

## REVIEWS

GÜNAY, G., JOHNSON, A.I. and BACK, W. (eds), 1993, Hydrogeological Processes in Karst Terranes, *Proceedings of the International Symposium and Field Seminar, Antalya, Turkey, 7-17 October 1990*, IAHS Pub 207, Wallingford, 412 pp. ISBN 0-947571-28-0  
(Reviewed by Steve Hobbs.)

The wide variety of hydrogeologic conditions encountered in karst aquifers has led to a number of problems in predicting their behaviour and adequately managing their resources. The 1990 symposium and field seminar was held in order to address some of these issues. Originally planned for publication in 1991, the *Proceedings* are no less relevant now, two years on. The thirty seven papers, of which only three are not in English, have been divided into seven subject areas, each of which is briefly reviewed here.

The first three papers, which are in the "Environmental" section of the *Proceedings*, include one concerning the impact of quarries, another, thermal and normal groundwaters in the Bursa region of Turkey and the third, and perhaps most interesting, the "Effects of Hydrogeological Development in Selective Karst Regions of China". The effects of human activity on a number of regions in China are discussed, specifically examining pollution, deforestation, desertification and karst collapse. A four fold classification of geological-ecological environments is proposed. This very general classification is used to highlight areas where natural evolution of the physical environment is likely to be modified by the influence of man.

The second section of the *Proceedings*, which includes seven papers, concerns "Geochemistry, Geomorphology, Geotechnics and Remote Sensing" — a very diverse group of topics. Three of the papers detail case studies associated with reservoir construction and dam building in karstic areas in Spain, Greece and the former Yugoslavia. Other papers include one discussing the correlation between karst features and lineaments (as determined using remote sensing methods) in Turkey, one concerning the relationship between karstic erosional phases and travertine deposits in Turkey, and another discussing the influences of geostructural setting on thermo-mineralisation in Italy. Of particular interest is the paper by Dreybrodt. This discusses a computer model used to simulate the development of secondary permeability from initial fractures in the rock. Karstification under natural conditions is examined, followed by artificial conditions under which accelerated rates of erosion may occur specifically around hydraulic structures such as dams. The importance of grouting in rock with a specific fracture size distribution is emphasised.

Of the nine papers contained within the "Hydrogeology" section two are in French, however, they do have English abstracts. The papers are generally case study type discussions of particular areas in countries which, include Turkey, Italy, France, Greece, Somalia, Mexico and Iran. Salt water intrusion, artificial recharge and thermal karst areas are discussed. Two papers consider the impacts

of aquifer mismanagement. The first discusses an area in north eastern Mexico where a well field was established without a full investigation into the extent of the aquifers and their hydrogeologic characteristics. Insufficient recharge to this area has resulted in several wells drying up, whilst poor well design has left others silted up. The lessons learnt from this costly exercise are well worth bearing in mind when well fields are proposed for development. The second paper by Milanovic and Aghill discusses mismanagement of the Kazeun karstic aquifer in Iran. The geologically complex area is divided up into seven sub-aquifers. To some extent these are in continuity, thus requiring a regional rather than local management strategy. Within this, local controls are required to prevent over abstraction and groundwater contamination from fertilizers and pollution. The need for artificial recharge in some sub-aquifers is also discussed.

There are three papers in the "Hydrology" section of which two are concerned with river flows (one specifically flood events) and the effect of karst drainage systems upon these, whilst the third examines co-kriging as a technique for estimating the spatial distribution of precipitation.

The Manavgat River karst system in Turkey is discussed in three of the six papers in the section of the *Proceedings* concerned with "Modelling". Of these, two are mathematical and one conceptual in nature. The fourth paper by Kresic *et al.* compares a stochastic and a finite difference steady state model for predicting spring discharge after a significant period has elapsed with no precipitation over an aquifer. The authors recommend that where possible both types of model should be applied as they tend to be complimentary in nature. Probably the most interesting of the papers in this section are the two which discuss the use of the double porosity concept for modelling karstic aquifers. The first of these papers by Souter concerns a moderately karstified aquifer (10% flow in conduits) in the Swabian Alb in south west Germany. After considering the general geology and hydrogeology the nature of the recharge, flow and storage processes at work in the aquifer are considered and quantified — no mean feat in itself. The one dimensional finite difference double porosity model used allows both the conduit and matrix storage and permeability's to be included in one model. A reasonable fit was achieved between modelled and measured spring discharges and aquifer water levels. Such work demonstrates that modelling karst aquifers can be successful, however, in this case the data input requirements are substantial. The second double porosity modelling paper is by Teutsch and also concerns case studies in the Swabian Alb, however, in this case a 3 dimensional model was used to include the effect of overlying alluvium, and vertical permeability variations in the underlying limestone. Simulations include those of tracer breakthrough curves. The models have obvious applications in terms of developing water resources in the modelled area.

Section 6 of the *Proceedings* includes five papers under the general title of "Regional Systems". Four of these discuss regional aquifers. The first by Bayo *et al.* concerns three regions in Catalonia, Spain, and looks especially at salt water/freshwater interactions in carbonate rocks. Blavoux and Mudry examine the use of physical variation in discharge of the Fontaine de Vaucluse, the largest spring in France. Such variations, combined with dye tracing have been used to

aid identification of the spring recharge area, with a view to providing source protection. The third paper by Finlayson & Sauro provides a useful (if somewhat out of place in this section) summary of international organisations concerned with karst and their current (1990) research areas. In the fourth paper Forti *et al.* discuss karst aquifers in three regions of Tuscany with special emphasis on determining available water resources. The final paper of this section is by Johnston and provides an overview of the historical development in the understanding of the Floridian aquifer in the United States.

The last section of the *Proceedings* contains four papers (one in French) concerning "Tracing". Of these only one, that by Leohnert concerning Cretaceous Limestone in Westphalia, Germany, is concerned with "classic" dye tracing, albeit combined with limited hydrochemical and recharge/discharge measurement. That by Plata discusses the use of both natural and artificial tracers to determine hydraulic parameters. Specifically radioactive and saline tracers are used in borehole investigations to determine vertical water movement, location of fractures and aquifer response to precipitation. The benefit of using radioactive and saline tracers is that tracer dilution can be monitored continuously. However, use of radioactive tracers has many associated health and safety problems. Natural tritium as a tracer is also discussed, especially its use in determining groundwater flow and residence time. Examples are quoted from Brazil, Jamaica and the Dominican Republic. Finally, variations of stable isotope concentration in groundwater were compared with those of artificially introduced tritium to examine the recharge source for water discharging from the Reocin Mine in Spain. The paper by Tulipano extols the virtues of using contemporaneous physical, chemical and isotopic parameters in groundwater to elucidate the hydrogeology in complex areas, with special regard to aquifer management. According to its English abstract the French paper by Dzikowski *et al.* examines the hydrodynamics of tracer movement through an aquifer.

In general the *Proceedings* are well produced, however, some of the more complex maps and more detailed tables are difficult to read. The diverse range of papers concerning karst areas in a number of countries should ensure that there is something of interest for all those workers in the field of karst. Conversely this diversity means that the whole reference is unlikely to be of value to any one person, but would prove a valuable addition to karst libraries.

CHAPMAN, PHILIP, 1993. *Caves and Cave Life*. Harper Collins, 219 Pages, with 97 black and white photographs, line drawings and maps. Hardback £27.50 ISBN 0 00 219907 6 Softback £12.99 ISBN 0 00 219908 4. (Reviewed by Steve Cottle)

This excellent book has been produced by Harper Collins as part of their long-established New Naturalist series. This is a series of over 80 books that will be familiar to many for its intelligent and straightforward approach to various aspects of natural history for the general reader combining clear explanation of their subjects with a reasonable degree of depth whilst avoiding any gimmickry.