF ROCK CREEK (PLUMAS 7).

About 2 miles north of the springs in Big Meadows, springs of much smaller flow issue 50 yards south of the road between Prattville and Susanville. The water rises in a marshy patch in a small swale on the lava slope and forms a stream that discharges perhaps 1,000 gallons a minute. The water has not been used directly, but it flows southward to Rock Creek and thence into Big Meadows, where it irrigates a portion of the natural hay land.

LARGE COLD SPRINGS EAST OF ROCK CREEK (LASSEN 15).

About 3 miles northeast of the springs last described, or 2 miles east of Rock Creek, are other large springs that issue at the western side of a small escarpment in the basaltic lava and yield a stream whose flow was estimated to be perhaps 20 second-feet (9,000 gallons a minute). Like the other springs of this region, their water has not been used directly, but it forms a tributary of Rock Creek.

LARGE COLD SPRINGS NORTHEAST OF AGER (SISKIYOU 6).

On the road to Klamath Hot Springs, in a small ravine at the base of a butte of lava agglomerate about 9 miles northeast of Ager, cold water issues at several places from the talus slope at the western side of the butte and is collected in a ditch and used for irrigation. Water from one of the springs is also piped several hundred yards northward for domestic use at the home of the owner of the property. The temperature of the springs is 47°, and their combined flow is perhaps 1,400 gallons a minute.

LARGE COLD SPRINGS NEAR LITTLE SHASTA RIVER (SISKIYOU 10).

About 13 miles east of Montague, or 1 mile northeast of Table Rock Spring (Siskiyou 9, p. 219), there is a cold spring which yields a constant flow of about 6,300 gallons a minute (reported measurement, 700 miner's inches). It rises from slopes of basaltic lava that form the mountains on the east side of Shasta Valley. The water is used in irrigating land near the spring, along Little Shasta River.

LARGE COLD SPRING EAST OF MONTAGUE (SISKIYOU 12).

A large spring that rises on Mrs. M. F. Martin's ranch, near the southern base of Table Rock, 12 miles east of Montague, has been mentioned in connection with Martin Soda Spring (Siskiyou 11, p. 219), which rises near it. The cold spring issues in full volume from beneath a small bank that is composed of lime-carbonate spring deposit and fragmental lava. It yields about 2,700 gallons a minute (reported measurement, 300 miner's inches) of water of very good quality that is used to irrigate meadowland to the west.

LARGE COLD SPRINGS NORTH OF SISSON (SISKIYOU 17).

A large amount of cold water rises in two springs at the west base of Black Butte, which is 1 mile north of Sisson, at the western base of Mount Shasta. The northern spring issues in a dense growth of vines and willows on the border of a strip of meadow and forms a stream carrying approximately 700 gallons a minute. The other spring, 125 yards southward, rises mainly in a cement-walled basin 15 or 20 yards across. A part of its yield escapes to the meadow through an overflow weir, but the main flow is conducted in a canal southeastward and is used for irrigation. Measurements of the total yield of the two springs gave approximately 12,000 gallons a minute, of which about 85 per cent was flowing in the canal. These springs form the largest tributary at the head of Sacramento River and are sometimes referred to as its source.

LARGE COLD SPRINGS AT HEAD OF MUD CREEK (SISKIYOU 16).

At the head of Mud Creek, on the southern slope of Mount Shasta, are large cold springs whose water is muddy from suspended material that seems to be a glacial clay or rock flour. The source of the springs is evidently the snow of the higher slopes.

LARGE COLD SPRINGS SOUTH OF McCLOUD (SISKIYOU 27).

Cold springs rise in a small marshy area along a creek 1½ miles south of McCloud, in the basaltic lava plateau at the southern base of Mount Shasta. The water forms a stream of considerable flow, which has been mentioned in the description of Warmcastle Soda Springs (Siskiyou 28, p. 223).

LARGE COLD SPRINGS ON EAST SLOPE OF MOUNT SHASTA (SISKIYOU 15).

Cold springs that are similar to the others in the vicinity of Mount Shasta issue on its east slope. They form a stream that is tributary to Ash Creek and through it to McCloud River. Other cold springs of smaller size issue at a number of places on the slopes of Mount Shasta and form streams of nearly constant flow. The source of all the springs is evidently the precipitation on the mountain. Considerable areas on its lower slopes are covered with coarse gravel that is probably of glacial origin. The town of Sisson is built on such material, and it is said to be difficult to obtain solid foundations for buildings at this place. It is said that men excavating in a railroad cut on the line from Sisson eastward to McCloud found ice interbedded with the gravel. The melting of large masses of ice that were covered by glacial gravel may partly supply several of the cold springs, especially those at the head of Mud Creek, which seem to issue directly from glacial material.

GLACIER SPRING (SISKIYOU 21).

Several large springs issue along the course of Sacramento River near the base of Mount Shasta. Glacier Spring is a few feet below the brink of the river canyon and one-third of a mile by zigzag trail northeast of Shasta Springs station. It rises quietly in a circular cemented pool about 8 feet in diameter and 4 feet deep, in a concrete spring house. A 3-inch pipe leads down the slope to the railroad station, and the overflow—perhaps 50 gallons a minute—forms the head of a stream that cascades down the slope near the trail. The size of the stream is greatly increased by water which issues along its course, so that where it enters Sacramento River the stream has a winter flow of perhaps 6 or 8 second-feet.

KEYSTONE SPRING (SISKIYOU 20).

Keystone Spring rises on the plateau on the eastern side of the canyon of Sacramento River, a short distance north of Glacier Spring. Its water has been piped to a tank and used for a domestic supply at Shasta Resort, which is situated south of the spring, near the canyon edge.

Both Glacier Spring and Keystone Spring issue from crevices or fissures in the lava at the southern border of the plateau that extends southward from Mount Shasta, and both are probably supplied by water derived from melting snow on the higher slopes.

MINOR PERENNIAL SPRINGS.

DISTRIBUTION.

There are in the State many perennial springs of essentially surface origin that are well known to prospectors and other travelers and are of sufficient importance as watering places to have received names. Many of these are on well-traveled roads, but by far the greater number are in less known regions and are not easily accessible.

In the northern part of the Sierra and in the Siskiyous and the northern Coast Ranges springs are numerous, but as there are also many streams in these well-watered regions the springs are of relatively little importance, though some of them supply roadside watering troughs. In the arid parts of the State, especially on the southwest side of San Joaquin Valley and in the eastern and southeastern sections, many springs of very small flow have become important because of their positions, for they may furnish the only water within a radius of 10 or 15 miles. Some of these desert springs yield water of poor quality, as it contains noticeable amounts of alkaline salts, but as they afford in some places the only available supplies they are welcome watering places.

The following descriptions cover most of the perennial springs which were visited or concerning which reliable information was obtained, together with a few minor fresh-water springs that are in the same localities as mineralized springs which have been described.

The springs are taken up in order from north to south along the eastern part of the State through the northern lava region, the Sierra, and the eastern and southeastern desert ranges, and then from south to north through the Coast Ranges. This order of discussion gives a convenient arrangement of the springs with regard to topographic and climatic conditions.

Other springs of similar character but mainly of lesser importance are briefly described later under the heading "Springs that are less well known," but the locations of these springs are not shown on Plate I (in pocket).

POTHOLE SPRING (MODOC 1).

A few springs of relatively small flow afford watering places for range cattle in the lava-covered region of western Modoc County. One of these, Pothole Spring, is situated in a small marshy area at the western base of Blue Mountain, about 35 miles northwest of Alturas. The water rises in a deep clear pool a few feet in diameter and is noticeably above the normal temperature but probably less than 70°. The flow is small and the water sinks in the marshland a short distance from its source.

BOTTLE SPRING (MODOC 2).

Bottle Spring is about 10 miles south of Pothole Spring and near the northern end of Fairchild Meadow. It yields cold water and the amount is said to vary greatly with the season.

COOL SPRINGS AT CAMPBELL HOT SPRINGS (SIERRA 2).

Two cool springs that furnish domestic supplies are situated on the grounds of Campbell Hot Springs, near Sierraville. These have been mentioned in the descriptions of the principal springs at the resort, and an analysis of water from the main cool spring has been given. (See p. 129.) Both cool springs are of slight flow, but they are conveniently situated and yield good water for cooking and other household purposes.

MUD SPRING (TEHAMA 6).

A few small springs form watering places near the western base of the Sierra, on the slopes of tuffaceous lava that border Sacramento Valley in eastern Tehama County. Mud Spring rises in a rock-walled pool, 6 feet in diameter, at the northern edge of the county road, 13 miles north of east from Red Bluff. Its water has been piped 200 yards westward to a watering trough near sheepmen's corrals and camp, where the measured flow was about one-half gallon a minute.

GEARY SPRING (TEHAMA 7).

Geary Spring is similar to Mud Spring in character. It is about 7 miles farther south at the side of a small drainage channel in the gentle, plateau-like slope. The water rises 50 yards south of a wagon road, in a rock-curbed pool, 3 feet in diameter, that is used as a watering and camping place by travelers and stockmen.

The water of Geary and Mud springs is of good quality, and their observed temperatures, which were respectively 66° and 62°, suggest that it rises from a depth of several hundred feet, probably from a layer in the bedded volcanic tuffs.

HENDERSON SPRING (BUTTE 1).

Henderson Spring issues from a steep bank of slate, in the bottom of the canyon of Big Butte Creek, 11 miles by road and trail, north of Stirling City. The water is said to have medicinal properties and has been used for a number of years by several residents of the region, but in the fall of 1909 no mineralization was noticeable to the taste. At this time, however, the water was diluted by storm water. The spring is not easy of access, as the canyon is steep and only a dim trail leads from prospectors' cabins on its upper slopes down to the creek and the spring.

BLACK SPRING (MARIPOSA 1).

In Yosemite Valley there are several perennial springs of cold water, of which Black Spring is perhaps the best known. It issues on the slopes on the northern side of the stage road, 4½ miles southwest of Yosemite post office, and is piped to the roadside, where it forms a watering place for horses as well as people. The water is cold and of excellent quality.

MOSS SPRING (MARIPOSA 3).

Moss Spring issues on the southern side of Yosemite Valley, about one-third of a mile south of Black Spring, in the lower land at the base of the valley wall. It is similar in character to Black Spring, but as it is not beside a main road its water has been little used.

FERN SPRING (MARIPOSA 2).

About one-third of a mile west of Moss Spring another flow of cool, excellent water that is known as Fern Spring issues in the valley land, but like that of Moss Spring it has not been used.

FOUNTAIN SPRING (TULARE 16).

A few springs issue along the western base of the southern Sierra and have been used to some extent for domestic and garden supplies. Fountain Spring, which is about 15 miles east of south from Portersville, has long been known and utilized for such purposes.

YANKEE SPRING (TULARE 17).

Yankee Spring is situated about 20 miles south of Portersville, in the foothills that border the valley land. Like Fountain Spring it is well known in this region, and has long furnished a domestic and garden supply.

WILLOW SPRING (KERN 5).

A few perennial springs which are similar in character to the two last described issue on the slopes of the southern Sierra, some distance from the open land of San Joaquin Valley. Among them is Willow Spring, which is about 30 miles east of south from Portersville. Like the other springs of the region its water has been used locally to some extent.

LANDERS SPRING (KERN 18).

Landers Spring is in the basin of Caliente Creek, about 25 miles east of Caliente railroad station. It is a well-known watering place in this portion of the southern Sierra and is of local value as a water supply.

BLACK LAKE SPRINGS (MONO 11).

Black Lake is a narrow body of water, about 2 miles long, that lies on a plateau east of the Sierra, in Mono County. The southern end of its basin is about 2 miles west of and 900 feet above Benton, and during periods of high water the lake overflows down a steep rocky canyon past the settlement. The water has a dark color (possibly derived from decaying tules) which has given the lake its name. The lake is said to be partly supplied by large springs that rise in it. In the fall of 1908 there was a tule swamp one-quarter of a mile long at the southern end of the lake, and beyond it a stretch of meadow 300 yards wide and one-half mile long, extending to the head of the canyon. In the tule swamp about 25 pools were counted, ranging in diameter from 1 foot to 15 feet, with vertical banks and with depths apparently greater than their diameters. There was little overflow from the pools, but all contained cold water of good quality. At the southern edge of the meadow a spring that yielded about 10 gallons a minute had been developed by a small cut in the granite slope.

The water of Black Lake Springs is apparently subsurface water from the surrounding granitic slopes. It collects beneath the alluvium that fills the narrow lake basin and rises to the surface in the numerous pools.

The following early analysis shows that when the sample was collected the lake contained a concentrated primary alkaline water:

Analysis of water from Black Lake, Mono County, Cal.

[Analyst, Oscar Loew (1876). Authority, Wheeler report. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		28
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		72
Secondary alkalinity		0
Tertiary alkalinity	(?)	

Constituents.	By weight.	Reacting values.
Sodium (Na)	7,224	314.2
Potassium (K)	375	9.6
Lithium (Li)	Trace.	Trace.
Sulphate (SO_4)	2,449	51.0
Chloride (Cl)	1,422	40.1
Bromide (Br) and iodide (I)	Traces.	Traces.
Carbonate (CO_3)	6,980	232.7
Metaborate (BO_2)	Trace.	Trace.
Phosphate (PO_4)	Trace.	Trace.
Silica (SiO_2)	50	1.7
	18,500	....

BANNER SPRING (MONO 18).

In the plateau region that extends southwestward from Benton there are a few small springs that are known to the Indian inhabitants and to prospectors. Banner Spring is one that is situated near a prospector's cabin 11 miles west of south from Benton. The water issues from gravelly material at the western base of a hill slope and in the fall of 1908 was piped to a watering trough near by, where it supplied about 3 gallons a minute.

MORAN SPRING (MONO 19).

Moran Spring is 2 miles south of Banner Spring, at the place where the road branches eastward to the Casa Diablo mines and westward to Long Valley. The water seeps to the surface at the eastern end of a small meadow. When it was visited there was no perceptible flow, but water of good quality stood in several shallow holes that had been dug. An Indian's cabin stood at the edge of a small cultivated field near by. Both Banner and Moran springs are in granitic material and the water seems to be essentially of surface origin.

SCOTTY SPRINGS (INYO 6).

A number of springs of considerable flow issue along the eastern face of the Sierra bordering Owens Valley. One of the groups of largest flow is at Scotty Springs, on the mountain side about 12 miles in a direct line northwest of Independence and 1,800 feet above the valley. Three springs rise here at short distances apart in a small marshy area and yield a considerable flow which is tributary to Division Creek.

SPRING NEAR STRING MEADOWS (FRESNO 3).

Beside a trail between String Meadows and Rattlesnake Lake, in the northern extremity of Fresno County, there is a cold spring of rather unusual character, as it issues in full volume from beneath a small bank. It yields about 15 gallons a minute of water of excellent quality, and its position beside the trail makes it well known to travelers.

THREE SPRINGS (FRESNO 7).

Three Springs form a group rising a few yards apart in a small meadow on the higher slope of the Sierra. They yield a combined flow of perhaps 100 gallons a minute, but as there has not been a well-traveled trail past them they have not been well known nor often visited.

RIVER SPRING (TULARE 6).

A few cold springs of excellent water and large flow issue on the western slope of the high Sierra, south of those that have just been described. River Spring, which is one of the largest of these, issues on the slopes above Ninemile Creek, a tributary of North Fork of Kern River. The spring is about 4 miles by trail northeast of Jordan Hot Springs (Tulare 7, p. 53). The water rises in full volume from beneath a granitic bowlder, 3 or 4 feet in diameter, beside the trail and forms a stream of about 550 gallons a minute. Numerous small cold springs issue in the many meadows of the Sierra, but springs of such large flow as River Spring are not common.

BARREL SPRINGS (INYO 9).[1]

There are several perennial springs in the Inyo Mountains on the eastern side of Owens Valley. One group of these, well known locally, is Barrel Springs, in Mazourka Canyon, about 10 miles northeast of Independence, or 6 miles north of Citrus railroad station. The flow is small but of good quality and furnishes a supply for prospectors.

[1] The descriptions of a number of springs in southeastern California are taken from a report by W. C. Mendenhall (Some desert watering places in southeastern California and southwestern Nevada: U. S. Geol. Survey Water-Supply Paper 224). This paper contains also descriptions of many wells and of slightly used springs that are not shown on Plate I of the present paper. See also Bailey, G. E., The saline deposits of California: California State Min. Bur. Bull. 24, May, 1902.

SPRINGS NEAR SOUTHEAST SIDE OF OWENS LAKE (INYO 23).

A small amount of water of fair quality issues in a group of several springs along the southeast side of Owens Lake. They are used by prospectors, who often camp near by, and they have long been a watering place on the road between Keeler and Mohave. The water is apparently of surface origin, coming from the slopes of the Coso Range to the south and rising in the alluvium of the lake basin.

Similar springs issue a short distance toward the lake from the hotel at Keeler and yield a small amount of fair water.

ARAB SPRING (INYO 24).

In the Coso Range several springs of small but perennial flow furnish camping and watering places for prospectors and other travelers. Arab Spring is one of these on the road between Keeler and Coso mining camp. It is situated on the eastern side of the range about 18 miles southward from Keeler. It is also known as Lower Centennial Spring, Upper Centennial Spring being a similar spring in the same ravine a mile south and 400 feet higher.

CRYSTAL SPRINGS (INYO 27).

Crystal Springs, which are about 8 miles southeast of Arab Spring, also afford a watering place on the road to Coso, being 6 miles north of this camp. The yield is small but of very good quality.

ROSE SPRING (INYO 25).

Rose Spring forms a watering place that is well known to prospectors in the Coso Range. The water issues near the western base of the range, about 4 miles south of Haiwee post office.

The three watering places last described—Arab, Crystal, and Rose springs—are supplied by the precipitation on the adjacent mountains and are essentially surface springs, though they are of nearly constant yield.

SPRINGS NEAR HAIWEE (INYO 26).

Cold water issues from the coarse gravel slopes at the base of the Sierra, at a ranch that is 28 miles southward from Keeler and that was the Haiwee stage station in the fall of 1908. When the place was visited a flow of about 20 gallons a minute was collected by ditches along the side of a small cienaga or marshy area and was used for domestic supply and garden irrigation.

GRAPEVINE SPRINGS (KERN 13).

Grapevine Springs are situated near the road between Keeler and Mohave and about 50 miles south of Haiwee. They yield a small flow of water of excellent quality. There is also running water during most of the year in Grapevine Canyon, a mile or two above the springs.

INDIAN WELLS SPRINGS (KERN 14).

Springs that are similar in origin and character to those at Haiwee stage station issue from the gravel slopes bordering the Sierra at Indian Wells, a ranch that is about 53 miles southward from Haiwee on the road from Keeler to Mohave. The springs at Indian Wells yield perhaps 10 or 15 gallons a minute of water of good quality that is used for domestic supply and for irrigation.

FREEMAN SPRINGS (KERN 15).

Freeman post office is at a small ranch on the Mohave-Keeler road, about 6 miles southwest of Indian Wells. The place was formerly known as Coyote Holes, as water is obtained from shallow pits excavated where coyotes had dug a short distance to water. A continual flow of perhaps 3 or 4 gallons a minute has been developed on the gentle slopes of a wide drainage wash.

SEARLES SPRING (KERN 16).

Searles Spring is about 5 miles west of the post office of the same name, which is 15 miles by stage north of Randsburg. Water is piped from the spring to Searles station and furnishes a supply that is small but of good quality.

SPRINGS AT SUMMIT DIGGINGS (SAN BERNARDINO 8).

Summit Diggings form a small gold placer camp near the main road, 6 miles north of Randsburg. The camp obtains an ample supply of water from several springs in the neighboring hills.

RICARDO SPRINGS (KERN 19).

Ricardo Springs issue in the stream wash of a tributary to Redrock Canyon, about 27 miles north of Mohave. They yield a small but perennial flow and have served as a watering place, the water being piped to a trough near the main road between Mohave and Keeler. During recent years the pipe line has not been kept in repair, but water has been obtainable at the springs.

KOEHN SPRINGS (KERN 20).

Koehn Springs, or Kane Springs, as the name is spelled on some maps, are on the western side of a dry lake of the same name about 24 miles northeast of Mohave. The springs yield only a small amount of brackish water, but they have been of some importance as a roadside watering place.

WATER STATION SPRINGS (KERN 21).

Water Station, about 9 miles east of north from Mohave, has been a water-supply point for many years on the Mohave-Keeler road. Shallow wells supply a portion of the water at this place, but water also rises to the surface in small springs near by.

COTTONWOOD SPRING (INYO 16).

A number of springs that are well known to travelers are situated in the Panamint Range, which lies between Owens Valley and Death Valley. One of the largest of these springs issues in the upper portion of Cottonwood Canyon, on the eastern side of the range, and forms a stream that usually flows for a couple of miles before sinking in the gravel of the wash. A main trail between Keeler and the north end of Death Valley follows down the canyon.

EMIGRANT SPRING (INYO 17).

Emigrant Spring is in Emigrant Canyon, which lies about 10 miles southeast of Cottonwood Canyon. The spring has been known since 1852, when it was used by emigrants from Salt Lake City. Emigrant Canyon is still the main pass across the Panamint Range, so the spring is a much-used watering place. The water issues in a wash at the base of a limestone cliff 25 yards west of the road. The supply is said to be about 1 gallon a minute, and the water is of good quality.

WILD ROSE SPRING (INYO 22).

Wild Rose Spring is in a canyon on the western side of the Panamint Range, about 14 miles south of Emigrant Spring and 20 miles north of Ballarat mining camp. It forms a much-used camping place on the road to Death Valley by way of Emigrant Springs. The water is very good and the supply is plentiful.

Like most of the springs in the desert ranges, Cottonwood, Emigrant, and Wild Rose springs are supplied only by the precipitation on the adjacent higher slopes, but their subsurface storage reservoirs are sufficiently large to make them of perennial flow, and hence they are dependable watering places.

LONE WILLOW SPRING (SAN BERNARDINO 1).

There is a spring in a small canyon near the pass between the Slate Range and Brown Mountain at the south end of Panamint Valley that is well known to travelers in the region, for not only is its water very good, but it is the only water to be had for a number of miles. The spring received its name, Lone Willow, from a tree that once grew near it. The water was formerly piped to troughs at the roadside, where it furnished one of the watering places on the route of the

"20-mule teams" that hauled borax from Death Valley to the railroad at Mohave.

TULE SPRINGS (INYO 28).

Water of poor quality issues at a few places in Death Valley and is obtained from shallow wells at a number of other places in the valley floor. One of the groups where water naturally rises is at Tule Springs, beside a wagon road on the western side of the lowest portion of the valley. There are several springs, which are marked by clumps of tules, but the water is brackish and of small quantity.

BENNETTS WELLS (INYO 33).

Five miles south of Tule Springs there are other springs of better quality, which have been protected by barrels and are known as Bennetts Wells. These springs or wells are marked by clumps of tules and by abandoned works of the Eagle Borax Co. They were formerly much used as a watering place, but they have not been of so great importance during recent years and they are occasionally choked by drifting sand. The water of Tule Springs and of Bennetts Wells is evidently of alluvial origin and is probably derived from the precipitation on the eastern side of the Panamint Range. It possibly rises under slight artesian head, but the supply is so small that the water becomes saline and alkaline from the salts near the surface.

SAND SPRING (INYO 10).

Sand Spring is in Termination Valley, at the extreme north end of the Grapevine Mountains, beside a road that extends northward along the base of these mountains and eastward into Nevada. The spring yields a small amount of good water and has long been used as a camping place.

STAININGER RANCH SPRINGS (INYO 11).

In the Amargosa Range of mountains, on the east side of Death Valley, there are several springs that form watering places which are well known to desert travelers. One of the northern of these watering places is at the Staininger ranch, in a canyon on the western slope of the north end of Grapevine Mountains. This ranch is on the road that leads southwestward into Death Valley from Bonnie Claire railroad station in Nevada. The ranch is supplied with water by several springs of ample yield.

DAYLIGHT SPRING (INYO 13).

A main road from Bullfrog, Nev., southwestward into Death Valley, crosses the Amargosa Range through Boundary Canyon, which is between the Grapevine and the Funeral mountains and 30 miles in a direct line southeast of the Staininger ranch. Daylight

Spring, which furnishes a watering place on this road, near the pass, issues a short distance north of the summit, on the hillside 300 yards west of the road, and yields a seeping flow of good water.

KEANE SPRING (INYO 14).

Keane Spring has a somewhat larger flow than Daylight Spring (Inyo 13). It issues on the western slope of the mountains, about 3 miles southwest of Daylight Spring, in a large wash some distance south of the main road.

Like most of the desert springs, those in the Amargosa Range are of essentially surface origin, and the two last described are hardly more than seepages, but they are of sufficient permanence to be dependable watering places and have long been used by travelers.

CHINA RANCH SPRINGS (INYO 36).

The China ranch is situated in the canyon of Willow Creek, half a mile or more above its junction with Amargosa River and 5 miles north of Sperry station on the Tonopah & Tidewater Railroad. Willow Creek is supplied by springs of considerable flow and of good quality, which issue from sandstones and clays of Tertiary age that form the canyon walls. The water is used to irrigate several acres of alfalfa and garden vegetables, and the ranch forms one of the few oases in the desert eastern part of the State. It is a stopping place and supply point on one of the main desert routes between the mining camps of eastern California and western Nevada. The springs were visited by Frémont in 1844, when returning eastward from his exploring expedition.

OWL SPRINGS (SAN BERNARDINO 5).

A number of small springs in the detached desert mountains and ranges of San Bernardino County form watering places on the principal routes of travel, these routes being, indeed, largely determined by the locations of the springs. Owl Springs are on the road that leads southwestward from South Death Valley to Randsburg, and are about 2 miles north of the pass between Owl Mountains and Avawatz Mountains. The water issues as seepages in trenches and pits that have been dug in a wash. It is slightly saline but is the only supply on the road for about 17 miles in either direction.

LEACHS SPRINGS (SAN BERNARDINO 7).

Leachs Springs, about 17 miles by road southwest of Owl Springs, form one of the principal camping places between South Death Valley and Randsburg. They are in a canyon on the northern side of Leach Mountain, 3 or 4 miles south of the direct course of the road, but most travelers leave the main road and make a night camp at the springs.

There is one main spring that supplies a small pool 100 yards from the camp ground, and other seepages issue for perhaps 200 yards up the canyon. The water is obtained in the gravel of the canyon bed and is of good quality.

CAVE SPRINGS (SAN BERNARDINO 6).

Cave Springs are near the summit of Avawatz Mountains, on a road that leads from South Death Valley to Daggett. The water issues in grottos or caves in two pools about 5 feet across that form collecting basins from which it may be dipped. It is of good quality and the place is one of the principal stopping points on the road. The nearest other water to the north is at Saratoga Springs (San Bernardino 3), which have been described among the hot springs (p. 137).

TOMASO SPRINGS (SAN BERNARDINO 12).

Tomaso Springs are at the northwest end of Soda Lake Mountains, about 12 miles southwest of the town of Silver Lake, which is on the Tonopah & Tidewater Railroad. The springs are mentioned by Frémont, who camped at them in April, 1844, and later they became a watering place on the emigrant road from Salt Lake City. They are still used by campers, but they have become of less importance since the construction of the railroad and the establishment of a pumping plant at Silver Lake.

DANTE SPRINGS (SAN BERNARDINO 13).

Dante Springs are near the north base of a butte at the northeast end of Soda Lake, and are about 3 miles east of Berry station, on the Tonopah & Tidewater Railroad. They furnish a watering place on the main route from Soda Lake Mountains, which are west of Berry, to Ivanpah Mountain, 35 miles to the northeast.

HALLORAN SPRINGS (SAN BERNARDINO 14).

Halloran Springs are near the base of a small butte about 12 miles east of Dante Springs. They have long been a camping place on the main route through this region and furnish a small but ample supply for desert travelers.

KESSLER SPRINGS (SAN BERNARDINO 15).

Kessler Springs are situated at the southern end of Ivanpah Mountain, near the eastern border of the State, about 6 miles northwest of Cima station, on the Salt Lake Railroad, and at the junction of roads to the mining camps of Rosalie and Ivanpah, which are, respectively, 12 miles northwest and 10 miles northeast of the springs. The water is of very good quality, and the supply is plentiful.

ROCK SPRINGS (SAN BERNARDINO 16).

Rock Springs are about halfway between the Salt Lake and the Santa Fe railroad lines, near the eastern border of San Bernardino County, on the old Government road to Fort Mohave, Nev. They yield a small amount of water of good quality—the only water for a number of miles.

PIUTE SPRING (SAN BERNARDINO 17).

Piute Spring is situated in Piute Pass, on the old military road to Fort Mohave, Nev., about 9 miles east of Blackburn railroad siding. It forms a watering place that is well known to prospectors, and yields a small amount of water of good quality.

VONTRIGGER SPRING (SAN BERNARDINO 18).

Vontrigger Spring is about 6 miles southwest of Piute Spring, on a road that leads to Goffs station, on the Santa Fe Railway, 9 miles southward. The water issues in a small canyon on the southern side of low hills, 2 miles north of Vontrigger, and like that of Piute Spring is of good quality and sufficient in quantity for travelers.

KLINEFELTER SPRINGS (SAN BERNARDINO 19).

Klinefelter is a station on the Santa Fe Railway, near the eastern border of the State. The railway company has installed tanks here for locomotive supply, the water being obtained from large springs that rise in the gravel of Sacramento Wash. In addition to the main springs, considerable water seeps from the banks at several places along the railway. The locality is the main source of water supply for prospectors in the mountains to the south.

SPRING NORTHEAST OF VICTORVILLE (SAN BERNARDINO 21).

At the southwest side of a northern spur of Granite Mountain, 14 miles northeast of Victorville, on the road between that place and Daggett, is a spring that yields a small flow of good water and was formerly the main watering place on this road. Within recent years, however, other supplies of water have been made available by wells that have been sunk several miles to the southwest.

ORD SPRING (SAN BERNARDINO 22).

Ord Spring is at the western base of Ord Mountain, about 18 miles south of Daggett, on a road that leads to San Bernardino Mountains. It yields water of good quality and is an old camping place that is well known to prospectors.

LE CONTE SPRING (SAN BERNARDINO 23).

Le Conte Spring is on the eastern side of Ord Mountain, about 10 miles in a direct line eastward from Ord Spring. It forms a camping and watering place on a road between Newberry railroad station and Victorville.

PEACOCK SPRING (SAN BERNARDINO 24).

Peacock Spring forms a watering place at the northern base of a western extension of the Bullion Mountains, 10 miles south of Lavic railroad station. It is on a road that leads southward to San Bernardino Mountains and is important because it furnishes the only water between Lavic and a well near a dry lake 15 or 20 miles to the southwest.

SURPRISE SPRING (SAN BERNARDINO 40).

Surprise Spring is in the open desert southwest of Bullion Mountains, on a road that leads to mining camps farther southeast. It yields water that is somewhat alkaline, but it is used by travelers. The spring receives its name because it is located in open land where natural springs are not to be expected.

MESQUITE SPRING (SAN BERNARDINO 42).

Mesquite Spring is about 12 miles southeast of and in the same desert flat as Surprise Spring. It forms a camping place where the water is of better quality and more abundant than at the northern spring.

Both Mesquite and Surprise springs are in a shallow desert trough and are probably points at which water rises to the surface through the desert alluvium under a slight artesian head. Other springs similar in character rise in the southern portion of the flat, at Twenty-nine Palms Springs (San Bernardino 44, p. 316).

BOX S SPRING (SAN BERNARDINO 28).

Several perennial springs issue in San Bernardino Mountains and supply small ranches, prospectors' camps, or cattle-watering troughs. Box S Spring is one of these desert springs that is situated at the northern base of the mountains, about 10 miles west of Old Woman Springs (San Bernardino 27, p. 316), at the foot of the road grade up the mountain. Its water seeps from a bank of decomposed granite at a rate of about 1 gallon a minute and is piped to a county watering trough at the roadside.

CUSHENBURY SPRING (SAN BERNARDINO 29).

Cushenbury Spring rises in a small area of marshy land near the base of the steeper slope of San Bernardino Mountains and is on the road about 2½ miles southeast of Box S Springs. It forms a small tule-grown stream that has a flow of about 3 gallons a minute near the road. It supplies a watering trough and has also been used for garden irrigation.

CACTUS FLAT SPRING (SAN BERNARDINO 30).

Cactus Flat Spring, which is also known as Hidden Spring, issues from an adit excavated in the hard, granitic material in the side of a ravine. The water is collected in a small reservoir formed by a dam across the ravine, and has been used for more than 20 years for domestic supply and for irrigation. It furnishes a convenient watering place on the stage road from Victorville to Bear Valley.

SARAGOSSA SPRING (SAN BERNARDINO 31).

Saragossa Spring is about 2 miles in a direct line or 3 miles by road southwest of Cactus Flat Spring. It has been developed by an excavation in gray granitic material and yields a small domestic supply that is of value in this poorly watered portion of the mountains.

MONTE CRISTO SPRING (SAN BERNARDINO 32).

Monte Cristo Spring is in Van Dusen Canyon, a mile or more in a direct line southward over Gold Mountain from Saragossa Spring. It yields about 1 gallon a minute of cool, fresh water that supplies the camp of the Rex Mining Co., which has been driving the Monte Cristo tunnel into the mountain.

WARRENS RANCH SPRINGS (SAN BERNARDINO 39).

Warrens Ranch Springs are situated a number of miles southeast of Cactus Flat, in a pass on the opposite slope of the mountains. The ranch is 28 miles eastward from Banning, on the main road to Dale mining camp, and is a regular stopping place for travelers. Its water is obtained from large springs below the ranch and is pumped to it by a gasoline engine.

The springs at the six localities last described (San Bernardino 28, 29, 30, 31, 32, and 39) are among those principally used of the numerous springs that rise in San Bernardino Mountains. All of them are of surface origin and owe their permanence to the precipitation on the slopes of the mountain range, whose higher peaks are capped with snow during a part of the year.

PALMDALE SPRINGS (RIVERSIDE 12).

An agricultural settlement was started at Palmdale, 8 miles south of Palm Springs railroad station, a number of years ago, but in 1909 the place was nearly abandoned. Water for irrigation was furnished partly by a group of springs that yield a considerable supply.

COTTONWOOD SPRINGS (RIVERSIDE 20).

Cottonwood Springs, on the road from Mecca to Dale mining camp, form a camping place that is well known to prospectors. They are in a pass in the Eagle Mountains, 26 miles by road northeastward from Mecca. The water seeps from granite and collects in a small concrete reservoir from which a pipe line extends northward to the Iron Chief mine. The water is of very good quality, as is that of most of the desert springs that issue from granitic rocks.

CORN SPRINGS (RIVERSIDE 22).

A stream of perhaps 50 gallons a minute rises in a small cienaga at Corn Springs, on the eastern side of Chuckwalla Mountains. The springs form a camping place on one of the desert lines of travel to mining prospects in the mountains farther east.

FRINK SPRINGS (IMPERIAL 2).

Frink Springs are on the eastern side of Salton Sink about 6 miles northwest of Frink station on the Southern Pacific Railroad. A wagon road between San Bernardino and Yuma, which was much traveled before the construction of the railroad, passes the springs, and they were formerly an important watering place. They are still of considerable importance, as they furnish the only water for a distance of several miles along the eastern side of the Sink. The water, which is of good quality, rises in small amount from sedimentary material.

MILL CAMP SPRINGS (RIVERSIDE 21).

Mill Camp is a mining camp on the western side of Chuckwalla Mountains and is 30 miles by road eastward from Salton. Good water in abundance is furnished by springs at the settlement.

MULE SPRINGS (RIVERSIDE 23).

Mule Springs are in the main pass on the west side of Palo Verde Mountains, near the southeast border of Riverside County, on a road between Mecca and the settlement of Palo Verde. The springs yield considerable good water, and their position is marked by a grove of small trees.

SUNSET SPRING (IMPERIAL 7).

Considerable water rises in a tule area at Sunset Spring, which is about 13 miles south of east from Brawley, in the Imperial Valley. The spring has been known for many years, but it has been used mainly by desert animals. Since the settlement of Imperial Valley and the introduction of irrigation the spring has become of even less importance as a watering place for travelers.

BOREGO SPRING (SAN DIEGO 6).

A few perennial springs of small flow issue in the hills on the western side of Colorado Desert and form watering places on the main lines of travel. Borego Spring, one of these watering places, is on the west bank of a broad wash, 33 miles by road northeastward from the mining town of Julian. The water rises in a small area of salt grass and rushes. It is alkaline but is the only water to be obtained in the locality.

VALLECITO SPRINGS (SAN DIEGO 8).

Vallecito Springs are about 33 miles by road south of east from Julian. The locality, which was formerly a station on one of the stage lines between San Diego and the East, is still marked by an adobe building, and a trough near it affords a convenient watering place. Water of fair quality issues at these springs, which are in a small valley along Vallecito Creek.

CARRIZO SPRINGS (SAN DIEGO 11).

Carrizo Springs lie about 18 miles eastward from Vallecito Springs. This place also was formerly a station on the overland stage road, which is still the main route between Julian and Imperial Valley, and the springs form a much appreciated watering place. The water issues in the wash of Carrizo Creek in a number of springs that furnish supplies of fair quality. A considerable flow of more alkaline water rises in a tule marsh near by.

Clay beds of Tertiary age that are eroded into a typical bad-land surface lie against the mountain slopes at this locality.

MASON RANCH SPRINGS (SAN DIEGO 10).

The Mason ranch is about 5 miles northeast of Carrizo Springs. It is supplied by springs of good quality that have been in part developed in the slopes of the locality. The ranch forms a watering place that is well known to travelers over the road past it.

MOUNTAIN SPRING (SAN DIEGO 18).

Mountain Spring is close to the southern border of the State, on one of the main roads between San Diego and Imperial Valley. It has been used as a watering place since the days of the stage line from San Diego to Yuma, when there was a station at the spring. The water issues in a ravine near the top of a steep grade down to the valley land and is piped to a trough at the roadside. It is of very good quality and of ample flow. In recent years it has been improved by the county for the use of travelers.

LA MESA SPRING (SAN DIEGO 14).

La Mesa Spring is beside a small drainage swale half a mile southeast of La Mesa railroad station, or 11 miles by railroad northeast of San Diego. It was formerly known as Indian Spring, as it was a favorite camping place for a few families of Mission Indians. A few years ago the spring was inclosed by a small building, and a bottling house was erected, but when the spring was visited in the summer of 1908 the water had not been placed on the market. A faucet near the house enabled campers and local residents to obtain the water. It is slightly alkaline and has a faint odor of hydrogen sulphide. At the spring the granitic rock is much decomposed, and the bed of the swale is covered with dark-colored alluvial soil.

EL GRANITO SPRING (SAN DIEGO 13).

El Granito Spring is at the base of the granitic slopes at the southern border of El Cajon Valley, 16 miles by railroad northeast of San Diego. The water issues in a small tunnel in decomposed granite at the side of a ravine and is piped about 50 yards to a bottling house. It has been on the local market for several years as a table water. The following analysis indicates that the water is primary saline and secondary alkaline in character and also has notable primary alkalinity.

Analysis of water from El Granito Spring, San Diego County, Cal.

[Analyst, Joseph Luce. Authority, advertising matter. Constituents are in parts per million.]

Temperature	17° C. (62° F.)	
Properties of reaction:		
Primary salinity		55
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		14
Secondary alkalinity		31
Tertiary alkalinity		14
Constituents.	By weight.	Reacting values.
Sodium (Na)	138	5.98
Potassium (K)	[a] 190	4.87
Calcium (Ca)	4.8	.24
Magnesium (Mg)	58	4.80
Iron (Fe)	Trace.	Trace.
Aluminum (Al)	5.4	.54
Sulphate (SO_4)	383	7.98
Chloride (Cl)	26	.72
Carbonate (CO_3)	208	6.95
Silica (SiO_2)	16	.53
	1,029.2	....
Carbon dioxide (CO_2)	38	1.73

[a] Probably too high, since as reported it is considerably in excess of the sodium.

BRADLEY SPRING (SAN DIEGO 7).

Bradley Spring is 6 miles by road northward from the railroad terminus at Foster station, or 30 miles northeast of San Diego. The water issues at the base of a granitic bowlder in a steep brushy ravine, 250 feet above the road. A cemented reservoir in the ravine collects the water, which has been piped to a storage tank at the roadside, whence it has been taken to San Diego and bottled as a table water. The spring seems to be of seepage flow and of essentially surface origin.

CORONA SPRING (SAN DIEGO 5).

A number of cold springs of excellent water rise along the southern border of Warner Valley, which is in the mountains about 60 miles by road northeast of San Diego. One of these springs was developed commercially a few years ago, and its water was placed on the local market as a lithia table water. The following analysis shows that it is a slightly mineralized water, primary alkaline and saline and secondary alkaline in character. The rather large proportion of lithium reported is noteworthy.

Analysis of water from Corona Spring, San Diego County, Cal.

[Analyst, Joseph Luce. Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	38
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	32
Secondary alkalinity	30
Tertiary alkalinity	9

Constituents.	By weight.	Reacting values.
Sodium (Na)	57	2.49
Potassium (K)	29	.75
Lithium (Li)	3.7	.53
Calcium (Ca)	26	1.32
Magnesium (Mg)	3.6	.30
Iron (Fe)	Trace.	Trace.
Aluminum (Al)	5.9	.65
Sulphate (SO_4)	60	1.25
Chloride (Cl)	28	.80
Carbonate (CO_3)	100	3.34
Silica (SiO_2)	14	.47
	327.2	....

In 1908 the water rose in a small cemented basin at the base of a 15-foot bank of black alluvium in the first ravine east of the road grade from Mesa Grande northward down into Warner Valley. A scum of brown iron-colored deposit, probably the vegetable growth known as Crenothrix, covered the surface of the water, and a few large bubbles rose in the basin. A pipe extended thence 200 yards down the ravine to the valley edge, where the water had been run into tanks and taken to San Diego for bottling. The water at the lower end of the pipe had a distinctly sulphureted odor. The discharge of the spring was approximately 30 gallons a minute.

A similar spring of smaller flow issues a few yards below the road grade, half a mile northwest of Corona Spring, and forms a roadside drinking spring. Two others of larger flow, that have not been used, issue in a ravine about 3 miles southeastward.

DAVIS SPRING (SAN DIEGO 3).

There is a spring of excellent water 2 miles northward from Nellie post office in the Palomares Mountains, 30 miles by road northeast of Escondido. The water issues at the base of a large alder tree 20 yards from a creek bed and is much used and appreciated by campers during the summer time. A small amount of iron is deposited at this spring, and larger amounts are in evidence at a lesser spring at the creek edge. Numerous other springs of cold water issue in marshy areas in this part of the mountains.

CONSOLE SPRING (RIVERSIDE 1).

On the granitic slopes a few miles east of Riverside there are a few small springs that have been utilized. One of these, which is known as Console Spring, issues in Reche Canyon, about 9 miles in a direct line east of Riverside, and yields perhaps 7 gallons a minute. The water was placed on the local market in 1906 as a table water. A partial analysis, published in advertising matter, indicates that the water contains about 250 parts per million of solids in solution, sodium, carbonate, and sulphate being the principal constituents.

BOX SPRING (RIVERSIDE 2).

Box Spring is beside the railroad in a small ravine 5 miles in a direct line southeast of Riverside and near the head of the grade to Alessandro and Perris valleys. A section house stands near the spring, which has been curbed and forms a domestic supply for the section hands. The spring yields a small flow of water of good quality. A similar but unused spring is situated in Mockingbird Canyon, 9 miles south of Riverside.

ROSE SPRING (LOS ANGELES 12).

A number of local natural waters are marketed in the larger cities of the State for table use, as they are preferable to the municipal supplies. Several waters are distributed in Los Angeles, but most of them come from wells. A few of them are derived from springs, however, of which Rose Spring is one of the chief. In the early days of the city it formed a roadside watering place on the eastern outskirts, but it is now well within the city limits. The water issues from crevices in a sandstone bank beside one of the principal avenues. It is piped a few yards to faucets in a bottling house, where 1-gallon and 5-gallon bottles are filled for the trade, and it has been on the local market since about 1900. The following analysis shows that it is a primary saline and secondary alkaline water:

Analysis of water from Rose Spring, Los Angeles County, Cal.

[Analyst, not given. Authority, advertising matter. Constituents are in parts per million.]

Properties of reaction:		
Primary salinity		42
Secondary salinity		0
Tertiary salinity		0
Primary alkalinity		0
Secondary alkalinity		58
Tertiary alkalinity		12

Constituents.	By weight.	Reacting values.
Sodium (Na)	88	3.81
Potassium (K)	3.9	.10
Calcium (Ca)	66	3.30
Magnesium (Mg)	27	2.21
Iron (Fe) Aluminum (Al)	.8	.03
Sulphate (SO_4)	62	1.29
Chloride (Cl)	93	2.62
Carbonate (CO_3)	165	5.51
Silica (SiO_2)	34	1.13
	539.7	....

KENTUCKY SPRINGS (LOS ANGELES 2).

Small springs of perennial flow issue at a few places in the more arid parts of the southern Coast Ranges and are important watering places for cattle. Some of these springs also furnish good sites for apiaries, as the bees may there easily obtain water. Kentucky Springs have been used for both of these purposes. They are situated about 4 miles south of Vincent railroad station, in the hills that border the southwestern side of Mohave Desert. Three seeping flows here issue in a small ravine, and the water from the principal one has been piped to a watering trough. A flow of approximately 10 gallons a minute was observable in July, 1909, and this yield could be considerably increased by cleaning the springs out to solid rock. The region is granitic, and the slopes are covered with a mantle of rock débris in which the supply of the springs is stored by the winter rains.

There are other springs similar in character to Kentucky Springs at points 3 miles south, 3 miles southeast, and 2 or 3 miles northward.

GRAVES SPRING (KERN 23).

Near the border of the valley land westward from Rosamond railroad station on the western side of Mohave Desert are small springs whose waters have been utilized. The western one, which is known as Graves Spring from the name of the owner, is 3 miles from Rosamond. A basin 3 or 4 feet square has been excavated at the spring, and the water is piped a few yards to a board-curbed pool that forms a watering place for cattle. In July, 1909, the visible flow was about 1 gallon a minute of water of good quality.

SPRINGS NORTHWEST OF ROSAMOND (KERN 24).

Springs that are similar to the one just described issue a mile northeastward and higher up on the slope. They have been used as a water-supply point and a camping place by prospectors. The water issues at two points a few yards apart on a gentle slope that rises northward to steep hills. One spring seeps from beneath a ledge of tuffaceous material. The other issues in a small excavation and forms a pool behind a cement dam. Each spring yields perhaps one-half gallon a minute of water of good quality.

The hills north of these springs are composed partly of volcanic material, and the water seems to issue from a porous tuffaceous layer. These springs, however, like Willow Springs (Kern 22, p. 318), which have been described among the artesian springs, issue at the upper edge of a gentle slope that lies between a flat valley and steep hills, and the water may rise along a small fault that borders the valley.

SPRINGS ON TEMBLOR RANCH (KERN 4).

In the Coast Ranges that lie along the southwest side of San Joaquin Valley there are a number of perennial springs that resemble in general character those in the southeastern part of the State, for they are in an arid region, are of small flow, and are of importance mainly because they form watering places. Those which are in the eastern portion of San Luis Obispo County and the western portion of Kern County have been of value as watering places for range cattle as well as for travelers, however, so have been more often used than those in the southeastern desert region. The water of most of them is notably brackish or bitter, and a number of them are also sulphureted. One strongly sulphureted spring (San Luis Obispo 12, p. 277), that is used to supply cattle-watering troughs, has been described among the sulphur springs. Springs that rise on the Temblor ranch, about 12 miles northwest of McKittrick, yield a supply of water that is sufficient for a small amount of irrigation. The water is not of very good quality, however, being noticeably hard.

THOMPSON SPRING (SAN LUIS OBISPO 6).

Thompson Spring is in Carrizo Plain, westward across the Temblor Range from McKittrick. The spring rises in a curbed pool about 8 feet square and 6 feet deep, at the base of a knoll of clay and gravel. It yields about 2 gallons a minute of slightly brackish water, which is piped to a cattle trough near by. Two smaller springs are situated respectively about one-half mile and 1 mile west of it, on the Hubbard ranch.

SPRINGS ON McALESTER RANCH (KERN 3).

The McAlester ranch is supplied with water by springs of considerable flow. Their yield has not been used for irrigation, however, for like other ranches in the region, the McAlester ranch is devoted almost entirely to stock raising. The springs are hence of importance mainly as furnishing a watering place for range animals.

SPRINGS ON STILL RANCH (KERN 2).

The Still ranch, at which Annette post office is situated, is supplied by springs that yield a considerable flow of water of fair quality. This water has furnished a domestic supply and has also been used in irrigating a vegetable garden.

A number of other springs in this region have not been used or improved to notable extent and are hence mentioned among the perennial springs that are less well known.

MUD SPRING (ALAMEDA 4).

Mud Spring is near the road on the northeast side of the canyon of Arroyo Mocho, about 1½ miles in a direct line northwest of Mendenhall Springs. It issues a few yards above the road, in a shallow board-covered pool, and its water is piped to a watering trough at the roadside. It is of surface origin and apparently seeps from altered sandstones and siliceous shales of the Franciscan group. A similar spring issues near the roadside 4 miles farther southeast and supplies another watering trough. Half a mile beyond this second spring a pit has been excavated at a small marshy place on the slope below the road and has furnished drinking water for the pupils of a public school near by.

Another Mud Spring of similar character issues on the north side of the canyon of Trout Creek, 6½ miles directly south, but it is unused.

BANTA SPRING (SANTA CLARA 1).

Banta Spring is near the northeastern border of Santa Clara County, about 13 miles south of Mud Spring (Alameda 4). It yields considerable water of fair quality, and the locality has been occasionally used as a camping place by parties in the mountains.

PEACHTREE SPRINGS (CONTRA COSTA 5).

Peachtree Springs form a watering place for range stock, on the northwest slope of Mount Diablo. They are said to be named from a peach tree that formerly grew near one of them. The water, which issues in two small marshy areas about 100 yards apart, comes from the Franciscan group of rocks that form the higher slopes of the mountain. Very little water flows from the springs, but they could probably be made to yield 8 or 10 gallons a minute.

CHAPARRAL SPRING (CONTRA COSTA 6).

A few small springs in the hills north of Mount Diablo are used to supply water troughs for cattle. One of the chief of these is Chaparral Spring, whose water issues in a small pool on the side of a ravine 3 miles southeast of Clayton and is piped a few yards to a trough. The water seeps from a bank of crushed shales that dip nearly vertically. It is of good quality, but the flow is very small. A similar spring in another ravine half a mile southeastward also supplies a watering trough.

PURITY SPRING (MARIN 4).

Purity Spring is situated on the slopes near Sausalito, on the northern side of San Pablo Bay. It yields a considerable flow of water that is not notably mineralized. For a number of years it has furnished part of the municipal water supply and the water has also been bottled, under several names, for table use.

SPRINGS AT VETERANS' HOME (NAPA 11).

The main supply of water for the Veterans' Home near Yountville is obtained from a spring on the adjacent hillside. This spring is about a quarter of a mile southwest of and 200 feet above the principal buildings, at a point where there was originally a small flow. The water now rises in an excavation about 10 feet wide, 25 feet long, and 1 or 2 feet deep within a spring house. Five holes 2 inches in diameter and 10 to 25 feet deep were drilled in the bottom of the basin that was formed, and the yield of water is said to have been increased by this means from a total flow of 7,000 gallons a day to one of 24,000 gallons (from about 5 to 17 gallons a minute). The water is piped to a reservoir near by and thence to the grounds of the institution. There is a small amount of the iron-secreting Crenothrix in the basin at the springs, and the water is faintly sulphureted but of good quality.

Another spring issues in an excavation at the side of a small creek about 300 yards down the slope from the main spring. It yields about 4 gallons a minute and supplies a watering trough a few yards away. The basin at this spring also contains a small amount of brown iron-colored material.

These springs issue from porous tuffaceous layers in rhyolitic lava that covers the slopes along this part of Napa Valley.

CRYSTAL SPRING (NAPA 5).

Crystal Spring is on the grounds of the St. Helena Sanitarium, which is in the hills on the eastern side of Napa Valley, 3 miles north of St. Helena. The water issues in a small adit on the hillside 100 yards southeast of the hotel and forms a part of the domestic supply. Its flow varies somewhat with the season, and in the summer of 1909 it was said to have decreased to nearly one-half its former flow of 12,000 gallons a day. The normal summer flow is said to be about 10,000 gallons a day (7 gallons a minute). The following partial analysis shows that the water is but slightly mineralized and is essentially secondary alkaline in character.

Partial analysis of water from Crystal Spring, Napa County, Cal.

[Analyst, E. W. Hilgard. Authority, owner of spring. Constituents are in parts per million.]

Properties of reaction:	
Primary salinity	12
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	7
Secondary alkalinity	81
Tertiary alkalinity	(?)

Constituents.	By weight.	Reacting values.
Sodium (Na)	12	.53
Potassium (K)	Small.	....
Calcium (Ca) Magnesium (Mg)	47	2.33
Sulphate (SO_4)	12	.26
Chloride (Cl)	2.5	.07
Carbonate (CO_3)	76	2.53
Organic matter and combined water	30	....
Silica (SiO_2)	Small.	....
	179.5	....

The water issues from lava which is similar to the material at the springs of the Yountville Veterans' Home.

Other smaller springs on the higher slopes also furnish part of the water supply of the sanitarium. A similar spring that issues at the Pacific College, a few miles to the northeast, is reported to yield 216,000 gallons a day (150 gallons a minute).

GIFFORD SPRINGS (LAKE 47).

In the mountainous portions of southern Lake County there are a few cool perennial springs, several of which have been improved for domestic and garden supplies. Gifford Springs are about 10 miles by road northwest of Middletown and 1¼ miles east of the stage road, on a small mountain ranch. Several years prior to 1910 the property was opened to the public as a mountain resort. The water issues at several points from lava slopes near a small creek which derives its supply mainly from springs beside its channel. Two small springs in banks near the creek have been improved, one for a domestic supply and the other as a small drinking spring. The water is locally believed to contain considerable iron, and the presence of this mineral is indicated by rust-colored vegetable growths as well as by the red, iron-stained color of the lava. In the summer of 1910, which followed a season of unusually low rainfall, the two improved springs yielded only 3 or 4 gallons a minute, whereas the creek carried perhaps ten times as much, but in seasons of more plentiful precipitation the yield of the springs, as well as the flow of the creek, is much larger.

SPRINGS AT BASE OF MOUNT HANNAH (LAKE 48).

Cool fresh-water springs that yield perhaps 75 gallons a minute issue at the southeast base of Mount Hannah and supply water for irrigation and other uses on a small dairy ranch. Like the springs on the Gifford ranch, those of Mount Hannah come from lava slopes and seem to be directly dependent on the annual precipitation for their supply.

In connection with these cold fresh-water springs on the Gifford ranch and Mount Hannah, it is of interest to note that no such springs are found on Mount Konocti, which lies at the edge of Clear Lake and overshadows Soda Bay.

SPRINGS SOUTHWEST OF CHALK MOUNTAIN (LAKE 28).

On the eastern side of Clear Lake and about 1½ miles southwest of Chalk Mountain, there are several small areas in which basaltic lava overlies the altered marine sediments that cover a large part of the region. At the northern border of one of the largest of these lava areas, which forms a hill or ridge, cool fresh water issues at two or three places. The supply from the main springs, which yield perhaps 75 gallons a minute, has been collected in a ditch and used for irrigation. These springs are of interest both because of their economic value and because springs of this character are not common in Lake County. Their position at the northern border of the lava area is of geologic interest, as is also their proximity to Quigley Soda Springs (Lake 27, p. 195), which issue within a quarter of a mile of the fresh-water springs.

LYONS SPRINGS (LAKE 22).

A supply of water for domestic use is furnished by springs at the home of Mrs. J. H. Lyons, on the hillside overlooking Clear Lake, 6 miles north of Lakeport. The water issues along the side of a swale and forms a small marshy area a short distance back of the house. A part of it is lifted into a storage tank by a hydraulic ram. The water seems to be of surface origin and to be supplied by the precipitation on the neighboring slopes, but springs of this character are not common in the hills of this region.

ALDER SPRINGS (GLENN 1).

Alder Springs are among the few perennial springs of palatable water in Glenn County. They are situated about 40 miles by road north of west from Willows. Although they are only mountain springs of small flow, the locality has long been used as a summer camping place and hence the springs are well known to many residents of the county.

PERENNIAL SPRINGS THAT ARE LESS WELL KNOWN.

In addition to the perennial springs that have been separately described and that are shown on Plate I (in pocket), there are many that are known locally as watering places on roads or trails, and still others that are utilized for domestic supply and garden irrigation. These minor springs are not indicated on the map (Pl. I), but some of them are here mentioned with such information as is available.

In the northeastern part of the State, on the stage road between Alturas and Cedarville, about 6 miles northwest of the latter place, there is a spring which yields 2 or 3 gallons a minute of water about 47° in temperature. It is in a ravine at a bend in the mountain grade a few yards from the roadside and furnishes a convenient watering place.

On the south side of Pit River, beside the stage road 2½ miles southwest of Canby or 27 miles south of west from Alturas, there is a rock-walled drinking spring which yields 8 or 10 gallons a minute of water 59° in temperature. A pipe leads from the spring down the slope to a horse trough at the roadside 50 yards away.

Several perennial springs of considerable flow issue in the lava beds south of Tule or Rhett Lake at the north end of the State, but as they are in an uninhabited region they are little known. One spring of this character lies near the west end of Medicine or Crystal Lake, which is 55 miles in a direct line west of Alturas, and another is situated at the north base of Black Fox Mountain, 17 miles to the southwest.

In the Lassen Peak region, in addition to the large perennial springs, several of which have been described among the large cold springs, there are several minor springs that are of local importance in this part of the State. One of these is Burney Spring which issues beside a road along the southern base of Burney Butte. It yields perhaps 10 gallons a minute and affords a watering place for range cattle as well as for travelers. Moon Springs, which lie farther east, about 10 miles south of east from Rising River (Shasta 11, p. 328), have been improved by piping their flow to troughs for watering range stock. There are two springs at the locality, but their yield is small. Coyote Spring is about 12 miles south of Moon Springs and like them it yields a small amount of water and is used by range stock. Tadpole Spring is on the southwestern slopes of Lassen Peak beside the stage road, 3 miles east of Paynes Creek post office. It yields a slight flow that is piped to a roadside watering trough, 100 yards to the northeast, and to a house near by for domestic use. The water issues from the tuffaceous material known as the Tuscan tuff, the supply probably being derived from water that collects in a porous layer of the material. Springs are not plentiful in the lower slopes of the lava area that surrounds Lassen Peak, so those which exist are of local importance. On the higher slopes, however, water is more plentiful and the presence of small springs of fresh water is of less importance.

In Plumas County, on the stage road between Quincy and Greenville, there are a number of springs that supply roadside watering troughs. Their waters issue from slate and shale along the canyons of Spanish and Indian creeks, and they yield flows of about 1 to 10 gallons a minute. Eight springs of cold nonmineral water that supply drinking pools or horse troughs were counted at the roadside along the canyons of these creeks. A number of cold springs issue in meadowland in Grizzly Valley, about 12 miles northwest of Beckwith, and furnish a considerable part of the flow of Big Grizzly Creek.

The lower portions of the western slopes of the Sierra contain relatively few perennial springs. Some of these surface springs were early made use of, however, by miners who were working gold placer gravels and ledges, and small settlements were formed near them. Forest Spring, which is 3 miles south of Nevada City, and Indian Springs, which are 8 miles southwest of the same town, lent their names to mining settlements. There are also several perennial springs in Eldorado County at places where mining camps were built up in the early days, but the springs are not now of great importance. Among these are Shingle, Mud, and Diamond springs, near the railroad between Sacramento and Placerville. Several other springs afford watering places on a road between Placerville and Silver Lake, which is a small water body in the northeastern corner of Amador County. Among them are Caple, Camp, Leek, and Tragedy springs, which are respectively about 26, 30, 40, and 47 miles by road eastward from Placerville. All yield cold water of good quality but are of small flow. A few springs near the boundary between Eldorado and Amador counties are also of some importance as watering places. Among these are Marble, Antelope, and Mud springs, which are, in direct lines, respectively 22, 28, and 35 miles east of Latrobe station on the railroad to Placerville.

Mountain Springs, 6 miles west of Jackson in Amador County, and Valley Springs, at the terminus of the railroad 10 miles west of San Andreas in Calaveras County, are at small settlements. There are also saline springs near the latter place, which have already been described. Cottage Spring, 5 miles northeast of Valley Springs, has been locally used as a water supply. Another Cottage Spring and Black Spring and Hermit Spring are near the road that runs northward from the north grove of the Calaveras big trees, in northeastern Calaveras County.

Colfax Spring, which is on the south edge of Tuolumne County, 25 miles in a direct line southeast of Sonora, has given its name to a small settlement. Gold Spring, 7 miles north of Sonora, and Cold Spring, 30 miles northeast of the same town, are locally known.

Frémont Spring, which is on the southeast slope of Bullion Mountains, 30 miles in a direct line northeast of Merced, is known to the miners of the locality. In the higher Sierra east of Merced there are a few small perennial springs, among the principal ones being Cold Springs, between Mariposa and the Mariposa Grove of big trees. A few larger ones in the Sierra have been previously described.

Numerous cool springs of perennial flow issue along the northwestern border of Mono Valley, in the eastern part of the State. Several of them afford watering places for range cattle and horses, and a few irrigate small meadows, but they have not been efficiently developed. One that rises on the southern side of Mono Lake a short distance from the water's edge was formerly known as Blairs Spring. The water is noticeably calcic, but it has long been used as a drinking spring. Other small springs rise in the lake and several of them issue from domes or crags of calcareous tufa that are built up from the lake bottom. These springs have been mentioned in the description of Mono Basin Warm Springs (Mono 8, p. 145), and an analysis of water from one of them is tabulated with that of water from the warm springs.

In the higher portions of the southern Sierra a few small springs form drinking places beside mountain trails. Among them are Windy Springs, which are on a tributary of South Fork of Kern River, about 13 miles in a direct line southwest of former Haiwee stage station (Inyo 26, p. 339); Boulder Spring, which is 18 miles by trail southeast of Onyx post office; and Bird Spring, which is 20 miles by trail southeast of Weldon post office and 6 miles in a direct line west of Boulder Spring.

Along the arid southeastern portion of the Sierra, southward from Haiwee to Mohave, there are very few perennial springs, though seepage or underflow in Red Rock Canyon and farther south, at Water Station (Kern 21, p. 341), yields a fairly dependable supply. South of Mohave, in the mountains bordering Antelope Valley, in whose basin lie the towns of Lancaster and Rosamond, there are a few permanent springs. Antelope, Lovejoy, and Moody springs are three which issue near buttes that rise in the valley proper and have been described as probably due to underflow water that is forced to the surface by the outcropping bedrock.[1] Several other springs that issue from the slopes above the valley have been used for domestic supply and for cattle, and one group has even been developed and piped to the settlement of Neenach, in the west end of the valley for a town supply.[2]

In the ranges of the desert eastern and southeastern portions of the State there are many springs of slight flow that are used as watering places by prospectors, but most of them are less important than those which are indicated on Plate I (in pocket) and which have been separately described. A number are here mentioned, however, because they are really more important than many larger springs in other parts of the State.[3]

On the slopes of the White Mountains and Inyo Mountains, along the east side of Owens Valley, a number of small springs that would receive little notice in a better-watered region are of importance to prospectors and others who have occasion to cross these ranges. Among them are Cedar, Coldwater, Black Canyon, and Goat springs, beside or near roads leading eastward from the town of Bishop into Nevada, and Graham and McMurray springs on the slopes a few miles east of Alvord.

Santa Anita, Willow, and Coyote springs are on the slopes of the Inyo Mountains, eastward from Independence, and are respectively 4 miles northwest, 5 miles south, and 9 miles south from Barrel Springs (Inyo 9, p. 338). Like the latter they furnish small supplies of water to prospectors in the region.

In the Coso Range, which lies southeast of Owens Lake, there are a number of small springs that are away from the traveled roads and are known mainly to prospectors. Among these are Willow Springs, about 4 miles northeast of Darwin post office, and a spring in the pass between the Coso and the Argus ranges, about 12 miles southward from Darwin. A third spring, which is on the eastern slope of the mountains, about 10 miles farther south in the same pass, also yields a small amount of water of good quality. All three of these springs have long been used and are marked by camp litter.

In the Panamint Range there are a number of springs of less importance than those in this range which have already been described. Rest Spring and Burro Spring are situated about 1½ miles apart, on

[1] Johnson, H. R., Water resources of the Antelope Valley, California: U. S. Geol. Survey Water-Supply Paper 278, pp. 52–53, 1911.

[2] Idem, pp. 54, 55.

[3] Most of the springs in the southeastern part of the State that are mentioned are described more fully by W. C. Mendenhall in Some desert watering places in southeastern California and southwestern Nevada: U. S. Geol. Survey Water-Supply Paper 224.

a trail that leads northeastward from Keeler. They are respectively on the western and the eastern sides of the Panamint Range, directly east of Independence. Each furnishes about 3 barrels a day (half a pint a minute) of good water. Goldbelt Spring is about 15 miles south of Rest Spring and is near the junction of trails that lead from it northward along the range and eastward to Death Valley. It yields perhaps 20 barrels a day (half a gallon a minute).

Several springs of minor importance issue along the eastern side of Death Valley and in the mountain slopes that border it. Grapevine Springs are about 3 miles by trail west of the Staininger or Grapevine ranch (Inyo 11, p. 342). They yield a supply of good water but are away from the main-traveled routes. Mesquite Spring is 6 miles farther south, in the east bank of the wash of Death Valley, and near the road. Triangle Spring is also near the road that leads southeastward through Death Valley. It issues in a clay bank near a clump of mesquite, about 25 miles southeast of Mesquite Springs. Tule Spring and Willow Spring are in the southern portion of the Grapevine Mountains, 3 or 4 miles westward from Daylight Spring (Inyo 13, p. 342), and about 3 miles apart, near a trail between Death Valley and Bullfrog, Nev. Fountain Springs are at the base of a butte on the eastern border of Death Valley and about 6 miles north of the Furnace Creek ranch (Inyo 20, p. 320). They yield a small water supply for prospectors in the near-by mountains.

There is another Tule Spring beside the road about 6 miles east of Tecopa railroad station and 2 or 3 miles southeast of Resting Springs (Inyo 34, p. 319), near the southern border of the county. It yields a small supply of water of fair quality and has been boarded over to protect it from cattle.

There are a few perennial springs of little importance in the mountains of the Randsburg mining district. Willow Springs, on the road 10 miles north of Randsburg, are of seepage flow and have been little used since an ample water supply was obtained in a well a mile to the northwest. Bedrock Spring, which is on the north side of Klinker Mountain, 10 miles northeast of Randsburg, yields a small water supply, but it is on a road that has not been much used. Squaw Spring is 5 miles east of Randsburg. It has no appreciable flow and is used mainly by prospectors.

A few springs in the northeastern corner of San Bernardino County are of local value to prospectors in the region. Horse Spring, on the eastern side of Kingston Range, yields good water from shale or slate. Coyote Holes are about 12 miles to the south or southwest, near the divide between Kingston Range and Shadow Mountains. Their water is brackish, and better water can be obtained at Kingston Springs, which are about 2 miles farther south. Cunningham Spring is at the northeast base of Shadow Mountains and is 6 miles southeast of Coyote Holes, and Pachanca or Pachalka Springs are 5 or 6 miles eastward, at the base of Clark Mountain.

In the mountains near the eastern border of the State, in the mining regions of Ivanpah, Leastalk, and Vontrigger, numerous small perennial springs are of great importance to the mining industry. Several of these springs have already been specifically described; others, which are of nearly equal importance, are Willow and Malpais springs, in the eastern portion of the New York Mountains, and Hackberry Spring farther southward, in the mountain of the same name. All these springs have been piped some distance to mines or to water troughs.

Harpers mining camps are two camps in the southern end of the Avawatz Mountains, about 12 and 15 miles, respectively, northwest of Silver Lake railroad station. Water has been obtained at the southern camp by tunneling into granite. At the northern camp an ample supply issues from beneath limestone.

Goleta Spring is at the southeast base of Fremont Peak and about 25 miles southeast of Randsburg, on an old road to Barstow. The spring was visited by Frémont on his last homeward journey across Mohave Desert, but there has been little travel past it during recent years and it has become of little importance.

Indian Spring is in the mountains about 25 miles in a direct line north of Daggett. It supplies a few gold miners who work dry placers in the locality, but it is unimportant to the desert traveler.

Canyon Spring is 6 miles east of Paradise Springs (San Bernardino 9, p. 52), and is beside a road that leads northward past Garlic Spring (San Bernardino 10, p. 303). This route of travel has been seldom used during recent years, so the spring has become of little importance.

Barrel Spring was formerly a well-known watering place near the western border of Soda Lake and 2 or 3 miles north of the crossing of the Salt Lake and the Tonopah & Tidewater railroads. Since the construction of these lines of travel the spring has been little used.

Marl Springs are 9 miles southwest of Cima railroad station and about 12 miles south of Kessler Springs (San Bernardino 15, p. 344), on a slightly used road that connects the two watering places. Like Kessler Springs the place has been used as a camp by prospectors.

There are at least three springs that are used by prospectors near Granite Mountain, which is about 25 miles north of east from Ludlow: Cottonwood Springs, near the northern end of the mountain, in the pass between it and the Providence Mountains, and on a road that leads to Kelso railroad station, 15 miles north; Cove Springs, near the road and 6 miles farther south, at the southeast edge of the mountain; and Willow Springs, at the southwest end of the mountain and 5 miles by trail west of Cove Springs. All three groups of springs yield small amounts of water of good quality.

Bonanza Springs form a good watering place on the south side of Clipper Mountain, which is southeast of Granite Mountain but northwest of the Salt Lake railroad. Still farther southeast Old Woman Springs yield a considerable flow in a canyon at the northeast end of a mountain of the same name. Other Old Woman Springs (San Bernardino 27, p. 316), which are about 90 miles farther west, have been described among the artesian springs. Sunflower Springs, 8 or 10 miles north of the springs on Old Woman Mountain, form a watering place for range cattle. On the western side of the mountain, about 8 miles southeast of Old Woman Springs, there is a spring of good water near the ruins of a mining camp, and at the southern end of the mountain there are other small springs that are used by prospectors.

Considerable water issues along the course of Mohave River near Victorville, apparently as springs of surface or possibly alluvial artesian origin. Little direct use is made of them, as more convenient water supplies are obtained from the river and from wells.

Kanes Spring is 9 miles southeast of Newberry Springs (San Bernardino 20, p. 317), at the eastern base of Kane Mountain, on a road to Victorville. Its water is of good quality, and it forms a convenient stopping place for travelers. Koehn or Kane Springs form another watering place of similar name (Kern 20, p. 340).

About 8 miles southeast of Kanes Spring, at the eastern side of Bessemer Mountain, there is another small spring. Its water is slightly brackish, but it has been used by miners who have prospected the iron deposits in the adjacent mountain.

A number of small springs issue in the northern portion of the San Bernardino Mountains. Rock Springs are in a canyon near the northern base of these mountains, about 6 miles east of Mohave River. They form a small watering place on a road between Cactus Flat (San Bernardino 30, p. 347) and Victorville. Rock Corral Spring is at the northeastern edge of San Bernardino Mountains and about 10 miles southeast of Old Woman Springs (San Bernardino 27, p. 316). The place is marked by a rock corral and the water is plentiful and of good quality. Twohole Spring issues from a 10-foot tunnel in a granite bank, about a mile east of the road and 6 miles northwest of Rock Corral Spring. It yields about 1 gallon a minute and has been used as a watering place for cattle. Terrace Springs, 5 miles farther west, also furnish a small supply that has been used for cattle watering. Viscera Spring is in a ravine that is tributary to Rattlesnake Canyon; it is about 7 miles southward by road from Twohole Spring but three-quarters of a mile from the main road. It is shaded by a scrubby willow tree and yields a very small flow of water that deposits considerable iron. About 1½ miles southeast of it another small spring rises beside the road and near the head of Rattlesnake Canyon. Saddlerock Spring forms a small watering hole for cattle in a canyon about $7\frac{1}{2}$ miles in a direct line east of Viscera Spring and twice as far southeast of Old Woman Springs. Burns Spring yields a small amount of good drinking water beside the road in the canyon of the same name 5 miles southwest of Saddlerock Spring; it seeps from gray decomposed granite along the creek side, from small holes dug in the bank for a distance of about 15 yards. Springs in the canyon of Pipes Creek, 3 miles south of Burns Spring, yield a small flow, which is piped some distance down the canyon to the ranch house known as The Pipes and also a quarter of a mile farther east to a small reservoir that serves as a cattle-watering place. Chaparrosa Springs are in a ravine about 3 miles south of The Pipes. Two springs, 100 yards apart, in this ravine furnish seeping flows from basins dug in the bank of the drainage channel and have been used by cattle as watering places.

There are also a few minor springs in the southeastern extension of San Bernardino Mountains. Stubby Springs, which are on the western slope of the range, 18 miles north of Indio, are locally known. Lost Horse Spring is about 8 miles farther eastward, near the eastern base of the range. At one time it supplied a 2-stamp mill near by.

McCoy Spring forms a watering place on the west side of Ironwood Mountains, on a road between the Colorado Desert and Ehrenberg, Ariz. The spring yields only about 4 barrels a day (less than one pint a minute), but the water is of good quality.

Two groups of springs in the Palo Verde Mountains, in the southeast corner of Riverside County, are of local value as watering places. One group is at the base of a westward extension of the mountains, beside a wagon road between the Colorado Desert and Ehrenberg, and is 5 or 6 miles west of Mule Springs (Riverside 23, p. 348); the other is at the northeast side of the Palo Verde Mountains and forms a watering place for cattle.

A few springs form minor watering places in the mountains on the west side of the Colorado Desert. Among these are Dos Palmas Spring, 14 miles in a direct line southwest of Indio; Asbestos and Potrero springs, which are respectively 3 miles west and 5 miles northwest of Dos Palmas Spring; and Cactus, Virgin, and Agua Alta springs, which are between 5 and 10 miles to the south. Most of these springs have been used as sources of water by prospectors in the region. Seventeen Palms Springs are on a road from the mining settlement of Julian northeastward to the desert and are 12 miles by road eastward from Borego Spring (San Diego 6, p. 349). The water is of fair quality when the springs are kept cleaned out, but as the road is seldom traveled the springs are usually choked by sand and weeds and the water is alkaline. Zacaton Spring is on the south side of the same road, about 5 miles farther east. Mountain Palm

Springs are 4 or 5 miles southwest of the Mason ranch (San Diego 10, p. 349), and about the same distance from the main wagon road, but they yield a fair supply of cool water and make a good camping place.

On the western slopes of the southern Coast Ranges a few perennial springs form roadside drinking pools, or pools that are known to hunters. Dog Spring is in a direct line about 12 miles northeast of San Diego, and Tule Spring is 13 miles eastward from the railroad terminus at Foster. Cold Spring, on the stage road between Descanso and Cuyamaca, yields perhaps 5 gallons a minute of water 55° in temperature and forms a drinking pool at the roadside. Durasnitos Spring furnishes a small supply about 4 miles southwest of Ramona or 3 miles northeast of Bradley Spring (San Diego 7, p. 350). Dripping Spring and Sawyer Spring are in canyons tributary to Temecula Creek and are respectively about 9 miles and 13 miles in direct lines east of Temecula, in southwestern Riverside County. They yield small flows of little importance.

In a canyon 3 miles north of Arrowhead Hot Springs (San Bernardino 36, p. 32), there is a cold spring of considerable size, and near the hotel is a cold spring (Fuente Frio), whose analysis is given with those of the hot waters. Another small cold spring issues several miles to the northwest, 3 miles south of the warm spring in Lytle Canyon (San Bernardino 34, p. 35).

Crystal Spring, on Mount Lowe in the San Gabriel Mountains, 20 miles northeast of Los Angeles, yields cold pure water that was at one time bottled for table use.

In the mountains 8 or 10 miles northwest of Santa Monica, which is on the coast west of Los Angeles, are several minor springs that form small watering places for range stock. Water is scarce in these mountains, however, and as the main perennial springs are sulphureted they have been described among the sulphur springs.

Several localities of perennial springs in the Coast Ranges along the southwest side of San Joaquin Valley have been previously mentioned and are indicated on Plate I (in pocket). Springs of similar character issue at other places in this arid region. Pataroma Spring, 11 miles in a direct line south of west from Maricopa, furnishes a small cattle-watering supply. Goat Spring, which is about 2 miles south of the sulphur spring in Carrizo Plain (San Luis Obispo 12, p. 277) yields slightly bitter or salty water that is used to some extent by cattle. Fivewillow Spring, which is 2½ miles northwest of the sulphur spring, yields water of fair quality for stock use, and a similar spring 2 miles southwest of Painted Rock ranch, or 9 miles northwest of the sulphur spring, also yields a small flow. Mustang Spring furnishes a small watering place beside a road, 4 miles west of north from Thompson Spring (San Luis Obispo 6, p. 354), but in summer it becomes nearly dry. Carnaza Spring, on the creek of the same name, 10 miles northwest of Thompson Spring, yields a larger supply than most springs of the region, as it forms a stream of perhaps 10 to 15 gallons a minute. Its water is of good quality, but as the spring is not on a road it has been used mainly by cattle. A small spring on the San Juan ranch, about 10 miles west of Thompson Spring, yields water that is noticeably sulphureted, but the spring is not distinctive in this respect, for most of the water of this region is distinctly sulphureted. Crocker Spring, on the creek of the same name, about 6 miles west of south of McKittrick, yields a small flow of mildly sulphureted water; it has furnished a camp supply for stockmen. Frazer Spring, 5 miles northwest of McKittrick, is an old roadside watering place, and Sheep Springs, 2½ miles west of Frazer Spring, yield small stock-watering supplies. Carneros Spring, 6 miles northwest of the Temblor ranch (Kern 4, p. 354), in a tributary to Carneros Canyon, yields fair water. Walnut Spring and Antelope Spring are about one-half mile apart and 8 miles in a direct line northward from Thompson Spring. The former yields a good flow of water of fair quality; the latter is of smaller flow and is less important. Napoleon Spring yields slightly bitter water in a tributary of Cedar Canyon, at a point about 2½ miles northwest of Antelope Spring. It is about 1 mile from a road, but it is well known to stockmen of the region. Aido Spring is on the north side of Antelope Valley and 6 miles in a direct line northeast of the Still ranch (Kern 2, p. 355). Its name was coined from the initials of the phrase "all in, down and out," by two oil prospectors who found it one hot summer day. It yields a small amount of water of fair quality. A spring in Cottonwood Canyon, 5 miles farther north, also yields a small quantity of fair water. Alamo Solo (Lone Poplar) Spring is about 4 miles north of the salt spring near Antelope Valley (Kern 1, p. 301) and yields a small water supply in the northeast end of the Devils Den oil district.

Farther northwest, in the Coalinga region, there are very few springs of even seeping flow, but in the vicinity of Mercey Hot Springs (Fresno 8, p. 78) there are a few of minor importance on the slopes tributary to Little Panoche Creek. Among the principal springs in this region, however, are probably those a few miles farther north at Laguna Seca ranch, which is about 20 miles southwest of Dos Palos, and Piedra Azul Spring, Carrisalito Spring, and the spring at Arburuas, the three last mentioned being on the Carrisalitos ranch, a few miles west of the Laguna Seca ranch.

There are a few perennial springs of minor importance in the ranges of northwestern San Luis Obispo and southwestern Monterey counties. Among them is Round Spring, which is in the Los Burros mining district and is 6 miles from Nacimiento River. A few other springs yield domestic supplies or form watering places for cattle in this portion of the Coast Ranges.

A domestic supply of good water is obtained at Tassajara Hot Springs (Monterey 3, p. 57), from cold springs in a canyon near the hotel. An analysis of a cold iron spring at this place has been given with the analyses of the hot springs.

In Santa Clara County a small spring of cool water forms a roadside drinking place between Gilroy and Gilroy Hot Spring (Santa Clara 9, p. 79), and larger cool springs near this resort furnish a domestic water supply.

Springs of considerable flow issue on the slopes 2 or 3 miles south of Alma railroad station, which is 12 miles southwest of San Jose. Similar springs form the water supply at a small mountain resort 2 or 3 miles farther west, and several others in the locality form roadside drinking springs.

In the great interior valley of California there are very few springs. On the eastern side of Sacramento Valley, near the base of the Sierra, however, there is an occasional small spring near a stream channel. Willow Spring, which is about 30 miles southeast of Sacramento, is one of these, and it is probably supplied by subsurface water from the slopes to the east.

Numerous cool nonmineral springs of perennial flow exist in the abundantly watered portions of the Coast Ranges north of San Francisco Bay, but as most of the mountainous country is sparsely inhabited, the springs are of little importance even on cattle ranges, for the many streams in the region furnish adequate watering places. A few of them form watering places along stage roads, however. Among those which are thus made use of the springs at Bell Springs station, near the northern border of Mendocino County, on the stage road 40 miles northward from Sherwood, are perhaps the best known.

A few small springs in Lake County furnish roadside watering places. One spring that is about 4 miles south of Middletown, beside the road to Calistoga, issues from serpentine and yields perhaps 2 gallons a minute of water of good quality. Another spring, about 2 miles farther south, also yielding about 2 gallons a minute, has been piped a short distance down the slope to a watering trough at the roadside. Three-fourths of a mile west of Allen Springs (Lake 11, p. 198) a slightly used road branches from the stage road, climbs southward across a divide, and thence descends into the valley of Wolf Creek. About a quarter of a mile southeast of its junction with the stage road a spring that yields about 2 gallons a minute of cool water of good quality issues from the road bank and forms a pleasant drinking spring. About 2½ miles beyond it, or a quarter of a mile north of the road summit and 25 yards from the road, there is another spring that has been improved by a joint of pipe and a half barrel so as to form a watering place. Both of these springs issue from crushed and altered sediments that constitute the greater part of the rocks in this region.

On the road that leads from Bartlett Springs (Lake 9, p. 200) to Crabtree Springs (Lake 5, p. 106), about halfway between the two places, on the grade north of Twin Valleys, a spring that issues from altered sandstone and forms a welcome drinking pool yields about 3 gallons a minute of good water.

Candybucket Spring is thus locally known because a candy bucket was for some time kept near it for the use of teamsters in watering their teams and of automobilists in replenishing their radiators. It issues at the side of the road between Stonyford and Fouts Springs (Colusa 3, p. 205), about 3 miles east of the latter place and 100 yards north of the summit of the grade between the two places. It yields a summer flow of 2 or 3 gallons a minute, but the water issues from altered sediments near an area of serpentine and is not very good.

Rattlesnake Spring is at the roadside about 6 miles east of Alder Springs (Glenn 1, p. 359). It yields a small flow that has been used as a roadside watering place, but it is of interest chiefly because water is not plentiful in the region.

In the portions of the Coast Ranges that drain into northern Sacramento Valley water is much scarcer than it is farther southwest. Among the springs in the higher part of this region may be mentioned one on the northern side of Toms Head Mountain, about 10 miles northwest of Colyear Springs (Tehama 10, p. 266), and another near the county line, about 8 miles farther northwest. Near the summit of the range, 25 miles farther north, Kenshaw Spring issues about 6 miles south of Deerlick Springs (Trinity 3, p. 261). A spring at the creek edge one-half mile south of Deerlick Springs is of interest because of the coldness of its water, a temperature of 47° being recorded in summer.

In the rugged portions of Humboldt County, back from the coast, there are several nonmineral springs, and a few that are better known issue in the less sparsely inhabited section along the larger streams. One of these springs is about 2 miles north of Mad River and 7 miles from the coast, and a larger one issues a mile east of Trinity River and 4 miles south of the northern border of the county.

In Del Norte County, which is in the northwest corner of the State, there are at least four springs of notable flow in the drainage basin of Smith River. Two of these springs are on branches of the south fork of the river and are respectively about 17 miles southeast and 10 miles south of east of Crescent City; the third spring is about 8 miles east of this town; and the fourth is on the north fork of the river, 15 miles northeast of the same place.

TABULATED DATA.

Table 1 contains an alphabetic list by counties of all the springs whose locations are shown on the map, Plate I (in pocket). The names of the owners of springs (so far as known) are given, and the approximate distances by the usually traveled routes from the nearest railroad station or from the principal town in the region. Many of the figures that give elevation, number of springs, temperature, and yield do not agree with figures previously published, but they were obtained mainly by personal observation and are believed to be approximately correct. The column showing development or use gives the conditions noted during the period covered by the field examination These conditions vary somewhat from year to year, for commercially developed springs are occasionally abandoned and undeveloped springs are improved as resorts or for bottling water or other purposes, but the total number of springs is almost constant.

Table 2 contains a list of the springs that were used during the period covered by the field examination either as permanent resorts or as camping places. It gives the distances from railroad or supply points, and the capacity, open season, and improvements of resorts, these latter three factors being of course changeable.

TABLE 1.—*Springs by counties.*

[Figures preceded by asterisk (*) were estimated or reported. Dagger (†) indicates number of principal springs.]

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	ALAMEDA COUNTY.							
	Alameda Warm Springs (Same as Warm Springs.)			*Feet.*		° *F.*	*Gallons a minute.*	
2	Mayhew Spring	H. A. Mayhew, Niles	200 yards north of Niles depot	125	1	67	1	Drinking.
5	Mendenhall Springs	W. M. Mendenhall, Oakland.	11 miles southeast of Livermore	1,800	2	58	1½	Resort.
4	Mud Spring		9 miles southeast of Livermore	1,415	1	57	1	Roadside watering.
1	Piedmont Springs	Frank Havens, Piedmont	3 miles north of Oakland	200	2	60	1	Drinking (recreation park).
6	Sweet Springs	Southern Pacific R. R. Co	18 miles southeast of Livermore	2,500	14	53–55	30	Cattle watering.
3	Warm Springs	J. W. Stanford, Warm Springs.	2 miles northeast of Warm Springs	350	4	85–90	15	Domestic and garden.
	ALPINE COUNTY.							
1	Grovers Hot Springs	Mrs. H. A. Grover, Markleeville.	4 miles west of Markleeville	5,900	12	50–146	100	Camping resort.
	BUTTE COUNTY.							
1	Henderson Spring	Diamond Match Co. (?)	11 miles west of north of Stirling City	3,450	1	50	1	Drinking.
3	Mount Ida Spring	Judge J. C. Gray, Oroville	6 miles north of east of Oroville	800	1	66	8	Bottled.
2	Richardson Springs	J. H. and Lee Richardson, Chico.	12 miles east of north of Chico	600	5	61–68	5	Resort.
	CALAVERAS COUNTY.							
1	Valley Springs	Valley Springs Mineral Water Co.	One-half mile east of Valley Springs	650	2	75	1⅛	Bottled.
	COLUSA COUNTY.							
12	Blancks Hot Springs		27 miles southwest of Williams	1,375	2	120	4	Bathing.
5	Cooks Springs	Cooks Springs Mineral Water Co.	30 miles northwest of Williams	1,400	3	63–65	6	Resort; bottled.
6	Deadshot Springs		28 miles south of west of Williams	1,750–1,950	4	65–79	11	Drinking (slightly).
3	Fouts Springs	C. H. Glenn	32 miles north of west of Sites	1,700	†4	60–75	20	Resort.
	Hot springs—							
7	At Elgin mine	J. W. Cuthbert et al., Wilbur Springs.	30 miles south of west of Williams	2,050	3	140–153	25	Unused.
10	On Manzanita mining property.	Manzanita Mining Co	26½ miles southwest of Williams	1,300	3	110–142	4	Bathing.
11	Jones Hot Springs	Tilden Jones, Sulphur Creek	do	1,325	1	125	2	Resort.
8	Oil Spring		24 miles south of west of Williams	1,400	1	76	2	Unused.

4	Salt spring north of Sites.	Peterson ranch	3½ miles north of Sites	*300	1	*60	(a)	Stock salt.
	Simmons Springs (Same as Wilbur Hot Springs.)							
	Sulphur springs—							
2	Southwest of Fouts Springs.		30 miles west of Sites	2,000	1	65	5	Drinking (slightly).
1	West of Fouts Springs.		do	*2,200	1	*65	*10	Unused.
9	Wilbur Hot Springs	Wilbur Springs Co	26 miles southwest of Williams	1,250	†12	65-140	35	Resort.
	CONTRA COSTA COUNTY.							
2	Alhambra Springs	L. M. Lasell, Martinez	6 miles west of south of Martinez	400	3	57-62	5	Bottled.
7	Byron Hot Springs	L. R. Mead, San Francisco	2 miles south of Byron	65	7	72-120	15	Resort.
6	Chaparral Spring		3 miles southeast of Clayton	1,050	1	50	1	Cattle watering.
1	Ferndale Springs	B. F. Van Amringe, Oakland	6 miles west of south of Martinez	450	4	58-60	3	Formerly bottled.
5	Peachtree Springs	Bolbones Rancho	3½ miles west of south of Clayton	1,150	2	50	8	Cattle watering.
8	Saline springs at Byron Hot Springs.	L. R. Mead, San Francisco	2 miles east of south of Byron	65	†1	*60	(a)	Unused.
	Sulphur springs—							
4	In Pine Canyon	Bolbones Rancho	4 miles north of Danville	500	1	67	5	Do.
3	Near Walnut Creek	J. M. Walker, Walnut Creek	2 miles northeast of Walnut Creek	100	6	75-81	5	Domestic.
	ELDORADO COUNTY.							
	Gilmores Glen Alpine Springs. (Same as Glen Alpine Springs.)							
4	Glen Alpine Springs	Mrs. J. E. Gray, Mrs. G. W. Pierce, and Mrs. J. L. Ramsay.	7 miles west of south of Tallac	6,850	2	47, 49	3	Resort.
3	Rubicon Springs	R. Colwell, McKinney	12 miles west of south of McKinney	6,060	4	50-57	1½	Do.
	Sulphur springs—							
5	Near American River.		35 miles east of Placerville	4,000	1	*50	*1	Drinking.
1	On Rubicon River	Eldorado National Forest	13 miles southwest of Tahoe	5,200	†1	*50	*1	Unused.
2	Wentworth Springs	Southern Pacific R. R. Co	20 miles south of west of McKinney	6,000	14	58-75	1½	Camping resort.
	FRESNO COUNTY.							
5	Blaney Meadows Hot Springs.	Sierra National Forest	30 miles north of east of Shaver	7,800	8	100-110	40	Do.
1	Carbonated spring in Fish Valley.	do	75 miles southeast of Yosemite	6,700	1	54	¼	Drinking.
9	Fresno Hot Springs	Kreyenhagon estate, Coalinga.	18 miles west of Coalinga	2,100	5	88-97	20	Resort.
2	Hot springs at head of Fish Valley.	Sierra National Forest	80 miles southeast of Yosemite	8,500	†2	*110	*5	Unused.

a No flow.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	FRESNO COUNTY—contd.			*Feet.*		° *F.*	*Gallons a minute.*	
4	Lower springs on South Fork of San Joaquin River.	Sierra National Forest	30 miles north of east of Shaver	6,700	† 4	100–112	* 25	Camping resort.
8	Mercey Hot Springs	F. C. Fry, San Francisco	25 miles south of Dos Palos	1,100	3	79–109	6	Bathing; formerly bottled.
3	Spring near String Meadows.	Sierra National Forest	70 miles southeast of Yosemite	8,500	1	48	10	Drinking.
6	Sulphur spring in Sulphur Meadows.	Fresno Flume and Lumber Co.	½ mile south of Shaver	7,300	1	49	½	Do.
7	Three Springs	Sierra National Forest	75 miles northeast of Fresno	7,600	3	* 50	* 100	Unused.
	GLENN COUNTY.							
1	Alder Springs		35 miles north of west of Willows	* 1,500	† 1	* 50	* 5	Drinking.
	Salt springs—							
3	In Salt Spring Valley	J. Pugh (?)	20 miles southwest of Willows	1,000	1	* 60	* 5	Stock salt.
2	West of Elk Creek		3 miles west of Elk Creek	* 500	† 1	* 60	* 1	Unused.
	HUMBOLDT COUNTY.							
4	Cook Spring	Mrs. E. A. Porter, Iaqua	35 miles southeast of Eureka	1,450	1	57	¼	Drinking.
5	Felts Springs	Dr. Ray Felt, Eureka	5½ miles northeast of Fortuna	* 200	3	* 55	* 1	Unused.
2	Humboldt Artesian Mineral Well.	Bayside Lumber Co.	1 mile south of Eureka	*a* 0	*b* 1	58	(*c*)	Mill supply; also bottled.
3	Mountain View Spring	Archie McBride, Kneeland	28 miles southeast of Eureka	950	1	53	½	Drinking.
1	Sulphur spring in Eureka.	George Knight, San Francisco.	In Eureka	10	1	53	(*d*)	Unused.
	IMPERIAL COUNTY.							
1	Fish Springs	Undeeded	13 miles south of Mecca	*e* 250	† 1	* 60	* 10	Submerged by Salton Sea; formerly roadside watering.
2	Frink Springs		6 miles northwest of Frink station	*e* 150	† 1	* 60	* 10	Roadside watering.
6	Kane Spring	Undeeded	43 miles east of south from Mecca	*e* 75	1	* 60	* 1	Unused.
4	McCain Springs	do	30 miles south of Mecca	*e* 100	† 1	* 60	* 1	Roadside watering.
5	Mud volcanoes	do	7 miles south of west of Imperial junction.	*e* 200	† 1	(*f*)	* 10	Unused (submerged by Salton Sea).
3	Soda Springs	do	25 miles south of Mecca	*e* 25	† 1	* 60	* 5	Unused.
7	Sunset Spring		13 miles south of east of Brawley	*e* 45	1	* 60	* 10	Unused (?).
8	Yuha Spring	Undeeded	20 miles west of El Centro	125	1	* 60	* 5	Roadside watering.

	INYO COUNTY.							
24	Arab Spring	do	18 miles south of Keeler	5,550	1	* 60	* 1	Do.
9	Barrel Springs	Inyo National Forest	10 miles northeast of Independence	6,500	† 1	* 60	* 1	Prospectors' supply.
33	Bennetts Wells	Eagle Borax Works	25 miles northeast of Ballarat	e 260	† 1	* 60	* 5	Roadside watering.
8	Blackrock Spring	City of Los Angeles	10 miles north of Independence	3,815	1	56	7,200-9,450	Part of supply to Los Angeles Aqueduct.
	Buckhorn Springs. (Same as Deep Springs.)							
15	Castalian Mineral Water		Owens Lake	3,575				Bottled.
36	China Ranch Springs		5 miles north of Sperry	* 1,500	† 1	* 60	* 50	Irrigation.
31	Coso Hot Springs	I. J. Woodin and W. T. Grant (in part).	17 miles southeast of Haiwee	3,600-4,000	† 3	* 176	(d)	Camping resort.
16	Cottonwood Spring	Undeeded	35 miles east of Keeler	4,800	1	* 60	* 1	Roadside watering.
27	Crystal Springs	do	4 miles northwest of Coso	6,300	† 1	* 60	* 1	Do.
13	Daylight Spring	do	60 miles northeast of Keeler	4,325	1	* 60	¼	Do.
2	Deep Springs		18 miles northeast of Alvord station	4,950	† 1	* 60	* 10	Irrigation.
17	Emigrant Spring	Undeeded	35 miles north of Ballarat	4,050	1	* 60	* 1	Roadside watering.
3	Fish Springs	City of Los Angeles	6½ miles east of south of Big Pine	3,900	† 1	58	* 50	Part of supply to Los Angeles Aqueduct.
5	Hines Spring	do	13½ miles north of Independence	3,860	1	56	450	Unused.
	Hot springs—							
35	Near Tecopa	Tonopah & Tidewater R. R. Co. (?)	2¼ miles west of north of Tecopa	1,600	2	108, 109	225	Railroad water.
1	South of Bishop		8 miles south of Bishop	4,175	1	* 130	* 20	Domestic.
14	Keane Spring	Undeeded	60 miles northeast of Keeler	4,100	1	* 60	* 1	Roadside watering.
7	Little Blackrock Spring	City of Los Angeles	10½ miles north of Independence	3,825	1	58	3,150	Part of supply to Los Angeles Aqueduct.
	Lower Centennial Spring. (Same as Arab Spring.)							
18	Poison Spring	Undeeded	35 miles northeast of Ballarat	e 200	1	* 60	* 1	Unused.
34	Resting Springs	S. P. Lee, Tecopa	5½ miles northeast of Tecopa	1,750	† 1	80	260	Domestic and irrigation.
25	Rose Spring	Kern National Forest	4 miles south of Haiwee	3,575	1	* 60	* 1	Roadside watering.
	Salt springs—							
19	North of Furnace Creek ranch.	Undeeded	45 miles northeast of Ballarat	e 200	† 1	* 60	* 1	Unused.
21	South of Furnace Creek ranch.	do	40 miles northeast of Ballarat	e 200	1	* 60	* 1	Do.
10	Sand Spring	do	45 miles east of Alvord	3,125	1	* 60	* 1	Roadside watering.
6	Scotty Springs	Inyo National Forest	16 miles northwest of Independence	5,700	3	* 50	1,500	Unused.
4	Seelys Spring	City of Los Angeles	17 miles north of Independence	3,875	1	60	600	Do.
26	Springs near Haiwee		1 mile south of Haiwee post office	3,725	1	55	25	Domestic and irrigation.
23	Springs near southeast side of Owens Lake.		2 to 10 miles south of Keeler	3,600	1	60	1	Roadside watering.
11	Staininger Ranch Springs		50 miles northeast of Keeler	3,000	† 1	* 60	* 10	Irrigation.
20	Texas Springs		40 miles northeast of Ballarat	150, 200	† 2	* 60	* 25	Do.

a At sea level.
b Well.
c Pumped (also flows).
d No flow.
e Below sea level.
f Scalding.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	INYO COUNTY—contd.			*Feet.*		*° F.*	*Gallons a minute.*	
28	Tule Springs	Undeeded	35 miles northeast of Ballarat	*a* 250	† 1	* 60	* 5	Roadside watering.
	Upper Centennial Spring. (See Arab Spring.)							
30	Vapor vents west of Coso Hot Springs.	....do	14 miles southeast of Haiwee	4,200	† 20	*b* 150–203	(*c*)	Unused.
	Warm springs—							
29	In Panamint Valley	....do	4 miles north of Ballarat	1,075	1	* 80	* 1	Roadside watering.
12	In Saline Valley	....do	30 miles east of north of Keeler	1,200	† 1	* 100	* 5	Unused.
32	Near Little Lake		18 miles south of Haiwee	3,200	1	* 80	* 1	Do.
22	Wild Rose Spring	Undeeded	20 miles north of Ballarat	3,700	1	* 60	* 1	Roadside watering.
	KERN COUNTY.							
	Agua Caliente Spring. (Same as Neills Hot Spring.)							
26	Buckhorn Springs	Southern Pacific R. R. Co.	14 miles south of east of Rosamond	2,275	† 1	* 60	* 10	Prospectors' supply.
12	Carbonated spring in Weldon Valley.	J. V. Roberts	10 miles northeast of Onyx	4,000	1	* 60	* 1	Unused.
9	Clear Creek Hot Springs.	Kern National Forest	51 miles northeast of Bakersfield	2,250	3	119	20	Do.
	Coyote Holes. (Same as Freeman Springs.)							
8	Delonegha Springs	E. H. Barbeau	45 miles northeast of Bakersfield	2,150	3	104–112	25	Resort.
7	Democrat Springs	D. D. Hill, Bakersfield	40 miles northeast of Bakersfield	2,100	5	100–115	25	Do.
15	Freeman Springs	F. S. Raymond, Freeman	47 miles east of north of Mohave	3,500	2	55	5	Domestic.
13	Grapevine Springs		57 miles east of north of Mohave	3,000	† 1	* 55	* 5	Roadside watering.
23	Graves Spring	Charles A. Graves	3 miles north of west of Rosamond	2,350	1	60	1	Cattle watering.
	Hobo Springs. (Same as Clear Creek Springs.)							
11	Hot springs near Kernville.	Pacific Light & Power Co	2 miles northeast of Kernville	2,675	2	98, 113	4	Bathing.
25	Indian Spring	George M. Holton	3 miles north of east of Rosamond	2,250	1	66	3	Cattle watering.
14	Indian Wells Springs	R. L. Prewitt	52 miles east of north of Mohave	2,750	† 1	* 50	* 10	Domestic; irrigation.
	Kane Springs. (Same as Koehn Springs.)							
20	Koehn Springs	C. A. Koehn	25 miles northeast of Mohave	1,900	† 2	* 60	* 1	Roadside watering.
18	Landers Spring	W. W. Landers, Weldon	25 miles east of Caliente		1	* 55	* 5	Drinking.
10	Neills Hot Spring	John Neill, Bodfish	7 miles west of south of Kernville	2,500	1	131	115	Domestic; bathing; irrigation
19	Ricardo Springs	John Schurs (?)	27 miles east of north of Mohave	* 3,000	† 1	* 60	* 5	Unused (formerly roadside watering).

1	Salt spring near Antelope Valley.	Samuel Eldridge	60 miles east of Paso Robles	* 2,500	1	* 60	* 1	Unused.
16	Searles Spring	Undeeded	20 miles north of Randsburg	4,200	1	* 60	* 10	Domestic.
24	Springs northwest of Rosamond.	B. S. Bailey and Mary L. Barr.	2 miles northwest of Rosamond	2,400	2	60	1	Prospectors' supply.
3	Springs on McAlester ranch	Carrizo Cattle Co	25 miles northwest of McKittrick	2,750	† 1	* 60	* 10	Domestic.
2	Springs on Still ranch		41 miles east of Paso Robles	2,000	† 1	* 60	* 10	Domestic; irrigation.
4	Springs on Temblor ranch	Miller & Lux	12 miles northwest of McKittrick	1,900	† 1	* 60	* 10	Do.
6	Sulphur springs near Glennville.	Wilkes and Converse	½ mile east of Glennville	* 1,700	2	60	10	Irrigation.
21	Water Station Springs		9 miles east of north of Mohave	* 2,800	† 1	* 60	* 5	Roadside watering.
17	Williams Hot Springs	R. Williams, Havilah	16 miles northeast of Caliente	3,700	5	60–97	20	Domestic; bathing; irrigation.
5	Willow Spring		15 miles south of west of Glennville	* 400	1	* 60	* 1	Cattle watering.
22	Willow Springs	E. M. Hamilton, Rosamond	8 miles north of west of Rosamond	2,550	7	64–66	35	Domestic; irrigation.
	LAKE COUNTY.							
44	Adams Springs	Dr. W. R. Prather	30 miles west of north of Calistoga	2,700	2	46	1	Resort; bottled.
11	Allen Springs	Geo. C. Comstock, Julius Loeb, and Emil Jacobson.	40 miles west of Williams	1,700	† 4	55–65	10	Resort.
26	Alum Spring	Hiram Kennedy	49 miles north of Calistoga	1,100	1	60	⅛	Unused.
55	Anderson Springs	Johanna Anderson	22 miles west of north of Calistoga	1,625	9	63–145	7	Resort.
45	Astorg Spring	Mrs. S. C. Boggs (?)	30 miles west of north of Calistoga	2,500	1	50	¼	Unused (formerly bottled).
53	Baker Soda Spring	Baker Quicksilver Mining Co.	40 miles north of Calistoga	* 2,000	1	* 60	* 1	Drinking.
9	Bartlett Springs	Bartlett Springs Co	44 miles west of Williams	1,950–2,300	4	54–60	* 15	Resort; bottled.
50	Bonanza Springs	H. G. Brown	29 miles west of north of Calistoga	2,500	3	50	1	Camping resort.
34	Bynum Spring	G. W. Crippen, Lakeport	7 miles southwest of Lakeport	1,700	1	50	½	Bottled.
	Carbonated springs—							
37	At southwest edge of Clear Lake.	John Behr	10 miles east of Kelseyville	1,300	† 10	70–100	5	Drinking.
30	In canyon of Scott Creek.		7 miles southwest of Lakeport	1,500	1	* 60	* 1	Unused.
23	Near northeast side of Clear Lake.		7 miles northeast of Lakeport	1,450	1	* 60	* ½	Do.
21	Near northwest edge of Clear Lake.	J. B. Robinson, Upper Lake.	8 miles north of Lakeport	1,300	1	* 60	* 1	Do.
3	Near Ranger Camp	California National Forest	45 miles north of Lakeport	* 2,500	1	* 60	* 1	Drinking.
2	On Bear Creek	Snow Mountain Stock Co	43 miles east of north of Lakeport	* 2,000	1	* 60	* 1	Unused.
25	On Chalk Mountain.	Hiram Kennedy (?)	49 miles north of Calistoga	1,150–1,200	† 3	67–70	3	Do.
42	On Cole Creek	William and Sarah J. Carr	4½ miles south of Kelseyville	1,800	2	60	1	Drinking.
12	On Wiley ranch		38 miles west of Williams	2,000	† 1	* 60	* 5	Unused.
	Carbonated wells—							
35	At Kelseyville		Eastern part of Kelseyville	1,400	d † 3	78	10	Irrigation.
19	Near Upper Lake	W. A. Taylor, Upper Lake	½ mile south of Upper Lake	1,300	d 1	60	5	Domestic; irrigation.
20	South of Upper Lake.	S. T. Packwood, Upper Lake.	1 mile south of Upper Lake	1,300	d 1	60	5	Unused.
41	Carlsbad Springs	Mrs. E. M. McGovern, Kelseyville.	5 miles south of Kelseyville	1,900	4	66–76	4	Unused (formerly a resort).

a Below sea level. b Boiling. c No flow. d Wells.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	LAKE COUNTY—contd.			*Feet.*		° *F.*	*Gallons a minute.*	
54	Castle Hot Springs	Castle Hot Springs Co.	25 miles west of north of Calistoga	2,300–2,425	† 2	65, 164	10	Resort.
14	Complexion Springs	Winfield Haring	28 miles west of Williams	1,650	3	74	1	Unused.
	Copsey Springs. (Same as Spiers Springs.)							
5	Crabtree Springs	S. T. Packwood, Upper Lake.	38 miles east of north of Lakeport	2,100	† 4	68–105	15	Camping resort.
	Dennison Springs. (Same as Hazel Springs.)							
24	Dinsmore Soda Spring	Robert Dinsmore	50 miles north of Calistoga	1,200	1	63	¼	Drinking.
	Elliott Springs. (Same as England Springs.)							
40	England Springs	C. C. Hopkins and C. E. Millar.	8 miles west of south of Kelseyville	1,800	7	56–76	8	Do.
32	Epsom Spring	Z. L. and W. Zook, Lakeport.	2½ miles south of west of Lakeport	1,500	1	* 55	(*a*)	Unused
47	Gifford Springs	Mrs. E. C. Gifford, Middletown.	27 miles west of north of Calistoga	3,000	† 2	53	25	Irrigation; domestic.
33	Glen Alpine Springs	Mrs. Ida E. Neal, Lakeport.	6 miles southwest of Lakeport	1,600	2	* 50	½	Drinking.
46	Gordon Hot Spring	Hoffman estate	28 miles west of north of Calistoga	2,400	1	92	5	Unused.
29	Grizzly Springs	Samuel Richardson	31 miles southwest of Williams	1,350	2	68, 70	3	Camping resort; bottled.
56	Harbin Springs	C. Monreal and J. A. Hayes.	20 miles west of north of Calistoga	1,500	3	90–120	10	Resort.
16	Hayvilla Sulphur Spring	R. F. McMath, Upper Lake.	5 miles northwest of Upper Lake	1,400	1	56	¾	Camping resort.
7	Hazel Springs	Amos Ogden	7 miles northeast of Upper Lake	* 2,000	2	* 60	* 1	Do.
39	Highland Springs	Highland Springs Co.	6 miles southwest of Kelseyville	1,450	11	52–82	20	Resort.
10	Hoppins Springs		44 miles west of Williams	2,000	2	60	2	Do.
	Hot Borate Springs. (Same as Soda Bay Springs.)							
38	Hot springs at Sulphur Bank.	Clear Lake Quicksilver Mining Co.	10 miles west of north of Lower Lake	1,350	† 10	83–120	(*a*)	Unused.
13	Hough Springs	Bartels Bros., Leesville	36 miles west of Williams	1,500	2	60, 66	¼	Resort.
51	Howard Springs	J. W. Laymance	28 miles west of north of Calistoga	2,250	† 26	48–110	135	Do.
31	Lee Soda Spring	J. T. Lee, Lakeport	6 miles southwest of Lakeport	1,500	1	* 60	* 1	Unused.
22	Lyons Springs	Mrs. J. H. Lyons	6 miles north of Lakeport	1,350	1	60	5	Domestic.
	Mills Hot Springs. (Same as Castle Hot Springs.)							
1	Morton Soda Spring	Snow Mountain Water & Power Co.	38 miles north of Lakeport	* 2,000	1	* 60	* 1	Drinking.
8	Newman Springs	S. W. Young, Bartlett Springs.	45½ miles west of Williams	1,900	† 9	70–92	25	Bathing.

4	Paramore Spring	Mary Smith	42 miles east of north of Lakeport	* 2,000	1	* 60	* 1	Drinking.
	Pearson Springs. (Same as Saratoga Springs.)							
27	Quigley Soda Springs	R. V. S. Quigley	48 miles north of Calistoga	1,150	3	61–65	2	Drinking.
	Richardson Springs. (Same as Grizzly Springs.)							
6	Royal Spring	Martha E. Holloway	50 miles north of west of Williams	1,950	1	63	1½	Do.
18	Saratoga Springs	John Martens, Bachelor	22 miles north of east of Ukiah	1,400	12	48–55	3	Resort.
49	Seigler Springs	J. B. Spaulding estate	30 miles west of north of Calistoga	2,150	† 13	58–126	35	Do.
	Soap Creek Springs. (Same as Newman Springs.)							
36	Soda Bay Springs	Soda Bay Land Co.	5 miles northeast of Kelseyville	1,300	† 5	80–87	400	Do.
52	Spiers Springs	Joshua Spiers, Middletown	24 miles west of north of Calistoga	1,300	2	78, 84	15	Bottled.
48	Springs at base of Mount Hannah.		34 miles west of north of Calistoga	2,000	† 1	* 55	75	Irrigation.
28	Springs southwest of Chalk Mountain.	R. V. S. Quigley	48 miles north of Calistoga	1,200	† 1	* 60	100	Do.
	Sulphur springs—							
43	In Sulphur Valley	Laura J. Ogden	33 miles west of north of Calistoga	* 2,500	† 1	* 50	* 1	Drinking.
17	Near Blue Lakes	W. H. Kemp, Midlake	18 miles north of east of Ukiah	1,400	1	46	¼	Do.
	Sweetwater Spring. (See Spiers Springs.)							
	Tunnel Spring. (Same as Astorg Spring.)							
15	Witter Medical Springs	Witter Medical Springs Co., San Francisco.	20 miles north of east of Ukiah	1,450	5	50–56	b 4	Resort; bottled.
	LASSEN COUNTY.							
17	Amedee Hot Springs	Nevada-California-Oregon Ry. (in part).	Near Amedee depot	3,975	† 7	c 178–204	700	Bathing.
	Artesian springs—							
4	Near Bailey Creek		40 miles north of Susanville	* 5,300	† 1	* 70	* 25	Cattle watering.
13	Near head of Rush Creek.		15 miles east of Karlo	* 5,000	† 1	* 70	* 100	Do.
7	Near Smoke Creek		15 miles northeast of Karlo	* 5,500	† 1	* 70	* 100	Do.
14	Near south end of Eagle Lake.		12 miles northwest of Susanville	5,200	† 1	* 70	* 100	Do.
8	On east side of Horse Lake Valley.		10 miles northwest of Karlo	5,000	† 1	* 70	* 100	Do.
6	On south side of Shinns Peak.		10 miles east of north of Karlo	* 6,000	† 1	* 70	* 100	Do.
1	Bassett Hot Spring	J. B. White, Bieber	2½ miles north of east of Bieber	4,200	1	173	175	Bathing; irrigation.
	Bruebecks (Branbecks) Hot Springs. (Same as Shaffer Hot Springs.)							
18	Cabin Springs	W. M. P. Reed or E. C. Ambrose.	4½ miles southeast of Amedee	4,000	2	62	1	Roadside watering.

a No flow. b 1 gallon mineralized; 3 gallons nonmineralized. c Boiling.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	LASSEN COUNTY—contd.			*Feet.*		° *F.*	*Gallons a minute.*	
19	Highrock Spring	G. W. Mapes, Reno, Nev.	10 miles south of east of Amedee	4,100	1	86	525	Domestic; irrigation.
	Large cold springs—							
15	East of Rock Creek		10 miles east of north of Prattville	4,800	1	45	9,000	Unused.
3	Southeast of Pittville.	Geo. Guthrie, Pittville	3 miles southeast of Pittville	3,400	1	64	900	Domestic; irrigation.
12	Secret Springs		8½ miles east of Karlo	4,150	† 1	* 70	* 100	Cattle watering.
9	Sellicks Springs	A. W. Sellick, Secret	1¼ miles northwest of Karlo Station	4,100	† 1	72	1,050	Irrigation.
16	Shaffer Hot Springs	S. W. Ferguson, San Francisco.	¾ mile southwest of Hot Springs station.	3,975	3	*a* 160–204	250	Bathing.
11	Sheep Springs	Mr. Ward	9 miles northeast of Karlo	* 6,000	† 1	* 70	* 100	Cattle watering.
5	Spanish Spring	August Penning	15 miles east of north of Karlo	* 6,000	1	* 70	* 100	Irrigation.
2	Stonebreaker Hot Springs	Roy Richmond, Bieber	6 miles south of east of Bieber	4,200	9	110–165	125	Do.
10	Tipton Springs	Mrs. M. M. Tipton, Secret	4½ miles north of east of Karlo	4,100	† 1	70	900	Do.
	LOS ANGELES COUNTY.							
13	Aqua Vitæ Mineral Well.	J. C. Efroymson	In northeastern part of Los Angeles	400	*b* 1	* 70	(*c*)	Bottled.
11	Bimini Hot Spring	Bimini Water Co	In northern part of Los Angeles	350	*b* 1	104	100	Bathing; sanitarium; bottled.
8	Carbonated springs on Encino ranch.		14 miles northwest of Los Angeles	750	2	84	5	Irrigation; domestic.
	Fulton Wells. (Same as Santa Fe Springs.)							
2	Kentucky Springs	Santa Barbara National Forest	4 miles south of Vincent station	3,700	3	59	3	Cattle watering.
10	Radium Sulphur Spring.	G. P. Gehring, Colegrove	In northwestern part of Los Angeles	300	*b* 1	* 80	(*c*)	Sanitarium; bathing; bottled.
12	Rose Spring	R. F. Smith, Garvanza	In the eastern part of Los Angeles	300	1	70	10	Bottled.
14	Santa Fe Springs	Hannah Nicolai	1 mile southwest of Santa Fe Springs Station.	150	*b* 3	* 70	(*c*)	Domestic (formerly a resort and bottled).
	Sulphur springs—							
5	At mouth of Bell Canyon.	Mr. Bell	5 miles southwest of Chatsworth	950	1	70	* 1	Bathing.
3	In Santa Susana Mountains.		5 miles north of Chatsworth	* 2,000	1	* 60	* 1	Unused.
7	Near Carberry store		20 miles northwest of Los Angeles	1,000	1	70	1	Cattle watering.
4	North of Chatsworth		1½ miles north of Chatsworth	1,100	1	70	8	Drinking.
9	On Tucker ranch		10 miles northwest of Santa Monica	* 1,200	1	* 70	* 1	Domestic.
6	South of Bell Canyon.	Mrs. Leffingwell	7 miles southwest of Chatsworth	1,000	1	70	* 1	Cattle watering.
1	Warm springs in Elizabeth Lake Canyon.	Santa Barbara National Forest.	13 miles east of north of Castac Station.	2,100	† 1	* 100	* 5	Unused.

	MADERA COUNTY.							
	Carbonated springs—							
3	At head of Agnew Meadows.	Sierra National Forest	70 miles south of east of Yosemite	9,500	1	* 50	* ¼	Unused.
5	In Soda Spring Flat.	do	75 miles south of east of Yosemite	7,550	3	48–56	2	Drinking.
8	Near Breeze Lake	do	45 miles southeast of Yosemite	9,500	1	* 50	* 1	Unused.
1	Near Foerster Peak	do	65 miles south of east of Yosemite	11,000	1	* 50	* 1	Do.
4	Near Pumice Flat	do	75 miles south of east of Yosemite	7,850	1	52	¼	Drinking.
7	On East Fork Granite Creek.	do	40 miles southeast of Yosemite	8,900, 9,100	2	45, 60	¼	Do.
10	On Middle Fork San Joaquin River.	do	65 miles southeast of Yosemite	5,000	† 1	* 50	* 5	Unused.
2	On Minaret Creek	do	70 miles southeast of Yosemite	8,500	1	* 50	* 1	Do.
9	On North Fork San Joaquin River.	do	55 miles southeast of Yosemite	6,000	1	* 50	* 2	Drinking.
6	Reds Meadows Hot Springs.	do	65 miles southeast of Yosemite	7,700	5	90–120	10	Camping resort.
	MARIN COUNTY.							
1	El Toro Spring	Mrs. Bodkin, San Francisco.	2½ miles northwest of Novato	400	1	63	4	Domestic.
4	Purity Spring	Purity Spring Water Co	Near Sausalito	100	1	* 60	(c)	Municipal supply; bottled.
3	Rocky Point Spring	Saucelito Rancho	6 miles northwest of Point Bonita	d 0	1	* 100	* 5	Unused.
	San Rafael Spring. (Same as Tamalpais Mineral Well.)							
2	Tamalpais Mineral Well.	Borello Bros	In San Rafael	25	b 1	57	(c)	Bottled.
	MARIPOSA COUNTY.							
1	Black Spring	Yosemite National Park	4½ miles southwest of Yosemite	3,900	1	* 50	* 10	Roadside watering.
2	Fern Spring	do	5 miles southwest of Yosemite	3,875	1	* 50	* 10	Drinking.
4	Iron springs in Yosemite Valley.	do	2½ miles east of Yosemite	4,000	2	48	30	Do.
3	Moss Spring	do	5 miles southwest of Yosemite	3,875	1	* 50	* 10	Do.
	MENDOCINO COUNTY.							
30	Artesian spring near Hopland.	E. C. Horst Co	1 mile northwest of Hopland	450	1	62	5	Irrigation.
17	Baker Mineral Springs	T. A. Templeton, Venice	18 miles north of east of Willits	1,600	5	50–55	3	Camping resort.
5	Cantwell Soda Spring	Mrs. S. Pinches, Laytonville.	18 miles northwest of Sherwood	1,900	1	* 50	½	Drinking.
	Carbonated springs—							
25	At Hazel Hill	Mr. and Mrs. B. C. Van Zandt, Philo.	5 miles northwest of Boonville	500	3	* 50	* 1	Do.
22	At Shoemaker Dell	J. W. Shoemaker, Ukiah	6 miles northwest of Ukiah	2,200	† 5	* 50	* 5	Drinking (mountain resort).
13	At Travelers Home	Mrs. Frances White	12 miles northeast of Willits	* 2,000	1	* 50	* 1	Drinking.
9	In Big Basin	Irvine & Muir Lumber Co	15 miles west of Willits	* 1,500	1	* 50	* 1	Do.

a Boiling. b Wells. c Pumped. d At sea level.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	MENDOCINO COUNTY—continued.							
	Carbonated springs—Continued.			*Feet.*		° *F.*	*Gallons a minute.*	
26	Near Boonville		25 miles northwest of Cloverdale	* 1,200	1	* 50	* 1	Drinking.
28	Near Feliz Creek	W. H. Copple, Hopland	3 miles west of Hopland	625	2	54, 58	1	Do.
8	Near Long Valley Creek.	Llewellyn Springs Co. (in part).	7 miles north of Sherwood	* 1,500	† 5	* 50	* 5	Camping resort.
21	Near Wendling	Stearns Lumber Co., Wendling.	25 miles west of Ukiah	700	2	* 50	15	Drinking.
34	On Garcia River		24 miles northwest of Cloverdale	* 900	† 1	* 50	* 1	Unused.
29	On Russian River	Mr. Hewlett, San Francisco	2¼ miles north of Hopland	475	† 2	* 50	* 1	Do.
15	On Snider Ranch		10 miles northeast of Willits	* 1,500	1	* 50	* 1	Do.
16	On White Ranch	Mrs. White, Willits	do	* 1,500	1	* 50	* 1	Do.
19	Southwest of Willits		10 miles southwest of Willits	* 1,500	1	* 50	* 1	Do.
10	West of Willits	Irvine & Muir Lumber Co	7 miles west of Willits	* 2,000	1	* 50	* 1	Drinking.
31	Duncan Springs	Duncan Springs Hotel & Mineral Water Co.	2 miles west of south of Hopland	600, 800	2	53, 60	2½	Resort; bottled.
23	Gobbis Soda Spring	D. Gobbi, Ukiah	1 mile southwest of Ukiah	650	1	58	¼	Drinking.
	Humanity Springs. (Same as Carbonated springs on Russian River.)							
6	Jackson Valley Mineral Springs.	Mrs. A. M. Nolan	18 miles northwest of Sherwood	1,700	3	* 50	7	Camping resort; bottled.
7	Jackson Valley Mud Springs.	A. H. Petrie, Willits	19 miles northwest of Sherwood	1,975	† 1	55	20	Unused.
14	Kinsner Soda Spring	Mrs. J. M. Kinsner, Willits	11 miles northeast of Willits	1,700	1	47	¼	Bottled.
	Llewellyn Springs. (See Carbonated springs near Long Valley Creek.)							
32	McDowell Springs	McDowell Springs Co., San Francisco.	5 miles southeast of Hopland	7[illegible]0	3	45–53	1	Resort.
11	Muir Springs	A. J. Muir, Willits	4 miles northeast of Willits	1,350	*a* 2	47	5	Gas used for domestic heating and lighting.
35	Ornbauns Mineral Spring.	J. S. Ornbaun, Ornbaun	20 miles northwest of Cloverdale	1,150	1	53	½	Resort.
20	Orrs Hot Springs	J. L. Orr, Orrs	16 miles northwest of Ukiah	850	7	63–104	25	Do.
2	Petersons Mineral Spring.	Mark Peterson, Santa Rosa	12 miles northwest of Laytonville	1,625	1	* 43	½	Camping resort.

33	Point Arena Hot Springs	W. A. McCornic, East Oakland.	15 miles southeast of Point Arena	500	2	110, 112	4½	Resort.
18	Salmon Creek Mineral Springs.	Mrs. Z. V. Blalock, Eldridge.	12 miles south of east of Willits	* 1,500	2	* 50	* 5	Camping resort.
27	Singleys Soda Spring	John Singley, Boonville	14 miles southwest of Ukiah	* 1,500	1	* 50	* 1	Drinking.
	Sulphur springs—							
3	Near branch of Eel River.	Wm. Mitchell, Laytonville	12 miles northwest of Laytonville	1,650	1	50	1	Unused.
1	Near Cummings	F. A. Cummings, Cummings.	30 miles north of Sherwood	1,500	2	* 50	15	Drinking.
4	Near Laytonville	Samuel Pinches, Laytonville.	½ mile north of Laytonville	1,800	1	70	200	Bathing.
12	On branch of Deep Creek.		4 miles east of Willits	1,350	† 1	60	5	Unused.
24	Vichy Springs	J. A. Redemeyer, Ukiah	3 miles northeast of Ukiah	800	7	59–90	30	Resort.
	MODOC COUNTY.							
9	Artesian spring near Alturas.		1½ miles southeast of Alturas	4,450	1	72	1	Cattle watering.
2	Bottle Spring		25 miles northwest of Alturas	5,000	1	* 50	* 5	Do.
12	Boyd Spring	Lon Clark, Fort Bidwell	12 miles east of south of Fort Bidwell	4,550	1	67	2,000	Irrigation.
	Hot springs—							
13	At east border of Surprise Valley.	T. H. Johnstone, Cedarville.	12 miles northeast of Cedarville	4,675	4	170–182	80	Sheep dipping.
3	In Little Hot Spring Valley.	Arch Hollenbeak, Day	25 miles northwest of Bieber	3,800	2	127, 170	225	Irrigation.
15	Near east side of Middle Lake.	Peter Peterson, Cedarville	20 miles north of east of Eagleville	4,600	1	* 120	* 200	Do.
17	Near southwest side of Lower Lake.	B. F. Murphy, Eagleville	8 miles east of south of Eagleville	4,700	† 1	* 120	* 100	Do.
11	Near southwest side of Upper Lake.		12 miles north of Cedarville	4,600	† 1	* 120	* 5	Unused.
16	Near west side of Lower Lake.	G. F. Gill, Eagleville	5 miles east of south of Eagleville	4,750	† 5	117–125	425	Irrigation.
10	On Bidwell Creek	Mrs. M. A. W. Gee, Fort Bidwell.	1 mile west of north of Fort Bidwell	4,850	5	97–108	75	Domestic; bathing; irrigation.
14	On east side of Surprise Valley.	Peter Peterson, Cedarville	12 miles northeast of Cedarville	4,625	3	140–149	225	Irrigation.
6	On Hot Creek	Siskiyou County Bank, Yreka	9 miles west of Alturas	4,450	† 5	80–92	700	Bathing; irrigation.
4	Kellys Hot Spring	John Kelly, Canby	4 miles northeast of Canby	4,400	1	*b* 204	325	Domestic; irrigation.
1	Pothole Spring		35 miles northwest of Alturas	4,950	1	* 70	* 10	Unused.
	Warm springs—							
18	At south end of Surprise Valley.	Bare ranch	12 miles east of south of Eagleville	4,750	† 1	* 70	* 5	Do.
5	In Warm Spring Valley.	C. H. Essex, Alturas	15 miles west of Alturas	4,500	1	81	275	Domestic; irrigation.
7	Near Canyon Creek		15 miles southwest of Alturas	* 5,000	† 1	* 80	* 100	Do.
8	Near Rattlesnake Creek.		9 miles west of north of Alturas	5,000	† 1	* 80	* 10	Unused.

a 1 spring; 1 well. *b* Boiling.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	MONO COUNTY.			*Feet.*		° *F.*	*Gallons a minute.*	
20	Artesian springs at Oasis	J. H. Forman, Oasis	30 miles northeast of Alvord railroad station.	5,100	† 1	* 70	* 50	Irrigation.
18	Banner Spring	Inyo National Forest	11 miles west of south of Benton	7,300	1	50	3	Domestic.
12	Benton Hot Spring	Benton Mining Co., Benton.	300 yards northwest of Benton post office.	5,640	1	135	400	Irrigation.
10	Bertrand Ranch Springs		6 miles east of north of Benton	5,600	† 1	* 70	* 100	Do.
11	Black Lake Springs	Peter Gilhoed, Benton	2 miles north of west of Benton	6,425	† 25	50	(a)	Do.
13	Blind Spring		3 miles east of south of Benton	5,900	1	* 50	* 1	Unused.
2	Buckeye Hot Spring	Mono National Forest	5½ miles south of west of Bridgeport	6,950	1	140	25	Bathing.
16	Casa Diablo Hot Pool		43 miles northwest of Bishop	7,025	1	120–180	(b)	Unused.
15	Casa Diablo Hot Springs		45 miles northwest of Bishop	7,250	† 20	c 115–194	35	Bathing.
1	Fales Hot Springs	Samuel Fales, Bridgeport	13 miles northwest of Bridgeport	7,300	† 2	97–141	300	Resort.
	Hot springs—							
3	Near Bridgeport	California Travertine Co	1½ miles southeast of Bridgeport	6,700	3	121–148	10	Sheep dipping; bathing.
14	Northeast of Casa Diablo Hot Springs.	Inyo National Forest	50 miles northwest of Bishop	7,025	1	* 170	* 5	Unused.
7	On Paoha Island	Undeeded	In Mono Lake	6,425	† 1	146–176	* 100	Goatherds' camp.
8	Mono Basin Warm Springs.	do	At east edge of Mono Lake	6,425	† 1	80–90	10	Unused.
19	Moran Spring	Inyo National Forest	13 miles west of south of Benton	7,000	1	50	1	Domestic.
9	River Spring	A. Matlick, Bishop	10 miles west of north of Benton	6,480	† 1	* 60	* 100	Irrigation.
6	Sulphur spring on Paoha Island.	Undeeded	In Mono Lake	6,425	1	60	10	Oil drillers' water supply.
	Warm springs—							
5	Between Bridgeport and Bodie.	C. L. Hayes (in part)	5 and 7 miles southeast of Bridgeport.	7,400, 7,600	† 2	* 100	* 10	Cattle watering.
17	In Long Valley		38 miles northwest of Bishop	6,950	4	74–100	450	Unused.
4	Near Bridgeport	California Travertine Co	1½ miles east of south of Bridgeport	6,500	20	70–105	25	Unused.
	Whitmore Tub. (Same as Warm springs in Long Valley.)							
	MONTEREY COUNTY.							
7	Banes Soda Springs		65 miles northwest of San Luis Obispo.	* 100	† 1	* 60	* 5	Unused.
5	Dolans Hot Spring	Philip Dolan	70 miles east of south of Monterey	* 200	1	* 100	* 5	Do.
8	Helms Soda Springs		65 miles northwest of San Luis Obispo.	* 500	† 1	* 60	* 5	Do.
1	Hot springs on North Fork of Little Sur River.	J. and Annabel Brown, Salinas.	30 miles south of Monterey	200	† 2	103–114	10	Do.
2	Paraiso Hot Springs	H. H. McGowan, Paraiso	8 miles west of south of Soledad	1,200	5	65–111	10	Resort.

4	Slates Hot Springs	J. A. Little, Posts	63 miles east of south of Monterey	50	10	110–121	50	Bathing.
6	Sulphur spring on Mission Creek.	Milpitas Rancho	12 miles west of north of Jolon	* 1,500	1	* 60	* 5	Unused.
3	Tassajara Hot Springs	J. E. Quilty, San Jose	50 miles east of south of Salinas	1,700	† 17	100–140	100	Resort.
	NAPA COUNTY.							
2	Ætna Springs	L. D. Owen, Lidell	17 miles north of St. Helena	850	6	63–92	20	Resort; bottled.
4	Calistoga Hot Springs	Stanford University	⅛ mile east of Calistoga depot	360	4	126–173	8	Bathing.
14	Congress Spring	Jessie W. Hamilton, Napa	3½ miles southwest of Napa	150	1	62	½	Drinking.
5	Crystal Spring	St. Helena Sauitarium	3 miles north of St. Helena	550	1	55	7	Domestic.
6	Gaillaumes Soda Springs.	Pierre Gaillaume	12 miles northeast of St. Helena	* 1,200	† 2	* 50	* 1	Drinking.
12	Jacksons Napa Soda Springs.	Anna Jackson estate	7 miles north of Napa	750	4	60–62	2	Resort; bottled.
9	Napa Rock Soda Springs.	Mr. Myers, St. Helena	15 miles north of east of St. Helena	1,100	2	79	15	Bottled.
13	Napa Vichy Spring	John Lepori, Napa	3½ miles east of north of Napa	150	1	66	1	Do.
8	Phillips Soda Springs	Bank of Halfmoon Bay, Halfmoon Bay.	15 miles north of east of St. Helena	1,200	2	68, 76	10	Unused.
	Priest Soda Springs. (Same as Napa Rock Soda Springs.)							
10	St. Helena White Sulphur Springs.	John Sandford, St. Helena	2 miles southwest of St. Helena	450	5	59–83	6	Resort.
7	Samuel Soda Springs	W. E. Meagher, Monticello	22 miles northeast of St. Helena	850	6	50–63	15	Resort; bottled.
11	Springs at Veterans' Home.	Yountville Veterans' Home	2 miles southwest of Yountville	200, 300	2	55, 56	17	Domestic; irrigation.
3	Walters Mineral Springs	H. L. Connor, Pope Valley	16 miles east of north of St. Helena	1,050	2	65, 66	2	Do.
1	Zem Zem Spring		5 miles southeast of Knoxville	* 1,500	1	* 60	* 1	Drinking.
	NEVADA COUNTY.							
1	Sulphur spring on Bear River.	South Yuba Water Co., San Francisco.	3 miles north of Colfax	1,900	1	60	2	Unused.
	ORANGE COUNTY.							
1	Fairview Hot Spring	Mrs. S. G. Hiles, Fairview	7 miles southwest of Santa Ana	75	d 1	96	15	Resort; bottled.
2	San Juan Capistrano Hot Springs.	Santa Margarita Rancho	13 miles northeast of Capistrano	700	6	121–124	35	Resort.
	PLACER COUNTY.							
	Berkeley Soda Springs. (Same as Summit Soda Springs.)							
8	Brockway Hot Springs	F. B. Alverson, Brockway	10 miles northeast of Tahoe	6,225	† 3	120–137	* 50	Resort.
	Carbonated springs—							
11	Near mouth of Powderhorn Creek.	Tahoe National Forest	15 miles south of west of Tahoe	6,000	1	* 50	* 1	Unused.
3	Near Sereno Creek	do	3½ miles south of Soda Springs station	7,000	1	* 50	* 1	Drinking.

a Slight flows. b No summer overflow. c Boiling. d Well.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	PLACER COUNTY—contd.							
	Carnelian Springs. (Same as Brockway Hot Springs.)			*Feet.*		° *F.*	*Gallons a minute.*	
7	Deer Park Springs	Miss Katherine Chandler	7 miles west of Tahoe	6,500	4	46–50	1½	Resort.
6	Florence Spring	Mrs. A. C. Freeman	10 miles east of south of Soda Springs station.	6,250	1	52	5	Drinking.
4	Heath Soda Springs		10 miles south of Soda Springs station.	5,400	† 3	50–60	* 10	Do.
	Iron springs—							
1	Near Cisco	Miners Ditch Co	½ mile north of Cisco	5,650	1	43	8	Do.
12	Near Lake Tahoe	Mrs. Westhoff	1 mile northwest of McKinney	6,300	2	49, 50	1	Do.
9	Salt springs on North Fork of American River.		2 miles east of Colfax	1,200	† 1	* 50	1	Unused.
	Scott Springs. (Same as Deer Park Springs.)							
	Sulphur springs—							
2	Near South Fork Yuba River.	Miners Ditch Co. (?)	1 mile north of Cisco	5,700	2	* 50	* 1	Do.
10	On Middle Fork American River.	Tahoe National Forest	20 miles north of west of Tahoe	5,600	1	* 50	* 1	Do.
5	Summit Soda Springs	Timothy Hopkins	10 miles east of south of Soda Springs station.	6,100	5	44–65	5	Drinking.
	PLUMAS COUNTY.							
12	Arlington Springs	W. P. Boyden, Greenville	6½ miles east of south of Greenville	3,500	2	53	1½	Do.
	Bach Springs. (Same as Arlington Springs.)							
	Carbonated springs—							
2	In Hot Spring Valley.	A. Sifford, Susanville	70 miles northeast of Red Bluff	5,350	1	83	8	Do.
9	In Humbug Valley		Near Longville	4,300	1	* 60	* 1	Do.
10	On Chip Creek		20 miles south of west of Longville	* 4,000	* 1	* 60	* 1	Do.
13	On Indian Creek		12 miles north of Quincy	3,050–3,225	6	57–68	3	Do.
14	On Spanish Creek	Theodore Hoskinson, Quincy.	10 miles north of Quincy	3,300	2	62, 68	8	Do.
1	Devils Kitchen	A. Sifford, Susanville	72 miles northeast of Red Bluff	5,600	† 25	*a* 150–205	* 50	Unused.
4	Drake Hot Springs	do	70 miles northeast of Red Bluff	5,350	† 4	123–148	20	Resort.
11	Kruger Spring	Frank Kruger	1 mile east of Greenville	3,550	1	94	1	Bathing.
	Large cold springs—							
8	In Big Meadows	Great Western Power Co., San Francisco.	5 miles east of north of Prattville	4,400	† 3	46	29,000	Irrigation.

3	In Hot Spring Valley.	A. Sifford, Susanville	70 miles northeast of Red Bluff	5,400	† 10	* 40	1,500	Do.
7	On Branch of Rock Creek.	Sierra Lumber Co.	7 miles east of north of Prattville	4,500	† 3	46	1,000	Unused.
16	Marble Hot Wells	Marble Bros., Kettle	5 miles east of south of Beckwith	4,900	*b* 3	125–161	350	Domestic; bathing; irrigation.
15	McLear Sulphur Springs	G. S. McLear, Clio	5 miles southwest of Beckwith	4,600	8	48–86	140	Domestic; irrigation.
5	Tartarus Lake		69 miles northeast of Red Bluff	5,500	† 10	170–190	(*c*)	Unused.
6	The Geyser	Undeeded	66 miles northeast of Red Bluff	5,450	† 6	*a* 120–205	8	Do.
	RIVERSIDE COUNTY.							
	Agua Caliente Springs. (Same as Palm Springs.)							
16	Agua Dulce Springs	Toro Indian Reservation	7 miles south of Mecca	*d* 185	† 1	* 65	*100	Irrigation.
15	Alamo Bonito Springs	do	5 miles southwest of Mecca	*d* 190	† 1	* 65	* 100	Do.
2	Box Spring	Atchison, Topeka & Santa Fe Ry. Co.	7 miles southeast of Riverside	1,500	1	55	3	Domestic.
4	Bundys Elsinore Hot Spring.	Mrs. F. A. Amsbury, Elsinore.	⅛ mile north of Elsinore depot	1,230	*b* 1	118	(*e*)	Resort.
1	Console Spring	John Console, Colton	12 miles east of Riverside	2,000	1	64	7	Bottled.
22	Corn Springs	Undeeded	40 miles north of east of Salton		† 1	* 60	50	Prospectors' supply.
20	Cottonwood Springs	do	26 miles northeast of Mecca		† 1	* 60	* 5	Do.
18	Dos Palmas Springs		6 miles east of Salton	*d* 50	† 1	* 70	* 25	Do.
8	Eden Hot Springs	N. Black, Beaumont	9 miles southwest of Beaumont	1,700	8	90–110	30	Resort; bottled.
5	Elsinore Hot Springs	C. N. Gardner, Elsinore	50 yards northwest of Elsinore depot	1,225	*b* 3	125	(*e*)	Resort.
17	Figtree Johns Springs	Toro Indian Reservation	10 miles south of Mecca	*d* 200	† 1	* 60	* 10	Irrigation.
3	Glen Ivy Hot Springs	Glen Ivy Hot Springs Co., Los Angeles.	11 miles east of south of Corona	1,225	† 1	102	15	Resort.
13	Magnesia Spring	Undeeded	15 miles west of Indio	500	1	* 60	* 1	Unused.
21	Mill Camp Springs	do	30 miles east of Salton		† 1	* 55	* 5	Prospectors' supply.
23	Mule Springs	do	10 miles northwest of Palo Verde	*1,000	† 1	* 55	* 5	Roadside watering.
6	Murrieta Hot Springs	Fritz Gunther, Los Angeles	4 miles north of east of Murrieta	1,200	† 3	134–136	* 75	Resort.
19	Orocopia Springs	Orocopia Mining Co.	6½ miles east of Salton	*d* 50	† 1	* 60	* 10	Mining supply.
12	Palmdale Springs		8½ miles south of Palm Springs station	450	† 1	* 60	* 50	Irrigation.
11	Palm Springs	Agua Caliente Indian Reservation.	6 miles south of Palm Springs station	500	2	* 100	* 5	Bathing.
7	Pilares Hot Spring	M. Bernasconi, Perris	8 miles northeast of Perris	1,450	1	* 100	* 3	Do.
	Relief Hot Springs. (Same as San Jacinto Hot Springs.)							
10	Ritchey Hot Springs	J. T. Ritchey, San Jacinto	2½ miles northeast of San Jacinto	1,700	6	70–111	25	Resort; bottled.
9	San Jacinto Hot Springs	S. J. Branch, Riverside	6 miles northwest of San Jacinto	1,550	6	83–116	20	Resort.
	Temescal Hot Spring. (Same as Glen Ivy Hot Springs.)							
14	Toro Springs	Toro Indian Reservation	9 miles south of Indio	*d* 115	† 1	* 65	* 100	Irrigation.

a Boiling. *b* Wells. *c* No summer overflow. *d* Below sea level. *e* Pumped.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908-1910.
	SAN BENITO COUNTY.			*Feet.*		° *F.*	*Gallons a minute.*	
1	San Benito Mineral Well	A. F. Anderson, Tres Pinos	4 miles southeast of Hollister	50	*a* 1	75	(*b*)	Domestic; bottled.
	SAN BERNARDINO COUNTY.							
36	Arrowhead Hot Springs.	Arrowhead Hot Springs Co.	7 miles east of north of San Bernardino.	2,000	† 2	110-187	* 50	Resort; bottled (from cool spring near by).
11	Bitter Spring	Undeeded	47 miles northeast of Daggett		1	* 55	* 1	Roadside watering.
28	Box S Spring	Box S ranch	30 miles southeast of Victorville	3,550	1	62	1	Do.
30	Cactus Flat Spring	J. C. Johnson, Victorville	35 miles southeast of Victorville	5,725	1	56	2	Domestic.
6	Cave Springs	Undeeded	30 miles southwest of Sperry railroad station.	3,675	2	* 60	(*c*)	Roadside watering.
26	Cottonwood Spring	C. F. Martin and A. Swarthout, San Bernardino.	40 miles south of east of Victorville	3,150	1	62	3	Domestic; irrigation.
29	Cushenbury Spring	John McFee, Victorville	32 miles southeast of Victorville	4,040	1	70	3	Domestic; roadside watering.
13	Dante Springs	Undeeded	3 miles east of Berry railroad station		† 1	* 55	* 1	Roadside watering.
41	Deadmans Holes	do	85 miles south of east from Victorville		† 1	* 55	(*c*)	Do.
10	Garlic Spring	do	35 miles northeast of Daggett	2,455	1	* 55	* 1	Do.
14	Halloran Springs	do	15 miles east of Berry railroad station	3,270	† 1	* 55	* 1	Do.
37	Harlem Hot Spring	B. J. Cloes, San Bernardino	5 miles north of east of San Bernardino.	1,150	*a* 1	120	(*b*)	Bathing; recreation grounds.
15	Kessler Springs	Undeeded	6 miles northwest of Cima station	5,500	† 1	* 55	* 1	Roadside watering.
19	Klinefelter Springs		Near Klinefelter station	1,425	† 5	* 55	* 50	Railroad water supply.
7	Leachs Springs	Undeeded	49 miles southwest of Sperry railroad station.	3,500	† 1	* 55	* 1	Roadside watering.
23	Le Conte Spring	do	22 miles southwest of Newberry station		1	* 55	* 1	Do.
1	Lone Willow Spring	do	27 miles east of south of Ballarat		1	* 55	* 1	Do.
42	Mesquite Spring	do	92 miles southeast of Victorville		1	* 55	* 1	Do.
32	Monte Cristo Spring	Rex Mining Co	40 miles southeast of Victorville	7,200	1	49	1	Domestic.
20	Newberry Spring	Southern Pacific R. R. Co.	600 yards south of Newberry station	1,900	1	77	*b* 175	Railroad supply.
27	Old Woman Springs	C. F. Martin and A. Swarthout, San Bernardino.	40 miles south of east of Victorville	3,190	2	68, 71	150	Domestic; irrigation.
22	Ord Spring	Undeeded	18 miles south of Daggett		1	* 55	* 1	Roadside watering.
5	Owl Springs	do	32 miles southwest of Sperry railroad station.	1,790	† 1	* 55	* 1	Do.
9	Paradise Springs	do	25 miles north of Daggett	2,500	4	85-102	25	Prospectors' supply.
24	Peacock Spring	do	10 miles south of Lavic station		1	* 55	* 1	Roadside watering.
17	Piute Spring	do	15 miles north of Goffs station	2,000	1	* 55	* 1	Prospectors' supply.
25	Rabbit Springs		25 miles south of east of Victorville	2,880	2	62	2	Cattle watering; roadside watering.
16	Rock Springs	Undeeded	15 miles south of east of Cima railroad station.	3,750	† 1	* 55	* 1	Roadside watering.

4	Salt Spring	do	5 miles southwest of Dumont station	* 300	1	* 55	* 1	Unused.
31	Saragossa Spring	C. L. Metzgar, Victorville	38 miles southeast of Victorville	7,500	1	54	1	Domestic.
3	Saratoga Springs	Undeeded	15 miles west of Sperry railroad station	360	4	82	125	Prospectors' supply.
8	Springs at Summit Diggings.	do	6 miles north of Randsburg	3,200	† 1	* 60	* 5	Prospectors' supply.
21	Springs northeast of Victorville.	do	14 miles northeast of Victorville	2,700	1	* 55	* 10	Unused.
43	Sulphur springs near Bullion Mountains.	do	95 miles southeast of Victorville		† 2	* 60	* 1	Prospectors' supply.
40	Surprise Spring	do	80 miles south of east from Victorville		1	* 55	* 1	Roadside watering.
12	Tomaso Springs	do	12 miles south of west of Silver Lake		† 1	* 55	* 1	Do.
44	Twenty-nine Palms Springs.		45 miles east of north of Indio		† 1	* 60	* 25	Do.
	Tylers Bath. (Same as Warm Springs in Lytle Canyon.)							
38	Urbita Hot Springs	San Bernardino Valley Traction Co.	1 mile south of San Bernardino	1,000	a 6	80–106	* 250	Bathing; recreation park.
2	Valley Spring	Undeeded	23 miles north of west of Sperry station	* 250	1	* 55	* 5	Unused.
18	Vontrigger Spring	do	2 miles north of Vontrigger	3,600	1	* 55	* 1	Roadside watering.
	Warm springs—							
33	At Baldwin Lake	E. J. Baldwin estate	40 miles southeast of Victorville	6,675	1	88	* 5	Bathing.
34	In Lytle Canyon	Undeeded	15 miles northwest of San Bernardino	2,800	1	92	* 5	Unused.
39	Warrens Ranch Springs		28 miles northeast of Banning	2,500	† 1	* 55	* 10	Irrigation.
35	Waterman Hot Springs		6½ miles east of north of San Bernardino	1,850	1	123	5	Bathing.
	SAN DIEGO COUNTY.							
9	Agua Caliente Springs		37 miles southeast of Julian	1,500	† 1	* 70	* 20	Roadside watering.
2	Agua Tibia Springs	Mrs. S. M. Utt, San Diego	30 miles northeast of Oceanside	1,200	1	92	10	Bathing; irrigation.
	Baldhead Spring. (Same as Isham Spring.)							
7	Bradley Spring	F. W. Bradley, San Diego	30 miles northeast of San Diego	1,775	1	55	1	Bottled.
6	Borego Spring		33 miles northeast of Julian	450	1	* 55	* 1	Roadside watering.
17	Buckman Springs	Mrs. Winnie Casbere, Campo	60 miles east of San Diego	3,400	6	60–65	5	Bottled.
11	Carrizo Springs		51 miles southeast of Julian	450	† 1	* 55	* 1	Roadside watering.
5	Corona Spring	Corona Springs Co	58 miles northeast of San Diego	2,850	1	62	30	Bottled.
3	Davis Spring	E. H. Davis, Mesa Grande	48 miles northeast of Oceanside	4,850	1	54	35	Camping resort.
1	Deluz Warm Springs	Mrs. Wm. Regan, Fallbrook	20 miles east of north of Oceanside	350	3	84–88	5	Do.
13	El Granito Spring	W. H. Fisher, El Cajon	18 miles northeast of San Diego	500	1	62	3	Bottled.
	Indian Spring. (Same as La Mesa Spring.)							
15	Isham Spring	A. H. Isham, San Diego	15 miles north of east of San Diego	450	1	69	12	Do.
19	Jacumba Springs	Archibald Campbell	80 miles south of east of San Diego	2,825	2	94, 96	15	Bathing; irrigation.
12	Lakeside Mineral Wells	Col. J. H. Gay, San Diego	22 miles northeast of San Diego	400	a 3	* 70	(b)	Drinking.
14	La Mesa Spring	D. C. Collier, San Diego	11 miles northeast of San Diego	500	1	*55	1	Do.

a Wells. b Pumped. c No flow.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	SAN DIEGO COUNTY—continued.							
	Las Aguas Calientes. (Same as Warner Hot Springs.)			*Feet.*		° *F.*	*Gallons a minute.*	
10	Mason Ranch Springs		45 miles southeast of Julian	* 1,000	† 1	* 55	* 5	Domestic; roadside watering.
18	Mountain Spring	Undeeded	85 miles east of San Diego	2,300	1	* 55	* 1	Roadside watering.
16	Nuvida Spring		23 miles north of east of San Diego	500	1	* 55	* 5	Bottled.
8	Vallecito Springs	Undeeded	33 miles southeast of Julian	1,600	† 1	* 55	* 5	Roadside watering.
4	Warner Hot Springs	Vale estate	65 miles northeast of San Diego	3,150	6	131–139	150	Resort.
	SAN LUIS OBISPO COUNTY.							
	Bitterwater Spring. (Same as Sulphur spring in Carrizo Plain.)							
5	Cameta Warm Spring	D. O. Mills, San Luis Obispo.	30 miles southeast of Paso Robles	1,500	1	74	3	Bathing.
4	Huer Huero Springs	E. H. Ashwood	13 and 15 miles southeast of Paso Robles	1,250, 1,300	2	59, 62	3	Camping resort.
10	Kessler Springs	Anthony Kessler estate	20 miles northeast of Arroyo Grande	1,700–1,800	† 10	60	1	Unused.
9	Newsoms Arroyo Grande Warm Spring.	Newsom estate	2½ miles east of Arroyo Grande	250	1	98	15	Resort.
2	Paso Robles Hot Springs.	Paso Robles Hotel Co	In southwest portion of Paso Robles	725	*a* 1	105	* 1,700	Do.
1	Paso Robles Mud Bath Springs.	do	2½ miles north of Paso Robles	700	† 3	55–118	* 100	Bathing; bottled
7	Pecho Warm Springs		15 miles southwest of San Luis Obispo.	300	2	72, 95	17	Drinking; bathing.
11	Salt springs near Kessler onyx marble quarry.	Anthony Kessler estate	20 miles northeast of Arroyo Grande	1,700–1,800	† 6	* 60	* 1	Unused.
8	San Luis Hot Spring	L. E. Mittendorf	8 miles west of south of San Luis Obispo	35	*a* 1	107	* 50	Resort.
3	Santa Ysabel Springs	Santa Ysabel Hot Springs Land and Water Co.	4 miles southeast of Paso Robles	775	2	94	150	Bathing; irrigation.
12	Sulphur spring in Carrizo Plain.		18 miles southwest of McKittrick	2,400	1	62	3	Cattle watering.
	Sycamore Springs. (Same as San Luis Hot Springs.)							
6	Thompson Spring		30 miles north of west of McKittrick	2,050	1	62	2	Do.

	SANTA BARBARA COUNTY.							
4	Bythinia Springs	Hope ranch	4½ miles west of Santa Barbara	300–400	† 3	* 55	* 1	Bottled.
	Cuyama Hot Springs. (Same as San Marcos Hot Springs.)							
1	Las Cruces Hot Springs	W. W. Hollister estate	4 miles north of Gaviota station	700	4	67–97	50	Bathing.
7	Montecito Hot Springs	S. P. Calef	6 miles northeast of Santa Barbara	1,400	11	111–118	50	Resort; part of water supply of Montecito.
	Mountain Glen Springs. (Same as San Marcos Hot Springs.)							
2	San Marcos Hot Springs	Ira W. Pierce Co	20 miles northwest of Santa Barbara	1,250	6	89–108	45	Camping resort.
	Santa Barbara Hot Springs. (Same as Montecito Hot Springs)							
5	Santa Barbara Springs	S. C. and Fred Pinkham, Santa Barbara.	2 miles west of Santa Barbara	150	† 6	* 55	* 1	Bottled.
6	Sulphur springs on Burton Mound.	Potter Hotel Co	In grounds of Potter Hotel, Santa Barbara.	20	† 1	60	* 2	Drinking; irrigation.
3	Veronica Springs	Hawley Bros., Santa Barbara.	4 miles west of Santa Barbara	50–150	† 12	* 55	* 2	Bottled.
	SANTA CLARA COUNTY.							
3	Alum Rock Park Springs	City of San Jose	7 miles northeast of San Jose	500	17	62–87	15	Drinking; bathing (city park).
4	Azule Mineral Spring	L. A. Spitzer, San Jose	12 miles southwest of San Jose	750	1	60	¼	Drinking; bathing.
1	Banta Spring		24 miles southeast of Livermore	3,700	1	* 55	* 5	Drinking.
12	Blodgett Magic Spring	Whitehurst estate, Gilroy	7 miles north of west of Gilroy	600	1	54	2	Camping resort.
10	Blodgett Mineral Spring	C. F. Bolfing, Gilroy	12 miles northwest of Gilroy	800	1	68	1	Domestic.
7	Coes Spring	Harry Coe, Madrone	13 miles north of east of Madrone station.	1,800	1	63	1½	Cattle watering.
5	Congress Springs	Peninsular R. R. Co	12 miles southwest of San Jose	800	2	60	1½	Drinking (picnic grounds).
9	Gilroy Hot Spring	G. B. Roop, San Jose	14 miles northeast of Gilroy	1,200	1	110	15	Resort; bottled.
2	Grant Spring	J. D. Grant	12 miles northeast of San Jose	* 1,500	1	* 50	* 1	Bottled.
6	Hillydale Sulphur Spring	A. M. Williams, San Francisco.	20 miles east of south of San Jose	1,150	1	56	½	Drinking.
8	Madrone Spring	J. D. Arnold et al., Madrone.	14 miles north of east of Madrone station.	1,500	1	59	1	Resort.
	Mills Seltzer Spring. (Same as Azule Mineral Spring.)							
	New Almaden Vichy Spring. (See Azule Mineral Spring.)							
	Pacific Congress Springs. (Same as Congress Springs.)							
11	Sulphur spring on Bodfish Creek.[a]		7¼ miles north of west of Gilroy	625	1	55	1	Drinking.

[a] Well.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	SANTA CRUZ COUNTY.			*Feet.*		° *F.*	*Gallons a minute.*	
3	El Pajaro Springs	T. Chittenden, Chittenden	½ mile northwest of Chittenden station	100	12	60–62	5	Drinking.
2	Hinns Sulphur Spring		15 miles northeast of Santa Cruz	2,000	1	* 55	* 1	Do.
	Nicholas Springs. (See Olive Spring.)							
1	Olive Spring		do	1,300	1	* 55	* 1	Do.
	SHASTA COUNTY.							
8	Big Bend Hot Springs	Mrs. M. E. Estill and Mrs. L. E. Hull, Henderson.	63 miles northeast of Redding	1,800	† 6	100–180	90	Resort.
	Bumpass Hell. (Same as Bumpass Hot Springs.)							
16	Bumpass Hot Springs	Lassen National Forest	60 miles northeast of Red Bluff	7,700, 7,800	† 25	(a)	* 100	Unused.
	Carbonated springs—							
5	Near Castle Creek		6 miles west of south of Dunsmuir	1,950	1	54	1	Drinking.
14	North of Soupan Hot Springs.	Milton Soupan	54 miles northeast of Red Bluff	8,000	† 1	* 60	* 1	Unused.
3	On Soda Creek		6½ miles east of south of Dunsmuir	2,300	1	48	¼	Drinking.
2	Castle Crag Spring	Pacific Improvement Co.	5 miles south of Dunsmuir	2,100	1	51	2	Do.
4	Castle Rock Springs	Castle Rock Springs Co.	5 miles west of south of Dunsmuir	1,975	3	55	* 5	Bottled.
12	Great Springs	V. W. Stevenson and Lassen National Forest.	75 miles northeast of Red Bluff	4,500	† 10	46	126,000	Irrigation.
	Hibbs Soda Spring. (Same as Castle Rock Springs.)							
7	Hot springs on Kosk Creek.		65 miles northeast of Redding	2,000	† 2	* 100	* 5	Unused.
	Large cold springs—							
6	At head of Fall River	Opdyke and Kirk	56 miles south of east of Sisson	3,400	† 5	47–54	675,000	Irrigation.
9	On Burney Creek		78 miles northeast of Redding	2,800	† 1	* 50	* 1,000	Unused.
	Lower Soda Spring. (Same as Castle Crag Spring.)							
11	Rising River	G. D. Hobson, H. L. Moody, and W. H. Berg.	76 miles northeast of Redding	3,200	† 1	58	112,500	Irrigation; domestic.
13	Rock Creek Springs	Northern California Power Co.	55 miles northeast of Red Bluff	5,000	† 1	* 50	4,950	Electric power generation.
15	Soupan Hot Springs	Milton Soupan	53 miles northeast of Red Bluff	8,000	† 10	* 175	* 5	Unused.

	Sulphur springs—							
1	On Castle Creek		10 miles southwest of Dunsmuir	2,500	† 1	* 50	* 2	Do.
10	Southeast of Carbon.		82 miles northeast of Redding	3,000	1	* 60	¼	Do.
	SIERRA COUNTY.							
1	Campbell Hot Springs	H. Pearce, Sierraville	2 miles southeast of Sierraville	5,000	11	65–111	80	Resort.
2	Cool springs at Campbell Hot Springs.	do	do	5,000	2	50	2	Domestic.
	SISKIYOU COUNTY.							
13	Artesian springs in Shasta Valley.		13 miles southeast of Montague	2,750	† 2	* 60	* 500	Irrigation.
	Campbell Springs. (Same as Upper Soda Springs.)							
	Carbonated springs—							
4	At edge of Beaver Creek.	Barton Mining Co	26 miles northwest of Yreka	1,950	1	48	¼	Drinking.
8	At edge of Little Shasta River.		10 miles east of Montague	2,800	1	57	8	Do.
3	At Soda Bar	Klamath National Forest	38 miles northwest of Yreka	3,400	2	* 55	* 1	Unused.
5	Near Little Bogus Creek.	Mr. White, Bogus	4½ miles northeast of Ager	2,500	8	54–76	6	Cattle watering.
19	Castle Springs		¼ mile north of west of Shasta Springs station.	2,500	4	42–50	5	Drinking.
25	Cave Spring		1¼ miles west of north of Dunsmuir	2,275	1	50	2	Do.
	Cinnabar Springs. (Same as Garretson Soda Springs.)							
	Freys Soda Spring. (Same as Upper Soda Spring.)							
1	Garretson Soda Springs.	Job Garretson, Gottville	40 miles northwest of Yreka	3,300	2	46,48	2	Camping resort
21	Glacier Spring	Pacific Improvement Co	⅓ mile northeast of Shasta Springs station.	2,850	1	45	* 40	Drinking.
14	Hot springs on Mount Shasta.	Shasta National Forest	11 miles northeast of Sisson	* 14,000	† 2	* 150	* 5	Unused.
2	Keller Soda Spring	Alex. Keller, Gottville	35 miles northwest of Yreka	2,600	1	53	2	Drinking.
20	Keystone Spring	Pacific Improvement Co	½ mile northeast of Shasta Springs station.	2,900	1	* 50	* 10	Domestic.
7	Klamath Hot Springs	Mrs. B. D. Edson, Beswick	20 miles northeast of Ager	2,650	7	100–152	25	Resort.
	Large cold springs—							
16	At head of Mud Creek.	Shasta National Forest	6 miles north of McCloud	* 7,000	† 1	* 45	* 200	Unused.
12	East of Montague	Mrs. M. F. Martin, Little Shasta.	12 miles east of Montague	2,900	1	48	2,700	Irrigation.
10	Near Little Shasta River.	Terwilliger estate	13 miles north of east of Montague	3,000	† 1	48	6,300	Do.

a Boiling.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	SISKIYOU COUNTY—con.							
	Large cold springs—Con.			*Feet.*		° *F.*	*Gallons a minute.*	
6	Northeast of Ager	W. K. McClintock, Bogus	9 miles northeast of Ager	2,650	† 1	47	1,400	Domestic; irrigation.
17	North of Sisson		1 mile north of Sisson	3,600	2	45,49	12,000	Irrigation.
15	On east slope of Mount Shasta.	Shasta National Forest	10 miles north of McCloud	* 7,000	† 1	* 45	* 200	Unused.
27	South of McCloud	McCloud Lumber Co	1½ miles south of McCloud	3,050	1	45	100	Do.
11	Martin Soda Spring	Mrs. M. F. Martin, Little Shasta.	12 miles east of Montague	2,900	1	55	1	Drinking.
18	Neys Springs	John Ney, Sisson	5 miles west of south of Sisson	3,100	3	*a* 45,47; *b* 48,55	5	Resort.
23	Oxone Spring	Pacific Improvement Co	1 mile south of east of Shasta Springs station.	2,925	1	47	5	Drinking.
	Poison Spring. (Same as Oxone Spring.)							
	Scott Spring (Same as Oxone Spring.)							
22	Shasta Springs	Mount Shasta Mineral Spring Co.	At Shasta Springs station	2,500	† 1	49	* 5	Resort; bottled.
	Shovel Creek Springs. (Same as Klamath Hot Springs.)							
9	Table Rock Spring	Terwilliger estate	12 miles north of east of Montague	2,950	1	65	8	Bottled.
24	Twin Springs		1¼ miles west of north of Dunsmuir	2,300	2	51	8	Drinking.
26	Upper Soda Spring	John Masson, Dunsmuir	¾ mile north of Dunsmuir	2,350	1	51	3½	Resort; bottled.
	Vesper Spring. (Same as Cave Spring.)							
28	Warmcastle Soda Springs.	McCloud Lumber Co	1¾ miles east of south of McCloud	3,050	4	45–48	15	Drinking.
	SOLANO COUNTY.							
1	Tolenas Springs	Tolenas Springs Co	6 miles north of Fairfield	725	1	57	1	Bottled.
2	Vallejo White Sulphur Spring.	J. B. Frisbie	4 miles northeast of Vallejo	400	1	68	15	Resort; bottled.
	SONOMA COUNTY.							
18	Agua Caliente Springs	Theodor Richards, Agua Caliente.	3 miles northwest of Sonoma	125	*c* 5	97–115	* 10	Do.

2	Alder Glen Springs	J. A. Serres, Cloverdale	miles northwest of Cloverdale	500	4	53–56	½	Do.
	Aqua Rica Springs. (Same as Agua Caliente Springs.)							
20	Boyes Hot Springs	Boyes Hot Springs Co	2 miles northwest of Sonoma	100	c 3	114–118	d 3	Do.
7	Carbonated spring near Little Sulphur Creek.	Nelson and Olsen ranch	3 miles north of Geyserville	400	1	* 55	1	Drinking.
	Eleda Hot Springs. (Same as Fetters Hot Springs.)							
	Fairmount Hot Springs. (Probably same as Hoods Hot Springs.)							
19	Fetters Hot Springs	Fetters Hot Springs Co	2¾ miles northwest of Sonoma	125	c 4	* 100	(e)	Resort.
	Geyser Spa Springs. (Same) as Lytton Springs.)							
	Geysers, The. (See The Geysers.)							
1	Hoods Hot Springs	O. R. Baldwin, Cloverdale.	15 miles north of west of Cloverdale	* 600	† 2	* 100	* 5	Bathing.
	Kawana Sulphur Spring. (Same as Taylor Sulphur Spring.)							
5	Little Geysers	Mr. McDonnell	22 miles south of east of Cloverdale	1,900	† 10	110–160	8	Camping resort.
15	Los Guilicos Warm Springs.		3½ miles southwest of Glen Ellen	350	2	78, 82	5	Resort.
9	Lytton Springs	Golden Gate Orphanage	½ mile west of Lytton station	275	2	56	¾	Drinking; bottled.
11	Mark West Warm Springs.	J. F. Mulgrew, Fulton	7 miles northeast of Fulton	500	9	60–82	30	Resort.
17	O'Donnells Springs	C. C. O'Donnell, Glen Ellen.	In north edge of Glen Ellen	* 300	2	* 60	* 5	Resort.
21	Ohms Spring	Mrs. F. Shirley, Sonoma	2 miles northwest of Sonoma	100	c 1	* 80	(e)	Do.
8	Skaggs Hot Springs	Skaggs estate	9 miles south of west of Geyserville	300	3	120–135	15	Do.
	Sulphur springs—							
12	In Franz Valley		5 miles west of Calistoga	* 1,000	2	* 60	* 2	Drinking.
6	Near Little Sulphur Creek.	J. T. Harlan, Geyserville	6 miles northeast of Geyserville	1,500	1	* 60	* 1	Do.
3	Near Sulphur Creek.		3 miles northeast of Cloverdale	600	1	* 60	1	Do.
13	Taylor Sulphur Spring	J. S. Taylor, Santa Rosa	2 miles southeast of Santa Rosa	300	1	60	1	Resort.
4	The Geysers	H. A. Powell, Oakland	18 miles south of east of Cloverdale	1,400–1,500	† 24	f 68–205	* 25	Resort; bottled
10	Wall Springs	H. C. Wall	14 miles northwest of Santa Rosa	175	5	49–63	3	Resort.
	Warm springs—							
16	Of State Home at Eldridge.	Eldridge State Home	6 miles west of north of Sonoma	250	1	72	10	Irrigation.
14	On McEwan ranch.		3 miles southwest of Kenwood	500	† 1	* 80	* 50	Do.
	STANISLAUS COUNTY.							
	Sulphur springs—							
1	On Crow Creek		10 miles west of Newman	125	1	* 60	* 1	Unused.
2	On Orestimba Creek		15 miles southwest of Newman	150	2	* 60	* 2	Do.

a Winter. b Summer. c Wells. d Also pumped. e Pumped. f Boiling.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908–1910.
	TEHAMA COUNTY.			*Feet.*		° *F.*	*Gallons a minute.*	
1	Big Clipper Springs	Northern California Power Co.	50 miles northeast of Red Bluff	4,000	† 1	* 50	2,250	Electric power generation.
10	Colyear Springs	J. A. Owen, Red Bluff	35 miles south of west of Red Bluff	3,300	7	52–55	10	Camping resort.
7	Geary Spring	Smith Crowder, Red Bluff	17 miles south of east of Red Bluff	1,075	1	66	5	Roadside watering.
9	Hensley Spring	Mary H. Braynard, Red Bluff.	38 miles south of west of Red Bluff	2,850	1	57	8	Unused.
4	Large cold springs on Gerber Ranch.	W. E. Gerber	20 miles northeast of Red Bluff	1,100	† 1	* 50	* 500	Irrigation.
	Lick Springs. (Same as Tuscan Springs.)							
2	Morgan Hot Springs	Morgan estate	53 miles northeast of Red Bluff	4,800	26	90–200	85	Camping resort.
6	Mud Spring	L. L. McCoy, Red Bluff	13 miles north of east of Red Bluff	1,075	1	62	½	Roadside watering.
	Poison and Kid Springs. (Same as Salt springs on North Fork of Elder Creek.)							
11	Salt springs on North Fork of Elder Creek.	Richard Owen, Palo Alto	32 miles southwest of Red Bluff	1,500	† 3	* 55	* 1	Unused.
	Sulphur springs—							
3	Near head of Battle Creek Meadows.	A. L. Conard, Red Bluff	47 miles northeast of Red Bluff	4,850	1	49	10	Drinking.
8	On South Fork of Cottonwood Creek.		45 miles west of Red Bluff	* 3,000	1	* 50	* 1	Unused.
5	Tuscan Springs	E. B. Walbridge, Red Bluff.	10 miles northeast of Red Bluff	700	† 20	55	20	Resort.
	TRINITY COUNTY.							
	Coumbs Springs. (Same as Deerlick Springs.)							
3	Deerlick Springs	Russell T. Joy	28 miles south of Weaverville	3,000	5	50–52	8	Camping resort, bottled.
1	Salt springs on Stewarts Fork of Trinity River.	Trinity National Forest	65 miles northwest of Redding	* 4,000	† 1	* 50	* 5	Unused.
	Sulphur springs—							
4	Near Hoaglin	W. P. White, Hoaglin	85 miles west of south of Weaverville		1	* 50	*5	Do.
2	On Browns Creek	Trinity National Forest	27 miles south of Weaverville	2,800–2,900	† 4	50	2	Do.
	TULARE COUNTY.							
18	California Hot Springs	California Hot Springs Co	35 miles southeast of Portersville	3,200	7	105–126	50	Resort.
	Carbonated springs—							
14	In Lloyd Meadows	Sequoia National Forest	42 miles northeast of Portersville	5,600	† 1	* 55	* 3	Drinking.

8	In Monache Meadows.	Kern National Forest	14 miles southwest of Olancha	8,000	† 1	* 100	* 2	Do.
1	In Upper Funston Meadow.	Sequoia National Forest	69 miles east of north of Portersville	10,700	† 1	* 55	* 1	Do.
5	Near Mountaineer Creek.	...do	43 miles northeast of Portersville	6,100	1	* 55	* 1	Unused.
3	Near North Fork of Kern River.	...do	58 miles northeast of Portersville	6,425	1	51	6	Drinking.
2	Near Quinn Horse-camp.	...do	71 miles east of north of Portersville	9,000	1	* 55	* 5	Do.
10	On Middle Fork of Tule River.	...do	24 miles north of east of Portersville	2,200	1	66	¾	Do.
12	On Soda Creek	...do	29 miles north of east of Portersville	3,800	1	61	25	Do.
11	On South Fork of Middle Fork of Tule River.	...do	27½ miles north of east of Portersville	3,200	1	77	25	Do.
9	Coburn Soda Spring	A. M. Coburn, Springville	At Springville	1,000	1	68	1¾	Do.
	Deer Creek Hot Springs. (Same as California Hot Springs.)							
4	Doyle Soda Springs	San Joaquin Light & Power Co.	31 miles northeast of Portersville	4,075	3	52–54	8	Camping resort.
16	Fountain Spring	S. A. Crookshanks	15 miles east of south of Portersville	* 700	1	* 55	* 5	Domestic.
7	Jordan Hot Springs	Kern National Forest	65 miles north of Kernville	6,500	14	95–123	75	Camping resort.
	Little Yosemite Soda Spring. (Same as Carbonated spring near North Fork of Kern River.)							
13	Nelson Soda Springs	Mrs. C. B. Smith and Carr Wilson, Springville.	33 miles north of east of Portersville	4,600	4	62–69	25	Resort.
6	River Spring	Kern National Forest	68 miles north of Kernville	8,850	1	49	550	Unused.
15	Tule River Soda Spring.	Tule River Indian Reservation.	16 miles south of east of Portersville	1,350	1	65	9	Drinking.
17	Yankee Spring	Matt Flynn	20 miles east of south of Portersville	* 800	1	* 55	* 5	Do.
	TUOLUMNE COUNTY.							
1	Lambert Soda Springs	Yosemite National Park	25 miles northeast of Yosemite	8,590	17	47–63	1	Do.
	VENTURA COUNTY.							
6	Lyons Spring	Mrs. G. A. Lyons, Matilija	7 miles northwest of Nordhoff	975	1	* 60	1	Resort.
7	Matilija Hot Springs	Sim Meyers, Matilija	6 miles northwest of Nordhoff	950	4	65–116	45	Do.
	Ojai Sulphur Spring. (Same as Sulphur spring northeast of Nordhoff.)							
1	Sespe Hot Springs	Santa Barbara National Forest.	22 miles west of north of Fillmore	2,750	† 4	97–191	125	Camping resort.
5	Stingleys Hot Springs	S. G. Stingley, Matilija	8½ miles northwest of Nordhoff	1,000	2	76,100	4	Domestic; bathing.

TABLE 1.—*Springs by counties*—Continued.

Map No.	Name.	Owner.	Location.	Elevation.	Number of springs.	Temperature.	Approximate yield.	Development or use, 1908-1910.
	VENTURA COUNTY—con.			*Feet.*		° *F.*	*Gallons a minute.*	
9	Sulphur Mountain Springs.	Sulphur Mountain Springs Co., Santa Paula.	6 miles north of Santa Paula	1,000, 1,150	2	62, 65	15	Resort.
	Sulphur springs—							
4	In Matilija Canyon		$8\frac{3}{4}$ miles northwest of Nordhoff	1,025	1	65	$\frac{1}{4}$	Unused.
8	Northeast of Nordhoff.	Mrs. Jacobs	$2\frac{1}{2}$ miles northeast of Nordhoff	1,250	1	66	1	Domestic (laundry).
3	Vickers Hot Springs	Sarah E. Haggett, Los Angeles.	9 miles northwest of Nordhoff	1,000	† 3	* 118	* 5	Unused.
2	Wheelers Hot Springs	W. C. Blumberg estate	$7\frac{1}{2}$ miles west of north of Nordhoff	1,500	4	62-102	40	Resort.

TABLE 2.—*Spring resorts in California.*

Name.	County.	Reached by—	Distance (miles).	Capacity (guests).	Open season.	Principal improvements, 1908–1910.
Adams Springs	Lake	Stage from Calistoga	30	400	May to October	Hotel, cottages, tents, pavilion, swimming pool.
Ætna Springs	Napa	Automobile stage from St. Helena.	17	150	May to November	Dining hall, cottages, clubhouse, swimming pool.
Agua Caliente Springs	Sonoma	Bus from Agua Caliente station	$\frac{1}{4}$	300	All year	Hotel, cottages, clubhouse, swimming pool.
Alder Glen Springs	do	Bus from Cloverdale	3	75	May to November	Hotel, cottages, tents, clubhouse.
Allen Springs	Lake	Stage from Williams	40	50	June to October	Hotel, cottages.
Anderson Springs	do	Stage from Calistoga	22	150	do	Do.
Arrowhead Hot Springs	San Bernardino	Electric car from San Bernardino	7	150	All year	Hotel.
Baker Mineral Springs	Mendocino	Outfit from Willitts	18			Camping resort.
Bartlett Springs	Lake	Stage from Williams or from Pieta.	44 or 50	250	June to October	Hotel, cottages, dancing hall, swimming pool.
Big Bend Hot Springs	Shasta	Stage from Redding	63	20	All year	Hotel, tents.
Bimini Hot Springs	Los Angeles	Urban electric car	3		do	Sanitarium, swimming pool.
Blaney Meadows Hot Springs	Fresno	Stage from Fresno to Shaver, outfit from Shaver.	60+30			Camping resort.
Blodgett Magic Spring	Santa Clara	Outfit from Gilroy	7			Do.
Bonanza Springs	Lake	Stage from Calistoga	29	75	June to October	Cottages, tents (camping resort).
Boyes Hot Springs	Sonoma	Near Boyes station	$\frac{1}{8}$	200	All year	Hotel, cottages, swimming pool.
Brockway Hot Springs	Placer	Boat from Tahoe	10	100	June to September	Hotel, cottages.
Bundys Elsinore Hot Springs	Riverside	Near Elsinore depot	$\frac{1}{8}$	75	All year	Do.
Byron Hot Springs	Contra Costa	Bus from Byron	2	200	do	Hotel, cottages, swimming pool.
California Hot Springs	Tulare	Stage from Portersville or from Ducor.	35 or 22	300	do	Hotel, cottages, tents, clubroom.
Calistoga Hot Springs	Napa	Near Calistoga depot	$\frac{1}{8}$			Camping resort.
Campbell Hot Springs	Sierra	Stage from Loyalton	16	100	All year	Hotel, cottages, swimming pool.
Castle Hot Springs	Lake	Stage from Calistoga	25	50		Hotel, pavilion, tents, and swimming pool.
Colyear Springs	Tehama	Outfit from Red Bluff	35			Camping resort.
Cooks Springs	Colusa	Stage from Williams	30	150	May to November	Hotel, cottages, dancing hall, swimming pool.
Coso Hot Springs	Inyo	Outfit from Keeler	45			Camping resort.
Crabtree Springs	Lake	Outfit from Lakeport or from Williams.	38 or 57			Do.
Deerlick Springs	Trinity	Outfit from Weaverville or from Redding.	28 or 62			Do.
Deer Park Springs	Placer	Bus from Deer Park station	2	150	June 1 to Oct. 1	Hotel, cottages, tents.
Delonegha Springs	Kern	Stage from Bakersfield	45	50	June to October	Hotel, tents
Deluz Warm Springs	San Diego	Stage from Deluz station	5			Hotel, tents (camping resort).
Democrat Springs	Kern	Stage from Bakersfield	40	100	All year	Hotel.
Doyle Soda Springs	Tulare	Outfit from Portersville	31			Camping resort.
Drake Hot Springs	Plumas	Outfit from Red Bluff	70	20	June to September	Farmhouse, tents.

TABLE 2.—*Spring resorts in California*—Continued.

Name.	County.	Reached by—	Distance (miles).	Capacity (guests).	Open season.	Principal improvements, 1908–1910.
Duncan Springs	Mendocino	Bus from Hopland	2	150	May 15 to Sept. 15	Hotel, cottages, pavilion.
Eden Hot Springs	Riverside	Stage from Beaumont	9	50	All year	Hotel, cottages, swimming pool.
Eleda Hot Springs	Sonoma	Bus from Agua Caliente station	½	150	do	Hotel, swimming pool.
Elsinore Hot Springs	Riverside	Near Elsinore depot	⅛	100	do	Do.
Fairview Hot Springs	Orange	Bus from Newport	3	50	do	Hotel, cottages, swimming pool.
Fales Hot Springs	Mono	Stage from Minden, Nev	60	10	do	Hotel, swimming pool.
Fouts Springs	Colusa	Stage from Sites	32	150	June to October	Dining hall, cottages, dancing hall, clubhouse.
Fresno Hot Springs	Fresno	Stage from Coalinga	18	100	do	Hotel, cottages.
Garretson Soda Springs	Siskiyou	Outfit from Yreka	40			Camping resort.
Geysers, The. (See The Geysers.)						
Gifford Springs	Lake	Stage from Calistoga	27	10	All year	Farm house (mountain resort).
Gilroy Hot Springs	Santa Clara	Stage from Gilroy	14	150	do	Hotel, cottages.
Glen Alpine Springs	Eldorado	Stage from Tallac	7	125	June 1 to Oct. 15	Hotel, tents.
Glen Ivy Hot Springs	Riverside	Livery from Corona	11	25	All year	Hotel, pavilion, swimming pool.
Grizzly Springs	Lake	Outfit from Williams	31			Camping resort.
Grovers Hot Springs	Alpine	Outfit from Markleeville	4			Do.
Harbin Springs	Lake	Stage from Calistoga	20	200	All year	Hotel, cottages, tents, gymnasium, swimming pool.
Hayvilla Spring	do	Outfit from Lakeport	16			Camping resort.
Hazel Springs	do	Stage from Ukiah	34			Do.
Highland Springs	do	Stage from Hopland	18	200	May to October	Hotel, cottages, clubhouse, swimming pool.
Hoppins Springs	do	Stage from Williams	44	25	June to October	Cottages.
Hough Springs	do	do	36	100	All year	Hotel, cottages, pavilion.
Howard Springs	do	Stage from Calistoga	28	150	June to October	Hotel, cottages, clubhouse.
Jacksons Napa Soda Springs	Napa	Stage from Napa	7	250	All year	Hotels, clubhouse, ballroom.
Jackson Valley Mineral Springs	Mendocino	Outfit from Sherwood	18			Camping resort.
Jones Hot Springs	Colusa	Stage from Williams	26½	100	All year	Hotel, cottages.
Jordan Hot Springs	Tulare	Outfit from Kernville, Portersville, or Lone Pine.	65,60,or 42			Camping resort.
Klamath Hot Springs	Siskiyou	Stage from Ager	20	125	All year	Hotel, cottages.
Little Geysers	Sonoma	Outfit from Cloverdale or from Healdsburg.	22 or 19			Camping resort.
Llewellyn Springs Camp	Mendocino	Outfit from Willitts	21			Do.
Los Guilicos Warm Springs	Sonoma	Bus from Glen Ellen	3½	50	May to October	Cottages, tents.
Lower Springs on South Fork of San Joaquin River.	Fresno	Stage from Fresno to Shaver; outfit from Shaver.	60+30			Camping resort.
Lyons Spring	Ventura	Stage from Nordhoff	7	50	May to October	Hotel, tents, pavilion.
Madrone Spring	Santa Clara	Stage from Madrone	14	50	All year	Hotel, cottages, pavilion.
Mark West Warm Springs	Sonoma	Stage from Fulton	7	100	May 1 to Oct. 1	Hotel, tents, clubhouse.

Matilija Springs	Ventura	Stage from Nordhoff	6	200	May to October	Hotel, cottages, clubhouse, swimming pool.
McDowell Springs	Mendocino	Stage from Hopland	5	50	May 15 to Oct. 15	Dining hall, cottages, tents.
Mendenhall Springs	Alameda	Stage from Livermore	11	75	All year	Hotel, cottages.
Montecito Hot Springs	Santa Barbara	Stage from Santa Barbara	6	100		Do.
Morgan Hot Springs	Tehama	Outfit or stage from Red Bluff	53			Camping resort.
Murrieta Hot Springs	Riverside	Bus from Murrieta	4	75	All year	Hotel, clubhouse.
Nelson Soda Springs	Tulare	Rail from Portersville to Springville; thence by saddle horse.	18+15	50	May to October	Hotel, cottages (mountain resort).
Newsoms Arroyo Grande Warm Spring.	San Luis Obispo	Bus from Arroyo Grande	$2\frac{1}{2}$	30	All year	Hotel, cottages, swimming pool.
Neys Springs	Siskiyou	Livery from Sisson	5	25	May 1 to Nov. 1	Hotel, tents.
O'Donnells Springs	Sonoma	Bus from Glen Ellen	$\frac{1}{2}$	25		Sanitarium.
Ohms Springs	Sonoma	Near Boyes Station	$\frac{1}{8}$	20	All year	Hotel.
Ornbauns Mineral Spring	Mendocino	Stage from Cloverdale	20	50	May to October	Do.
Orrs Hot Springs	do	Stage from Ukiah	16	50	All year	Hotel, cottages, pavilion, swimming pool.
Palm Springs	Riverside	Stage from Palm Springs Station.	6	10	do	Cottages.
Paraiso Hot Springs	Monterey	Stage from Soledad	8	200	do	Hotel, cottages, pavilion, swimming pool.
Paso Robles Hot Springs	San Luis Obispo	Bus from Paso Robles depot	$\frac{1}{4}$	250	do	Hotel, swimming pool.
Petersons Mineral Spring	Mendocino	Outfit from Willitts	40			Camping resort.
Point Arena Hot Springs	do	Stage from Cazadero	60	50		Hotel, cottages.
Radium Sulphur Springs	Los Angeles	Urban electric car	4	50	All year	Sanitarium.
Reds Meadows Hot Springs	Madera	Outfit from Yosemite	65			Camping resort.
Richardson Springs	Butte	Stage from Chico	12	150	All year	Hotel, cottages.
Ritchey Hot Springs	Riverside	Livery from San Jacinto	$2\frac{1}{2}$	25	do	Hotel.
Rubicon Springs	Eldorado	Stage from McKinney	12	50	June 1 to Sept. 1	Do.
St. Helena White Sulphur Springs.	Napa	Livery from St. Helena	2	25	All year	Dining hall, cottages.
Salmon Creek Mineral Springs.	Mendocino	Outfit from Willitts	12			Camping resort.
Samuel Soda Springs	Napa	Stage from St. Helena	22	75	May 1 to Nov. 1	Hotel, cottages.
San Jacinto Hot Springs	Riverside	Stage from San Jacinto	6	100	All year	Do.
San Juan Capistrano Hot Springs.	Orange	Stage from San Juan Capistrano	13	50	May to September	Hotel, tents.
San Luis Hot Springs	San Luis Obispo	Stage or train from San Luis Obispo.	8	150	All year	Hotel, cottages.
San Marcos Hot Springs	Santa Barbara	Outfit from Santa Barbara	20			Camping resort.
Santa Fe Springs	Los Angeles	Near Santa Fe Springs station	1	10	All year	Hotel.
Saratoga Springs	Lake	Stage from Ukiah	22	250	do	Hotel, cottages, clubhouse.
Seigler Springs	do	Stage from Calistoga	30	150	do	Hotel, cottages, swimming pool.
Sespe Hot Springs	Ventura	Outfit from Fillmore	22			Camping resort.
Shasta Springs	Siskiyou	Near Shasta Springs station	$\frac{1}{4}$	150	May to September	Hotel, cottages, clubhouse, swimming pool.
Skaggs Hot Springs	Sonoma	Stage from Geyserville	9	100	May to October	Hotel, cottages.
Soda Bay Springs	Lake	Stage from Hopland	28	150	do	Hotel, cottages, clubhouse.
Sulphur Mountain Springs	Ventura	Stage from Santa Paula	6	150	May to September	Dining hall, cottages, tents.
Tassajara Hot Springs	Monterey	Stage from Salinas	50	75	May 1 to Oct. 15	Hotel, tents, pavilion.
The Geysers	Sonoma	Stage from Cloverdale or from Healdsburg.	18 or 15	75	All year	Hotel, cottages, pavilion.

TABLE 2.—*Spring resorts in California*—Continued.

Name.	County.	Reached by—	Distance (miles).	Capacity (guests).	Open season.	Principal improvements, 1908–1910.
Tuscan Springs	Tehama	Stage from Red Bluff	10	200	All year	Hotel, cottages.
Upper Soda Spring	Siskiyou	Bus from Dunsmuir	$\frac{3}{4}$	25	May to October	Hotel.
Vallejo White Sulphur Spring	Solano	Stage from Vallejo	4	100	....do	Hotel, cottages, pavilion, swimming pool.
Vichy Springs	Mendocino	Stage from Ukiah	3	50	May 1 to Oct. 1	Hotel, cottages.
Wall Springs	Sonoma	Bus from Green Valley station	1	75	All year	Hotel, cottages, pavilion.
Walters Mineral Springs	Napa	Stage from St. Helena	16	50	May to November	Do.
Warner Hot Springs	San Diego	Automobile stage from San Diego or from Foster.	65 or 40	50	May to October	Hotel, cottages, tents.
Wentworth Springs	Fldorado	Outfit from Auburn	50	....	....	Camping resort.
Wheelers Hot Springs	Ventura	Stage from Nordhoff	$7\frac{1}{2}$	250	May to October	Hotel, cottages, tents, swimming pool.
Wilbur Hot Springs	Colusa	Stage from Williams	26	150	All year	Hotel, cottages, tents.
Witter Medical Springs	Lake	Stage from Ukiah	20	200	....do	Hotel, cottages.

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