Notes on International Conference on "Groundwater and Man"

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Internal Report 84-1

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Introduction

The Australian Water Resources Council, the Australian Academy of Science, the International Association of Hydrogeologists and the International Association of Hydrological Sciences jointly sponsored a conference on "Groundwater and Man", from 5th to 9th December 1983, at the University of New South Wales, Sydney. Approximately 270 scientists attended, of whom some 100 were from outside Australia. Most stayed in residences on the campus, affording the opportunity for informal discussions after each day's presentations.

The programme was arranged in three concurrent sessions, each with its own theme: the investigation and assessment of groundwater resources; groundwater and the environment; groundwater and development. The author attended the conference in view of his interests both in low grade geothermal energy from sedimentary basins and in the disposal underground of hazardous material. Funding was provided by the geothermal energy programme (58%) and by the nuclear fuel waste management programme (42%). A paper by Drury, A.M. Jessop and T.J. Lewis, entitled "Geothermal logging for the detection of groundwater flow" was presented and published in the conference proceedings.

A list of papers published is attached (Appendix I). There was an unusually high proportion of withdrawn papers. The proceedings were published in three volumes by the Australian Government Publishing Service (ISBN 0 644 02921 8) at a price of Aust $40.

Highlights of the technical programme

Each day's session began with a keynote address. The most interesting for the present author were the first and last talks. The first was given by R. A. Freeze of the University of British Columbia, who talked about regional groundwater analysis in surface and subsurface hydrology. Many of his examples were from the western Canadian sedimentary basin. Having discussed steady-state regional groundwater flow, Freeze showed some model examples of transient regional groundwater flow. Transient effects include those that are man-made, such as pumping from reservoirs. One important point made by Freeze, with a specific mention of underground disposal of hazardous material, was that natural transients can occur at great depth in very large flow systems over geologic time. At great depth, presently measured flow directions may not be in equilibrium with current surface topography in areas that have been glaciated in the past few millions of years. Freeze points out that this finding "has considerable impact" on "the siting of nuclear-waste repositories".

The final keynote address was given by P.L. Airey of the Australian Atomic Energy Commission, on isotope hydrology of the Great Artesian Basin of Australia. Because of the size of the Basin and the long residence times of the groundwater, standard ^{14}C radio-dating techniques can be used only to delineate recharge areas. However, environmental ^{36}Cl can be used to estimate the age of water up to 10 Ma. Isotope hydrological studies are being used in some projects of the Canadian geothermal energy programme. In the geothermal energy context the speaker noted that in some parts of the Great Artesian Basin fresh water at 90 - 100°C is obtained from approximately 2000 m. The water

must be allowed to cool before it can be used for its intended purpose, irrigation.

Brief summaries of some of the papers that were of particular relevance to the author's interests are now presented. Scheduling difficulties prevented personal attendance at all of them.

Erdelyi, M. "Investigation of groundwater movement using indirect methods".

Unfortunately, the paper by Erdelyi was not given orally. The published version is, however, of great interest in that it relates hydrogeological studies to geochemical and geophysical, principally geothermal, techniques. An important point made is that in many deep sedimentary basins the presence of dissolved natural gas is a common phenomenon, which makes hydraulic head data unreliable. Hydrodynamics is becoming increasingly important as a tool for locating hydrocarbon resources, so that other, more reliable exploration techniques are required. Erdelyi advocates an interdisciplinary approach, using lithologic, structural, hydraulic, hydrochemical and geothermal data for developing an understanding of groundwater movement in deep sedimentary basins.

Kelly, W.E. and R.K. Frohlich "Relations between aquifer electrical and hydraulic properties".

The results of field and laboratory studies of relations between aquifer electrical properties and hydraulic conductivity were reported, in a disappointingly confusing paper. The authors' conclusions seemed to be that estimates of hydraulic conductivity can be derived from field

observations of electrical resistivity data if there exists in the aquifer material an inverse relationship between porosity and grain size. Such a limitation would mean that hydraulic properties of aquifers could be estimated from surface geoelectrical surveys, quantitatively in some hydrogeological environments, but qualitatively only in other environments.

Smith, D.I. and M. A. Greenaway "Fluorometric dye techniques: Their application to ground water tracing and borehole studies".

Groundwater flow has historically been traced visually by means of dyes; the development of filter fluorometers and fluorescent dyes, resistant to decay under field conditions, have greatly enhanced the viability of the technique. The authors presented results of the direct tracing of flow in fractured rocks, and of borehole studies. In carbonate aquifers flow can be traced over several kilometres. Direct tracing is also possible in non-carbonate fractured rocks if the groundwater velocity is sufficiently high. Borehole studies involved single hole experiments, in which dilution measurements can be used to obtain information on groundwater velocity, and borehole-to-borehole tracing techniques. The authors concluded that the general principles of fluorometric dye techniques are similar to those used for radioactive tracers, but fluorometric techniques are generally cheaper and safer than radioactive tracers.

Fritz, P., Y. Al-Mooji, S.K. Frape and E. Salati "Saline groundwaters in crystalline rocks, isotopic and geochemical considerations on their origin" (not presented)

The paper by Fritz et al. describes occurrences of saline groundwaters in crystalline rocks, and it includes examples from the Canadian Shield and from a granodiorite in the Saanich Peninsula of Vancouver Island. Because of the slow weathering processes of primary silicate materials, most groundwaters in crystalline rocks contain only small amounts of total dissolved solids. Although the existence of salt waters and brines in mining environments has long been known, their origin has not been previously explained. The paper describes the use of stable isotopes and selected geochemical parameters in an attempt at providing such an explanation. For the Saanich study, in which values of over 3 g/l TDS were measured, it is suggested that salts deposited in pore spaces and grain boundaries in a palaeohydrothermal system are now being leached by circulating groundwater. For the Canadian Shield studies, in which values of over 200 g/l TDS were measured at depths of 1000 m or more, the original salts are possibly derived from past evaporating oceans.

Landa, I and V. Rumynin "The determination of the migration parameters in fracture aquifers - basic schemes"

(The author was unable to attend the session in which the paper was held and cannot, therefore verify that it was actually presented).

The paper is rather difficult to follow, but the thrust of it is a summary of the theory of migration (eg. of indicators) in fracture aquifers. Mathematical models of migration are present for the various stages of the process. It is recommended that great attention be given to theory, method of data acquisition and method of data evaluation when actual observation are made, although the basis for the recommendation is not readily apparent.

Sargent, K.A., M.S. Bedinger and J.E. Reed "Geohydrologic considerations in disposal of high-level radioactive waste in the arid southwestern United States".

(Paper orignally to be presented concurrently with that by Drury et al., subsequently rescheduled)

The abstract to the written version of this paper begins "Geohydrologists working on disposal of high-level radioactive waste in deep mined repositories acknowledge that high-level waste will not be completely contained within the repository during the extremely long period of concern. The most likely natural process by which radionuclides could move from a repository to the biosphere is by groundwater flow".

The paper describes work being done for the U.S. radioactive waste disposal programme in the Basin and Range Province, an arid to semiarid region of the southwestern United States. The study includes "considerations of natural hydraulic and geochemical barriers to

radionuclide transport, as well as considerations of groundwater conditions that minimise the possibility of human intrusion into a repository area". Consideration is being given to the possibility of waste disposal in both the unsaturated and saturated zones, with the former being favoured.

Ideally, there should be multiple barriers to radionuclide transportation between a respository and the accessible environment. A rule has been proposed by the U.S. Nuclear Regulatory Commission that a repository be situated such that the waste would be completely contained for 1000 years following closure, and that the flow time from a repository to the limit of the controlled area be at least 1000 years. Long-lived elements persist for times that are far beyond credible predictability for the groundwater flow system.

Bedinger, M.S. "Groundwater flow systems in the Basin and Range Province, U.S.A"

Although scheduled in a different theme, Bedinger's paper complemented the one by Sargent, Bedinger and Reed. The 780,000 km^2 Basin and Range Province is complex, both geologically and hydrologically. Some topographically closed basins are coincident with closed groundwater systems. However, many flow systems are not coincident with topographic basins, because groundwater flow patterns are significantly affected by distribution of recharge and discharge, and by permeability of rock. Groundwater flow between structural basins occurs through permeable rock, and through basin-fill deposits that are continuous between some structural basins. Large regional flow systems, interconnected by permeable bedrock beneath basins, discharge to systems several thousands of square kilometres in extent, and extend under many topographically closed basins that have no other groundwater discharge.

The paper well illustrates the potential complexity of regional groundwater flow systems.

Habermehl, M.A. "Hydrogeology and hydrochemistry of the Great Artesian Basin, Australia".

The Great Artesian Basin occupies about 20% of Australia's surface area. It is up to 3000 m thick, and it forms a large, synclinal structure, uplifted and exposed along its eastern margins and tilted southwestwards. The basin is a large, multilayered, confined groundwater basin, comprising aquifers in continental quartzose sandstones and confining beds of marine mudstone and siltstone of Triassic, Jurassic and Cretaceous age. Recharge occurs mainly in the eastern marginal zone, and large-scale groundwater movement is towards the southern, southwestern and western margins. Natural discharge occurs from many springs in these areas. Flowing and pumped artesian wells are common, and free flows exceeding 100 l/s have been recorded. The groundwater generally contains 0.5 - 1.5 g/l TDS (c.f. Regina, approximately 100 g/l TDS). Geothermal gradients in the Basin range from about 15-100 mK/m. Temperatures of water in wells tapping Cretaceous aquifers, at 1000m or less, generally range from 30° to 100°C at the surface outlets. Spring temperatures range from about 20° to 45°C. There is some evidence that geothermal gradients determined from water wells are greater than those determined from deeper petroleum exploration wells. High gradients occur near some discharge areas, adjacent to some major faults and where shallow basement ocur. As in the western Canadian sedimentary basin, there are clear correlations between geothermal gradients and groundwater flow patterns.

The papers discussed above were those that the author found particularly interesting and relevant to his interests. With such a large programme covering a wide range of disciplines, many of the conference presentations were of only peripheral interest to the author. Several of the groundwater resource papers mentioned the problems arising from over-production of aquifers, or of problems resulting from too close a spacing of wells. This is not presently a problem with geothermal energy development in Canada, but in other parts of the world, for example the Paris Basin, such difficulties are beginning to arise.

The paper by Drury et al. was particularly well received. It was scheduled in a four-paper session, but one was withdrawn, allowing more time for the remainder. Consequently the author's 15 minute formal presentation was followed by 20 minutes of questions and discussion, and further informal questions and comments throughout the rest of the week. Several hydrogeologists said that they regularly used temperature logs qualitatively to identify groundwater inflow and outflow zones. The author found such a response most encouraging.

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SYDNEY, 1983

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