Groundwater and Hydrocarbon Change

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Ineson 2014 Abstracts

Aquifers and shales: a study of their spatial relationships in England and Wales

John Bloomfield, Rob Ward and Marieta Garcia-Bajo

British Geological Survey Maclean Building, Crowmarsh Gifford, Wallingford

OX10 8BB

jpb@bgs.ac.uk

If shale gas resources are to be developed in the UK the implications for groundwater will need to be considered as part of wider environmental risk assessments. An important step in such assessments is to understand and quantify the spatial relationships between potential shale gas source rocks and overlying aquifers. As part of a project co-funded by the British Geological Survey and the Environment Agency, a series of national scale maps showing the full crop of the eleven Principal Aquifers in England and Wales; the full crop of six major shale formations, parts of which could be targets for future shale gas development; and the vertical separation between pairs of geological units where aquifers overly shales have been produced. These national-scale maps have a number of uses: they can be used as a high-level screening tool, for example to identify areas where aquifers and shales may be in close proximity; are informing the selection of sites for BGS' baseline monitoring of methane in groundwater; and provide a common, independent source of information for policy makers, regulators, industry and the public alike.

The context for the study will be outlined. Then a description of how the separation maps have been produced and some examples of the resulting maps will be presented. The modelling methodology will be discussed and issues associated with the definition of the base of aquifers and potentially productive areas of shales will be highlighted. There is a need for future work to refine both the aquifer and shale surfaces and include some understanding of the hydrogeological properties of the intervening rock units. This will be discussed briefly, as will the importance, and difficulties, of making the results of such 3D geological modelling available to the public in an accessible manner.

Aquifer-shale maps and underlying data are available through the BGS website at: http://www.bgs.ac.uk/research/groundwater/shaleGas/aquifersAndShales/home.html

Environmental Baselines: methane in groundwater in the UK

Rachel Bell

British Geological Survey, Nicker Hill, Keyworth, Nottingham, NG12 5GG

rabell@bgs.ac.uk

Methane in UK groundwaters has been studied for three decades, driven in part by serious explosive incidents such as Loscoe and Abbeystead, both of which required in-depth investigation of how methane is produced and its migration through the subsurface. Other work at BGS has investigated the impact of hydrogeological setting on the variation of methane in principal UK aquifers, and the impacts of these methane concentrations on the UK methane emissions budget. The data collected during this research has formed the basis of the current BGS National Methane Baseline Survey, the aim of which is to improve understanding of the baseline levels of methane within a broad range of UK aquifers. This is necessary in case unconventional hydrocarbon development takes place in the UK (experiences in the USA, where no methane baseline was established before development, demonstrate the desirability of this precautionary approach). The history of UK groundwater baseline studies and past methane research will be reviewed and then put into the context of the aims of the present survey. Samples are being collected from aquifers which have been identified as overlying potential shale-gas source rocks, with a subset of the chosen sites being sampled quarterly to assess the potential for seasonal variations in dissolved methane concentrations.

The survey is continuing into 2015 and the interim data disseminated using the BGS webpages at

http://www.bgs.ac.uk/research/groundwater/shaleGas/methaneBaseline/home.html.

Shale gas development in the NW of England and issues for public water supply

Phil Merrin

United Utilities plc, Thirlmere House, Lingley Mere, Great Sankey, Warrington, WA5 3LP

phil.merrin@uuplc.co.uk

Fracking. Is there a real risk to public water supplies or is the actual perception of the risk being fuelled by media hype?

The occurrence of seismic activity associated with shale gas exploration near Blackpool hit the headlines three years ago and questions were asked about how vulnerable are our aquifers when things go wrong?

Occurring as it did within United Utilities operational area, this posed obvious concerns for our company, not least because our operational area which stretches from Carlisle in the north to Crewe in the south, has several potentially large exploitable reserves of unconventional gas currently under investigation. These sites are predominantly located in the Fylde area where shale gas deposits exist within the Carboniferous Bowland Shale, but other gas reservoirs and exploration activities are also occurring in parts of Cheshire and Manchester. The Triassic Sandstone aquifer overlies all of these gas reservoir formations in these areas. Given the high profile protests and resulting media exposure, water company customers across the UK are understandably concerned about the use of mains water to support shale gas extraction and the possible consequences to the environment if things may go wrong.

Through its representative industry body and collaborative research arm, the UK water industry has sought to lobby regulators to ensure the importance of (the safety and security of) public water supplies features in the energy debate. It has also sought to ensure that despite the media hype that is prevalent around this issue, a balanced view of the risks is presented in order that water companies can make informed decisions on any potential risks to their customers' drinking water supplies.

This talk is based on research conducted in order to answer this and other questions regarding the safety of unconventional shale gas extraction using factual evidence and data. It will highlight the key issues that water companies are required to evaluate in order to reassure our customers, some of which may not be familiar….

Natural attenuation of petroleum fuel hydrocarbons and oxygenate compounds in the Chalk aquifer - a multidisciplinary approach for performance assessment

Steven Thornton

Groundwater Protection and Restoration Group, Kroto Research Institute, North Campus, University of Sheffield, Broad Lane, Sheffield S3 7HQ

s.f.thornton@sheffield.ac.uk

Natural attenuation is widely accepted as a strategy for the risk-based management of groundwater contaminated with many important organic contaminants, including petroleum fuel compounds and chlorinated solvents, among others. While the natural attenuation of such contaminants is well studied in shallow sand and gravel aquifers, this is not the case for fractured dual porosity bedrock aquifers, such as the Chalk in the UK and NW Europe. This knowledge gap therefore limits the implementation of monitored natural attenuation (MNA) for the management of contaminated groundwater in such aquifers, given the inherent challenges posed by this hydrogeological setting and the data quality required to support MNA.

This presentation will describe a multidisciplinary approach developed for the performance assessment of natural attenuation at an unleaded fuel release site on the Upper Chalk aquifer. The study focuses on petroleum hydrocarbons (BTEX) and ether oxygenate compounds (MTBE, and TAME) in the fuel release, and explores how novel site investigation methods combined with microbiological and stable isotope analysis undertaken at field and laboratory-scale can provide a deeper insight on the potential for natural attenuation of these contaminants in this aquifer. The approach adopted helps to identify the controls on natural attenuation at field-scale, considering the aquifer hydrogeology, understand the role of dual porosity transport in contaminant attenuation and estimate biodegradation rates for the compounds of interest. Overall, the methodology provides significantly improved understanding of the fate and transport of unleaded fuel compounds in fractured rock aquifers, leading to better informed decision-making regarding the environmental risk posed and selection of site management strategies.

Is sustainable remediation now a self-sustaining concept? An international progress report on evolving contaminated site management strategies

Prof Jonathan Smith

Chair, SuRF-UK steering board.

HSE Technology (PTS/T), Shell Global Solutions, Lange Kleiweg 40, 2288 GK Rijswijk, The Netherlands

jonathan.w.smith@shell.com

Sustainable remediation – the consideration of environmental, social and economic factors associated with soil and groundwater risk-management options, to help select the best overall solution - has been a rapidly evolving topic in recent years. The first published reference to 'sustainable remediation' was in the title of a 1999 conference paper by Kearney *et al*., (1999), but activity really accelerated in the middle of the 2000's, with establishment of a number of collaborative sustainable remediation fora, and increased publication rates in the peer reviewed literature.

This presentation will review the international progress of sustainable remediation concept development and application in regulatory and corporate decision-making processes. It will look back at what has already been achieved, provide an update on the latest initiatives and developments, and look forward to what the future of sustainable remediation might look like. Specifically it will describe:

- Sustainable remediation frameworks: synergies and international collaboration;
- Latest guidance and tools developed by the various sustainable remediation organisations (SuRFs), including the work prepared by SuRF-UK;
- Best practice standard development by ASTM and ISO;
- Regulatory acceptance of sustainable remediation, including incorporation into legislation, and the NICOLE – Common Forum Joint statement on 'risk-informed and sustainable remediation' in Europe;
- Examples of corporate adoption of sustainable remediation principles.

The presentation will conclude with a look forward to a vision of sustainable remediation in 2020.

How do we identify supercomplex mixtures of pollutants in process and groundwaters? Case studies from the oil sands and oil platforms

Prof Steven Rowland

Petroleum & Environmental Geochemistry Group, Biogeochemistry Research Centre and Centre for Chemical Sciences, School of Geography, Earth & Environmental Sciences, University of Plymouth, Plymouth,PL4 8AA, Devon

srowland@plymouth.ac.uk

Many of the organic chemical contaminants of concern in groundwater exist as mixtures which are so complex that they have defied attempts at identification for over a century. Examples include hydrocarbons, particularly those from petroleum, and a group of organic carboxylic acids, known by the loose term, 'naphthenic acids'. It is difficult or impossible to assess the toxicological importance of unknown chemicals, so identification of at least some representative compounds in these mixtures would be very beneficial.

A five year Advanced Investigator's Award from the European Research Council (2009-2014) has allowed the speaker and his team to investigate methods for improved identification of these 'supercomplex' mixtures (http://www.pegg.org.uk). The basis of our approach is separation by multidimensional chromatography, acquisition and interpretation of mass spectra, synthesis and confirmation of candidate compounds and toxicological assessment of the same.

In support of Prof Jim Barker's award lecture, examples of the application of these methods will focus mainly on characterisation and toxicity of the 'naphthenic acids' originating from the Canadian oil sands and related well and ground water samples. The same methods are applicable to identification of acids in petroleum and in offshore oil platform produced waters.

Ineson Lecture 2014

From BTEX, coal tar creosotes and fuel additives at Borden to Canada's oil sands: Evolving hydrocarbon threats to groundwater

Jim Barker, Emeritus Professor

Department of Earth & Environmental Sciences – University of Waterloo, Waterloo, Ontario, Canada

jfbarker@uwaterloo.ca

Groundwater contamination by industrial organic chemicals became the focus of hydrogeologists in Canada and the US by the 1980's. Petroleum hydrocarbons were of particular interest to me. It became evident that the migration and fate of organics in groundwater could not be fully understood from lab studies and mapping of plumes from uncontrolled releases, and so John Cherry and his colleagues at Waterloo initiated controlled-release experiments in the Borden research aquifer in Canada. I have been involved in about twenty such experiments, involving gasoline (BTEX), creosote, pesticides, gasoline additives MTBE and ethanol. The initial experiment with BTX, experiments elucidating the impact of ethanol-fuels on BTEX plumes, and a long-term experiment with coal tar creosote will be presented. By the 1990's interest focused on developing and demonstrating in situ remediation, again with demonstrations at Borden. The Borden research has been critical to the current confidence in dealing with hydrocarbon contamination of groundwater.

Meanwhile, in this century, Canada has come to possess the world's third largest proven reserves of oil with about 97% of this oil in the oil sands of Alberta. In 2011, about 1.6×10^6 barrels (0.25×10^6 m^3)

of oil was produced per day from the oil sands. About 715 km^2 of boreal forest has already been disturbed by oil sands mining. The hot-water extraction of bitumen from oil sands has led to an accumulation of about 830×10^6 m^3 of fluid fine tailings within tailing ponds covering more than 190 km^2. A lot of water has gone into oil sands production.

Early hydrogeology investigations in Alberta's Athabasca oil sands established that fresh water resources were limited in the area, with saline groundwater dominant in the underlying carbonate bedrock aquifers. When surface mining of oil sands got underway, the critical issue became the control of tailings waters. The major source of aquatic toxicity in tailings water stems from a diverse group of carboxylic acids, termed naphthenic acids, and associated, acid-extractable hydrocarbons. This was the focus of our groundwater studies prior to 2010, while the saline groundwater was seen mainly in the dewatering of sands immediately underlying bitumen-rich sands required for mine operation. More recently, the saline bedrock groundwater has come back, literally, with the ingress of very saline groundwater into a mined pit. Such ingress into an active mine, if not controlled, would spell disaster for the mine.

This talk will also touch upon some water-related issues encountered in oil sands mining. It will also highlight the challenge that groundwater poses to reclamation of mined areas. The ultimate success of the oil sands mining industry will rest upon the success of this huge reclamation effort. Technical innovations in reclamation will be essential. This speaker has confidence in this endeavour derived from personal observation of the training, skills, and commitment of the young engineers and scientists engaged in this effort.

Poster titles

Posters will be displayed throughout the day in the Main Library

The following poster was the recipient of the IAH British Chapter – 2014 John Day Bursary (£1000) to support students in undertaking hydrogeology-related fieldwork outside Great Britain as part of their postgraduate studies:

An evaluation of basic geophysical and borehole logging approaches for improving borehole placement and wellbore construction: A case study examining a saline-contaminated fluvial aquifer in southern Malawi

Richard Cheal, University of Strathclyde

De-risking migration pathways in unconventional oil and gas projects

Gareth Digges La Touche, Golder Associates (UK) Ltd

GDiggesLaTouche@golder.com

Hydrogeological risk screening for unconventional oil and gas development

Barnaby Harding, ESI Ltd

BarnabyHarding@esinternational.com

Numerical assessment of potential impacts of hydraulically fractured Bowland Shale on overlying aquifers

Zuansi Cai & Ulrich Ofterdinger, Queen's University Belfast

z.cai@qub.ac.uk

Hydrogeological aspects of the Environmental Impact Assessment for shale gas exploration in Lancashire

Jenny Lightfoot, Arup

jenny.lightfoot@arup.com

2-D Sand tank experiments to assess the influence of transient water table influence upon LNAPL re-distribution: Design and preliminary data

Simiao Sun, Michael Rivett, Alan Herbert, University of Birmingham

SXS1011@student.bham.ac.uk