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IMPACT OF QUARRIES ON KARST GROUNDWATER SYSTEMS

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ABSTRACT

Quarrying of carbonate rocks for various purposes dates back to early times. The impact of quarries on the environment and particularly on the groundwater system in terms of quality and quantity has often been ignored until the last few decades. Regardless of the small amount of quarried rock compared to the volume of an outcrop, the result of removing the protective cover of an aquifer may cause severe pollution of the groundwater. Another impact is that groundwater flow patterns may change due to manmade effects, such as blasting. Sites of quarries, therefore, should be selected by considering the hydrogeological, environmental and economic factors.

INTRODUCTION

Quarries provide blocks and limestone chippings for the cement industry and the construction industry. About 30% of Turkey is underlain by carbonate rocks that are lithologically suitable for such purposes. The site of for a quarry should be studied in detail for hydrogeological, economic, geological, and technological aspects, which, until the last decade, have often been ignored.

Carbonate rocks cover productive aquifers in many places particularly where karstification is well developed. Removal of this cover through quarrying may result in dramatic changes not only in the groundwater regime but also in the quality of the karst water. This problem directly affects human health. Quarried landscapes should be restored for aesthetic reasons.

PARAMETERS TO BE CONSIDERED IN THE SELECTION OF SITES FOR QUARRIES

Quarrying is one of the oldest methods for utilization of limestone. Until recent times, the operational economy was the most important factor in the selection of quarry sites. Generally sites with smooth relief and easy accessability are preferred. Therefore, sites not far from cities are favoured in order to minimize transportation costs. In Turkey, carbonate rocks that are lithologically suitable for use in the cement industry can be found over a vast area. Since remote areas generally have a steep and rugged topography, these are not suitable. Instead, sites are selected in areas with smooth topography, a parameter which also affects the selection of sites for the settlement of man.

Some landforms including hills, valleys, caves and closed depressions which are of great importance in a karst groundwater system are often destroyed by quarries. Geological factors such as structural elements, the strike and dip of the strata, the underlying and overlying lithology, and landslide problems are generally less important in the selection of quarry sites.

Landforms of quarried rock slopes are generally analogous to natural limestone features like limestone towers, collapse dolines, rock debris chutes, cones and flows which have resulted from a combination of solutional and mechanical processes (Gagen & Gunn,

1987). The hydrogeological and environmental parameters should also be considered in the site selection study for a quarry.

IMPACT OF LIMESTONE QUARRYING ON A KARST GROUNDWATER SYSTEM

Regardless of the small amount of quarried rock compared to the volume of an outcrop, removing the protective rock cover of an aquifer may cause some undesirable results. In many areas of quarries, the limestone bears a significant amount of groundwater resources. These potential resources are available in most places for domestic use. In the case of quarrying a limestone outcrop which acts as a protective cover for the underlying aquifer, two major changes may occur in the hydrogeological system related to water quality and the flow system. Where the groundwater flow is in conduit karst aquifers, or where the water table of a flooded fractured/fissured aquifer is near the surface, removal of the limestone outcrop leads to contamination. The scar created by a quarry may easily act as a sinkhole which conveys surface water to the groundwater system rapidly (Gunn et al., 1985). Quarries surrounded by villages may become a source of pollution for springs that emerge downstream (Fig. 1).

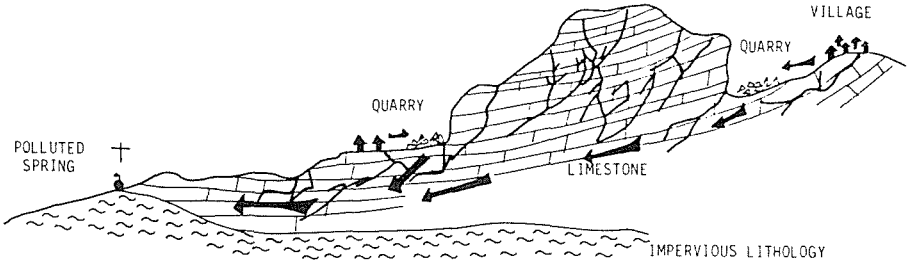

Fig. 1 - Limestone quarries as sources of water pollution.

The other impact of a quarry is that quarry blasting may result in the destruction or disruption of groundwater flow paths, changes in the pattern of groundwater movement and changes in the quantity of water flowing through the karst system (Fig. 2). The flow path may change direction and contribute to another karst subsystem or spring. Thus the amount of water abstracted from boreholes fed by the system may decrease significantly.

CASE STUDY OF THE IMPACT OF LIMESTONE QUARRYING AT BEYTEPE, ANKARA, ON THE QUALITY OF GROUNDWATER

A limestone outcrop of about 30 km^2 was selected as a site for quarrying at Beytepe near Hacettepe University. The limestone unit of Permo-Triassic age is underlain by impervious Paleozoic greywacke. The limestone is the aquifer utilized by wells and springs on the Campus and by local people.

There are four active quarries on this outcrop removing the relatively thin cover of the aquifer. Besides studying the impact on the flow regime of the groundwater, a systematic sampling programme was implemented particularly for microbiological analyses.

Springs that are downstream of the quarries were found to be microbiologically polluted while those far from the quarries were still clean. Karst hydrogeological studies showed that this might be due to the removal of the protective cover. This removal caused a rapid

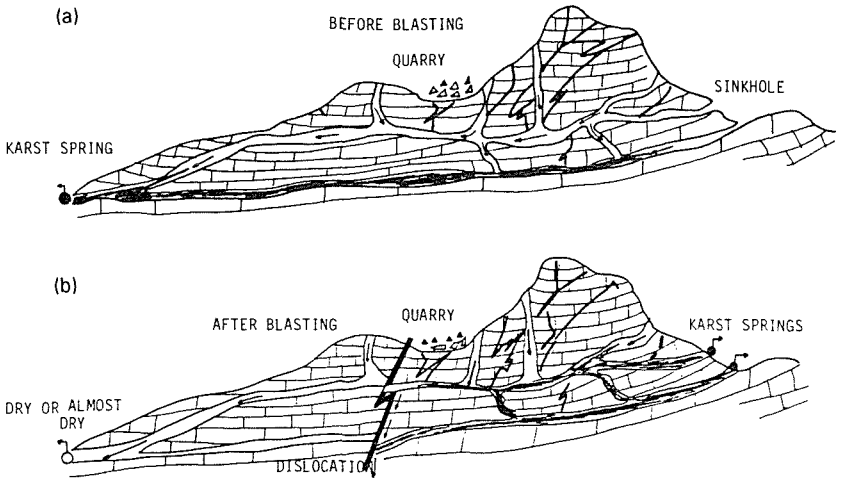

Fig. 2 - Impact of quarries on a karst groundwater flow system: (a) before blasting, and (b) after blasting.

infiltration of surface runoff from the adjacent villages that carried debris containing animal wastes and other contaminants. The relation between the distribution of quarries and the polluted springs is shown in Fig. 3.

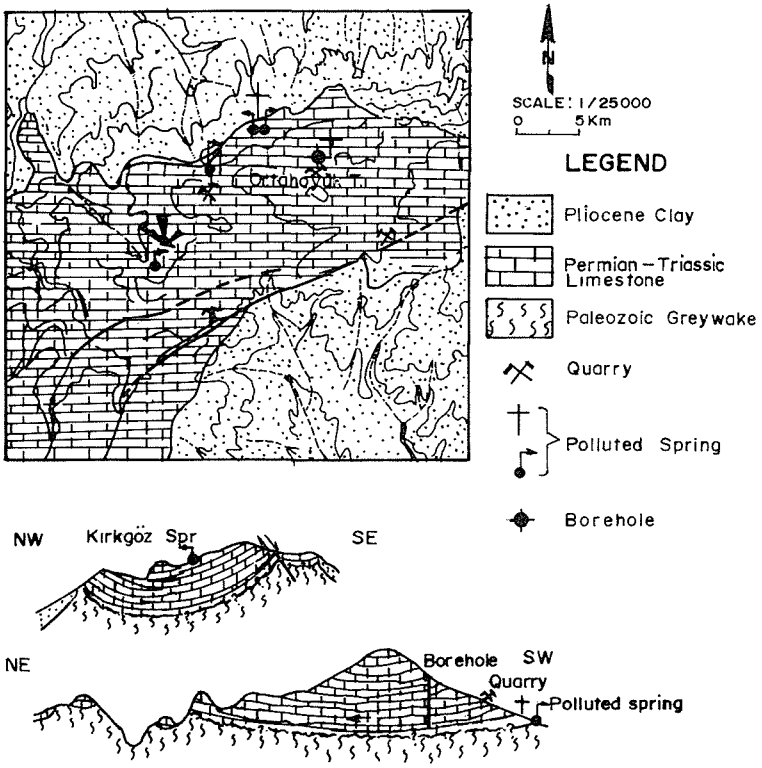

Fig. 3 - Hydrogeological map of the study area.

CONCLUSIONS

The karst groundwater system can be altered by limestone quarrying in greater magnitude and extent than by any other activity of man. This change may be concentrated within a small area compared to the whole limestone outcrop, but its negative effects on the quality and quantity of the groundwater resources potential can extend further.

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