EMRG Meeting Reports 2002 (continued)

Forensic Geology (Geoforensics)
17 October 2002
Report by Geoffrey Jago, with acknowledgement and thanks to Dr. Donnelly

The longer the experience of geology, the greater is the appreciation of the enormous breadth of studies covered by the science. The September meeting of East Midlands Regional Group at British Geological Survey, Keyworth illustrated a new perspective on how geology can contribute to society. Forensic work is defined as that relating to courts of law, so geoforensics describes the part that geology can play; and that is a very significant one.

From his wide experience of the subject, our speaker, Dr Laurance Donnelly, a geologist with International Mining Consultants and a Research Fellow of the British Geological Survey, left us in little doubt.

Geoforensics is about helping the police. The first notion that springs to mind is the identification of the sources of mud and minerals on the shoes or clothes of a suspect. Detective writers Sir Arthur Conan Doyle and R Austin Freeman both used this idea. Dr. Watson noted how Holmes could recognise different soils on clothing, and identify where in London an individual had been walking, while FreemanÂ¹s pathologist character Dr. Thorndyke traced a body at Gravesend from loam containing foraminifera. As long ago as the nineteenth century it was discovered that the myriad minerals and micro-fossils in traces of mud could yield such abundance of information that murderers who lacked the foresight to burn their shoes before the police sequestered them were left with scant choice but to own up.

The search for graves of murder victims takes up overwhelming amounts of police time. Here the skills of a geologist with the expert eye to landscape provided by mapping training can be brought into play and Dr. Donnelly has devoted much time alongside the police with some very useful conclusions. A disturbance of surface structure of a rough moorland scene is often invisible to the eye of the layman but to a geologist who knows the characteristics of the ground, evidence of recent digging can be obvious. Coupled with an understanding of the various modern techniques of geophysics, immeasurable help can be provided by the geoscientist towards diminishing the difficult tasks of the constabulary. Surveys using electrical conductivity, magnetism, gravity and ground penetrating radar (GPR) have all been used effectively. This applies equally to geological maps which have been used in police investigations to identify potential burial sites and topographic features mentioned in witness or suspect statements. Again, geological maps can be used to eliminate areas of ground which are less likely to conceal buried objects, thereby enabling the more cost-effective use of resources and reducing the time spent on unsuccessful searches. Similarly, aerial photographs when interpreted by an experienced geologist can provide much information, including the highlighting of areas of ground deformation. In mining circles especial care has to be observed when ore samples are assayed. A few years ago the shares of a company rose rapidly following news of enormous gold reserves in Indonesia. Imagine the disillusionment of shareholders when geoscientists were able to point out that the shape of gold particles in rock core samples betrayed their river bed origin.
Geologists are not always such spoilsports.

Photographs of rock structures can help a lot. In 2001 the famous videotape from Afghanistan which was displayed universally on television enabled the search for the subject to be narrowed dramatically. Rock exposures were recognised by a field geologist with extensive local field mapping experience. These particular rocks, which occur only in the Katawaz Basin in the southeastern part of Afghanistan, are soft, coarse, shallow-water Pliocene sandstones and limestones. These have the tendency to form natural caves and support man-made tunnels and chambers.

A lighter note concerns the owner of a Canadian store who was disappointed to discover, in boxes purporting to contain bottles of whisky, material of a less intoxicating nature in the form of an equivalent number of lumps of limestone. Where, over its long journey from the UK, could such a deceit have been effected? Our science was able to define with certainty that the stone could only have come from a particular quarry in England whence the suspect had been seen carrying home rock samples.

Dr. Donnelly concluded by drawing attention to the requirement, as yet unfulfilled, for training courses both for investigating officers and geologists so that their separate skills can be understood and shared.

A speech of thanks was given by Professor Martin Culshaw.

From Sandcastles to Snowballs - Exploring the Physical Properties of Rocks
6 November, 2002
Report by Geoffrey Jago

The speaker at our meeting of 6th November 2002 at British Geological Survey, Keyworth was Michael Lovell, Professor of Petrophysics in the Department of Geology at Leicester University. The sandcastle section of his talk dealt with the petrophysical properties of rocks while snowballs referred to methane hydrates, those enigmatic sub-oceanic gas reserves which must one day be tapped when homo sapiens finds that oil is becoming a luxury.

In the meantime, an increasing proportion of our gas and oil comes from marginal deposits and their efficient recovery depends upon the best understanding of how liquids move through rocks.

The four main attributes in the study of how liquids behave in porous rocks are porosity, permeability, water saturation and capillary pressure. There is no simple law to relate porosity and permeability. If all grains were perfect spheres of equal size calculation would be easy but since nature does not provide such integrity, permeability depends upon the sizes, shapes and interconnections of the spaces between particles. Porosity is reduced if a rock undergoes cementation, whereby the grains are coated and stuck together.
From his work on the flow of water through sand, Henry Darcy (1803 -1858) defined permeability as the measure of the ease of flow through a medium under pressure, his name being perpetuated as the standard unit of permeability. Gravels have values of 1 to 3 darcy, plutonic rocks are low, volcanics are variable while sediments, from sands to clays, can differ by a factor of a million. G.E. Archie found that there is a linear relationship (Archies "law") between electrical resistivity and porosity which depends upon the shape of the grains.

Water saturation is the proportion of water to air in the spaces between sand grains.Capillary pressure adds to the complexity because liquids defy gravity in small spaces, a characteristic of which use is made when sponging beer from the kitchen floor to obviate discovery by oneÂ¹s spouse. Wetability, another factor, depends upon the nature of the liquid. Mercury does not wet a surface but water does. Water fills part of an unsaturated void by sticking to the sides, and the narrower the spaces the greater the water attraction. Rocks with many different particle sizes make for high wetability and greater capillary pressure.

Professor Lovell then went on to the second part of his talk. The snowflakes he referred to are gas hydrates of which methane hydrates, existing at depth in certain areas, mostly below the sea, may well represent a greater energy source than all other sources combined. Water molecules can entrap gas molecules in cage-like spheres, rather like the lattice domes of the Eden Project except the crystal patterns differ - gas hydrates crystallise in the cubic system. This is a physical rather than a chemical phenomenon, and the volume of gas comprises about 200 times the volume of its imprisoning water. Methane hydrate forms in cold high pressure zones at depths between 100 m. and 1200 m. Below this zone lies non-hydrated methane gas, because with increasing temperature the hydrates disassociate.

These hydrates can be brought to the open air in drill cores where they occur typically in very thin frozen layers, white or brown in colour. On surface they do not last long. Their potential as an energy source would be attractive but for the cost of extraction; but research continues, particularly in Japan where hydrates exist and where lack of indigenous oil is a strong incentive. Commercial exploitation may be seen within five years.
The report on these pages of our GroupÂ¹s meeting of April 1999, when Dr. David Long of BGS Edinburgh spoke on gas hydrates, is also relevant.

Professor Lovell rounded off his interesting talk with illustrated advice, of clear value to parents, on the best water content to make a stable sandcastle on the beach.

A speech of thanks was given by Professor Martin Culshaw.

Geochemistry at the Global Scale 12th December 2002.
Report by Geoffrey Jago

The last meeting of East Midland Regional Group in 2002 was devoted to a talk by Professor Jane Plant, Director of British Geological Survey, Keyworth and President of IMMM. Her illustrated talk on *Geochemistry at the Global Scale* was devoted to the work which BGS, in association with a number of other organisations worldwide, undertakes to study the global and local effects of chemicals in the ground upon the environment and the health of human populations. Predictions for the growth of world population show a steep rise for the next half century, almost wholly accounted for by people outside the industrialised countries.

In combating illness, an initial step is to seek and define the cause; and here BGS and its associates continue to contribute valuable information internationally. Much of this work concerns the heavy metals and other harmful elements. Amongst those listed were beryllium, radon, thorium, uranium, arsenic, cadmium, mercury, antimony, titanium, lead, tin and ruthenium. However, there are many other elements and compounds that have to be taken into account. To appreciate the extent of the task that geochemical study incurs, one had only to read a BGS work, provided as an example, Regional Geochemistry of Northeast England in which detailed information on nearly forty elements has been obtained and mapped.

A large number, but not all, diseases arise from ingestion, directly or indirectly, from soils. In the study of how the human body can absorb chemicals directly, tests have been devised to emulate the digestion of food passing through the human digestive tract, with its radical change of acidity over a day or so. When a pollutant has been found, it is necessary to seek its source and the pathways it takes prior to accumulating within the human body. Persistent organic pollutants (POPs) and their relative mobility in oxidising and reducing environments is another area of work under investigation.

Some disorders result from a deficiency rather than an excess of certain elements. For example, soils in large areas of China, where the diseases Keshan and Kashin-Beck occur, have low selenium.

Aside from these elements, China has health problem with domestic coal combustion, one coal-related disease being fluorosis which causes deformed bones.

The incidence of cancers of various sorts in males and females has been studied by populations. Radon gas has been proved to cause lung cancer and in certain cases in the Middle East is estimated to result in harm equivalent to smoking 60 cigarettes a day.

Professor Plant devoted part of the evening to specific instances. Of these, one referred to uranium which has been found to occur in many individual deposits all situated around the Mediterranean. Nearer home, other maps showed areas around Manchester and Liverpool where elevated copper, lead and tin values have been found, consistent with fenland infilled with foundry waste.

A Stoke on Trent survey revealed pockets of variable acidity where lead is present. Nitrate and sulphates in surface waters show a much higher occurrence along the Welsh border, against low values in central Wales.

In replying to questions following this interesting and important lecture, Professor Plant made the points that a major hope for the future of the human race lies with education and that women should be allowed to play a larger part in society.

A speech of thanks by given by Professor Martin Culshaw.

Landfill & Legislation- Where Are We Now?

15 January, 2003

Report by Geoffrey Jago

Humans of the wealthier nations throw away ever-increasing volumes of crud. As suitable places to put it all, such as completed quarries, are used up ever more rapidly this burgeoning problem was the subject of our first speaker for 2003. Ms. Leslie Heasman is an environmental chemist, Technical Development Director of Marion Carter Associates and a leading specialist in landfill management. No better introduction to her valuable presentation can be provided than from her own synopsis:- [3]The legislation controlling the landfilling of waste recently has been subject to unprecedented levels of change.

The UK approach to landfill has to change fundamentally following the implementation of the Landfill Directive. As the Directive is a poorly drafted and ambiguous text which is not based on easily identifiable logic, in order to implement the legislation we are reliant on interpretation by Department for Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (EA) of the meaning of the legislation.[2] Because of the very complicated written definitions of waste, which differ in each country, the final word is normally left with the national or European courts. There is a move towards simplification and a necessary broadening of wording. For example, the farming industry, whose lobbyists ask many questions, generates a huge amount of waste; and further legislation is needed in respect of the mining industry.

LANDFILL

On the main topic of her talk, Ms. Heasman maintained that the Landfill Directive (LD) has an immediate requirement to be made clearer and its ambiguities resolved. Implemented through the Landfill (England and Wales) Regulations 2002 in tandem with the Pollution Prevention and Control (PPC) Regulations, the clarity of its objective has faded with its growth. The final document is prescriptive regarding construction but not so regarding environmental impact. Far from offering generalisations, Ms. Heasman went on to make specific and constructive suggestions as to what are the main requirements, under nine headings.

1. Site location
2. Permitting sites
3. Finance costs
4. Definition of landfill
5. Banned wastes
6. Reduction of landfill of municipal.wastes
7. Site types
8. Site engineering
9. Acceptance criteria.

1. **Site location:** Already covered in part by existing planning legislation, more general requirements are necessary for landfills, taking into account distances from housing, water / flooding regimes and cultural heritage and so on.
2. **Permitting sites**: Permissions are already covered by PPC legislation for new sites and all must have permits by 2007. Some directives go into unnecessary detail.
3. **Financial Position**: Sites must ensure that charges are adequate to cover all operations over the whole life of the operation, including thirty years of aftercare, until the permit is surrendered.
4. **Definition of landfill**: A waste disposal site is one lasting more than a year, and includes in-house waste disposal. There are exemptions, for example where recovery operations are carried out, for fertiliser spreading, for the deposit of inert wastes in permitted development and water-course dredging. Here, clarification of interpretation is awaited.
5. **Banned wastes**: These include certain liquid wastes plus explosive, oxidising, corrosive, and infectious materials. In respect of rubber tyres, however, where some categories are fine and the rest are not, Ms. Heasman invited her audience to read the rules and weep.
6. **Reduction in landfilling of biodegradable municipal waste**: Implemented through the Waste Strategy, this reduction requirement will affect everyone before too long and can be expected to be costly Targets for reduction have been set in three stages down to 35% of 1995 levels by 2016 (or 2020). Incineration, very unpopular, may be the only answer. Apart from a little paper, none of the stuff can be sold or reused. Whereas third world countries recycle much of their waste, in the UK totting is not allowed under Health and Safety Regulations. Local Authorities would like to encourage

householders to minimise but at present there are no incentives. Perhaps one may see the council issuing smaller bins!

7. **Site types:** Sites are categorised as inert (a narrow range), non-hazardous (broadly stable and non-reactive wastes without biodegradable material) and hazardous.
8. **Site engineering**: All sites must have a geological barrier, of specified thickness according to site type, combined with a top and bottom liner.
9. **Acceptance criteria**: Ms. Heasman provided considerable detail on this subject for which space here is insufficient.

Implementation: We were given a series of dates by which implemention of the various types of landfill must be in place.

Ms. Heasman ended her very comprehensive presentation firstly by advising a regular check on Environment Agency¹s website and secondly by displaying the banner headline:

INTERESTING TIMES AHEAD.

A speech of thanks was given by Professor Martin Culshaw.

December 2005: A Double Bill on Climate Change

The committee extends its appreciation to thespeakers and convenors for their efforts in making our 2005 meetings so successful.

Noting the burgeoning kilometres of column length that the press had been devoting to the subject of climate change, our Group, ever in the vanguard, laid on twice the normal number of monthly meetings in December 2005.

1. Climate Change: L'Allegro:
Effects on Geological Engineering

On the 5th the distinguished geologist and consulting engineer Dr. Peter Rankilor gave his striking wake-up call to geoscientists to be aware of the changes that will affect their work.

In order to lay the foundation for understanding the changes Mother Earth is enduring, Dr. Rankilor began at the earliest stage with the coalescing of cosmic dust and followed this by a lucid history of how rocks, sea and life had transformed to the present day. As regards our climate, we have a reasonable knowledge of how it has changed in the last few thousand years from Antarctic ice cores, while for past centuries we can call upon several data sources which include temperature records, lake pollen sediments, tree rings and radio-carbon dating of organic remains. A graph showed that the ice age of yore is still with us and that we are merely enjoying a warm interglacial period.

In Recent times, on the geological time scale, sea levels have varied by as much as 300 metres. We read much of the effects of burning carbon and melting ice caps, but is ice melt in fact the culprit for the present rise in sea level? Could change in the volume of the oceans be to blame? Water, which of course changes volume with temperature, can store about four times as much heat as most solid substances and there is lots of it: if the Earth¹s crust was smooth instead of mountainous, the sea would be 2,600 metres deep.

Average temperature, which had been falling linearly for the past thousand years, suddenly changed to a rising trend around 1930, and has since risen nearly one degree centigrade. However, while averages may point out gradual trends and are much reported, the media should understand the importance of the vast energy stored in the sea. For instance, hurricanes pick up their power over the sea and release it over land. The killers to look out for are not the averages but the extremes. It is these that professional technical advisors must recognise as being the most crucial because some severe effects can be expected in the coming decades. Island communities like the UK are most at risk. In western Europe, the Gulf Stream furnishes us with much more warmth that most places of similar latitude, so a small modification of this North Atlantic circulation could have a major impact. Scotland is gradually rising, recovering from the weight of its erstwhile ice covering while the south of England, on the other end of a seesaw, is sinking. Winter flooding, eroded coastlines and a shortage of fresh water are all to be expected. Further reduction in Arctic ice is predicted - in fact, infrastructure in northern Canada is already being built, the Northwest Passage being no longer a lost hope. He believed that we are past the point at which human action, for example enacting the Kyoto accord, could exert significant mitigating effect upon climate change.

Dr. Rankilor stressed the duty that consultants have to act now with these facts in mind, with special attention to the effect of water shortage on society. Planning is needed now in anticipation of soil moisture deficit. Some standard procedures which consultants have a duty to follow already require revision. He expressed some concern with British Standard climate forecasts, seeing many as imperfect, but which consultants acting in expert witness capacities are, however, professionally obliged to embrace.

But be of good cheer, citizens - temperature change could present a less onerous impact compared with another extremely devastating hazard of which we were reminded: a reversal in the Earth¹s magnetic field. Paleomagnetism in the spreading lava on the Mid-Atlantic Ridge shows us that these switches happen regularly and abruptly, and the position of the north magnetic pole had been fidgeting of late which, Dr. Rankilor said, may itself already have contributed to climate change. A reversal could happen at any time, perhaps even before this text hits the web page.

Change is something we all have to live with but those who consider all advice, such as in this thought provoking presentation, are in a better position to weather it out.
A speech of thanks for a very interesting evening meeting was given by Dr. Sarah Davies.

2. Climate Change and BGS Science: Il Penseroso

Our second, and equally impressive lecture in December 2005, held on the 13th, also at British Geological Survey featured Dr. John Rees of their staff, whose work as a Head of Department includes planning which projects BGS addresses.

Dr. Rees said that, of the several glaciations the Earth had suffered, a periodicity of about 90,000 years was evident between glacial and interglacial times. By means of comparative graphs derived from studies of these variations he showed that there was a close correlation between carbon dioxide levels and temperature. The Earth had been cooling for the last thousand years until around 1850 when temperatures began to rise slowly. The eighteenth and nineteenth centuries had seen an enormous rise in carbon dioxide levels and there now seemed little doubt that some action is called for on the part of mankind.

BGS are actively tackling the subject of climate change science in several fields. What drives the changes? What impacts on geohazards and resources may be expected? Can they be mitigated and how?

In the past, reconstructions of paleoclimates have been made and, in association with the Universities of Bristol and Portsmouth, these old models are being replaced with ones that inspire better confidence.

Ice laid down over very long periods of time is being sampled via the Integrated Ocean Drilling Programme to shed light on past climates and the atmospheres which then existed; and fossil carbon dioxide levels are being especially recorded. (On these web pages see also our meeting on Arctic drilling. of February 2004 with Dr. Andy Kingdon of BGS.)

One puzzling conundrum is why the Cretaceous period was so hot and this is a subject which BGS is to address. Could methane be involved? Working with Leicester University, the study of methane hydrates is attracting renewed interest by the National Environmental Research Council. What is their significance in climate change? As a greenhouse gas, methane is twenty times more potent than carbon dioxide and so only a small amount is required to effect a major change in climate. In a physical rather than a chemical association, under either low temperature or high pressure conditions, methane crystallises with a small proportion of water to form methane hydrate and, normally in marine settings, lots of this occurs at depth. In fact, at a conservative estimate, 10,000 billion tonnes of carbon exists as hydrates which is more than all the combined other sources of hydrocarbons the Earth ever stored away. This curious substance breezes off rapidly at normal temperatures but, for purposes of laboratory study, can be generated in small quantities using very high pressure cells. (On these web pages see also our meeting of November 2002 with Professor Michael Lovell of Leicester University.)

Where gas hydrates exist they are very stable, commonly constituting a region of hydrate cement in sandstone beneath which the pores contain free methane. The stability of hydrates means that gas release is uncommon and recovery as a resource is very costly. Rarely, destabilisation can occur naturally however and the end-Permian and end-Cretaceous extinctions appear to have been associated with such gas release. This may have occurred by slumping of submarine coastal rocks but geologists have looked for such fossil slides and found very little.

Amongst issues potentially affected by climate change that BGS are studying are landslides, collapsible soils, coastal and valley flooding, soil erosion, coastal erosion, groundwater resources and seabed resources. In Britain 365,000 homes are at risk from landslides and 250,000 from soil shrinkage or compression. Models are being developed the better to understand the many processes and to devise prediction techniques aimed at improved methods of avoiding problems or overcoming those that occur.

Dr. Rees went on to outline a number of ongoing BGS work programmes. These included studies of estuary erosion including those of the Humber and Thames, erosion increase in the Himalayas with its effect on river deltas and the understanding of how ice-stream dynamics have affected Scotland since the last glaciation.

Turning to possible methods of mitigation of climate change, Dr Rees estimated that it would be necessary to capture and store a gigatonne of carbon every year. To remove this amount of carbon by tree planting would require forests of impractical size but carbon dioxide could, in theory, be pumped below a stable methane hydrate area. Since 1996 the Norwegians have buried eight million tonnes by pumping into exhausted oil or gas wells.
As to the future, BGS plans, in association with others, to increase the type of work projects described, continually raising its own profile.

On this evening we were especially pleased to welcome Geological Society President Peter Styles, who, in giving a speech of thanks, paid tribute to the work of BGS in seeking answers to the problems that had been explained. In particular he referred to the continuity of the work being carried out at BGS as representing a big asset, by comparison with which university work, although very valuable, was sometimes short-lived owing to funding and other problems.

We are also glad to greet those from other learned bodies including, on this evening, members of the Institution of Civil Engineers.