Preface

Theme Issue on Confining Units

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The impetus for this theme issue on confining units came from a Geological Society of America theme session on field investigations into clayey aquitards, co-chaired by Garth van der Kamp and myself (Vicki Remenda) in the autumn of 1998. The response to the session, both in the number of abstracts received and in attendance, indicated that a wide range of research activity is focused on the hydrogeology of clayey confining units, and that a volume dedicated to this topic would be of interest to many readers.

The terms “confining unit” and “aquitard” (used interchangeably in this issue) are historically defined not by what they are, but rather by what they are not, namely aquifers. Clayey aquitards are abundant, contain sufficient clay and/or silt to have low permeability, and although they may be fractured or contain zones of higher permeability material, they transmit water poorly or of insufficient quantity and thus are not usually exploitable for water supply. However, because they generally surround aquifers and have comparatively high specific storage, confining units often control the hydraulics of aquifers. In addition, they usually contain high concentrations of solutes and solids available for hydrogeochemical reactions. Thus, clayey confining units, or aquitards, are deposits of sufficient areal extent and thickness whose hydrogeological and hydrogeochemical characteristics are defined by the presence of clay minerals and clay-sized particles.

This issue comprises eight articles, four of which are topical overviews (van der Kamp 2001; McMahon 2001; Rodvang and Simpkins 2001; Sacchi et al. 2001), and four of which are site reports (Boisson et al. 2001;

Desbarats et al. 2001; Gautschi 2001; Gerber et al. 2001).

Many aquifer-instrumentation techniques, field and laboratory procedures, and some basic assumptions (Neuzil 1986) cannot necessarily be used to determine either the physical parameters of aquitards (e.g., van der Kamp 2001) or the geochemical and isotopic nature of pore fluids in aquitards (e.g., Sacchi et al. 2001). Neuzil, in his landmark 1986 paper on groundwater in low-permeability environments, states that “the ability to test conceptual models of flow in low-permeability environments is severely limited by constraints of time; response on a large scale takes too long to observe.” He suggests that “one way around the problem is to seek evidence for long-term behaviour of porous media by studying the geologic evidence of processes which have been operative for a long time.” This approach is particularly relevant to the development of suitable procedures for investigating candidate sites for nuclear-waste repositories. Two such studies appear in this issue. Gautschi (2001) and Boisson et al. (2001) provide overviews of the investigations conducted, respectively, by the Swiss National Cooperative for the Disposal of Radioactive Waste (NAGRA) on the Opalinus clay and by the French Institute for Nuclear Protection and Safety (IPSN) on the Upper Toarcian claystones at the Tournemire site. The results of these studies indicate that confining units of exceptional stability and low permeability are potentially suitable repositories for nuclear and other hazardous waste.

Aquitards can be considered part of the Earth’s “plumbing,” because ultimately they control both the quantity and quality of water reaching aquifers. For example, Desbarats et al. (2001) report on a geostatistical procedure for estimating large-scale leakage of water through a confining unit that, although it is regionally extensive and generally thick by as much as 50 m, in places also contains “windows,” or areas of zero thickness. This unit overlies the Oak Ridges Moraine complex which supplies as much as 25% of the drinking water to north-suburban Toronto, Canada. Working in the same geographical area and with an adjacent aquitard, Gerber et al. (2001) focus on the syn- and post-depositional features that enable rates of recharge through a dense clayey till to be much higher than would be expected on the basis of smaller-scale permeability.

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As is noted in van der Kamp (2001), heavily pumped confined aquifers could not sustain their current usage without these secondary recharge avenues within the low-permeability matrix.

Confining units generally contain a nearly inexhaustible supply of hydrogeochemical reactants, both in the pore fluid and the adjacent solids. As McMahon (2001) reports, it is in the mixing zones or interfaces between aquifers and aquitards where much of the biogeochemical activity occurs. Rodvang and Simpkins (2001), in their overview of the fate and occurrence of agricultural contaminants in North American aquitards, indicate that the reserves of organic carbon and pyrite in unweathered aquitards have the potential to reduce nitrate and sorb pesticides well into the future. Weathered aquitards, with higher rates of groundwater flow and thus lower concentrations of organic carbon and pyrite, are not as effective in reducing concentrations of agricultural contaminants.

The papers contained in this volume are by no means representative of all of the research currently being conducted in both shallow and deep confining units. The papers do, however, represent an excellent cross section of critical questions: How do we extract representative pore fluid from compacted, clay-rich deposits? What useful transformations occur in aquitards and at aquifer/aquitard interfaces? How do we evaluate the in-situ hydraulic conductivity of confining units on a useful scale? Can we account for both syn- and post-depositional variations in aquitard composition? How do we verify the future stability and safety of nuclear- and other hazardous-waste repositories? I anticipate that these papers will provide the reader with new insights into processes and procedures.

Keywords confining units · general hydrogeology · equipment/field techniques · hydraulic properties · laboratory experiments/measurements

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