East Midlands Regional Group Meeting Reports 2003

End of Permian Mass Extinction and the "Fungal Spike" - 12 February 2003

Report by Geoffrey Jago

Much publicity has been given in recent years to the disaster which caused the extinction of the big lizards 60 million years or so ago; but the planet has undergone a number of such catastrophes. Possibly the most severe happened 255 million years ago at the end of the Permian period (indeed the Paleozoic era) when, by whatever means, the sun is assumed to have been obscured in what we now call a ^{3}nuclear winter^{2} and 96% of marine life died out.

This phenomenon was the background to our February meeting when Dr. Mike Stephenson of British Geological Survey spoke on his research into the rocks of this special age across the world.

The horizon contains abundant quantities of a specific micro-organism, unknown elsewhere either in the present day or in other rocks. Occurring as spores, the organisms were common in the last millennia of the Permian but died out during the early part of the Triassic. From data graphs, their lifespan was taken to be brief and was called the ^{3}fungal spike^{2}.

Under the microscope the spores can be seen to be about 60 microns long, sausage shaped and with a double-layered skin. All have open ends with terminal rims, referred to as craters, and have a dark area inside; and they nearly always occur in chains. Those that lived near the then equator are smaller than those which grew in more temperate zones. Occurrences in rocks in China, the Southern Alps, Israel, Russia, Australia and elsewhere have all been studied.

Dr. Stephenson showed pictures of a classic exposure of the Permian - Triassic boundary in a quarry at Meishan, China where the government has honoured the site with an obelisk surmounted by a giant model conodont. In grey dolomite, the boundary is here exactly defined, together with, only centimetres apart, the horizons of three mass extinctions - two below in the Permian and one above in the Triassic.

A theory propounded by Eshet, Visscher and others in the mid 1990s put forward the idea that, since the sun and photosynthesis must have been thoroughly out of fashion following the disasters, vast quantities of dead matter would have been available for the taking and the likely beneficiaries would have been fungi because they nourish themselves from other organic matter, needing little energy from light. However, in providing details of the methods used in the extensive research, Dr. Stephenson explained that there was no proof of the theory and evidence points to these organisms being algae rather than fungi. Their postulated environment is fresh- or low salinity water, perhaps in a shelf sea around the margin of the Tethys ocean. Although there are big differences, the nearest kindred with modern life forms are pond algae like ^{3}pond hair^{2}; but unlike modern algae, the studies revealed no evidence of sexual reproduction and unless further research indicates otherwise it must be assumed that propagation was wholly asexual.

So - no fungus. What of the ^{3}spike^{2}? Well, no spike either because the organism^{1}s life probably spanned 20-30 ma - from the Permian well into the Triassic.

The puzzle remains as to how a light-dependent plant could thrive in a dark world. Many theories have been put forward to explain the cause of the severe changes at the end of the Permian age, among them meteor impact, volcanoes, nutrient depletion and global cooling. Perhaps, as today^{1}s holiday brochures promise, there was sufficient sunshine somewhere.
This was a very interesting and well illustrated visit to geology under the microscope.

A speech of thanks was given by Dr. William Read.

Bioengineering and Slopes
7th April 2003
Report by Geoffrey Jago

Weathering gradually makes cliffs and rock slopes steeper and more waterlogged. Eventually some suffer landslides which can cause deaths and irreparable land damage. For engineers and builders employed in construction projects where rock slopes are present or are being constructed, it is most important to know as accurately as possible whether a slope is as stable as the rock of ages or liable, after some dirty weather, to allow gravity to reshape half the scheme. A slope can be physically reinforced, given sufficient space and access, but often at such high cost that only very high-risk slopes qualify.

For generations the study of how rock slopes fail has absorbed the attention of some of the best physicists and mathematicians in geoscience. Based upon the study of natural as well as man-made rock slopes, many formulae have been derived to give a factor-of -safety figure indicating the risk of a slope giving way. Studied characteristics include how cohesive the rock is, how slippery is a potential slip plane, block weight, pressure of water in the cracks and so on, data being derived from site surveys and laboratory experiments.But another factor often enters the equation which is more difficult to define: plant growth can have a marked effect.

John Greenwood of Nottingham Trent University together with participants in a number of European countries asked the questions: Can vegetation assist the engineer, and if so how can it it be quantified? Hence John¹s multidisciplinary project and the title of his informative talk, given at Loughborough University jointly to the East Midlands Geotechnical Group and our Regional Group.

Several case studies were undertaken involving not only laboratory work but the monitoring of slopes via drill-core samples and by the installation of instruments including slip plane indicators, neutron probes and stand pipes. The relationship between tree and woody plant architecture, root anchorage and root reinforcement was investigated and correlated to soil mechanical and physical properties, as well as slope stability. Since strong roots penetrating a potential slip plane can have a marked stabilising effect, tests of root strength and their resistance to being pulled out was an important study activity; and for this, because of the many variables, a complex notation was devised.

The Gault clay in the south of England is notorious for letting down the harder overlying Greensands and in one study of this bed affecting the M20 motorway near Maidstone an artificial trial slope at one in three was constructed. Despite its obstinacy in failing to fail regardless of encouragement, this slope still provided much useful information.

It may be concluded that bioengineering provides an important link between engineering and the environment and that roots, while they cannot at present be relied upon when compiling stability reports, have an important effect and theory needs to be supported by more research. Judith Nathanail gave a speech of thanks.

Further details are available on the website:
http://www.ecoslopes.com/

Data, Information & Geology
22 May 2002

Report by Geoffrey Jago

Of all the treasure that man can inherit, surely that which proves the most valuable is good, sound knowledge.

Our May 2003 meeting, held on the 22nd at British Geological Survey, Keyworth, featured a geoscientist who oversees that vast treasure house of geological information at the Kingsley Dunham Centre at BGS which stores intelligence collected since 1790. Our speaker was Jeremy Giles who is the Centre's Information Manager.

In his care reside all those documents dating from before the birth (in this country) of geology as a science, up to the present day. They include geological maps and reports, shaft sections, borehole sections, rock samples, borehole cores, geophysical logs, photographs and notebooks (some very old) of geologists and engineers. Fossil specimens are counted in millions. Tens of thousands of reels of geophysical records cover over 600 areas. Ground water has been monitored continuously since 1836. The number of borehole logs runs into seven figures, British Coal alone having drilled over 1,000,000 boreholes. The earliest cores were recovered in 1825 during work at Portsmouth dockyard.

Altogether a resource of prodigious value. An estimate of the cost of reproducing the work condensed into all the BGS field slips came to £174 million!

However, Jeremy's work extends far beyond that of a custodian, as became apparent as his talk progressed. He drew attention to the importance of understanding the nature of the data. Business data is ephemeral, its form designed to meet a clearly defined business need with a short life history. By contrast geological data is not ephemeral. Derived from observation, it is processed, corrected or converted, interpreted and processed again with other values. He listed three basic equations

- Data with Context becomes Information.
- Information with Experience becomes Knowledge.
- Knowledge with Customer Focus provides Solutions.

A phrase came merrily buzzing in and settled on the screen: *Context is provided by Metadata*. Initially bells of comprehension failed to peal; but it was soon explained that metadata is data that relates to other data. For example the list of your correspondent's family books that he dreams of compiling would be metadata. Shame at not recognising the word was later mitigated when it was not found in either of two 1999 dictionaries.

Scientific information must be underpinned by repeatable observation. Science builds upon past work and geologists must retain observations and the interpretations of those observations. The vast resource of raw data is there in store, but how to produce a usable distillate, and one that a layman can understand? The task of selecting and interpreting the available information for a particular use was ever a very considerable one and this is where the procedures and disciplines of metadata show their power. Metadata management is a tool for linking a model to underlying data sets - vital if the model is to be useful.

When computers began to draw graphics rapidly, a new and strong challenge arrived. Any presentation nowadays includes three-dimensional high resolution computer models. Since 80% of sensory input is through our eyes, this allows the viewer to assimilate information quickly, the integrity of which is more easily checked by visual diagrams. Cross-sections can be made from two-dimensional maps and then many sections can be combined to give impressive three-dimensional models. Geoscience data helps build robust models, allows better planning of work, reduces costs and risks and, where potentially dangerous work is involved, can even save lives.

Who uses this information? Broadly, the two categories of professional and private users; and for the private user clear simple answers are especially important.

When one reads news items of all the tasks, problems and endeavours of everyday life one often wonders why geologists are not consulted more frequently. The thought so often seems never to occur to those involved, whether they are local authorities, builders, house agents, politicians, journalists, police, engineers, or archaeologists. The wisdom of many generations of geologists is there at British Geological Survey on the end of a telephone line - and most of it free!
Their email address is: Enquiries@bgs.ac.uk

And relevant web pages are: www.bgs.ac.uk/geoindex
www.bgs.ac.uk/discoverymetadata/home.html

A speech of thanks was given by Judith Nathanail.

Report by Geoffrey Jago (with thanks to Mike Rosenbaum).

Military Uses of Underground Space: RAF Fauld (Crater) and other examples.

Our June 2003 meeting and July field excursion centred upon the enormous Fauld explosion crater near Tutbury, Staffordshire. On 24th June at British Geological Survey, Keyworth, our speaker was Paul Nathanail of Nottingham University and (since you asked) husband of E.M. Regional Group Chair, Judith.

The Military Underground

Paul began his talk by listing several underground spaces with a history of military use. Such voids can be natural or man-made and have been used since time immemorial as weapons of war or for shelter, resources, living space, storage, undermining enemy emplacements or as a means of keeping out of sight. In World War I tunnelling was employed at Vimy Ridge. The Rock of Gibraltar was originally tunnelled as a defence against the Spanish and the tunnels were extended in World War II. Churchill had a replica war room beneath the Dollis Hill Post Office but was apparently less than comfortable with it and it was seldom used. It boasted 37 rooms but no lavatory. The very extensive Willieczka Salt Mine in Poland was put to military use. In the demilitarised zone between North and South Korea several tunnels were excavated. More recently much press space has been devoted to speculation on the use of the White Mountain caves in Afghanistan by a civil engineer, one Bin Laden.

The Fauld Crater

The Upper Triassic Mercia Mudstone to the west of the small town of Tutbury contains two thick beds of gypsum and anhydrite, the Tutbury and, 75m. of red mudstone below, the Newark. Both gypsum and anhydrite consist of calcium sulphate; the latter lacks water of crystallisation and occurs at greater depths. The Tutbury Sulphate Seam is a discontinuous mass of gypsum/anhydrite, separated by silty mudstones, up to four (exceptionally six) metres thick and has been extensively mined between Tutbury and Draycott in the Clay for plaster and the easily carved ornamental alabaster, a pure form. The strata outcrop on a scarp slope on the south side of the Dove valley and dip south. By 1937 the pillar and stall workings had exhausted the shallower mineral, the few small mines were consolidated into one with a plaster factory at the entrance and the Air Ministry took over part of the excavation to store munitions. By wartime up to 40,000 tons (not tonnes in those days) were in store consisting mainly of 250- to 4000-pound bombs.

What initiated the happening at 11.11 am on 27th November, 1944 is not certain but the likely cause is that in part of the mine which lay 35 m. underground, a Stilson wrench, unsuitable for this particular purpose, was applied to a sensitive part of a 1000-pound bomb that had been returned, damaged. As they say, don¹t try this at home. The explosion detonated over 3,500 tons of munitions which removed the roof of of the mine for a diameter of 250 m and killed 80 people above and below ground. A farmstead and plaster works disappeared and a reservoir of six million gallons failed. Some rock travelled ten kilometres and a wide area was covered in ten centimetres of dust. The noise was heard in London and Weston Super Mare (190 Km.) and seismographs trembled as far away as Casablanca. Only three larger explosions occurred during World War 2 , all nuclear.

Not all of the mine was destroyed and some underground personnel survived. A year of careful work followed to extricate many thousands of tons of remaining munitions and to secure the working sections of the mine. Even so, an estimated 3000 tonnes of unexploded bombs, many weighing 4000 lb, still remain and no public access is allowed to the crater. At present mining continues to the southwest where the evaporites, containing a higher proportion of anhydrite, lie at greater depth.

A speech of thanks was given by Mike Rosenbaum

Field Trip to the Fauld Crater

On the hot sultry evening of 9 July 2003 a dedicated group of about thirtyfive people including all four members of the Family Nathanail coalesced at Hanbury before traversing eastwards 600m. to convince themselves that not all geological features are formed either naturally or slowly. Professor Tony Waltham, who led the party, distributed copies of his excellent paper published in 2001 in the Mercian Geologist - available at

- www.nhm.ac.uk/hosted_sites/emgs/pdf/v15pt2_fauld_crater.pdf

On gazing over the securely fenced rim of the ninety feet deep crater the effect is immediately breathtaking that such an immense feature could be created in an instant purely by chemicals. Most of the floor is obscured by trees and the slopes are overgrown except where the red Mercia Mudstone has been exposed in a few small slides and where white lumps of gypsum stand out. A simple memorial of granite donated by the Italian government contains the names of seventy of those who died, including those of Italian prisoners of war.

Tony Waltham and fellow-professor Martin Culshaw provided a commentary and question-and answer session before all returned to Hanbury to replace fluid lost in perspiration on the walk with cooling elixirs in the garden of a premises which had required rebuilding after the blast - the now very hospitable Cock Inn.

A speech of thanks was given by Martin Culshaw.

Further information available for downloading is:

- http://www.carolyn.topmum.net/tutbury/fauld/fauldcrater.htm - the story in detail
- http://freespace.virgin.net/kehla.barnes/disaster.htm - a good historical account
- http://freespace.virgin.net/kehla.barnes/walk1.htm - a description of the walk
- http://www.healeyhero.fsnet.co.uk/rescue/individual/news_fauld.htm - personal accounts http://www.healeyhero.fsnet.co.uk/rescue/individual/fauld.htm - more personal accounts
- http://www.ap.pwp.blueyonder.co.uk/st_misc.htm - for the geological context

Soft Bodied Fossils
18 September 2003

Report by Geoffrey Jago

Congregating after the rigours of the holiday season those at our well-attended meeting at British Geological Survey were stimulated by a compellingly illustrated talk by Dr. Phil Wilby of BGS who has studied the techniques of finding information about those elusive bygone creatures which lacked any bones, teeth or other stable bits. Even in the case of fossils composed of durable remains, such as good looking shells, seeking the fleshy sections is important because no fossil can be described as well preserved where no trace remains of the soft parts. An impressive first slide of a fossil octopus demonstrated how in favourable conditions very much can still be seen of the structure of the animal.

Dr. Wilby has worked on deposits in Brazil where many millions of fossils of soft bodied creatures have been preserved in phosphatic and calcareous concretions. The replacement of soft tissue by apatite allows the study of all external and internal features. Slides of the muscles of Cretaceous fish, magnified to the minute level of cell structure, showed exact similarities to the layout of those delicious muscular flakes in the battered haddock of today. Studies were possible across a wide range of coexistent fauna, allowing deductions of how each type of creature lived alongside or predated upon its contemporaries.

We saw slides of squid-like Jurassic fossils from two locations near the villages of Christian Milford and Ashton Keynes in the Cotswolds, clearly showing internal features such as the ink sac. Dr. Wilby wryly postulated the removal of Mesozoic ink for tasting, albeit of a rather gritty texture, along with modern sea-food. Where mass extinctions had taken place a study had been made of the positions assumed by the morituri, some clutching their fellows, inspiring touching surmise as to their train of thought at the time.

Preservation of insects in amber is well known and much of this resin, 30 - 35 million years old, is found in the Dominican Republic. We saw several beautiful slides of encapsulations, including one of two ants of different sizes, one with a grub in its mandibles, presumable a worker and soldier as in present colonies. The more interesting the contents the greater the price demanded of amber; and we were told that some impressive examples are forgeries. These can be made by scooping out part of a piece of genuine amber, inserting as intriguing a collection of modern fauna as can be found, and resealing with resin.

Much information can be gained from the study of coprolites, the droppings of ancient creatures. Surprisingly, in the USA, a comparative study has been made between those of Tyrannosaurus with the less ponderous equivalents from modern canines where remarkable similarities have been proved to exist. By this method much has been discovered about the digestive and other metabolic processes of the big lizards, even to conclusions about the state of health of the producer at the time. The present has always been the key to the past and such study amply illustrates the dedication of geologists to their science.

This engrossing evening illustrated how skilled work and clever reasoning can reveal a wealth of information about life down the ages.

Isotopes and Ancestors

16 October 2003

Report by Geoffrey Jago

The various sciences that cluster under the banner of geology cover a wider range than most disciplines and over the years our Group committee have reason to be grateful for the far-reaching expertise and wide range of knowledge of their speakers. On 16th October 2003 at British Geological Survey, Notts, we gained insight into more than one further aspect on our chosen science, when Jane Evans, geologist and archaeologist, spoke on how the study of isotopes assists a range of studies.

Most elements occur in more than a single variety, or isotope, each with its own atomic weight; and knowledge of the proportions of differing isotopes in a particular element can provide the scientist with a remarkable grasp of such diverse subjects as wildlife research, anthropology, archaeology and even forensics.

Isotopes fall into two main types: stable and radiogenic. Radiogenic isotopes such as rubidium and iridium change at a regular rate and are useful to measure geological time; but Dr. Evans spoke mostly of her work with the stable varieties of lead, strontium and oxygen. Lead can tell us about culture, and general pollution levels and isotope analysis can identify the source of the metal. It occurs in our bodies at less than one ppm and may be ingested from foods such as wine and fish. In past centuries it was used in make-up; but modern lead exposure has been mostly from petrol, although there has been a significant drop since the advent of unleaded fuel.

Oxygen occurs mainly as the two isotopes of atomic weight 18 and 16, the ratio between the two telling us much about climate and climate change. We were shown how contours of oxygen isotope ratios can be drawn, in this instance on a map of Scotland.

Strontium enters one¹s body from soil via milk, meat and vegetables. Because geographic and geological constraints exist in its occurrence, strontium recovered from bones and teeth can reveal, for example, where an individual grew up by the characteristic isotope pattern. The migration of the wading birds redshanks has been traced using this method. Of two sub-species, one breeds in Iceland and the other in Scotland. Iceland lies generally on young geologically homogeneous basaltic rocks, so Icelandic redshanks differ from their Scottish counterparts in their ingested strontium. Sources used for this study included wing bones, young birds, and adults culled by raptors. From bird migration Dr. Plant went on to speak of the migration and influxes of human populations which she has studied as part of her archaeological work on the islands of Lewis and Uist in the Outer Hebrides. On Lewis, Norse people lived in coastal strips. On Uist a mummified body was found beneath an ancient dwelling, the body being 600 years older than the house in which it was buried. Bodies found on Uist and Lewis both had high strontium levels and an almost identical isotope pattern although differing in age by as much as 2,500 years.

Here, questions arose regarding ancient populations firstly whether changes to burial rites could indicate an influx of newcomers, known as first generation immigrants, and secondly whether it is possible to distinguish locals from immigrants by examining their interred remains. Bones vary and suffer secondary alteration in the soil, presenting a problem with material buried for a long time, so teeth provide better clues. Even so, the softer dentine is prone to partial change and absorption of strontium from the soil. Strontium, lead and oxygen tests were made and differences between dentine and enamel were noted. Fortunately tooth enamel, being tough and resistant to alteration, is a more reliable and unchanging substance than bone or dentine for strontium analysis; and something of the geology of the area in which the subject grew up can be deduced.

Examination of graves of early Norse age near the village of Cnip on the Atlantic coast of Lewis provided a special opportunity to investigate the nature of local populations which may have included Norwegian Viking immigrants. Here strontium isotope analysis played a major part. Of eight skeletons, six appear to have been of locals but a middle-aged man probably grew up on Tertiary volcanic rocks, perhaps from the Inner Hebrides or northern Ireland, while a woman of similar age spent her early years on marine carbonate rocks.

The paper ^{3}Sr isotope evidence for population movement within the Hebridean Norse community of NW Scotland[2] on page 649 in the Geological Society Journal of September 2003, of which Dr. Evans is co-author, is recommended.

A speech of thanks was given by Dr. William Read.

Implications for climate change for hazardous ground conditions in the UK

Report by Geoffrey Jago

In Hamlet's time, 500 BT (before tranquillisers), he found adequate grounds for dismay in the ability of outrageous fortune to aim a desultory sling or arrow without specifically worrying about how Mother Earth could add to his problems without prior notification.

Modern times and some sensationalism on the part of the media have made us more aware of the dangers we now call geohazards; and where there are dangers it is wise to know about them in case some action is advisable, if only to stand a few metres back.

Step in, Geoscience. The speaker at our Group's meeting of November 13th 2003 at British Geological Survey, Keyworth, was Al Forster of BGS. He defined geohazards simply as events that cause harm and went on to catalogue them under the headings of volcanoes, earthquake, tsunamis, landslides, shrinkable clay, rocks subject to dissolution, underground gases and flooding.

Confronted by such a nerve-racking list the audience settled itself more comfortably in its chairs in the manner of the congregation when told of their certain doom by the hellfire preacher in "Cold Comfort Farm". Warming to his theme, our speaker went on to relate what happened in Iceland in 1783-4 when a huge fissure sent lava fountains as high as 1400 m. and gases to 15 kilometres while 14 cubic kilometres of lava was disgorged to cover 564 square kilometres. Europe suffered a marked drop in temperature as winds carried the cloud southeastwards.

In attempting to predict the gravity of risks from geohazards it would clearly be of help to predict trends of climate change. Will Britain embrace a Grecian climate or experience a new ice age? Depending upon your choice of tabloid the jury is not merely out but in the bar across the road.

BGS, as ever, can adopt more hard-headed techniques in seeking reliable insights into the climate of past years. Assessment and prediction can be probabilistic - based on past events, or deterministic - based on causal factors.

One test is to analyse cores of thick ice sheets where the ratio of normal water to heavy water - that is water with deuterium as its isotope of hydrogen - reveals past temperatures. Layers with more deuterium tell of warmer periods. Other tests include determining ratios of loess grain size and ratios of oxygen isotopes on the seabed. Satellites assist in the measurement of the amount of water landlocked in ice caps and, taken in conjunction with other data, estimates can be made of ice cap dissimilarities in the past and consequent changes in sea level. Cycles of climate change, measured in millennia, have been linked to the eccentricity of the Earth's orbit and tilt in its axis of rotation.

Studies of climate over the last 1000 years show that those living in the 14-16th centuries experienced a mini ice age, following which things began to warm up, albeit slowly. The frozen Thames supported a fair in 1739. The Dickensian tradition of white Christmases is a hangover from colder Victorian times. Crops are good climate indicators, especially vines. The Romans listed 43 vineyards in Britain, but by the time of Henry VIII numbers had declined, not by reason of monks being at a premium, but because temperatures were lower. Nowadays there are several hundred vineyards in the UK.

Moving on to the list of geohazards, we were shown a map of earthquakes in Great Britain. The more severe ones lie on an arc along its western half from Cornwall to the Inner Hebrides. Photographs were shown of landslides at Holbeck Hall in Yorkshire, Coombe Farm on the North York Moors, Black Ven and Holderness. Heavy rainfall is the major factor affecting landslide in the short term while in the longer term the risk of coastal slides increases with sea level rise.

The giant waves known as tsunami can be generated by earthquakes and it has been suggested that they could also be caused by submarine rock slides when deep methane hydrates turn suddenly into gas.

Shrinkable clay does much damage to buildings, in respect of which insurance claims have escalated since 1993. Argillaceous rocks like the London clay and gault place London and southeast Britain most at risk, where building is concentrated, and hot summers do not help matters.

Limestone and gypsum can dissolve into cavities and we saw an illustration of spectacular gypsum subsidence near Ripon. In dry seasons a fall in water level in limestone caverns has been known to cause subsidence when running sand fills a space.

Hazards from underground gases are from methane and carbon dioxide, from carboniferous strata or landfill, and radon from granite. Rises and falls in the barometer can have the effect of pumping gas out of the ground.

As regards flooding we were shown pictures of the disaster at Lynmouth, caused by excessive rain over Exmoor, amplified by displaced rocks and debris in the hinterland. We also saw pictures of the local Trent valley floods of November 2000 showing how river terraces on the flood plain remained just above flood level.

Of the future, predictions have been made for the 2020s, 2050s and 2080s which can be summed up in that the UK climate is likely to become drier overall. While winters will be wetter, summers will become very dry.

Finally it was stressed that when dealing with geohazards it is necessary to understand the processes and thereby to plan for avoidance and consequent litigation.

A speech of thanks was given by Judith Nathanail.

The Impact of Cities on Urban Ground Water

12 December 2003

Report by Geoffrey Jago

The speaker at our December meeting, held jointly with a number of kindred learned organisations at British Geological Survey, Keyworth, was Professor David Lerner who leads the Groundwater Protection and Restoration Group at the University of Sheffield. This Group, which includes Visiting Professors and Research Fellows, is an international centre of excellence for scientific research and for the dissemination of information.

Part of any community[1]s source of water comes from underground and beneath towns such water is at risk of pollution. This challenging subject has been poorly understood: How much is there? Do we abandon it? Are some areas being recharged, and to what extent? While stream beds dry up in some places, not all areas experience depletion. For example, under Birmingham a lowered water table of past decades has now recovered to original levels.

The study of recharge pathways covers roof soakaways, infiltration systems, water main leaks, irrigation excess, sewer leaks, septic tanks, direct recharge, runoff and evaporation. House building, with its associated areas of extra tarmac, inhibits natural recharging.

Pollution results largely from industry and from broken drains. Significant amounts of chlorinated hydrocarbons from industrial cleaning processes have found their way down and, in severe cases, this can result in the abandonment of boreholes.

Professor Lerner provided some information from his team[1]s specific studies at Nottingham (moderate rainfall and low ground leakage), Hong Kong (high rainfall and high leakage) and Lima, Peru (low rainfall and low leakage).

In the examination of borehole water from various levels, differing sources such as rain, leaking mains and sewers can be identified by the ratios of chlorine, nitrogen and sulphates, each water having its own signature. Nitrogen compounds originate from plant root zones, sewers, industrial use and spillage. With depth, the proportion from residential sources decreases while that from agriculture increases.

In respect of groundwater pollution risk in urban areas a major aim of the Groundwater Protection and Restoration Group is to develop a management tool to map the risk.

Having barely touched down on *terra firma* following a conference in San Francisco, Professor Lerner deserves all the more praise for his erudite exposition of this significant subject.

He concluded by saying that there is ground water aplenty, albeit at risk of pollution; but the risks can be managed.

A speech of thanks was given by Martin Culshaw.

For further reading, see Professor Lerner[1]s book Urban Groundwater Pollution and the following section of Sheffield University Web Site: www.shef.ac.uk/gprg

End of 2003 Meetings