The Route to Chartership

Meeting at British Geological Survey, Keyworth, on 20 January 2010

Report by Geoffrey Jago

Sound advice given to new graduates is that they are now about to learn the greater part of the knowledge relevant to their job. Hence the importance the Society affords to Continuing Professional Development (CPD) in providing the way to the usefulness and polish of a reliable professional. Our Society therefore firmly believes that it is in the interest of all professional members to seek Chartership status, a rank that applies to fewer than 2,500 members at present.

Following our Annual General Meeting on 20 January 2010 at BGS, Keyworth, a clear exposition of the route to be taken was given by our speaker, Chartership Officer Bill Gaskarth.

The History

Bill first explained how, in the 1980s, the Institution of Geologists took the first steps towards gaining a recognised status for geologists on a par with engineers and other professionals. The IG formed as a breakaway group from the Society (though its members still remained as Fellows of the Society as well) to seek a way to offer Chartered status for geologists. The Society at the time felt unable to do this without endangering its Charter. When the IG approached the Privy Council for a Charter for itself they were told that the Society could use its Charter with just some bye-law alterations. This was the best solution and the IG was re-united with the Society. We now have the situation whereby the GSL is both a Learned Society and also able to speak for the interests of its Professional Fellows.

Classes and Criteria of Chartership

At present three classes exist: Chartered Geologist, EuroGeologist and Chartered Scientist - CGeol, EurGeol and CSci respectively - and in time it is hoped that Chartered Environmentalist will be added. 2009 saw the institution of new regulations relating to application.
Chartership calls for seven criteria:

1. An understanding of the complexities of geology in relation your own speciality.
2. Critical evaluation of geoscientific information to predictive models.
3. Effective communication by both speech and written words.
4. Awareness of Chartership Health and Safety and environmental issues and such statutory obligations as are relevant to your work and your status in that work.
5. A clear understanding of the meaning and needs of professionalism, of the Code of Conduct and of commitment to its implementation.

6. A commitment to CPD throughout your career.
7. Competence in your area of expertise.

Friendly Help

Our Society's officers stress that their role should not be seen as that of a stern inquisitor. On the contrary they try to get candidates to succeed, not reject them, and they are very willing to help those meeting the criteria to attain their Fellowship. Equally, members who may not yet have attained Fellowship standards in all aspects are offered help and advice on the best paths to a successful outcome.

Many applicants have some difficulty in being sure exactly what is needed in the Professional Report and the Supporting Documents. Further they may also have problems with just exactly what is called for under CPD. All should seek advice from a mentor or a senior geologist (CGeol) in their workplace. Another source of help and information is via the Regional Group and of course the Fellowship Office at Burlington House and the Chartership Officer are always happy to give advice.

The Road to Application

Bill explained the procedures whereby all applications are processed including interviewing and other work by the scrutineers.

So how and when to apply? Firstly, see if you have sufficient years of experience. A degree and some other qualifications allow a shorter process. Ensure your CPD is in order and that the book entries are up to date. Ask your employer for a mentor to guide your career. Find two Fellows who will be your sponsors and contact the Fellowship office (membership@geolsoc.org.uk) at the Society's Head Office at Burlington House.

Advantages

Chartered members have been found to earn salaries greater by £1,000 to £2000 per year. Companies of consulting engineers can charge more for work by Chartered staff because of their confirmed status and because they are empowered to sign official reports.

So, all you unchartered members, read the web page at
www.geolsoc.org.uk/chartership
and become a dyed-in-the-wool geologist. You are assured of a helpful and friendly greeting at Burlington House and your Regional Group committee members will be glad to help as well.

Be a Mentor or Scrutineer

Finally, the Society encourages those who are already Fellows to put their names forward as scrutineers. Many of these have also offered to become mentors to help those who seek to improve their careers. However, it is hoped that some members who may not wish to become scrutineers will offer their services as a mentor.

A speech of thanks was given by Vanessa Banks.

Engineering Geology of Sustainable, Risk Based Land Quality Management

Meeting at British Geological Survey, Keyworth, on 23 March 2010

Report by Geoffrey Jago

On 23 March 2010 at the British Geological Survey, Keyworth, our speaker reminded us of Socrates' opinion of his knowledge: "One thing only I know and that is that I know nothing." Despite the Athenian sage not having ventured into geoscience before the completion of his career with a stiff double hemlock, we could still be advised that a shrewd counsellor realises his shortcomings and should not shrink from consulting other experts because no one can be the master of all disciplines. This is especially true of the wide field that geoscience covers.

Professor Paul Nathanail of Nottingham University's School of Geography is certainly an expert of many and we enjoyed his presentation of a repeat of the Glossop Lecture that he gave to the Society's Engineering Group at the headquarters of the Royal Geographical Society last November.

Glossop Lectures

For newcomers it is worth including a note, copied from this web page, on Rudolph Glossop (1902-1993), in whose honour were initiated the prestigious Glossop Lectures and Glossop Awards. He is credited with bringing together academics and practitioners in engineering geology in the UK; he was involved in setting up the Engineering Group in 1964 and, in 1966, the Quarterly Journal of Engineering Geology, having previously also help set up the Geotechnical Society and the journal Geotechnique in 1948. Glossop was the eighth Rankine Lecturer in 1967; he was also Chairman of the Engineering Group (1965-68) and Vice President of the Geological Society (1969).

The annual Glossop Lecture is the UK's premier Engineering Geology event and each year the Glossop Lecturer is chosen both on the grounds of their contribution to Engineering Geology and the esteem in which they are held by the Engineering Geology community. The Glossop Award is made annually to an outstanding engineering geologist not older than 30 – this year's recipients was Stacy English of WA Fairhurst & Partners for her work on rockfall protection on St Helena.

Engineering Geology

Paul began by paying tribute to many of the scientists and teachers who had helped him in his career. His work as lecturer and engineering geologist includes a specialisation in the study of degraded land and its remediation.

Engineering geology links industrial applications to geology. Its science is long-lasting, perpetual, arguable and endurable. There being nothing steady about geological processes, its practitioners frequently work on catastrophes, and their knowledge comes from experience. Paul's work has taken him to glaciers, volcanoes, reefs and earthquake centres – as well as gasworks, landfills and derelict factories.

Improving Life

Maps of the world and of the USA showed the relationship of population to industry and of areas most affected by job losses. Towards improving the lifestyle of the world's peoples, there is much scope for better planning of the use of land and scientific management of water resources. Despite their opinion of themselves, humans are not very rational beings and need the benefit of logical guidance. As an example, just after the New York Trade Centre disaster of September 2001, many people took to motoring instead of the safer air travel and road accident figures rose.

Land Quality Management

Paul's specialities include Land Quality Management which covers the protection, remediation and restoration of land and the art/science hybrid of Risk Based Land Management (RBLM), where land contamination is present, or at least suspected. Risk is assessed by considering the combination of the probability of a hazard occurring and its possible consequences. A severe earthquake in a large unpopulated area carries a lower risk than a small 'quake near a densely populated area. The formula is: Risk equals Probability multiplied by Consequences. Described as an art as well as a science, it was stressed that you must understand a site before you can manage it, sifting the important facts from what is normally a mass of information. To this end, cogent logical processes have been conceived, several of which were explained with reference to specific sites.

Conceptual Modelling

After collecting and ordering the facts to your satisfaction a conceptual model can be constructed which aims to make the reality understandable, often for the benefit of clients who cannot be expected to be familiar with all that is involved. A conceptual model should include plans, cross-sections as well as topological matrix and network diagrams to demonstrate what drives the risk and how remediation plans have been conceived.

Diagrams should show the water regimes including the connections between sources and receptors of contaminated water.

Evaluation and Judgement

Paul showed us a list of categories of risk. There is a level above which it is unacceptable and a level below which it is tolerable. A zone exists between the two where the engineering geologist must contribute to a judgement being made. The value of this expertise cannot be overstated.

The Nathanails and East Midlands Group

Paul and Judith his wife have kindly given a number of excellent talks to our Group: Paul in April 1997 (Geosciences, Risk & Society), January 2000 (Land Contamination Risks) and June 2003 (Military Uses of Underground Space). Judith, like Paul a member of Land Quality Management Ltd., an expert on land remediation and past leader of our Group, spoke on 26 April 2006 (Creating Conceptual Models for Contaminated Land Evaluation) and November, 2008 (Making Conceptual Site Modelling Easy). Reports of these meetings appear on these pages

Distinguished expert on engineering geology and past leader of our Group Professor Martin Culshaw made a speech of thanks.

Ediacaran Enigmas – glimpses behind the scenes

Meeting at Derby University, on 21 April 2010

Report by Geoffrey Jago

Two schoolchildren, independently on separate occasions in 1956 and 1957, found what looked like a fossil in the Precambrian rocks in Charnwood Forest, Leicestershire. One showed a pencil rubbing to her geography teacher and the other took his father along to have a look. What followed broke new ground in geological knowledge.

At the evening lecture on 21 April 2010, to round off Careers Day at Derby University, Dr. Michael Howe, Chief Curator, British Geological Survey, Keyworth, spoke on the history of finding vestiges of life in the youngest strata of the Precambrian, formerly assumed to be barren. Named after the Ediacara Hills of South Australia, these rocks belong to the Ediacaran Period of the Neoproterozoic, aged between 635 to 542 Ma.

The Search Begins

By good fortune the schoolboy's father was a friend of Dr Trevor Ford of the Department of Geology at Leicester University and a hunt was on. More organic traces were found, all imprints preserved on bedding planes, time having ensured that nothing organic or mineral of the originals remained. What were they? Termed biota, even today it is unknown whether they were animal or vegetable - or something else. Some could have lain on the seabed, others dropped an anchor. Some resemble modern sea pens with a foot moored in the seabed while the delicate upper structure collects whatever food drifts by. Many are ring-like structures, some of which could be the feet of kelp-like algae. A number of illustrations showed conjectures of how the fossils would have appeared in life. Certain associations can be recognised and Canadian geologists have attempted a classification.

Rock Structure

Some rocks of Charnwood Forest are igneous and others fine-grained volcniclastic, all metamorphosed. Curved line structures (fiamme) in the tuffs could have been left as gas bubbles collapsed. Turbidite sediments were probably laid down in water on the flanks of volcanic cones. Similar sedimentary structures to those in the rocks strewn out by the Montserrat volcano in the 1990s can be identified. Angular blocks indicate the collapse of a volcanic cone and elsewhere the folded structure of hot sliding slump breccia can be detected.

Ring structures in Charnwood had been observed as early as 1850, and had puzzled geologists including Andrew Ramsey, of the Geological Survey, who postulated seaweed swishing round. In 1877 Hill and Bonney wrote that ring structures could not have been formed on deposition, because they remained undeformed by subsequent metamorphism - rather they must be later concretions. Then in the 1960s Martin Glaessner published an extensive study of Australian Edicarans.

Work by BGS

Disturbed by finding that some of the rings had been smashed by collectors, BGS initiated a Moulding Project, together with Natural England and GeoEd Ltd to take casts. We were shown a photo of a massive silicone rubber cast being made of a bedding plane in a Charnwood quarry. Plaster of Paris poured into the inverted silicone moulds produces archival casts which show fossils in such greater detail that a thousand new ones have been recognised and new communities identified.

Take-Home Messages

Mike expressed his thanks for fossil work carried out by colleagues Phil Wilby and John Carney and we were sent on our way with good advice for fossil spotters. Firstly, good observations should be shown to experts - don't fear to "break the fashion" if it appears a find does not conform to current thinking. Secondly, always do your homework – the data may be out there somewhere.

And the young fossil-finders?

Roger Mason had Charnia masoni named after him. Tina Negus was told by her geography teacher that the pencil rubbing which she had made had no significance because Precambrian rocks had no fossils - the accepted belief at the time. However, Tina kept her rubbing and fifty years later she and Roger attended a ceremony to commemorate the significant find with a celebratory cake. No doubt Tina had a slice.

A speech of thanks was made by Andrew Johnson, palaeontologist at Derby University.

Engineering sediment management and landscape-scale evolution in California's coastal environment

Meeting at British Geological Survey, Keyworth, on 15 May 2010

Report by Geoffrey Jago

Glamorous landlocked San Francisco Bay with its Golden Gate entrance was originally flanked in part by extensive spans of deltaic marshes; but land reclamation by means of artificial levees - 1,100 miles of them - has brought large acreages into agriculture. However sea and storms never relent in trying to reverse hard work, and scientific study into how to protect this and neighbouring stretches of the coastline was the topic of our Group's meeting on 15 May 2010 at British Geological Survey, Keyworth when Dr. David Brew, Senior Coastal Geomorphologist with engineering and environmental consultancy Royal Haskoning, spoke on his work in California.

Three Projects

His talk described the work of assessing potential geomorphological impacts on the Californian coast in three areas, a project named the Delta Risk Management Strategy (DRMS).

Firstly, the sea occasionally breaches the levees in San Francisco Bay, making repair necessary using draglines and barges. However where continental plates are wont to grind together assessment must be made of the potential impact of a powerful earthquake. The famous San Andreas Fault runs parallel to the coast and right across the Golden Gate. San Andreas is currently snoozing quietly but two cousins to the east, the Hayward and Calaveras faults, are more fidgety and shocks of up to magnitude four are commonplace. A severe earthquake could trigger catastrophic levee failure in the San Francisco delta and flood large areas, mainly farmland. Secondly, in Monterey Bay, large tonnages of beach sand have been mined and a detailed study has been made of how this, modified by sedimentation, has affected coastal erosion. Thirdly, the work was described of assessing the impact of large-scale wetland restoration projects in south San Francisco Bay and its effect on wildlife.

The Delta Risk Management Strategy in San Francisco Bay

Before the levees were erected 1,500 sq km of freshwater tidal marsh plain were fed and drained tidally by an area of 120 sq km of dendritic channels. Some levees now protect island areas and crops are grown at levels as low as twenty feet below high water. The questions were how would things stand a century hence either assuming a major earthquake or following a hundred years of normal weathering, levee maintenance and rise in sea level.

A hypsometric analytical method was employed which is a graphical way of measuring changes in ground level relative to rise to sea level. The relevant graphs for each possibility were shown and explained, followed by slides of phenomena such as channel scour and loss of mudflats. From this work scientific predictions, essential to future planning, have been made of various possible impacts.

Problems on California's Sandy Coast

Looking next at the coast south of San Francisco Bay, slides of sandy beaches illustrated that all was not quite so idyllic as the holiday brochures parade. River dams restrict sediments that would otherwise nourish the beaches while armouring similarly cuts normal supply from the cliffs and changes the patterns of alongshore and shore-normal sediment transport. Sediment is also lost in submarine canyons, coastal harbour dredging and an offshore shelf. Moreover some beaches suffer mining for building material.

Fortunately such problems affect only certain areas so Regional Sediment Management (RSM) schemes are raised to focus on local issues with the aim of reducing erosion and storm damage and re-establishing natural sediment supply from rivers, impoundments and dredging.

Currently there are three ongoing initiatives, listed from north to south: southern Monterey Bay, Santa Barbara/Ventura, and San Diego.

Monterey

John Steinbeck's "Tortilla Flat" and "Cannery Row" came to mind when our speaker next took us to southern Monterey Bay, eighty miles south of San Francisco, where he managed the Coastal Regional Sediment Management Plan which spanned the sixteen miles of coast from Moss Landing southwards to Monterey Headland. The Salinas River brings in sediment but much sinks into a large submarine canyon in the northern section. Active dunes exist along the four miles north of the river but to the south inactive dunes behind sandy beaches, deposited 3000 to 5000 years ago, now suffer natural erosion aggravated by beach deposit mining. Between 1950 and 1990 five former companies had dug away the beaches at a yearly rate of over 100,000 cubic yards but today only a single company persists with a much lower rate of abstraction.

On the plus side, natural dune erosion adds to the river sediment; but a table illustrated how beach mining appears to have increased the annual erosion rate at

Marina State beach from one foot to nearly five feet. Most buildings are set back adequately but photographs illustrated how some hotels and other facilities lie dramatically close to the sea.

In summary the Regional Sediment Management concluded that the Monterey Bay coast is stable to the north of the Salinas river and may be nourished at its southern end; but the ten-mile centre span shows continued dune erosion which is allowable but should be accompanied by a reduction in beach mining and the removal of some structures. Furthermore, potential coastal and submarine sand deposits, including the Monterey Submarine Canyon, exist which could be exploited to nourish the beaches with benefit to tourism, recreation, species habitats, public access and public safety.

Protecting Flora and Fauna

The southern reaches of Monterey Bay play an important role as habitat for unique flora and fauna both vertebrate - birds, marine mammals, fish - and, as food and habitat, plants and invertebrates. These important factors must be taken into account when planning beach enhancement. In particular the endangered western snowy plover nests, forages and winters here.

Marshes and Salt Ponds

Returning to San Francisco Bay, we were told that before the settlers arrived it was bounded by tidal marshes and mudflats which had evolved over 4000 years of rising sea level, maintaining their heads above water by accumulating mud and organic matter. Over the last century much of the southern section, the South Bay, has been diked to form evaporation ponds to produce salt. Many of these have now been bought by the California Coastal Conservancy for a large project to restore natural ecosystems, which will radically change the landscape. Much sediment will be needed, so is enough available and what will be the long-term effects?

Proposed Options

Three options are proposed: firstly Managed Pond Emphasis with 50:50 Tidal Habitat to Managed Pond; secondly Tidal Habitat Emphasis (90:10 Tidal Habitat to Managed Pond) and thirdly, to assume the relaxed attitude of masterly inactivity more associated with coastal society further south, which would result in unplanned levee breaching and approximately 30:70 tidal habitat to managed pond.

To determine how much sediment would be needed and the long-term effects, a conceptual model was devised to show how the South Bay sediment system works, as well as a budget of sediment quantities. In this way the anticipated changes in fifty years time can be foreseen and we were shown a map of the model together with explanatory graphs and a schedule of budget quantities.

The Conclusions

As regards the South Bay Sediment Project, a significant increase in tidal marsh habitat and a loss of offshore mudflats could be ameliorated by adaptive management. The sediment budget analysis is a constructive tool to assess the ecological implications of physical habitat change and to manage the restoration project.

Overall, California has big issues in coastal management with vulnerable levees, sand mining and, in San Francisco Bay, large-scale restoration work.

Geoscience and Future Generations

Future Californian surfers enjoying a glass of local wine after a day on the beach can expect to owe much to the work of Dr. Brew and his colleagues in providing a thoroughly scientific and valuable approach to profound problems.

Professor Peter Jones gave a speech of thanks.

Geology and Human Health

Meeting at Derby University, on 5 October 2010

Report by Geoffrey Jago

It was inevitable that the British, in fathering the industrial revolution, should have left some troublesome matter lying around within their small island. In addition, some of the abundant diversity of Britain's naturally occurring minerals are pretty poisonous.

One of the very many facets of the work of British Geological Survey is to study the problem in depth and to assist developers and planners so that risks to the population can be minimised.

Derby University was our meeting place on 5th October, 2010 when Dr. Mark Cave, geochemist at British Geological Survey, Keyworth, spoke on Geology & Human Health. His talk focused on the development of methods to assess the exposure of humans to harm, the understanding of the controlling factors and the assessment of their spatial distribution.

Radon

Detectable only with instruments, the radiation hazard radon can lurk in basements and under unventilated floors. Generated from the decay of uranium in magmatic batholiths, it is present in the granitic areas of Devon and Cornwall and north-eastwards as far as the Scottish border, following the outcrop of Mesozoic rocks.

Dust and Soil

In the form of dust, we all ingest around 100 mg of soil each day principally by ingestion. Some comes from wind-blown sources which can be of local origin or as far away as the Sahara desert. The majority, particularly for children, comes from hand to mouth activities..

Arsenic

Many of the metal mines of Devon and Cornwall are notorious for the waste arsenic they left on the ground from the days of large insecticide sales to American cotton growers, but while the southwest has the highest concentrations, a map of England and Wales demonstrated that arsenic is also found in the soils overlying the Jurassic and Cretaceous rocks across central and eastern England. BGS has taken arsenic samples from about 28,000 sites in England. Owing to the toxicity of certain elements such as arsenic, lead and cadmium , the UK government has established Soil Guideline Values (SGV) to aid appraisal of health risks, and where these are exceeded there is a requirement to determine whether remedial work or further assessment is indicated.

Testing People and the BARGE Method

In the UK, risk to human health is assessed by applying the model of seeking the three elements of source - pathway - receptor.

An international inter-laboratory project has been established in the BioAccessibility Research Group of Europe (BARGE), BGS playing a leading role, under the chairmanship of our speaker. It brings together many disciplines including chemists, geochemists, pharmaco-kineticists, geologists and risk assessment practitioners. The following web address calls up the appropriate page from the BGS website:
www.bgs.ac.uk/research/environmentAndHealth_UBM.html

People living in potentially contaminated areas can provide samples, termed biological markers or biomarkers, to estimate the level of exposure to harmful elements - a realm of science using the terms bioaccessibility (the potential for a substance to interact with or be absorbed by an organism) and bioavailability (the amount of a substance which reaches the site of physiological activity).

Tests from blood and urine are ephemeral because contaminants are soon expelled, but hair, fingernails and toenails provide better information. Samples have also been taken from young pigs because pig metabolism is not dissimilar to human. An in vitro sampling procedure has been devised which simulates the pathways of exposure by ingestion in the gastrointestinal tract. Work is being carried out to develop a similar test to simulate inhalation and absortion by the lungs. The Unified Barge Method (UBM) processes soil samples chemically as they would be treated inside humans and in this way determines bioaccessibility. This enables a much wider regime of samples taken from soil to yield results similar to those taken from people and reduces the need to seek samples from the local population or from animals. We were, however, advised that bioaccessibility tests should always be backed up by geochemical tests.

Case Study: Tamar Valley

The practical application of BGS's methods was clearly explained using the results of their work in the Tamar valley catchment area of Cornwall and Devon. These included regression modelling and demonstrating by graph the relationship between bioaccessibility and bioavailability.

Your correspondent's library revealed that between 1844 and 1901 the rich mining group of Devon Great Consols situated west of Tavistock produced nearly 3.5 million tons of copper ore, but it also mined and sold arsenic worth £625,000. It is what remains of the latter mineral that led to the worst patch in today's problem, vividly illustrated by a map showing arsenic values. Not all arsenic came from the mines, however, because there is native mineral in topsoil.

Case Study: Northampton

BGS surveyed an area covering Northampton and its surrounds as part of the Geochemical Baseline Survey of the Environment (G-BASE) project, finding naturally elevated levels of arsenic in the Jurassic soils. Industrial activity which concentrated on shoe and other leather work also left its mark. We were shown maps which illustrated the distribution of three bioaccessible elements: arsenic, lead and chromium, and Dr. Cave explained how arsenic was distributed in soil components.

Air Pollution Long Term

Reference was made to a posting on the web site of the Health Protection Agency in that the Committee on the Medical Effects of Air Pollutants (COMEAP) suggests that air pollution has a greater effect on mortality in the UK than previously thought. An analysis of particulates trapped by air filters over a fortnight in 2007 was described, covering fifty-five elements.

BGS Philosophy for Environment and Science Research
Dr. Cave's lecture culminated in listing the philosophy for environment and science research at BGS: measurement, modelling and mapping.

- Development of relevant robust measurements of the hazard vector

- Understand the form, fate and transport of the vector (modelling) in the environment
- Provide a spatial framework for the hazard vector (mapping)

The work described represents a very important instance of how the geoscience to which we are devoted proves of universal benefit to the community when applied by BGS with the latest professional techniques.

Dr. Clive Roberts gave a speech of thanks.

Opencast Backfill: a Beginner's Guide

Meeting at British Geological Survey, Keyworth, on 19 October 2010. Speaker: Sam Wood I Eng. AIMMM

Report by Dr. Vanessa Banks

Our meeting at British Geological Survey, Keyworth on 19th October, 2010 attracted a satisfactorially large audience which included many whose professions and disciplines ranged beyond that of strict geoscience.

Sam introduced his presentation by explaining that it built upon a presentation on the geotechnical and slope stability aspects open cast mining delivered by Jerry Sturman one year earlier. Sam promised and delivered the personal views of an engineer/ geologist at the "sharp end". Having set the context of open cast mining: which dates from the Second World War; offers the attraction of minimal equipment requirements when compared with deep mining; open cast extractions progressively grew during the 1950s and 1960s, peaking in the late 1970s to early 1980s and continuing to make discrete, but significant contributions of coal; Sam went on to describe the extraction and backfill process, geological influences, guidance and procedures, plant, on-site testing techniques and "the human factors".

Opencast coal mining is used for resources that extend to a maximum depth of about 100 m. Underground mining techniques are required for resources that exceed this depth. Sites are operated on a cut and fill basis, which requires considerable planning particularly in terms of space management and overcoming unforeseen ground conditions. In particular, faults and bedding dip impact on the operational procedures both in terms of access to resources and potential instability. Additional hazards include the potential to encounter abandoned mine workings at depth. Historically, many sites were restored as "greeenfield" and the compaction requirements were less rigorous. More recent focus on building on "brownfield" land has driven the requirement for systematic backfill placement and compaction, in order to minimise the potential for settlement and in particular differential settlement.

Guidance takes the form of the Department of Transport Specification for Highway Works, which was developed from work by the Road Research Laboratory. Sam very effectively guided us through table 6/1: Acceptable Earthworks Material; Classification requirements for layer thickness, compaction, explaining the testing requirements that are specified, with a particularly clear description of material grading and optimum moisture content testing and its interpretation and implications. He also had the answers for managing moisture deficit or surplus, which essentially amount to wetting, or exposing the material to air by turning or breaking it up, as necessary. Essentially, the requirement is likely to be 95% of maximum dry density at optimum moisture content +/- 2%.

The description of plant was particularly well illustrated and included images and descriptions of:

- Bomag BW6 roller (6 tonnes, 2 m wide vibrator pulled by CAT bulldozer)
- Self-propelled machines, with smooth or sheeps'-foot rollers (name derived from the historic use of flocks of sheep to compact soil), which have teeth on the wheels. Also the Bomag Deep Impact machine, a new development incorporating hexagonal wheels
- Cat 825 (30 tonne machine with rows of narrow feet on the wheels to break materials, especially mudstone);
- Motor Graders with long wheel-base and blades in the middle are often used to smooth the ground off before final compaction with rollers.

Sam noted that large materials, including boulders can become a problem when they are discarded to one side. It is more favourable to plan for these arisings and place them at the base of compaction zones.

A number of testing techniques and procedures were described ranging from the core cutter (density determined from mass and known volume, with dry density determination from the moisture content), to the sand replacement test (measured volume of sand filling a fixed excavation size), and nuclear density gauges. The latter has to be considered in the context of health and safety regarding its use. It comprises a gamma ray emitting probe and a neutron source, thus its use requires a Health and Safety Executive licence. The difficulty associated with interference by hydrocarbons was discussed. Recent developments include the option for roller instrumentation, with GPS plotting, to identify any areas that have not been compacted.

The human factors that Sam referred to included information on safety and supervision. Much emphasis was placed on the size of the site vehicles and therefore the "invisibility" of site supervisory and visiting staff. This was well illustrated with images that showed that "even a Landrover is not indestructible" with an instruction not to mix light and heavy vehicles, or any vehicles and pedestrians on site. Clearly Quality Assurance (QA) testing is required, thus the checking engineer needs to take precautions, such as working close to the support vehicle, ensuring that the vehicle is as visible as possible (use of bright colours and flags recommended). Pedestrians should make eye contact with heavy plant operators in their working area. This may even require the throwing of light stones to attract driver attention! Much of the new heavy plant has been fitted with better reversing cameras and mirrors, which has improved the situation. Site induction procedures have improved, however they are aimed at experienced staff. Inexperienced staff should be working under supervision for the first ~ two weeks of their site role. It was noted that the Health and Safety Executive (HSE) produce much documentation that can be accessed via their website. With respect to the supervisory role itself, Sam recommended that one should appreciate the skills of others on site and enjoy the work. It was noted that historically contractual relations were very clearly defined, but could be confrontational at times. More recently contracts have been collaborative and therefore easier to work with.

A vote of thanks was extended by Mr Leeming (Mines Inspectorate), who noted that we had appreciated the clear scene setting, plant descriptions and illustration, the sharing of operational detail and contractual experience and technical descriptions that avoided complex mathematics.