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East Midlands Geological Society

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Front cover: High Tor and the Matlock Gorge; the cover photograph on the new BGS 1:50,000 geological map, Sheet 112, of the Chesterfield area. Photo: Paul Witney, British Geological Survey.

Back cover: Landslides on the Jurassic Coast, see page 75. Photos: Graeme Guilbert.

Contents

VALE

Trevor Ford, 1925-2017

Trevor was born in Essex but brought up in Sheffield, where he began a lifelong friendship with Peter Harrison and an association with Speedwell Cavern. During the early years of the war, he used to cycle the 20 km out to Castleton on weekends, where he guided tourists through the cave, contributed to the cave's re-survey, and even explored new passages in his spare time. It was appropriate that a much later discovery, by others, was named Ford's Cavern.

He served in the Royal Navy from 1944 to 1946. Mainly land-based in various parts of Asia, he was always happy to recall that he did not *go doolally* when he was stationed for some time at Deolali (the notoriously dreadful place outside Mumbai). After demobilisation, he obtained a place at Sheffield University, where he studied geology for his BSc, and then stayed on to earn a PhD in 1953 for his fieldwork and thesis on *The Upper Carboniferous rocks of the Ingleton and Stainmore Coalfields*.

In 1952 Trevor was appointed Assistant Lecturer in the Geology Department at Leicester University, and was successively Lecturer, Senior Lecturer and Associate Dean, before being made an Honorary Research Fellow on his retirement. For his 38 years at the university he was an inspirational teacher, hugely respected and always fondly remembered by his legions of students.

A sprightly Trevor, at the age of 53, in the far reaches of Speedwell Cavern, Derbyshire.

Trevor perhaps helping one of his caving colleagues in the limestone karst of the Derbyshire Peak District.

During that time he became established as a leading authority on the geology, mineral deposits, lead mines and caves of the Derbyshire Peak District. He produced more than 500 research papers, reviews, reports, guides and books, as well as contributing to and editing various compendium volumes. He also edited the journals of the Peak District Mines Historical Society, the British Cave Research Association and the Leicester Literary and Philosophical Society for a grand total of 82 years.

Besides his roles at Leicester, he was Visiting Professor at four universities in the USA, and for 13 years was Chairman of the Board of Studies in Earth Science at Nene College (later the University) in Northampton). For some 30 years he served as a juryman for the Great Barmote Court, with its traditional powers to settle disputes within the lead mining districts of Derbyshire. He also served terms as president of the East Midlands Geological Society, the Leicester Literary and Philosophical Society, the British Cave Research Association and the Peak District Mines Historical Society.

Trevor was widely read and had a remarkable memory for detail in so very many aspects of geology. He was regarded by many as a font of geological knowledge, was always ready to help others, and was also an impressive speaker on aspects of Derbyshire geology and many other topics besides. His lectures, publications and other outreach activities greatly enhanced public awareness of the relevance of geology and of cave science, particularly in relation to Derbyshire and the Peak District National Park. He was awarded an OBE in 1997 for services to geology and to cave science, and a well-deserved honorary doctorate from the University of Derby in 2015.. Though his research focussed mainly on the geology of the Peak District and Charnwood Forest, Trevor's activities also extended elsewhere, and included geological mapping on the Isle of Man and along the floor of the Grand Canyon of Arizona.

Lying close to Leicester, Charnwood Forest fell to Trevor's researches. In 1957, a Leicester schoolboy, Roger Mason, saw a fossil exposed in the Precambrian rocks of Charnwood, and went to the university to report it, where Trevor happened to be the only lecturer in the department at the time. Sceptical but always helpful and alert, Trevor drove out to Charnwood with Roger, and instantly recognised the fossil for what it was. *Charnia masoni* Ford, 1958 (to give it the full scientific name) was the first Precambrian fossil to be discovered, and is still one of the finest specimens known. Trevor's published description of *Charnia* remains a milestone in palaeontology, and was recently described as representing "a clear threshold for the study of early life on Earth". His subsequent pursuance of Precambrian fossils took him to Arizona, South Australia, Sweden, the Canadian Rockies and Newfoundland.

Then in December 1965, a meteorite descended on the village of Barwell, just outside Leicester. The university department organised a grand search for fragments in the fields around the village. Trevor went to the wrong meeting place, so he walked on his own into an adjacent field, and found the largest single chunk of the meteorite, some 5 kg of it, lying in a crater half a metre deep. It is still among the largest fragments known from any recent meteorite that fell on Britain.

Trevor's wide knowledge of the local geology combined with his editorial skills to make him a co-editor of *The Geology of the East Midlands*, a massive tome that was published in 1968 and is still a primary source for the region.

The Derbyshire Peak District was always Trevor's first love, and his weekend home in Castleton was frequently a meeting place for geologists young and old. The minerals, mines, caves and karst were the main themes of his extensive research and many publications on Peak District geology. His edited volume, *Limestones and Caves of the Peak District* (1977), is the standard reference on the karst and he was subsequently involved in the first absolute dating of Quaternary cave sediments. His own book, *Derbyshire Blue John* (2000), is regarded as the definitive description of Derbyshire's distinctive variety of fluorite. His guidebook *Castleton area, Derbyshire* (1996), and his *Lead Mining in the Peak District* (2000, with Jim Rieuwerts) are also definitive resources. He wrote many papers on the genesis of the Derbyshire minerals, and one of his last contributions was a major review of mineralization in the South Pennine orefield, co-authored with Noel Worley and published by the Yorkshire Geological Society in 2016.

In March 2013, the Leicester Literary and Philosophical Society organised an all-day seminar and reception to pay tribute to Trevor's achievements. Officially entitled "From Bradgate Park to the Grand Canyon: celebrating the geological achievements of Dr Trevor Ford OBE", the event was widely known as the Ford Fiesta, and was a fitting compliment to his widespread popularity and multiple achievements.

Trevor Ford was a great geologist and a great character. His departure is our loss, but he will be remembered by many, and his published works will support future generations of geologists.

These notes are based largely on the eulogy presented by Jan Baxter, Trevor's daughter, at his funeral service on 9th March 2017.

Trevor Ford: clockwise from lower left: deep in contemplation on the salt flats of California's Death Valley; as he will be remembered by many, explaining the local geology on a Society excursion; in lecturing mode at the university; and at home in his quieter years.

A polymath is defined as a great scholar who knows everything, and Trevor had a hugely wide knowledge of geology; so perhaps we should remember him as a polygeolimath.

GEOBROWSER

William Buckland: genius or 'buffoon'?

If anyone deserves the epithet of 'eccentric genius' it would have to be Professor William Buckland (1784-1856). The son of a parson, and himself deeply religious, he was nevertheless a free-thinker who acknowledged that the Earth supported life long before the existence of humans, let alone Adam and Eve. Among his many scientific achievements was the world's first formal naming of a recognized non-avian dinosaur, *Megalosaurus*, in 1824, as well as the discovery of mammal-like representatives among the same fossiliferous assemblage in Oxfordshire. He pioneered the study of coprolites, and suspected that those containing small bones in Kirkdale Cave (Vale of Pickering) were fossilized dog droppings. He confirmed this by taking into his house a pet hyaena, feeding it on live guinea pigs, and studying what was passed out (e.g. *Strange Science*, *2015*).

With his presidency of the Royal Geographical Society Buckland's reputation grew, as did his eccentricity. As recounted by Fraser Lewry *(The man who ate everything: Guardian, Feb 25, 2008)*, his role at the Society for the Acclimatization of Animals allowed him to import a virtual menagerie into Britain, fulfilling a lifelong personal ambition to eat an example of every animal in existence. No living creature was spared: mice on toast were a favourite, and guests were also treated to bluebottles, porpoise, puppy, panther and mole; although even Buckland's palate was offended by the last, which he described as being horrible' (*Augustus Hare*: *Story of My Life, vol 5, 1900*). His unique talents nevertheless enabled him to debunk the legend that a stain on the floor of St Paul's Cathedral was caused by the spillage of fresh saint's blood. Upon licking the stained flagstones, Buckland immediately identified the mystery liquid as bat urine.

Perhaps his most extraordinary exploit came on a visit to Lord Harcourt, the Archbishop of York, at Nuneham Courtenay, just outside Oxford. His host's most treasured possession was a silver casket which contained what was claimed to be the heart of the 'sun king' Louis XIV, apparently looted by activists during the French Revolution. The shrivelled item was passed around the dinner table; that is, until it reached Buckland, who promptly ate it (albeit washed down with port), observing that he had "never eaten the heart of a king before".

Realising that natural science bored many of his contemporaries, Buckland always injected humour into his talks, prompting Charles Darwin to churlishly claim that he "… was incited more by a craving for notoriety, which sometimes made him act like a buffoon, than by a love of science". Buckland has the last laugh though, when a sketch he published in 1836 was included in the Geological Society of America's 2015 session on 'The Great Images in Geology' *(Timothy Oleson; www.earthmagazine.org/article/illustrating-geology-great-images)*. There it stands alongside such icons as William Smith's 1815 geological map of Britain and the 'Duria Antiquior' of De la Beche *(see also, Mercian 2010)*. Buckland's watercolour combined an idealized cross section of European geology drawn by Scottish geologist Thomas Webster with 120 sketches of animals and plants from the different ages represented, many probably the work of Buckland's wife, Mary. Unlike the 'Duria Antiquior', which is essentially a single snapshot in time, Buckland's depiction embodied a growing perception that rock strata contained the record of life that must have evolved over a very long period of Earth history.

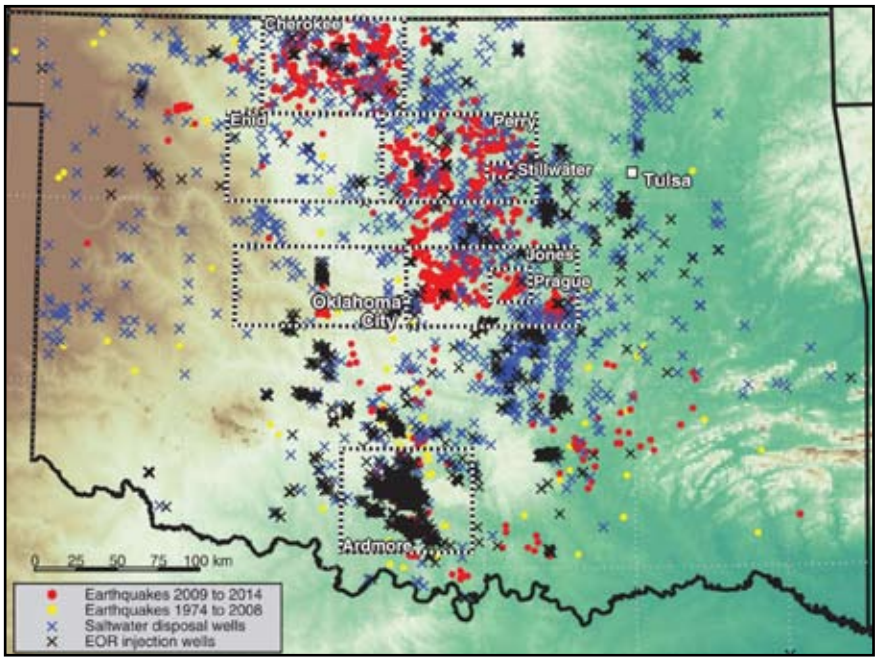
Ancient Egyptians 'mined' meteorites

At a time when 'futurists' are seriously considering mining asteroids for rare minerals and diamonds, it is worth noting that extra-terrestrial objects were greatly valued more than five thousand years ago. One of the puzzles uncovered by the famous archaeologist Howard Carter in 1925 was a dagger found within the wrapping of the teenage king Tutankhamun, dating back more than 3300 years ago. The dagger had a gold handle and was clearly a prized possession; but more than this, ironwork was extremely rare at this time in ancient Egypt, which was still in the later stages of the Bronze Age.

To investigate the source of this iron, Italian and Egyptian researchers studied its chemical composition, and found high levels of nickel and cobalt that strongly suggest an extra-terrestrial origin. They then compared the composition with known meteorites within 2000 km of the Red Sea coast of Egypt, and found similar levels in one meteorite (*Comelli et al., Meteoritics & Planetary Science, 2016: DOI: 10.1111/maps.12664)*. This meteorite, named Kharga, was discovered 240 km west of Alexandria, at the seaport city of Mersa Matruh. The researchers concluded that "…ancient Egyptians attributed great value to meteoritic iron for the production of fine ornamental or ceremonial objects". They also advanced an hypothesis that great importance was placed on rocks falling from the sky (*see also Geobrowser, 2014)*, and went further in suggesting that this finding of a meteorite-made dagger adds meaning to the use of the term "iron" in ancient texts, noting that around the 13th century BC, a term "literally translated as 'iron of the sky' came into use … to describe all types of iron". The high quality of the blade suggests that Tutankhamun was served by workers skilled in iron-working who, despite the relative rarity of the material, anticipated Western culture by more than two millennia.

This discovery also confirms what had previously been argued, for example in 2013 by Egyptologist Joyce Tyldesley of the University of Manchester, who excavated nine decorative iron beads from a cemetery near the Nile in northern Egypt. Analysis proved that they too were fashioned from meteorite fragments *(www.nature.com/news/iron-in-egyptian-relics-came-from-space-1.13091)*.

Egyptian dagger with its blade made from meteoritic iron (photo: Astronomy Magazine).



Locations in Oklahoma of the recent earthquakes (2009–2014), historical earthquakes (1974–2008) and of wells, used either forenhanced oil recovery (EOR) or for saltwater disposal, where injection exceeded 30,000 barrels (~4800 m^3) in any month within the most recent three years of data (from Walsh & Zoback, 2015).

Fracking and earthquakes

Last year's *Geobrowser* discussed issues over groundwater contamination associated with high-volume hydraulic fracturing ('fracking'), or rather the wells drilled for that purpose. However, the magnitude 2.3 and 1.5 earthquakes recorded at Cuadrilla's experimental shale gas site in Lancashire (*see Geobrowser, 2012*) highlighted another concern that will become prominent in the lead-up to fracking, should the government of the day push ahead with it. There are indeed some extreme examples of earthquake swarms directly related to exploitation of the major shale oil and gas producing regions of North America, and fluid injection at depth is the main culprit. The problem is complex, however, and in case studies from Oklahoma and Alberta, two different modes of fluid injection are implicated.

In Oklahoma, researchers have found that the underground disposal of 'waste' fluid (flowback fluid) left over from fracking was the main cause of a startling increase in seismicity (*Walsh & Zoback, 2015, doi: 10.1126/sciadv.1500195)*. In this process waste fluids are injected into dedicated saltwater disposal (SWD) wells that intersect sedimentary formations with high porosity and permeability. Unexpectedly however, this caused an increase in pore pressures throughout the aquifers, resulting in slippage along already-stressed fault planes. The result is that earthquake frequency has greatly accelerated in a state where, prior to 2008, there were only a few 'historical' events distributed over a relatively wider area. In 2015 for example, some 900 earthquakes of magnitude 3 or greater were recorded (*Associated Press; March 08, 2016*). Moreover, Walsh and Zoback found that far more damaging events could not be ruled out in the future; the prediction was soon fulfilled by the magnitude 5.8 Pawnee earthquake of 2016. The strongest ever recorded in the state's history, it caused damage up to 300 miles away and precipitated the immediate closure of 69 fracking wells around the epicentre.

In our second example, from the Alberta Province of Canada, hundreds of quakes have been recorded in a major fracking region (*huffingtonpost.ca/2016/11/17/fracking-earthquakes*). There, researchers have found that underground fluid disposal was not the primary cause of this induced seismicity. Instead, it seems that certain faults were preferentially reactivated by increased pore pressures initiated during the hydraulic fracturing process itself - a conclusion also reached for the Lancashire seismicity.

Although fracking will never be carried out on such a vast scale in Britain, where prospective areas (as opposed to the licence blocks) are much smaller, the North American (and indeed Lancashire) examples show that some induced seismicity can be expected. On the plus side, copious amounts of research in the USA are suggesting that whatever the cause, the problem can be controlled and mitigated by better regulation involving a combination of strict seismic monitoring along with geological and hydrological modelling of the fracking prospects. This responsible approach is embodied in the UK Environment Agency's most recent guidelines (*EA Onshore Oil & Gas Sector Guidance, Version 1 August 2016*), which state that: '*Operators must carry out prior geological analysis to identify natural faulting, background monitoring of seismicity before operations start and on-going monitoring during operations. Operators must also submit a Hydraulic Fracturing Plan to the Oil & Gas Authority for approval. Operators must use the 'traffic-light system' to ensure that operations can be stopped quickly and reviewed if seismic activity is detected. If the magnitude increases the operation may need to be reconsidered or stopped altogether*.' These regulations indicate an intention to deal with the problem but are unlikely to satisfy the most hard-line anti-fracking groups, some of whom oppose borehole drilling, even for monitoring purposes.

FROM THE ARCHIVES

Reticulite

This does not go very far back into the archives, but just to 1990, when a number of Society members were on in a field trip to Hawaii, run under the auspices of the University of Nottingham's Department of Adult Education. On August 10th, the group descended the flanks of the ever-active Kilauea volcano, and stopped on the Chain of Craters Road where it crosses spectacular lavas, with adjacent pahoehoe and aa flows both less than 18 years old.

Closer inspection of the ground revealed unusual quantities of Pele's Hair. These delicate strands of basaltic glass had been drawn out by the wind from airborne droplets of very liquid lava ejected during a fountaining phase of one of Hawaii's volcanic vents. They are likely to have emanated from one of the eruptions at the Pu'u O'o vent, and within the previous year or two, as the fibres do not survive long in a weathering environment.

Then along with the Pele's Hair, some of the group found fragments of reticulite. This is a foam of volcanic glass that solidified in mid-air before its contained gases had escaped. And within the brief interlude of solidification, most of the very thin walls between the vesicles had collapsed, leaving only filaments of glass along the triple junctions between bubbles. The end result is a rigid 3-D lattice of glass fibres with a bulk porosity of about 98%, giving it the lowest density of any rock. It is extremely fragile, is easily crushed in the fingers, and would not last for long on the windswept slopes of Kilauea. This accounts for it being one of the least known volcanic products. A few small samples were collected and preserved in the usual film canisters.

One of the small chunks of reticulite that was found in 1980 on the lower slopes of the Kilauea volcano; this piece is just 50 mm long.

Phil Small's splendid micro-photograph of the Kilauea reticulite. The near-translucent rods of basaltic glass form a lattice that remains from the boundaries of gas bubbles, each of which was about 1 mm across.

A fine example of Pele's Hair, with droplets of black glass drawn out into golden fibres, and the scale given by the typed label.

Pahoehoe and aa lavas at the reticulite locality being inspected by Billah Fletcher, at the side of Kilauea's Chain of Craters Road.

Overall, reticulite has a gloomy brown lustre as its glass is mostly semi-translucent and tinted brown, though the finest elements in its lattice are almost clear. It is also known as thread lace scoria, a term that may be descriptive of its texture but hardly flatters a rare geological material that is considearbly more spectacular then most scoria.

Back home in Nottingham, one small piece of the reticulite was photographed, at great magnification and with great difficulty, by Phil Small, who is sadly no longer with us. But some of his photographic archives were copied into the writer's archives, and that splendid image recently re-surfaced. It is a fine testament to Phil's skill and enthusiasm.

Tony Waltham

BACK COVER

Landslides on the Jurassic Coast

Designating the Jurassic Coast, of Devon and Dorset, as a World Heritage Site was readily justified by its superb exposures of a long sequence of Mesozoic rocks. One component of its geological value is provided by the many large landslides that continue to re-activate. Seldom a month goes by without the media reporting a new rockfall or landslide that has taken out a section of cliff path and then landed on the foreshore.

The photographs by Graeme Guilbert on the back cover of this issue show some of the landslide events during the first half of 2016 (reference numbers apply to the BGS National Landslide Database, listed in their GeoIndex).

At the top, the large landslide at Bowleaze Bay (#870), east of Weymouth, was a classic multiple rotational slip in the Corallian limestones and the underlying Oxford Clay. It left a head scar in the Osmington Oolite, which was itself broken by subsidiary slips with much smaller displacements, as in the next photograph down.

The third view is of Worbarrow Bay (#1063), east of Lulworth, where steeply dipping chalk failed along multiple fractures perpendicular to the bedding, in what was the largest of many recent landslides in this cliff.

The lowest of the four photographs was taken at Littleham Bay (#766), east of Exmouth, where Permo-Triassic mudstones slumped in a rotational landslide over long, curving slip surfaces.

A detail of the head scar on the Bowleaze Bay landslide.

THE RECORD

EMGS 2016 summer programme: 6 excursions.

A visit to Richard Hawkes' workshop at the Sherwood Forest Arts and Crafts Centre at Edwinstowe focussed on the intricate techniques used in the preparation of museum quality fossil specimens.

A weekend visit to the Lleyn Peninsula was led by David Bate in glorious weather. Saturday covered the debate over the Precambrian/Cambrian/Ordovician age of the Gwna Melange, a giant submarine slide deposit well exposed along the north coast. Sunday was spent inland, including visits to Garn Fadryn, a mid-Ordovician sub-volcanic microgranitoid with associated andesitic lavas, and a col with exposures of a remarkable tourmalinite and fossiliferous sediments of Longvillian age.

A town walk to inspect the natural springs in and around Buxton, led by Albert Benghiat, was nearly marred by too much water. In equally bad weather, the visit to Grace Dieu Woods, on Charnwood Forest, led by Keith Ambrose to look at exposures of Precambrian, Carboniferous and Triassic rocks was cut short by rain.

Jim Riding repeated from the previous year his visit to the Bees Nest and Kenlow Top pits at Brassington to view the Miocene sediments preserved as karstic fills that survived Neogene and Quaternary erosion.

A visit to the Ashover inlier was led by Colin Bagshaw, taking in exposures of the Carboniferous sequence of limestone, shale, sandstone and tuff, together with the remains of the extensive lead and fluorite mining.

EMGS 2016-2017 winter programme: 8 meetings.

Rory Mortimer vividly brought geology and WW1 history together during his lecture on the Chalk of the Paris to London fast railway route. Collapse of part of the railway track along the TGV Paris-Lille line in 1994 caused a high-speed train to leave the track. Subsequent investigation by the French Geological Survey (with the speaker as International Reviewer) found that an undetected cavity remaining from the First World War frontline was the cause of the collapse. After intense rainfalls in 2000 and 2001, many ground collapses were reported close to the railway along the Somme valley and the Vimy Ridge, where chalk was the bedrock.

Daniel J Myhill described using carbonate clumped isotope thermometry to determine the precipitation temperature of carbonate minerals alongside their bulk isotopic composition (δ18O and δ13C) and to deduce compositions of the mineralising paleo-fluid δ18O. Constraints on the temperature fluid composition of mineralisation in the South Pennines indicate its association with late Variscan brittle failure, with mixing of warm basinal brine and cooler meteoric fluid.

Leah Nolan described Carboniferous gigantoproductid brachiopods from the Peak District that were sampled at high resolution (within individual growth lines) to assess seasonal variation within the organism's life-time. Analysis of the stable isotope composition (δ18O, δ13C) of biogenic calcite can reveal equatorial seawater temperatures and seasonality at a key point in Earth history, just prior to the main phase of the late Paleozoic glaciation. The data will contribute to debates regarding Palaeozoic tropical seawater temperatures that are considered by some to be warmer during interstadials such as the Brigantian.

Neil Worley described the complex development of mineralisation of the South Pennine Orefield, thought to have begun in the late Westphalian, when subsidence due to thermal sag took the limestone to burial depths of about 4000 m. Mineralized palaeokarst features are interpreted as hypogenic, formed by the interstratal circulation of confined hydrothermal water. Subsequently, acidic F-Ba-Pb-Zn-enriched fluid evolved in the Namurian basinal rocks and migrated into fractured limestone, to form the stratiform mineral deposits (flats) and the more irregular pipes. Fluid inclusions indicate that the mineralizing fluids were chloride-fluoride-rich, typical of oilfield brine, and isotope profiles suggest a sulphate evaporate source of sulphur, mainly from the Chadian Middleton Anhydrite.

Nick Longrich described giant marine reptiles and whales during the Eocene-Oligocene cooling event in transition from the marine reptiles that became extinct at the end of the Cretaceous. Fossils from the late Eocene of North Africa show that marine reptiles thrived alongside early whales, before disappearing near the Eocene-Oligocene boundary, which was associated with severe global cooling, the start of glaciation in Antarctica and the beginning of an Ice Age regime. The main new marine lineages were mammals such as warm-blooded pinnipeds, otters and birds that may have an advantage in colder waters because they can maintain high levels of activity compared to their cold-blooded prey.

Tom Dijkstra illustrated the catastrophic geohazards in Central China, specifically in the tectonically active region along the eastern margins of the Tibetan Plateau, within Gansu, Sichuan and Yunnan. All-too-common are destructive landslides in the dissected loess terrains around Lanzhou. He then described the 2010 Zhouqu disaster, where a debris flow destroyed more than 200 buildings and killed more than 1500 people.

Andrew Bloodworth used the construction of the mobile phone to demonstrate the recent rapid development of uses for many of the earth's rarer elements, including rare earth elements, platinum group elements and others from beryllium to zirconium. This included a look at ideas related to metal supply from geological and other sources, challenging some assumptions relating to non-renewable mineral resources and physical scarcity.

This year's Presidential Address by Vanessa Banks looked at the hydrogeology of the Peak District, notably the effects of the underlying geology on flow systems. Modelling of the catchments incorporates recharge, through-flow and discharge, in order to improve river basin management planning and fully utilise the value of the water resources in the Peak District for supply, leisure and ecosystem services.

Janet Slatter