15th INESON meeting, Friday 18th November 2005: Programme and Abstracts

14.00 Registration (free for members of IAH and the Geological Society, and for students; £10 for others, payable on the door) and afternoon tea

14.45 Introduction to the Ineson Meeting 2005
Mike Rivett, Hydrogeological Group of the Geological Society

14.50 Does a lot of data reduce uncertainty?
Dr. John Heathcote, ENTEC-UK

The nuclear industry has historically collected large data sets on hydrogeological properties, in connection with radioactive waste management issues. These datasets are much larger than would be collected with investigations in connection with water resources or chemical ground contamination management. How do these large datasets improve knowledge? Datasets from the sedimentary sequences near Sellafield and Dounreay will be discussed.

At Sellafield, the sedimentary sequence comprises up to 1000 m of predominantly fluvial sandstones, with relatively minor argillaceous horizons. There is generous number of conventional pumping tests from water resources investigations, a lot of core plug data, two elaborate 3-D pumping tests, as well as a calibrated regional model. The regional average hydraulic conductivity value in the regional model is not well predicted by any of the other measurements, considered simply. It is only when the complexity of the geology, both depositional and post-depositional, is considered, that a consistent picture can be envisaged.

At Dounreay, the sedimentary sequence comprises up to 300 m of lacustrine deposits, ranging from limestones to sandstones, but typically silty sandstones and sandy siltstones. The largest dataset comprises over 150 'drill-stem' tests – short duration abstraction or injection tests over relatively short intervals of formation. The nature of the formation suggests that the hydraulic conductivity may be strongly anisotropic, and also that fracturing is important in enabling flow. The larger-scale effective behaviour of the system is again constrained by regional modelling and the relationship of these values to the small-scale measurements sheds light on possible flow mechanisms.

The conclusion is that large datasets demonstrate the degree of variability of the systems studied, which in small datasets appears as uncertainty. The uncertainty is reduced by encapsulating the variability into conceptual understanding. This results in reasonable certainty in large-scale groundwater flow, and gives a means of considering the nature of small-scale water flow and also solute transport.

15.20 Performance assessment of a nuclear waste repository: upscaling coupled hydro-mechanical properties for far-field transport analysis
Professor Rae Mackay, University of Birmingham

A bench mark test (BMT) was carried out as part of the third phase of the international collaborative research programme DECOVALEX (Development of Coupled Models and their Validation through Experiment). The BMT was concerned wit the identification of the impact on advective travel times from a buried waste repository to the land surface of coupled thermal, hydraulic and mechanical processes and properties. A data set for a simplified Sellafield-like geological setting was used to allow numerous research teams to perform numerical analysis to obtain travel time distributions and uncertainties. A methodology for addressing the BMT is presented. Hydro-mechanical modelling was conducted on fracture networks generated from fracture length and density statistics, described by a power law. For each rock formation in the test, effective hydraulic conductivity tensors were derived for a range of mechanical parameters and depths below ground level. The upscaled hydraulic conductivities were then used in a site scale continuum model of groundwater flow and transport to assess performance

indicators, including time of travel from repository to ground surface. Initial results show that interpretation of the fracture length and density data can have a significant effect on upscaling calculations, including the determination of a suitable hydraulic representative elementary volume. Hydro-mechanical modelling shows that there is a non-linear decrease in the change of fracture aperture with depth, and that although large aperture fractures remain at depth, the majority of fractures tighten to almost the residual aperture at about 750 m below ground level. Anisotropy of the effective hydraulic conductivity also changes with depth. Flow and transport modelling at the field scale indicates that, of the controls investigated, mechanical properties of the rock have the greatest influence on solute travel times. Most importantly, a large uncertainty level exists in the simulated results given the heterogeneity of the rock mass.

Chair: John Chilton, IAH British National Committee

15.50 Ineson Lecture 2004: . Dr. Leonard F. Konikow, U.S. Geological Survey

Geologic Repository in Deep Salt Beds: Are transmissivities calibrated for a ground-water flow model adequate to predict solute transport?

Federal regulations in the U.S. recognize the existence of hydrogeologic uncertainty and require that safety assessments for geological repositories be conducted within a probabilistic performance assessment (PPA) framework. As useful as the probabilistic approach has been, it is not yet clear to some skeptics that reliable risk assessments can indeed be generated by applying a PPA to complex *natural* hydrogeological and geochemical systems. Much of the concern is with the magnitude of the uncertainty in characterizing natural systems, where predicting solute transport hinges on defining heterogeneity within the system—a most difficult and challenging task. The linking of multiple, complex, deterministic models in the PA approach makes it difficult to find weaknesses in the underlying conceptual models, errors generated by faulty linkages among various submodels, or possible bias introduced by the statistical sampling procedure.

WIPP is an approved operational repository for transuranic wastes in deep bedded salt deposits located near Carlsbad, New Mexico, in the southwestern U.S. At WIPP the presence of natural resources in the area increases the likelihood that drilling or production activities by future generations may cause a breach of the repository. The WIPP PPA analysis included an evaluation of hypothetical releases of contaminants from a future borehole that might result in lateral off-site migration through an overlying dolomite. The dual-porosity solute-transport modeling approach used to demonstrate compliance with regulations has several weaknesses. For example, the ground-water flow models were based on state of the art parameter-estimation methods for the transmissivity of the aquifer. The calculated velocities were then used in the solute-transport models used to demonstrate safety. However, it is reasonable to ask whether an estimated transmissivity field that appears sufficiently accurate and precise for reproducing observed hydraulic heads necessarily provides an adequate basis for predicting solute transport through that same aquifer system. An independent analysis of the WIPP system using a method-of-characteristics transport model indicates that this is not the case.

16.50 Discussion

17.00 Wine reception and finger buffet (£8.50 payment at reception)