An Evening Devoted To African Water Resources

Meeting at Loughborough University on 19 January 2012

Report by Geoffrey Jago

The introduction used by the Two Ronnies of "and in a packed programme tonight" came to mind at our meeting at Loughborough University which featured no less than three expert speakers, all preceded by our Group's Annual General Meeting.

Dr. Michael Smith of Loughborough University, before introducing the speakers, briefly described the work of the University's Water, Engineering and Development Centre (WEDC) that is one of the world's leading education and research institutes for developing knowledge and capacity in water and sanitation for low- and middle-income countries. Its web address is: http://wedc.lboro.ac.uk/.

In the context of increasing population and water-using infrastructure in Africa, our theme for the meeting was the burgeoning need for increased clean water supplies.

Water Well Drilling in Ethiopia

Our first presenter, MSc student Addise Amado Dube, spoke of his experience of the water drilling industry in Ethiopia.

Many drilling organisations work in the country, subject to conditions controlling their efficiency in the context of social, technical, geographic and economic constraints. The operators are well versed in well design, drilling technology, ground water assessments, construction quality and logistics and it is planned to sink many thousands of new boreholes to increase the water cover in the country.

The Influence of Landscape Evolution and Hydrology on Alluvial Units in the Katonga Valley, Uganda

Graham Bradley, from University College London, next described his PhD work in the Katonga Valley in southwest Uganda. The broad, open, flat, 200 km valley joins the vast Lake Victoria in the east to the much smaller Lake George to the west. A river in the westernmost 40 km flows westwards to Lake George while Lake Victoria receives the rest of the valley water. Bedrocks are various gneisses and granite overlain by alluvium and, to the east, fluviolacustrine deposits.

Uganda's population and productive work doubled and redoubled in the twentieth century intensifying the need for water. A deeper understanding of the genesis and nature of water-bearing rocks is the key to better skills in planning water supply. Here, the best geophysical study method was found to be electrical resistivity, in the basic method of which four electrode spikes are pushed into the ground in a line and direct current (regularly reversing to avoid unwanted polarisation effects) is pumped into the outer electrodes. Then voltage is read across the inner electrodes. A graph is drawn of a series of readings with increasing electrode spacing which provides a vertical section based on the electrical resistance of variable rock layers. Nowadays a multi-electrode device uses 72 electrodes spanning 160 metres which are used in a profusion of patterns, automatically producing tomographic resistivity profiles both as vertical sections and in area coverage.

Of the valley's geological history, three broad cycles of erosion and deposition have been identified: The original ancient valley with hardened glacial strata, the remains of river and lake deposits of Neocene (upper Tertiary) age and the late Quaternary channel with recent wetland deposits. But this is on the western side of Great Rift Valley country and Lake Victoria has been heaved up and down over the ages, leaving river and lake deposits at varying levels. Fluctuating climate trends have been added to the mix, further to exercise geoscientists' interpretative skills.

A number of cross-sections were shown of the sandy and silty deposits stretching along the long valley, and their significance was explained. Fortunately the water yield from boreholes in this countryside is nearly always sufficient for local use and in some places would supply a town.

Groundwater and Climate Change in Africa

Our third speaker, Dr. Alan McDonald, Principal Hydrogeologist at British Geological Survey, Keyworth, began by pointing out that 300 million Africans, having no easy access to water, were forced to carry it, often for several kilometres. Infant mortality is higher where water is scarce and the heavy work of water handling wastes time and energy as well as keeping children from schoolwork. Consequently, providing clean water is one of the best services that can be offered to underdeveloped countries.

Lack of water inhibits crop yields while, on the other side of the coin, multinationals sometimes aggravate the problem by growing thirsty crops such as maize which overuse available water.

The need must be met by groundwater but the important unknown factor is the resilience of this supply to climate change. To develop a base of groundwater maps from all existing sources of information is vital work. These data would include groundwater storage which, although varying widely from place to place, is commonly quite high at twenty times the annual use by handpump.

Part of the study is concerned with recharge from rainfall. Generally the African continent contains large reserves which are sufficient for handpumps even if access is sometimes difficult, but yields higher than that pumped by hand may not be sustainable.

To avoid conflicts between ever thirstier communities, the hydrologist's contribution becomes increasingly significant. The following web address provides further reading: www.bgs.ac.uk/gwresilience/.

To complete this interesting evening Dr. Smith's final speech included thanks to our three speakers.

Geochemical Mapping in the United Kingdom

Meeting at the University of Nottingham on 7 February 2012

Report by Geoffrey Jago

Our country's rocks and soils contain many chemicals. Some comprise a valuable resource, many are contaminants and some present problems because of past industrial activity. Hence, a register of where they lie and in what concentration is clearly a valuable asset.

Nottingham University was host when Andreas Scheib, Geochemist with the British Geological Survey, described his work with the Geochemical Baseline Survey of the Environment (G-BASE) project. Soil, stream sediment and water have all been comprehensively sampled and studied by BGS experts to provide a geochemical baseline of the UK. While this information has widespread value and interest in our crowded island, where it becomes increasingly necessary to bring old industrial sites back into beneficial use, this information has particular relevance to developers, researchers and those who study the environment.

Background and Baseline

Beginning some 40 years ago with mineral exploration as its centre, G-BASE has evolved into a high-resolution survey with available information on over 50 elements and its methods have been adopted internationally. This knowledge falls into two major classes: Background, which describes the amounts of elements which occur naturally, and Baseline, which also includes the changes made by man. Study areas fall into the two classes of Regional and Urban.

Where relevant, the elements As, Ba, Ca, Cu, Fe, K, La, Mg, Mn, Ni, Pb, Se, Sr, U, V, Zn and Zr all feature in the analyses of samples as does acidity (pH) and other parameters.

We were shown a number of maps of the United Kingdom each devoted to specific elements or groups of them.

In conclusion Dr. Scheib recapped by stressing that Geochemistry is necessary to establish baselines, legislative initiatives, archives, contributions to domestic and world-wide initiatives, for example in training, improvements to the quality of life and safer and healthier environments.

Further reading is available at www.bgs.ac.uk/gbase.

A speech of thanks was given by Group Chairman John Black.

Hydrogeology and Contaminated Land

or the 'dark art' of understanding head

Meeting at the British Geological Survey, Keyworth on 27 March 2012

Report by Geoffrey Jago with thanks to the speaker.

Those at the back grew wan at best:
They feared the master's voice.
"Today you're going to have a test
"A simple multi-choice."

The bard's enduring words came to mind in the new De la Beche theatre at British Geological Survey, Keyworth (the site of the old De la Beche having suffered acute surface erosion prior to a change of use) when our Group Chairman, John Black, Director of In Site Hydro, spoke on the increasingly important work of assessing the water regime where land contaminated by past industry is to be found a new role, often with public access.

M. Darcy's Law

John's wide knowledge and straightforward approach to the way water behaves underground places him in the best position to explain the complexities to layman and specialist alike. Modern science centres around the law by which in 1855 M. Henry Darcy defined the way water flows through any permeable rock. A head (or pressure) of water across a given earthly medium produces across it a gradient of head. A generation earlier Herr George Ohm had enacted his very similar law of electricity. But botheration and geology banish all simple solutions. We were led into the mysterious world of how a head of water sneakily deceives the investigator.

A Typical Example

The example site was a suburban site in Durham with a bedrock of Namurian Carboniferous and Magnesian Limestone over which the ice sheets had laid down a glacial till of silty sand with boulder clay on top. Some of the latter had been made into bricks, taken from a pit covering half the site area, and the void had then been filled with refuse. Four boreholes together with a number of trial pits and window samples provided subsurface information. The hydrogeologist's task was firstly to assess and interpret the groundwater regime and then to report on the suitability of the site for its intended future use as a public park, in this case bearing in mind any hazards of undue flooding or any perils traceable to the deposited refuse.

Heads Down Look In

And so to the exams which could have been predicted by each of us having been given a card to display. They showed A on one side and B on the other. Not difficult so far. The audience was divided into three groups: professionals dealing in contaminated land, hydrogeologists and the rest.

Maps and a cross-section gave the picture: gently sloping eastwards with layers of glacials on the bedrock of Namurian Carboniferous and, further east, Magnesian Limestone. We were shown three geological cross-sections with the observed water levels in the test holes followed by three (differing) interpretations of the site's water regime by three consultants.

Audience participation was next sought in the form of a test on our understanding of M. Darcy's work in 1855. He had set up a sloping column of typically permeable rocks, applied a head of water to the top, measured the head at points along the column and then how fast the water ran out at the base.

Now for the first tests. No talking at the back. We were shown alternative instances of vertical water flow, one where the lower end was sealed (no flow) and the other not (gravel and small flow). We were asked to choose in each case between displayed correct and incorrect consultant's interpretations of how head varied with depth. A and B cards were duly waved. Memories were sparked of school when the success of those who smirked was ascribed to chance by the rest of us.

Two conclusions were drawn: the water table is where the ground water pressure equals atmospheric, and gravel will saturate to the top when recharge rate equals saturated permeability.

Heads and Flows

Further diagrams demonstrated what head of water could be expected in varying rocks and conditions of water flow. For example, in silt with small flow, head reduces as it flows downward.

After having been shown mock Darcy experiments by John, we were given a second look at the three cross-sections with observed water levels and again asked to vote. John pointed out that such information could indicate either fully saturated strata or perched water tables.

An important point is that a regime of perched water tables is a high permeability system, whereas saturated vertical flow occurs in an average to low permeability system.

All formations (not just gravels) saturate to their tops when faced with recharge equal to their saturated hydraulic conductivity.

Example Site Summary

John gave his summary of the hydrogeology of the example site:

The park is underlain by Glacial Till with a water table very close to the surface except in the old landfill where it is lower down.

All recharging water in the immediate area is leaking downwards into the glacial sands and gravels that underlie the till.

The downwards-leaking water meets upwards-leaking water from the Magnesian Limestone and both flow within the glacial sands and gravel southwards towards the local river (which they augment).
Any historical contamination from the landfill is either in the glacial sands to the south of the site or has already migrated into the local river.

No gas pathway is likely (contrary to conclusion of consultant's report).

Waste Disposal System, Drigg, Cumbria - A Contrast

By comparison an example was given of a site where the density of test holes was much greater than at the previous example. The waste disposal system at Drigg is on a low-lying area near the coast where drift deposits overlie Triassic Sherwood sandstone. This site was perceived as a perched water table system above a regional flow system and the site presented many problems. One was to distinguish between the water regimes of drift and bedrock where "headroom" was low owing to the flat topography, and a specific technique was described.

Finally Some Dos and Don'ts

- Don't use the term 'lack of hydraulic continuity' and be suspicious of anybody who does use it
- Don't use water table and piezometric level interchangeably
- Don't use Allen et al., 1997 as a 'bible'
- Convert all water levels and pressures into heads
- Don't use terms like aquiclude, aquitard, and semi-confined to describe formations under natural conditions since the terms are derived from pump testing and only apply to the formation's response to the peculiar stress of a pump test
- Bear in mind that a borehole in a low permeability formation could take a year or more to fill up to an equilibrium level – 'dry' doesn't necessarily mean dry.
- Don't believe driller's 'first strike' water levels

And Some Simple Rules of Thumb

- Perched water tables are unusual in UK (most common in high dry deserts)
- Only occur in high or steep places (not valley bottoms)
- Use simple basic information like relief (water flows downhill) and amazing how often surface water indicates conditions
- Maximum recharge that any formation will take is its own value of saturated hydraulic conductivity
- Take notice of geological formation names: i.e. Boulder Clay, Lacustrine Fluvial/Pebbly Clay
- A perched water system requires low K layers in a high K system not high K lenses in a low K system
- Perched water systems require more headroom than you think

David Bailey gave the speech of thanks for an interesting and stimulating evening

Nucleation in Lime Stabilised Soils

Meeting at Loughborough University on 19 April 2012

Report by Geoffrey Jago

The Egyptians had found that a mix of roasted limestone and sandy clay slaked with water was handy for plastering a pyramid. A couple of millennia later the Romans used the mix as a mortar that would last for centuries; but many centuries later the process of hardening has yet to be fully understood.

On his home ground of Loughborough University, our speaker Paul Beetham, Research Engineer, described a part of a two-year engineering doctorate program which introduced us to the mysteries of the ancient chemistry in the context of making soft ground more able to bear the weight of building development.

Stabilisation and Improvement

Modern society demands more and more sites to be brought inyo reuse, many having hitherto been rejected because the soil was too soft for building. Enter in a canter the White Knight of science with a range of sustainable panaceas, one of which was the subject of our evening's study.

Soft soil can be made more competent by mixing a surface layer with quicklime or slaked lime, using either a plough and disc harrow or a purpose built rotovator. This obviates the expensive alternative of trucking in harder surface material.

Quicklime

Our speaker concentrated on the use of quicklime. The calcium carbonate that comprises the main part of limestone or chalk can be thought of as a combination of calcium oxide and carbon dioxide, and roasting separates the two. Calcium oxide is quicklime which with water converts readily to calcium hydroxide (hydrated, or slaked lime) producing a large amount of heat in the process. Mixing either slaked lime or quicklime into soft soils will, over the the course of a few weeks, produce a soil sufficiently hard to sustain building. Quicklime, at a proportion of 3.5% to 5%, has an advantage over slaked lime because the heat released in the slaking process helps dry the soil.

Nucleation

However this is where simple chemistry has to give way to research into how nucleation and the growth of secondary minerals cause hardening. Modification and stabilisation depends on clay in the soil. A diagram illustrated how clay, in the form of platelets, naturally lie in stacks like a horizontally laid slate wall, but lime jumbles them up and so increases soil strength while increasing inter-aggregate porosity. An optimum moisture content is sought because over-dry soil has too many voided while over-wet soil is too compact. Initial hardening is rapid, in less than a day, but a slower hardening involves silica and alumina in the clay as calcium silicate hydrates or calcium aluminate hydrates form slowly over the coming weeks and months.

Experiment Foils the Critics

Criticism from industry that book theory differed from practice had been largely answered by practical experiment at Loughborough. Suitably shaped samples are prepared from as-dug clay which is pulverised by hand before quicklime and water is added and thoroughly mixed in. The samples undergo strength testing, some dried in air and others soaked in water. A graph showing comparisons between untreated clay with treated samples after 7-day, 31-day and 6 months curing periods demonstrated that treated soils hardened rapidly at first, improving progressively with age.

Fractures, Crystals, Gels and Research

Knowledge of the microscopic processes involved when lime meets clay can lead to cheaper and more efficient practice in soil stabilisation, so work at Loughborough have employed the microscope and x-ray diffractor to peer deeply into the structure of the soil nodules which form after treatment and have studied their fracture patterns. Fracture patterns affect strength take a stepped form after a month but by six months they become irregular.

In time a gel forms around the clay platelets the edges of which weld onto the faces of their fellows increasing strength and leaving a more permeable structure. There is a tendency for calcium to migrate into the nodules, making them more alkaline in the centre.

The nature of the gel is interesting. Could it be a calcium silicate hydrate and is it amorphous or crystalline? Current thought is that it is amorphous and appears to be an alumino-silicate compound rather than a calcium silicate.

Summary

Paul summed up his talk:

- Modifications increase porosity which aids compaction
- Strength gains after this are driven by gel formation
- This fills inter-aggregate porosity
- This is visible on a macro scale through ‘module’ growth
- This promotes macro fissures as the weakness

Group chairman John Black completed the proceedings by thanking the speaker.

Drilling in the 1st Century - Do We Need Geoscientists?

Meeting at BGS, Keyworth on 24 May 2012

Report by Geoffrey Jago, with thanks to the speaker.

Of the many technologies that maintain our living standards, the importance of drilling holes in the ground deserves better appreciation by the public. Water, oil and gas production are the obvious benefits but boreholes also allow mineral resources to be assessed, produced gas to be stored underground, global warming carbon dioxide or other undesirables to be buried, geothermal heat to be accessed and the ground to be examined prior to civil engineering work.

Our speaker at British Geological Survey, Keyworth on 24th May 2012 was John Beswick, Director of PR Marriott Drilling Group. With forty-five years experience and an entertaining presentation style, he packed his talk with information on the extraordinary progress of geodrilling over the past five or more decades.

Working Together

Covering many disciplines, successful drilling is dependent on the relationship and communication between engineers, geologists, geophysicists, geochemists, scientists, IT specialists and many others, the key ingredient being the effective integration of skills and communication of knowledge. Good practice has improved safety and environmental responsibility while abstracting more information in greater detail from each hole.

Deep drilling, especially, is a changing industry. Many managers and those taking planning decisions could be better informed of the technical limitations facing drillers and hence time spent discussing the work with them is necessary and usually worthwhile.

Exploration Drilling

Exploration drilling has grown to a sophisticated industrial process involving many disciplines which require a wide range of equipment and processes and in his talk John focussed on the essential interrelationship between drilling and geoscience.

The initiator of any project faces a number of decisions to ensure that the drilling rig or rigs will prove up to the job. For example, one must decide on the hole diameter, depth range, sampling by conventional coring or wireline, type of casing, type of drilling fluid, casing and cementing design and, from a whole range of geophysical and other logging methods, how data is to be gained and recorded. For deep holes the effect of rock stress must be taken into account.

The Business End

Where the formations allow, the selection of the type of cutter head is moving away from conventional roller cone to synthetic diamond bits, where the geology permits. More durable cutters save money by reducing the time between hoisting and replacing the drill string (tripping). Some exceptional bits can drill for as much as several kilometres before they need replacing. The absolute cumulative footage record is 358,307 ft (109,283.6 m), by a 6-1/4 in PDC (Polycrystalline Diamond Compact) bit, set in Alberta, Canada in 2003 on the 166th run where the average rate of penetration was 165.4 ft (50.4 m) / hr.

The use of motors at the cutting end obviates the need to rotate the drill string (rods); and ever more sophisticated down-hole devices (rotary steerable tools) allow the driller to point the hole in any direction and to drill branches from the main hole. It is now common practice to drill vertically to a desired horizon, bend the hole up to a curvature of say 15o/30 m and continue horizontally for long reaches.

Glorious Mud

Drilling fluids, which provide cooling and lubrication and on many wells are selected for density to control gas/oil pressure, are subject to continuous development. Oil base muds have certain benefits in some cases, but environmental considerations now focus attention on more exotic water based muds.

Geothermal Engineered Systems

The search for subsurface inorganic energy includes tapping into areas of hot rock, solid or fractured, and hot aquifers. In the past, research holes were drilled in Cornish granite where the temperature rises more rapidly with depth than in many places to investigate the possibility of extracting heat from granites at depth. The currently thinking for these engineered geothermal systems is to sink three wells, one to inject and two to produce, with flow rates of up to 100 litres per second; but hot rocks are hard and costly to drill and the eyes of investors tend to glaze over when faced with the cost of the first well. Risks include short circuit and induced seismicity.

Work is being carried out in many countries to develop more and more natural geothermal energy resources with a current world-wide installed yield of 10,000 megawatts.

Shale Gas

Gas from shale is now available thanks to improvements in drilling technology, including the ability to worm a path accurately along shale beds deep underground, despite concerns over induced seismicity and fear of ground water pollution which provide the press with material almost daily. [Our Group's lecture of 27th September, 2011 featured this subject.] Shale gas exists in certain areas on all the continents and an estimate in the assessed basins alone totals 175,000 billion cubic metres.

Gas Storage

Underground gas is produced faster than it can be burned so a need arises to store it economically. Temporarily putting reserves back underground is now planned via accurately drilled wells and forming leached caverns in salt deposits often up to 2000 m deep. Against the average daily UK use of about 268 Mcm, the area around Aldbrough in East Yorkshire has a 330 Mcm capacity and the planned storage facility at Preesall in Lancashire will have a capacity of 600 Mcm.

Geological Disposal of Radioactive Waste

Deep borehole disposal of some radioactive wastes remains an option and future programmes for investigation of potential sites for a deep radioactive waste repository are planned in the UK. The Westbay Multilevel Groundwater Monitoring System addresses the concern of ground water pollution and pressures and a licence for its use in the UK was obtained in 1978. However, we were told it took fourteen years to convince the geotechnical industry in the UK of its value.

In the 1990s the comprehensive geological and hydrogeological investigation into potential sites for a deep mined repository at Sellafield and Dounreay was world class.

Profound Matters

Both the USA and Soviet Russia sank ultra-deep holes in the 1970s. The Americans drilled the Bertha Rogers well to 9583 m (5.95 miles) in 1974 but were upstaged by the Russian effort in 1989 of 12,262 m (7.62 miles) or about a third of the thickness of the 22 miles of the Earth's crust that exists where it was drilled - the Kola peninsula in northwest Russia. A downhole motor was used at the end of drill rods made from an aluminium alloy and the work provided a useful new understanding of deep coring and deep wireline logging.

In 1987 to 1994 in Bavaria, the German Continental Deep Drilling Project (KTB) reached

9001 m (5.59 miles) through crystalline rocks. It is thought that it would penetrate two tectonic plates but no boundaries were detected.

Two very deep wells were drilled in the Vienna Basin in the late 1970s and early 1980s. The deepest well, Zistersdorf UT2, was drilled to 8553 m (5.31 miles) after the first well blew out.

Entirely in granite in an impact crater, the Swedish Deep Gas Project reached 6,600 m (4.10 miles) in 1988 to 1990 in search of abiogenic methane.

The world record for well length, beating its rival at Kola by less than half a furlong, was achieved in an oil and gas field on Sakhalin Island north of Japan. Drilled by the Exxon Neftegas consortium which includes ExxonMobil with Russian, Japanese and Indian firms, a long reach well reached 12,345 m (7.67 miles).

Tools Now and Things to Come

Automation in drilling is already here and advanced techniques already include MWD (Measurement-while-drilling), directional control and information, geosteering, natural gamma recording and LWD (Logging-while-drilling), a substitute for wireline logging. In situ welding of casing strings is possible at speeds of up to twelve welds an hour, or forty times as fast as that achieved by traditional welding.

The burgeoning need for energy will keep up the momentum of drilling research as the advantages of the microchip are adopted; and future drillers expect to spend more time at a keyboard than on a drill platform. He or she already controls operations, reads data and sends commands via pulses in the drilling fluid system (mud pulse telemetry).

Drilling will extend into more remote areas, including the Arctic, and into deeper waters.

Preserving Skills

John drew our attention to the high proportion of skilled drilling staff who will retire before 2020. There is a need for a more aggressive training programme so that the valuable resource of gained experience may be passed on and not lost. At the same time politicians and the public must accept responsibility for resource development or the lights will go out. As fortune favours the brave, countries and companies less fearful of risk may be those who reap the greater benefits.

And a Salute to the Driller

In a world that must make the most of its resources of fuel, water and minerals, the very difficult and skilful work of the drilling industry, described here only briefly, highlights the vast span of fruitful usefulness that it provides to society.

David Boon gave a speech of thanks for this very interesting evening.

Olympic Park 3D Model

An Evening Lecture at British Geological Survey, Keyworth on 20 June 2012

On 20 June 2012, Dr. Kate Royse, manager of the BGS Cities Underground Project, described the programme of work undertaken by her team and herself to build a 3D geological model to better understand the geology beneath the Olympic Park site in the Lower Leen Valley in the East End of London. This 3D model was one of the first to demonstrate the benefits of 3D data for understanding the variability of bedrock and superficial deposits beneath major infrastructure projects in urban areas.

An article on this work by Dr. Royse has been published in the National Environmental Research Council's publication "PlanetEarth", Summer 2012, and may be read at

www.nerc.ac.uk/publications/planetearth/2012/summer/index.asp?cookieConsent=A

The PDF file "Grounds for success (Olympic feature)" may then be opened.

Helen Burke spoke to thank the speaker for an interesting and informative evening.

Soft Ground Tunnelling Through London

An evening Lecture at British Geological Survey, Keyworth on 3 July 2012

On 3 July 2012 Dr Ursula Lawrence, an engineering geologist working for Crossrail, speaking to our Group in the De la Beche Lecture theatre, described ground investigation and engineering work involved in extending the underground railway across London. The geological setting and stratigraphy along the tunnel route were described as were the construction risks as influenced by the geology, groundwater conditions and man's activities.

An article on this work by Ms. Lawrence has been published in the July 2012 edition of Geoscientist and may be read online.

David Entwisle spoke to thank the speaker for this interesting and informative evening.

The Untold Story of Onshore Oil Exploration in the East Midlands

Meeting at Leicester University on 9 October 2012

Our Group's meeting on Tuesday 9 October 2012 was at Leicester University when Andrew Naylor, of University of Nottingham and BGS, spoke on "The untold story of onshore oil exploration in the East Midlands". The following is his synopsis:

British onshore oil exploration has proceeded in a low key, episodic manner for almost two centruries. Britain's coal to oil modernaty is deeply etched into the cultural and historical geographies of the East Midlands. However, the narrative has remained hidden, fragmented and largely neglectd by the intellectual community. Britain's black golconda is intimately embroiled in the physical qualities of the region's geology. Relinquishing Britain's incarcerated enclaves of oil was made possible through the scientific, technical and entrepreneurial actions of several key individuals, many of whom share an intimate relationship with the East Midlands.

This talk reveals the interconnected relationships of six epistemological field sites (Riddings, Hardstoft, Eakring and Dukes Wood, Caunton and Kelham Hills) which were discovered in a west to east succession from 1846 to 1943 and examines the ways in which a string of individuals added their own scientific lithology's to reconfigure a modest, low key sideline venture in Derbyshire into a multimillion pound global industry.

During WWI and WWII British onshore oil exploration sparked heated geopolitical debates centred on land and mineral ownership, monopolisation, royalty payments, state regulation and overall domestic energy autonomy. Ultimatly, the discovery of four inland oil fields in Nottinghamshire provided a time critical supply of domestic oil during WWII, serving as secret oil carriers the enemy could not sink.

Is Shale Gas a Global Game Changer?

Annual Christmas Lecture by Professor Mike Stephenson at British Geological Survey, Keyworth, on 4 December 2012

Report by Geoffrey Jago

Aldous Huxley observed: “Such prosperity, as we have known it up to the present, is the consequence of rapidly spending the planet’s irreplaceable capital.”

A Momentous Resource

When one compares the time anthropoids have been intelligent with the period that they have been able to recover oil and gas, the latter span - only a century and a bit - is remarkably brief. Even so, all the easy reserves have already been sucked up and burnt. Enter, upstage, the methane trapped in shale which is predicted to provide respite for a few more decades.

Professor Mike Stephenson of the BGS Shale Gas Project spoke firstly on the potential for the recovery of gas from shale by underground fracturing (fracking). He followed this by a discussion on environmental concerns and then explained the role of independent and peer-reviewed science in shale gas development. This being a very topical subject, our Group had in September 2011 hosted a previous lecture on the practical aspects of fracking, given by Dr. Turner of Cuadrilla Resources.

And So to Shale Beds

The evening began with an animated cartoon entitled “Fact Fiction and Fracking” featuring a two dimensional Professor Stephenson presenting a popular image of the subject and describing how the public image of fracking differs from reality.

This was followed by an illustration of how it can be predicted that gas from fracking could equal or outperform the combined other energy sources. China, USA, Mexico, Canada, Argentina and France have large potential shale gas resources. Poland is in the spotlight because, although it mines its own coal, it depends on other states to the east for its gas while having potential shale gas within its boundaries. In Polish power stations, switching from coal to gas would decrease CO_2 emissions by between 41% and 49%.

The UK is predicted to have abundant shale gas in a zone which extends from south Nottinghamshire northwards under the Pennines to north Northumberland, taking in parts of Lancashire en route.

The Recovery Process

Shale gas lies deep, typically two to three kilometres down. It is accessed by boreholes which, when they reach these depths, are twisted to continue horizontally through the shale beds. When complete, water mixed with sand is pumped down at sufficiently high pressure to open cracks in the shale. The sand remains to prop open these fissures so that they cannot re-close. This pumping process can involve some short-lived noise but thereafter the gas seeps out and is accessed via the same boreholes.

Earthquakes and Ground Water

Any new process awakes ever-present worries over any drawbacks, and TV reports of American water taps producing flaring methane along with the expected product are nothing if not eye-catching. Earth tremors in Lancashire, which were provisionally put down to drilling, delayed work; but permission to continue has recently been given.

Some contamination of water supplies by methane has been experienced in the USA but later operators have learned by this experience and believe that better practice can provide the answer.

Two Kinds of Methane

In seeking whether the gas in groundwater came from deep shale or from "everyday" shallower rocks, would it not be useful to make a distinction? This is certainly the case and isotopes provided the clue.

Underground methane can be classified as either biogenic or thermogenic. Biogenic methane is usually generated by bacteria, and isn't usually associated with deep shale. Thermogenic methane, generated by heat on the organic matter in shale, is usually deep but sometimes occurs naturally in shallow aquifers. Showing that methane in a water well is thermogenic (when the ™13C of the C in the CH4 is less than about -50 ‰) might be one way of telling if a deep fracking operation is leaking, but you have to know what the baseline natural levels of methane are as well. It's a little known fact that many of our aquifers in Britain contain methane – biogenic and thermogenic. Knowing how much is natural – so that you can distinguish it from possible leaked methane – is only possible if you've measured baseline levels. This is why the BGS is working on a baseline survey at the moment.

A Game Changer?

In conclusion Professor Stephenson pointed out that shale is a common rock holding much old organic material. The UK has large volumes of shale with gas potential. Peer reviewed independent science has a special role in building regulator, investor and public confidence.

The Web

For those with access to the internet very much more information is available from the BGS web page at
www.bgs.ac.uk/shalegas/

An Appreciative Audience

The lecturer's attractive and interesting style of presentation went down well with the large audience in the new De la Beche lecture hall at BGS and an engaging question and answer session followed.

Our Chairman John Black completed the evening with a speech of thanks.