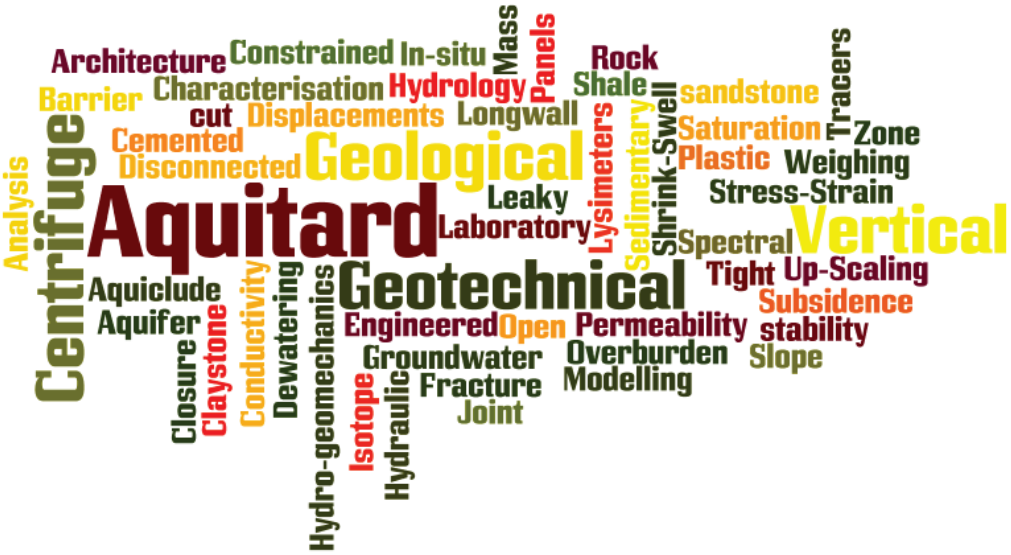
Aquifers, aquitards & mining

Workshop on Aquifers, Aquitards & Mining

Edited by: Steve Bouzalakos, UNSW Australia and Wendy Timms, UNSW Australia



27-28 March 2014 - UNSW Australia

NATIONAL CENTRE FOR GROUNDWATER RESEARCH AND TRAINING

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Water Research Laboratory
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Workshop on

Aquifers, Aquitards and Mining

Booklet of Abstracts

Steve Bouzalakos and Wendy Timms
(Editors)

27-28 March 2014

University of New South Wales, Australia

Preface

Welcome to the Workshop on Aquifers, Aquitards and Mining held 27-28th March 2014 at the School of Mining Engineering, University of New South Wales (UNSW), Australia. This workshop was organised jointly by the National Centre for Groundwater Research and Training (NCGRT), and the Australian Centre for Sustainable Mining Practices (ACSMP) at UNSW. The NCGRT is a Special Research Centre co-funded by the Australian Research Council and National Water Commission since 2009.

Low permeability geological materials, known as aquitards, caprocks, and sealing strata play a critical role in: disconnecting or partially disconnecting shallow and deep aquifers; limiting subsurface movement of poor quality water and sequestered waste; and providing a crucial seepage barrier where underlying mineral and energy resources are developed.

Mining and farming both use significant volumes of water, and the direct value of groundwater to the national economy is around $7 billion a year, according to a recent report which NCGRT commissioned from Deloitte Access Economics[1]. The study shows that:

- Our cities use 303,000 megalitres (ML) of groundwater a year.
- Mining uses 410,000 ML, and groundwater underpins mining production of $24.5 billion each year.
- Agriculture typically uses about 2,000,000 ML (or 2 gigalitres, GL) of groundwater each year, mainly for irrigation and livestock, and groundwater underpins $4.7 billion of production.

In addition, environmental systems and considerable social benefits are underpinned by our aquifer and aquitard systems, particularly in inland or arid areas of Australia where much mineral and energy wealth is also buried. Many communities and ecosystems rely on groundwater.

This workshop presents technical developments in characterising aquitards in groundwater systems, and related research in mining and coal seam gas. Professor Craig Simmons (Director of NCGRT) and Professor Ros Taplin (Research Director of ACSMP) kindly agreed to open the workshop and welcome you, the participants.

We especially thank keynote speakers Professor Lee Barbour (University of Saskatchewan, Canada) and Dr Ken Mills (Strata Control Technology) for

[1] http://www.groundwater.com.au/news_items/media-release-future-mining-dining-booms-depend-on-water

their contributions focused on mine hydrology, subsidence and mine closure, and invited presentations from our colleagues at UNSW and Flinders University. Our International Scholar of note for the NCGRT Program 1B, Professor Jim Hendry (University of Saskatchewan, Canada), has provided valuable guidance to UNSW and Flinders University research personnel throughout.

We also highlight research with partners in the NCGRT including Queensland University of Technology (QUT), the NSW Department of Trade and Investment, and Geoscience Australia. We thank all our colleagues throughout UNSW and industry and government colleagues with whom we are working.

We look forward to continuing and new collaborations to further develop technologies and systems for sustainable mining initiatives and sustainable water resources on which our civilisation depends.

Sydney
March, 2014

Steve Bouzalakos
Wendy Timms

Contents

Geological Weighing Lysimeters – Applications to Mine Hydrology

Lee Barbour[1]

Abstract · The primary hydraulic properties of an aquifer or aquitard are the compressibility and the bulk hydraulic conductivity. The compressibility is related to the small strain constrained modulus in soil mechanics, a property which is highly sensitive to disturbance due to sampling and can only be obtained through back analyses from load tests, interpretation of seismic tests, or thru sophisticated in situ test methods (e.g., pressure meter). In recent years there have been an increasing number of studies which have utilized monitored pore-pressure responses within deep sediments to atmospheric barometric fluctuations to obtain in situ measurements of compressibility. These measurements also allow for the interpretation of soil moisture loading (e.g., infiltration or evapotranspiration) and are consequently also known as Geological Weighing Lysimeters (GWLs).

The results from a series of field studies using GWLs are presented and discussed in this talk. These results are used to highlight the application of GWLs in a variety of field situations, in both natural and mine affected settings. These GWLs have been used to obtain small-strain (<0.0005%) estimates of soil compressibility and large-scale estimates of hydraulic conductivity. They have been also used to monitor soil moisture loading and consequently provide valuable information in interpreting surface water balances. They also show promise in identifying changes in compressibility that may occur as a result of disturbance and can provide information on the distribution of soil stiffness with depth within the geological units.

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Evidence for Tight and Leaky Aquitards

Wendy Timms[1,2], Richard Crane, Steve Bouzalakos

Abstract · Increasing attention on low permeability strata (aquitards) has led to advances in understanding and development of improved assessment techniques. Aquitards can limit potential impacts of depressurization that is associated with underground resource extraction associated with mining and coal seam gas (CSG) development. Aquitard studies in a number of geological settings indicate that multi-scale and multi-disciplinary assessments are essential. While the principle that relative permeability of strata is more important than absolute permeability values is well established, there is incomplete understanding of coupled hydro-mechanical and hydro-geochemical processes for specific geological settings. Examples presented include sedimentary strata (sandstone, shale and claystone), semi-consolidated alluvial settings, glacial till and constructed earth barriers for mining and waste disposal. A leaky aquitard could be attributed to several factors such as: relatively large and connected pores; lack of applied stress or consolidation; limited lateral continuity of the deposit; geological heterogeneity; and preferential flowpaths due to jointing, fractures, faults and leaky bores. Conversely, a tight aquitard occurs with favourable factors including: thick, laterally extensive and homogeneous geological strata; poorly connected pores due to cementation, clay minerals, and semi-saturated conditions; over-consolidated matrix; and strata that if subject to changing stresses responds by ductile and plastic deformation. Seepage, recharge and solute transport through tight aquitards could be negligible except over large areas or decades to millennia. Geophysical surveys (e.g., resistivity imaging) and hydrochemical evidence including isotopes and trace anthropogenic organics may help identify preferential leakage in certain cases. However, evidence for zero permeability (an aquiclude) over large areas requires thorough investigation and long term monitoring of response to hydraulic stresses and recovery.

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Spectral Analysis of Gravity Data to Quantify Subsurface Moisture Changes

Ian Acworth[1,2,3]

Abstract · A Gphone gravity meter was established on the Liverpool Plains at the Breeza Farm trial site. The gravimeter was installed on top of a 15m deep concrete pile next to a range of piezometers. Rainfall, atmospheric pressure and groundwater levels were monitored close by. The results of 10 weeks of monitoring will be described during a period that included significant rainfall events and a regionally rising groundwater surface. The regional earth tides were backed out using the TSoft routines and the residual anomaly derived for the site. Fourier analysis is used to identify the different frequencies in the record related to the earth tides. The gravity record shows a response to the regionally rising groundwater levels but not to the local changes in piezometric pressure from local groundwater pumping. There is also uncertainty as to the confining nature of the smectite dominated clay silt at this site with the possibility that deep cracks have opened up in the upper layers. The TSoft package is used to investigate these effects and to establish the barometric efficiencies of the piezometers installed at the site. It is anticipated that a joint interpretation of the gravity data, the piezometric heads and other associated geophysics data will help shed light on the hydraulic nature and storativity of this complex sedimentary unit that is of particular significance on the Liverpool Plains with the nearby coal-seam gas extraction and open-cast coal mining activities.

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Characterising the Hydraulic Conductivity and Shrink-Swell Properties of Natural and Engineered Clay-Bearing Materials Using Centrifuge Permeameter Techniques

Richard Crane[1,2], Wendy Timms

Abstract · Characterising and predicting the transport and fate of dissolved substances is of great importance in subsurface hydrology. In the current work, a novel centrifugation technique (Broadbent GT18, 2 m diameter centrifuge permeameter) has been applied to assess the hydraulic conductivity, shrink-swell properties and transport of conservative tracers and reactive constituents in both synthetic (Na-bentonite and native soil/sediment mixtures) and natural aquitard samples. Results demonstrate that the hydraulic conductivity of clay-bearing materials is highly dependent on the geochemical composition of the pore water used for testing. A well-defined positive correlation between cation valence and/or concentration with hydraulic conductivity is recorded for all clay-bearing materials tested, which is attributed to a decrease in the swell of the material (due to interlayer charge neutralisation). Findings indicate the standard permeability testing techniques using deionized water provide erroneous results if the core or porous sample contains a clay fraction. For such samples, native groundwater, or influent chemistry that is synthesized to match porewater chemistry is required. Results provide clear evidence that the efficacy of clay-bearing materials as natural and engineered aquifer barrier systems can be significantly decreased in the presence of high ionic-strength and/or valence permeate fluids.

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Remote Sensing Techniques for Detecting Vertical and Horizontal Displacements

Simit Raval[1]

Abstract · The monitoring of surface subsidence is an important aspect in many underground mines. There are various methods that can be used for deformation monitoring, including optical levelling, GPS, tiltmeters and InSAR. This presentation proposes the use of advanced InSAR approaches for measuring ground displacement information due to the high density of measurement points and millimetre precision. A mine in the Southern Coalfields of New South Wales is used to assess the precision of the technique by comparing the results with traditional ground-based approaches. Two stacks of ENVISAT radar imagery (87 total images) acquired between June 2006 and August 2010 were analysed using the SqueeSAR algorithm to detect and measure surface deformation. The use of a multi-image approach allowed movements to be assessed on a quasi-monthly basis with the generation of time series of deformation for every measurement point identified. By combining imagery acquired from different orbits, both vertical and East-West horizontal movement were measured. InSAR results were also compared with ground-based GPS survey measurements.

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Observations of Ground Disturbance above Longwall Panels and Implications for Groundwater

Ken Mills[1]

Abstract · Longwall mining is recognised to cause disturbance to the overburden strata as the overburden strata moves downward into the void created by mining. These ground movements have been observed as surface subsidence over many decades and by numerous researchers through numerous surface and sub-surface monitoring programs, in a wide variety of different geological settings, using a wide variety of monitoring techniques. This monitoring provides an excellent database of experience from which to characterise the nature and extent of disturbance within the overburden strata above longwall panels. This characterisation is intended to provide a basis for better understanding the effects of longwall mining on the surrounding strata and, particularly in the context of groundwater interactions, the formulation of hydrogeological models used to predict groundwater impacts about longwall panels.

The extent and nature of zones within the overburden are characterised in this paper on the basis of the level of disturbance and the nature of this disturbance. Zones characterised by tensile changes or stretching behaviour are found to be located directly above each panel with the level of disturbance above the mining horizon graduated as a function of panel width from the mining horizon through to about three times panel width above each individual longwall panel. These stretching zones and their influence on the hydraulic conductivity of the overburden strata contrast with zones of increased compression located directly above the chain pillars that separate individual longwall panels.

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A Framework to Estimate the Hydraulic Conductivity of Jointed Rocks Using Analytical Methods

Mahdi Zoorabadi[1], Serkan Saydam, Wendy Timms, Bruce Hebblewhite

Abstract · Rock discontinuities play important role in water circulation within the jointed rocks. They occur at various forms and scale and provide pathways for water flow. They act as channels inside rock mass and their inter-connection creates a fracture network. The hydraulic conductivity of fracture network is controlled by the geometrical properties of rock discontinuities. Unlike numerical methods, analytical methods provide fast and easy to use tools to estimate the hydraulic conductivity of jointed rocks. These methods use the geometrical properties of rock discontinuities such as orientation, areal extent, spacing and aperture to calculate the 3D tensor of hydraulic conductivity. The results of the analytical methods can be used as a guide for designing of required field tests and also as input data for initial project design.

This presentation includes a framework to apply the analytical method for estimation of the hydraulic conductivity. It covers a review on the existing methods, a new developed method, step by step procedure to calculate the hydraulic conductivity tensor, and finally the variation of hydraulic conductivity with depth. A real example was used to present the calculation framework.

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New Insights in Field Tests to Estimate the Hydraulic Conductivity of Jointed Rocks

Mahdi Zoorabadi[1], Winton Gale, Yvette Lewis

Abstract · Hydraulic conductivity of jointed rocks is a challenging parameter to be measured. It is a 3D tensor quantity and is controlled by geometrical properties of rock discontinuities. Field tests are the best tools to measure the hydraulic conductivity of jointed rocks. Although the single-hole tests such as packer test (Lugeon test) and slug test are so common in practices, they are not capable to measure the anisotropic hydraulic conductivity of jointed rocks. Furthermore, the effected volume of jointed rocks in these tests is not representative of real conditions in most cases. The interference test (crosshole conductivity test or multi-well test) covers a larger volume of jointed rocks and provides the required data to calculate the 3D tensor of hydraulic conductivity. The existing solutions to calculate the anisotropic conductivity from interference tests are applicable only for a medium with small ratio of anisotropy. In this presentation a new technique was introduced to solve the head change equations. This technique relies on curve fitting procedure and is applicable for confined aquifer (horizontal anisotropy) and for general cases to calculate the real 3D tensor. The effect of nonlinear flow condition on the results of packer test also was discussed in this presentation. The application of this technique was explained using real case studies. A 3D numerical modelling (FLAC 3D) was used to verify the proposed solution.

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Response of Overburden (Constrained Zone) above Longwall Mines – Hydrogeology, Geomechanics and Isotope Tracer Techniques

Katarina David[1,2], Wendy Timms, Rudra Mitra, Andy Baker

Abstract · The constrained zone within the overburden of longwall mines is of particular importance as a protection barrier to overlaying aquifers and surface water bodies. Overburden strata may include several aquitards comprising either clayey rocks or sandstones with degrees of tightness reflecting geological, geochemical and geomechanical conditions. There is uncertainty over coupled hydro-mechanical processes including changes in pore water pressure and storage associated with strata relaxation and deformation, and the potential for long term re-saturation. This study combines hydrogeology, geomechanics and isotope tracer techniques to explain the change in pressure distribution, desaturation and re-saturation potential. The analysis of vibrating wire piezometers data is discussed in interpretation of pressure responses within the constrained zone. This is complemented by the vertical hydraulic conductivity testing of core under in-situ stresses using the centrifuge permeameter, and standard core- and site-scale techniques. Detailed chemistry and clay mineralogy data and geochemical modelling will provide more information on the importance of fluid-solid interactions in re-saturation. Geomechanical properties of the confining strata will be assessed to understand elastic properties and stress-strain responses. An innovative isotope tracer technique will be discussed that allows pore water characterisation directly on the drill core without the need for intrusive squeezing and/or pressing, or drilling and/or installation of numerous piezometers. High resolution depth profiles of $^{18}O/^{2}H$ and Cl are used to identify flow and mixing where distinctive end members occur to correlate between strata and sites. In combination with other methods, the isotope and Cl tracer techniques can assist in assessment of recharge mechanisms.

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Mitigating Up-Scaling and Dual-Phase Flow Errors

Daan Herckenrath[1,2], John Doherty, Sorab Panday

Abstract · Both regional reservoir models and groundwater models are developed for assessment of the impact of coal seam gas (CSG) extraction on regional groundwater systems. A first study describes the errors that can be incurred in regional drawdown calculations by failing to simulate dual-phase flow in proximity to CSG extraction wells. Subsequently a modified single-phase flow simulator (MODFLOW-USG) is presented which includes a head-dependent desaturation function to mitigate such drawdown errors. Comparison with ECLIPSE* simulations show that the presented single-phase simulator may provide acceptable simulation capabilities for assessing the effects of CSG extraction on regional groundwater systems. Next, we will address the performance of both ECLIPSE* and MODFLOW-USG (with desaturation capacity) in a grossly up-scaled environment. Special attention will be given to the lithological nature of coalbeds which contain complex sequences with a strongly varying permeability. As part of this study, detailed reservoir models are compared with up-scaled model variants, after which up-scaled hydraulic property values and predictions of pressure are compared with fine-scale simulations in a stochastic framework. This study ultimately aims to provide insights on how to up-scale rock properties in a regional CSG groundwater impact model and how up-scaled model properties can be related with smaller-scale field measurements.

(* mark by Schlumberger)

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Aquifer Architecture and its Influence on Hydraulic Conductivity in Sedimentary Basins

Bryce Kelly[1,2]

Abstract · In many groundwater flow models throughout the Murray-Darling Basin the lithofacies of the valley filling sedimentary sequence is simplified to an unconfined layer overlying one or two semi-confined layers. While this may be appropriate for determining the water balance of a catchment, it poorly represents the lithofacies heterogeneity of fluvial systems. If the goal is to understand pathways of hydraulic connectivity and make predictions about the impacts of groundwater extracts at depth on near surface groundwater dependent ecosystems, then consideration needs to be given to better representations of the lithology. This presentation will highlight why it is important to consider the depositional environment, and how this can guide the development of the hydrogeological framework. Information will also be presented on how the 3D distribution of sand and gravel bodies influences the percolation threshold.

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Stress-Dependent Geotechnical Behaviour of Aquitards

Steve Bouzalakos[1,2], Wendy Timms

Abstract · Clayey-silt aquitards of relatively low hydraulic properties account for 60% of the ~100 m thick alluvial sediment sequence of the Gunnedah Basin. Laboratory measurements made on minimally disturbed samples from drill core below the saturated zone (22.5 and 34.3 m depth) show that vertical hydraulic conductivity (K_v) is sensitive to effective stress. Oedometer consolidation tests found K_v to vary over 2.5 orders of magnitude (0.5×10^{-11} to 3×10^{-9} m/s) between vertical effective stresses of about 11 and 1,450 kPa. Pre-consolidation stresses ranged from 120 - 220 kPa, and over-consolidation ratios (OCR) from 0.3 - 2.7. Geotechnical centrifuge (0.8 m radius, up to 300*g*) testing of 100 mm diameter, 50-80 mm length cores found K_v values to vary from 2-3 $\times 10^{-9}$ m/s at 80*g* with stresses equivalent to in-situ (e.g., 150 kPa). However, K_{v_max} of 10^{-8} m/s occurred at stresses of ~80 kPa to control swelling, and $K_{v\_min} < 10^{-11}$ m/s at increased stresses of >2,000 kPa. Vertical leakage of shallow saline porewater could occur through these aquitards, particularly in zones of higher silt content, and may be increased with larger hydraulic gradients due to water abstraction. The results imply that the stress-dependent response of aquitards is critical to understand the sensitivity of groundwater resources in the Gunnedah Basin. Groundwater for irrigation, water supply and base flows to rivers must be sufficiently disconnected from depressurisation with coal and gas extraction that may occur adjacent to the alluvial groundwater system.

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Aquitard Permeability at Various Scales: In Situ, Laboratory and Geotechnical Centrifuge Technology

Wendy Timms[1,2], Richard Crane, Doug Anderson, Steve Bouzalakos, Dayna McGeeney, Ian Acworth

Abstract · Direct measurement of hydraulic connectivity at multiple scales (core, bore, site, and basin scale) using multiple methods can provide confidence in numerical groundwater models that may be non-unique. Bore testing methods are typically limited to hydraulic conductivity in a horizontal (K_h) orientation, while aquifer pump tests have a lower limit K of 10^{-8} m/s. Harmonic analysis of high frequency pore-pressure data that fluctuates due to surface loading or dewatering is recommended for in-situ vertical (K_v) permeability, despite possible bore casing leaks, provided that site specific compressibility (specific storage) data is available. Core scale testing can also add value to drilling data by providing high resolution vertical K_h or K_v and other properties. For example, testing of silty cores by standard rigid and flexible wall column techniques require 1-2 weeks, compared with <1 week in a geotechnical centrifuge permeameter (CP). Hydraulic testing of half cores or semi-saturated cores (20 to 100 mm diameter) may only be viable by CP, with advantages for ultra-low K materials, and variable K as a function of stress, moisture and fluid chemistry. The CP is a powerful technology to quantify minimum core scale permeability (current lower limit of 10^{-10} or 10^{-11} m/s), provided that appropriate coring and preservation methods are adopted and influent chemistry is equivalent to in situ conditions. Multi-method assessments for several semi-consolidated and rock aquitards are presented demonstrating scale independent and scale dependent hydraulic connectivity.

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Evaluation of Soil-Atmosphere-Vegetation Interactions for Mine Closure Applications

Lee Barbour[1]

Abstract · Water transfers across the soil-atmosphere-vegetation boundary are of interest to wide range of scientific and engineering disciplines including hydrologists, hydrogeologists, geoenvironmental engineers, and soil scientists. In most cases, each discipline has a particular interest in one component of the water balance for the upper active zone of the soil profile. For example, hydrologists want to understand runoff processes and hydrogeologists, or geoenvironmental engineers charged with reclaiming mine waste, may be primarily concerned with net percolation (groundwater recharge) while soil scientists focus on available soil water for plant use.

The focus of this talk is to highlight a few examples of both conventional and novel methods of monitoring and estimating the various components of the surface water balance taken from research studies associated with the reclamation and closure of mine wastes. A long-term case history of conventional water balance monitoring for a constructed reclamation cover over saline-sodic shale mine waste is presented which highlights the importance of climate variability and modelling in understanding the dynamics of the surface water balance.

Some recent, ongoing studies involving novel methods of measuring components of the surface water balance in mine waste are also presented. These methods include the use of Geological Weighing Lysimeters (GWL), Distributed Temperature Sensing (DTS) using fibre optics, deep profiling of the stable isotopes of water, and Cosmic-Ray Soil Moisture Observing System (COMOS) measurements.

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Using Porewater Chemistry Profiles to Infer Vertical Fluxes through a Regional Aquitard

Michelle L. Irvine[1,2], Glenn A. Harrington, Peter G. Cook, Stanley D. Smith, M. Jim Hendry

Abstract · Quantifying fluid flux across low-permeability formations is important where these units are used for containment of wastes or hydraulic barriers to mitigate the impacts of activities such as coal seam gas extraction. Aquitards can also exert a strong influence on the water quality of aquifers, with pumping inducing the leakage of saline waters.

This regional study constructs environmental tracer profiles through an aquitard subject to both upward and downward hydraulic gradients, along the full length of the flow path in the Willunga Basin, South Australia. The aquitard is within a coastal sedimentary basin and lies between two significant regional aquifers. Initial flow modelling of this multi-layered groundwater system indicates the hydraulic conductivity of the aquitard could be in the range 10^{-3} to 10^{-4} m/day. However these values are highly uncertain due to the non-uniqueness of models calibrated to head data alone.

Using coring methods for sample collection, porewater profiles across the aquitard were constructed for noble gases ($^{4}He/^{20}Ne$), stable H/O isotopes of water and chloride. The measured profiles were modelled using MODFLOW and MT3DMS to determine the dominant mechanism of solute transport in the aquitard, and to estimate the advective flux for comparison with current hydraulic conditions.

The primary advantage of using tracer profiles to estimate fluid flux is that the scale of measurement is the entire formation thickness (10^{1} – 10^{3} m), whereas many conventional methods, including DSTs and permeametry, provide information at much smaller scales (10^{-1} – 10^{0} m). This approach can also reveal information about the paleohydrology of the groundwater system. However, the use of porewater chemistry methods can be limited if boundary conditions are uncertain (e.g., the chemistry of adjacent aquifers) or if diffusive transport of solutes dominates over advective transport.

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Simulating Impacts of Geological CO_2 Storage on Groundwater Flow

Furqan Hussain[1], Karsten Michael, Yildiray Cinar

Abstract · A simplified numerical model is used to simulate the migration of formation water caused by pressure build-up during CO_2 injection. A stacked-reservoir consisting of a storage formation overlain by a geological seal and freshwater aquifer is modelled. We use a commercial reservoir simulator to run various realizations with different seal permeabilities, injection rates, outer boundary conditions and groundwater production rates. We track salinity changes in the simulations. We find that outer boundary conditions and seal permeabilities are most critical parameters that govern lateral and vertical displacement of formation water. If the seal permeability is high or outer boundary is closed, the vertical fluid displacement dominates the lateral displacement. This has the potential to cause significant salinity change in the overlying freshwater aquifer. If the seal permeability is low or outer boundary is open then the lateral displacement becomes dominant. If the storage formation extends to an updip shallow freshwater formation, the higher the lateral fluid displacement the higher the increase in salinity of the freshwater.

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Selected Applications of iTRAX Core Scanner and Laser Ablation ICP-MS

Helen Rutlidge[1,2], Christopher E. Marjo, Sarah J. Kelloway

Abstract · This talk will focus on applications relevant to the analysis of aquitards of laser ablation inductively coupled plasma mass spectroscopy (LA ICPMS) and iTRAX core scanner that are two elemental based techniques for solid samples.

LA ICPMS since its development has found many applications in a wide range of fields. A major advantage of LA ICPMS is its ability to provide information on the spatial distribution of elements of interest.

The iTRAX core scanner uses X-ray fluorescence spectroscopy to provide the elemental profile along core samples. As part of the analysis, the iTRAX core scanner collects a radiographic image to explore the structure of the sample and detect different layers present in the sample.

This talk will also explore other instruments available at the Mark Wainwright Analytical Centre at UNSW Australia that might be appropriate for the characterisation of aquitards.

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Geological Characterisation of Clayey Drill Core

Dayna McGeeney[1,2], Wendy Timms, Bryce Kelly, Ian Acworth

Abstract · The alluvial sediments of the Liverpool Plains are a valley filled sequence, with sediments primarily sourced from rocks in the surrounding catchment. Smectite clays, for example, are likely to be weathered from Early Permian to Late Eocene and Mid Miocene volcanics. Clayey drill core was collected from three aquitard sites located within the Upper Namoi Catchment for geological characterization. The cores range in depths from surface to 31.5 m to 43 m and were drilled near nests of monitoring bores in the filling upwards alluvial sequence. The purpose of the characterization is to assist in the understanding of the aquitards formation, permeability, moisture storage capacity, and degree of hydraulic connection or disconnection. Focus will primarily be on the Cattle Lane drill core which to date has had the most complete examination. A suite of geological analyses has been conducted consisting of; bulk density and moisture content, cation exchange capacity (CEC), Inductively coupled plasma mass spectrometry (ICP-MS), iTrax X-ray fluorescence (XRF), loss on ignition (LOI), malacology studies, optically stimulated luminescence (OSL) age dating, particle size distribution and X-ray diffraction (XRD). This data will be used in conjunction with groundwater and geophysical analysis to form a more complete understanding of the Namoi alluvial aquitard.

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Further Information and Publications

The following NCGRT information sheets are available at:

http://www.groundwater.com.au/resources

http://www.groundwater.com.au/research_programs/innovative-characterisation-of-aquifers-and-aquitards

- Understanding the Groundwater Impacts of Coal Seam Gas
- Understanding Aquitards and Aquicludes
- 3D Geological Modelling: Stuctural, Facies, Properties and Conductivity
- Vertical and Horizontal Groundwater Movement

Further information on research outputs and publications from authors presenting at this workshop are also available from:

http://www.engr.usask.ca/faculty/Barbour_S.php

http://www.sct.gs/

http://www.acsmp.unsw.edu.au/

http://www.engineering.unsw.edu.au/mining-engineering/

http://www.flinders.edu.au/

http://www.connectedwaters.unsw.edu.au/

http://www.wrl.unsw.edu.au/

http://www.engineering.unsw.edu.au/civil-engineering/

http://www.engineering.unsw.edu.au/petroleum-engineering/

When is aquitard seepage trivial? Innovative characterisation of seepage for mining CSG and sustainablewater resources.

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