Hydrogeological Processes in Karst Terranes

Edited by

GÜLTEKİN GÜNAY
International Research and Application Center for Karst Water Resources, Hacettepe University, Beytepe 06532, Ankara, Turkey

A. IVAN JOHNSON
A. Ivan Johnson Inc., 7474 Upham Court, Arvada, Colorado 80003, USA

WILLIAM BACK
US Geological Survey, MS 431, National Center, Reston, Virginia 22092, USA

Assistant Editors:
HAYATİ KOYUNCU & HATİM ELKHATİB
International Research and Application Center for Karst Water Resources, Hacettepe University, Beytepe 06532, Ankara, Turkey

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PREFACE

Limestone and dolomite are common sedimentary rocks that are moderately soluble (50-400 mg/l) in meteoric waters. These rocks outcrop over approximately 12% of the dry land area of the earth, being found in every morphostructural and climatic region (Fig. 1). Calcareous soils formed on them have been preferred for cultivation for thousands of years. This has led to a disproportionate concentration of people upon the carbonate rocks, so that today it is estimated that 25% of the world’s population depends largely or entirely upon karst aquifers for their water supplies.

Most outcrops of carbonate rocks display karst dissolutional enlargements to some extent; many are intensively karstified. The sedimentologic and diagenetic environments of limestone and dolomite are so varied that the number of distinctly different types of these rocks that occur is greater than the number of all other types of consolidated sedimentary rocks. When the fracturing effects of differing tectonic histories in differing regions, and the episodes of paleokarstification that are often found, are superimposed upon this initial lithologic variety, it will be appreciated that the range of hydrophysical conditions encountered in modern karst aquifers can be very large indeed. Some are amenable to treatment as classical Darcy-flow granular aquifers, other as fracture aquifers or as double porosity (fracture-granular or wide fracture-narrow fracture) aquifers, while yet others are purely conduit systems (cavernous) that can be analysed only as complicated pieces of piped plumbing. Many karst aquifers range between these differing conditions over distances as little as a few tens or hundreds of metres. The problems of predicting their behaviour, of managing them and conserving their valuable properties are correspondingly great.

This complexity was considered at the International Symposium and Field Seminar on Hydrogeological Processes in Karst Terranes held at Antalya, Turkey, in October 1990. The papers were divided into sessions that considered karst geochemistry, geomorphology, (input) hydrology, hydrogeology, quantitative and analytic modelling, groundwater tracing, remote sensing, geotechnical installations, and regional studies. All of these themes are represented in the 37 papers from 14 nations that are included in these Proceedings.

Paper sessions at the attractive coastal resort of Kemer were interspersed with one-day excursions to the Hellenic hill town of Termessus with its cisterns (enlarged caverns) for the dry season caulked with yolk of eggs, and to the great travertine terraces and springs above Antalya; then to an astonishing calcareous formation, the Koprucay Conglomerate, which forms half of a mountain and regional springs with a discharge that never fall below 30 m$^3$/s even during severe droughts. Following the papers there was a five-day field seminar across the Taurus Mountains west of Antalya to the shores of the Ionian Sea. In the interior we were shown major closed basins such as Elmali Polje (karstic capture of a river valley, with the downstream polje newly replaced by an artificial tunnel to regulate flow) and the hot springs and travertines of the Pamukkale geothermal basin. The coast was reached at Ephesus and Koycegiz, a spring-fed lake on the shore. Two days were spent visiting Gokcesu, Orenkoy and other large springs in karstic canyons that discharge the Lycian nappes of the western Taurus. The seminar concluded with an unforgettable voyage along the seashore, spotting mixing zone springs and visiting the sunken Hellenic city of Kekova, whose fate impressed upon us the tectonic vigour of this beautiful karstland. All foreign participants will join me in thanking Professor Gunay and his impressive team of young hydrogeologists at the International Research Center for Karst Water Resources, Hacettepe University, for their hard work on our behalf. The arrangements for the meeting were excellent.

The work and the Proceedings of this Symposium should be viewed within two broader contexts:
Fig. 1 - Major outcrops of the carbonate rocks (from Ford & Williams, 1989).
The neglect of karst in the general practice of consulting hydrogeology. In the English-speaking world, at least, too many hydrogeology professionals have trained only in conventional granular and fracture aquifer procedures. They are profoundly ignorant of the distinct nature of many karst aquifers, despite the latter's widespread occurrence and economic importance. For example, a recent textbook published in the United States is advanced, well ordered and comprehensive in most subjects that it considers, but discusses karst in only four or five pages scattered among seven hundred pages; yet more than 40% of the USA east of the Mississippi River is karstic to a significant extent. The erroneous practice, incorrect recommendations and waste of money that result from this neglect are considerable. Quinlan & Ewers (1985) have emphasized the need for special training and procedures when dealing with carbonate terranes. The contributors and readers of these Proceedings are urged to stress them at all meetings with other hydrogeologists, as well.

The entire karst system and its fragility. The circulation of groundwater through pores, fractures and/or caverns is the core, but the whole system is larger than this. At the groundwater input end are the distinctive landforms created by water sinking underground, such as karen, corridor karst, dolines and cockpits, dry valleys and gorges, marginal poljes and internal basins; we saw representatives of most of these in the Taurus Mountains. At the outlets are springs, springhead gorges, and travertines. In between, the living aquifer may display river caves with large volumes of clastic sediment in transit through them. Above the active galleries every mature karst displays higher levels of older caves with relict sediments and precipitated secondary minerals. The beauty of such caves has been appreciated by all peoples, and they have preserved the majority of artefacts and other evidence of early human culture. In the face of demands from a growing world population with an increasing ability to alter terrain by engineering works at all scales, every component of the karst system is threatened. Karen are ripped up for ornamental stone; everywhere, dolines are treated as pre-dug garbage pits. A polje can appear to be a prefabricated tailings pond for a bauxite mine, and a dry gorge an ideal site for a hydroelectric dam. Caves are filled by sediments washed from carelessly developed roads, or destroyed entirely by quarries. All of this damage diminishes our natural and cultural heritage and, to return to the theme of the Symposium, it pollutes the aquifers which we study and wish to manage and conserve. Contributors and readers are urged to teach their colleagues, farmers, engineers, politicians, etc. and the general public about the fragility of karst, the dangers of polluting its aquifers, and the difficulties and costs of restoring them.

Derek Ford
Department of Geography, McMaster University
Hamilton, Ontario, Canada L8S 4K1

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