

East Midlands Regional Group meeting reports 2006

Tight Gas Sands Potential in England

Report by Geoffrey Jago

With the last of our North Sea oil and gas bonanza disappearing the way of all flush, a government minister has recently observed that Britain is no longer self-sufficient in fuel and that by 2010 an estimated 80% of our gas will be from foreign sources. We in our Group flatter ourselves that we try to keep well up on current affairs, so our AGM on 17th January, 2006 was followed immediately by a talk on an important aspect of fuel supply.

Our speaker was Tony Hodge of ROC Oil and his subject was the recovery of gas from Tight Gas Sands in the UK.

ROC Oil, a company based in Sydney, Australia, has world-wide interests and is currently working in China (Beibu Gulf), offshore in Australia, New Zealand, Angola, equatorial Guinea (in very deep water), Mauritania, UK Onshore and UK North Sea, the work in Mauritania and UK North Sea being undertaken in partnership.

Tight Gas Sands are sandstones containing fuel gas which, owing to the low permeability of the rock, is yielded slowly when tapped by a borehole. Despite any images of vasty underground gas-filled caverns cherished by the Man in the Street the reality is that the gas occupies very small pores, usually in sandstone.

The business of gathering fuel from such rocks has taken off in America, especially since a certain large company revised its reserves and because, unlike in the UK, the USA government grants tax benefits. Now ROC Oil have begun to seek similar reserves in Britain.

Much study of the targeted sandstones is undertaken on rock porosity and permeability. The two terms do not equate to one another - for instance, no gas or liquid would flow through a porous body where no pores interconnect. Porosity is expressed in percentage while the more mysterious permeability is defined in milli-Darcies (mD), after the law defined by Mr. W.K. D'Arcy, an eminent English oil man.

Photomicrographs of a selection of thin sections of several sandstones were shown together with their porosity and permeability values. Some very productive Triassic rocks in America have porosities of 22% to 24% with mD of over 500 while the also productive Permian North Sea rock, the Rotliegende sandstone, is typically 12.5% and 23mD; but rocks with much less encouraging values can still produce.

There is as yet no clear definition of what is a Tight Gas Sand but the definition in the US and Canada is a rock with a permeability greater than 0.1mD. With Tight Gas Sands, unlike most gas wells, production falls off rapidly after tapping and slow migration means that more tapping points are required for a given field.

What makes a valid TGS "play"? In America bed thicknesses range from 10 to 100 ft and in rare instances up to 300ft with porosities ranging from very low values up to 10%, typical values lying between 0.5% and 1.0%.

The potential for gas production from these rocks in England lies mostly in the Yorkshire and Lincolnshire coastal areas but with a few other prospects in Lancashire and elsewhere. ROC Oil's first choice is a reopened borehole at Cloughton, a little way north of Scarborough. A slide illustrated that a certain amount of JCB work was needed before the capped wellhead came to light. At Cloughton P & P values of 5.6% and 0.22 mD respectively look sufficiently promising. The Mesozoic shallower rocks are underlain, beneath the Permian to Carboniferous unconformity, by the lower Carboniferous Namurian and then the Dinantian. Two beds in the Namurian and one in the Dinantian will hopefully all yield gas, with most from the lowest bed.

Three-dimensional seismic work would be completed before further drilling but, given satisfactory results, a pattern of 17 further boreholes is planned to exploit the gas field fully, demanding an investment of several million pounds prior to any gas production.

American practice has shown that down-hole techniques can be used to increase the gas flow considerably. Hydraulic fracture technology is a method of pumping fluid under pressure into a selected bed with the object of

creating fractures in the rock. Often the artificial voids thus produced can close up again when the pressure is taken off and to avoid this a further technique can be employed known as propped fracture placement whereby a suspension called proppant is forced into the strata to restrict closure.

Tony completed this comprehensive presentation with a plea for a national focus on UK onshore tight gas. Because there are no local firms specialising in this type of work, costs here are more than twice those in the US or Canada and, it is worth reiterating, UK firms enjoy no tax concessions as do their Transatlantic friends.

A good lecture, leaving little doubt of the wisdom of making the most of any remaining indigenous fuel.

A speech of thanks was given by Judith Nathanail.

Pterosaurs- Top & Bottom Deckers

Report by Geoffrey Jago

Cosily sheltered from a wintry northeaster, February 21st, 2006 saw us marshalled in our habitual meeting place, thanks to British Geological Survey, Keyworth. Dave Martill, Reader in Palaeobiology at the Palaeobiology Research Group of the School of Earth & Environmental Sciences at the University of Portsmouth, had kindly motored up from his home on the Isle of Wight to speak to us on a specialist subject of his, one which has ever fascinated scientist, layman and child alike, that of ancient animals which took to the air.

There is more in the league of pterosaurs than a layman would expect. Fifty genera have already been listed with five more being added annually and their fossils are not uncommon, particularly in parts of Brazil where by good fortune Nature preserved many of them from compression by concreting them in.

The manner in which their flight first developed is a riddle because all pterosaur fossils discovered so far have been of those well evolved to be sophisticated fliers. Natural flight is either falling or gliding. Of vegetable life, plant seeds glide while the fate of heavier varieties is merely to fall. For instance, the coconut, conceded to be of limited airworthiness, could only evolve a hard and coir-covered exterior to cushion its landing. So true flight lies not with plants but with animals - insects, birds and bats all possess powered flight. Spiders can drift on threads while squirrels are good leapers and this may have been how flight developed. There are two theories: either that early contenders honed their ability to leap - the ground-up theory - or began by jumping from high spots - the trees-down theory. Of modern semi-aeronauts, flying fish and flying squirrels illustrate the two theories.

Turning to fossil evidence of flight, flies certainly existed in the Carboniferous and, from the discovery of some fragments, may have their ancestors in Devonian times. As early as the Permian there were gliding lizards and then, part way through the Triassic more than 220 million years ago, pterosaurs became the first vertebrates to develop genuinely powered flight and, flying proficiently by the Middle Jurassic, survived until the early Cretaceous. There is no evidence that any animals other than pterosaurs could fly well enough to gain height.

Much thought has been given to the way pterosaurs flew. All modern aerodynamics, rocket science aside, has emulated nature except that today's powered aeroplanes need lots of energy. And so to the title of our talk, Top and Bottom Deckers, or whether wings are attached to the top or bottom of the body. Like birds, bats and insects nearly all pterosaurs adopted the more stable top decker style with the centre of gravity below the supporting wing. One, however, was a bottom decker possibly because it could utilise what is called the Wing Ground effect for takeoff when increased air pressure is generated as speed builds up.

Of other aspects of pterosaur structure, a long neck is necessary to feed, and for efficient flight short tails are the best. From the study of today's birds it is thought that certain features were preferred by the females and this may have led to longer tails than required for efficient flight. Love interest may similarly be responsible wide diversity of head crests.

How do pterosaurs fit in with other animals? They are not dinosaurs but have been 'dumped in' with them because they lived simultaneously. They are diapsid reptiles: a subgroup of reptilia which have two holes in the skull behind the eye and another two in front. However the consensus is that they are much more closely related to dinosaurs than are crocodiles. Birds, which do appear in the dinosaur lineage, differ because they use feathers, which did not evolve for the purpose of flight. Feathers are dead and have to be shed but fleshy membranes can be retained. Pterosaurs appear to have been small furry animals, perhaps with a down or

bristly coat. Like bats, which incidentally did not appear until the lower Eocene or just before, long after the pterosaurs died out, pterosaurs used their hands to fly. A single finger (which one of the four is unknown) formed the bony leading edge of the wing with membranes extending to the sides of the body both fore and aft. A third membrane stretched between the legs. These membranes were very thin and acted as radiators to shed heat.

Until recently no pterosaur had been found with any teeth, intelligence ignored by makers of plastic models which usually arrived with a full set, a special glamour expected by kids and enhancing the price. More recently, however, a fossil sporting a needle-like array turned up, an instance of commerce anticipating science.

Pterosaur bones are especially interesting in the way they show exceptional strength for their weight. They are lamellar, a micro-ply of perhaps 20 layers in a quarter of a millimetre. Some species have thin cross-struts within the bone while others have spiral ridges in the inside of the bone-tube. Others even save weight via an air-sac system extending from the lungs through the bones.

A few pterosaurs were very large including one with a 12 metre wingspan, and a neck vertebra from another measures 800 mm; but reports based upon footprints in Mexico and bones in Israel of 20 or 25 metre wingspans are not now thought to be of pterosaurs.

Dr. Martill's interesting and comprehensive talk also included a history of those who first found and described these fascinating creatures.

A speech of thanks was given by Judith Nathanail.

Britain from Top to Bottom: How the Geology of the Deep Crust Shapes the Surface

Report by Geoffrey Jago

Geology began with the examination of rocks on the surface, and it took the flair of William Smith to draw sections to disclose what lay further down. A little under two centuries later, looking deeper and interpreting fine detail is the domain of those who know the art.

Dr. Richard England of the University of Leicester, our speaker at British Geological Survey, Keyworth on 8th March, 2006 described the work that he and seven colleagues are undertaking in revealing the chronicle which the deeper rocks have to tell with particular reference to how it relates to the scenery we enjoy in the British Isles. Nowadays many techniques are available including stratigraphy, sonic logs, apatite fission track data, conodonts and vitrinite reflectance which can reveal how deeply rocks have been buried.

Of particular significance in the study is the prominent sweeping line of the base of the Permian on the geological map of England from the Tees to the Exe in southeast Devon, to the east of which especially severe erosion seems to have taken place. The search for fuels in the UK in recent decades has furnished huge quantities of information including seismic data which, by means of graphs, Dr. England presented in some detail to show how his work was progressing.

A major postulation from the work is that uplift of the Paleogene (Paleocene to Oligocene) rocks was caused by magmatic underplating. This (a term new to your correspondent and, comfortingly, to his equally venerable geological dictionary) is a process modifying the density of the lower part of the crust. The cause of the later uplift of the younger Neogene rocks remains unknown.

In an account of this nature it is not possible to include the detail or indeed most of the content of this very interesting evening which, after a scholarly question and answer session, was concluded by a speech of thanks by Gareth Jenkins.

Creating Conceptual Models for Contaminated Land Evaluation

Report by Geoffrey Jago

Our lecture of 26th April, 2006, featured Judith Nathanail, our Regional Group active and successful Chair for the last three years. The meeting was held once again at Keyworth, thanks to the kind offices of British Geological Survey, where their ample Meeting Room No. 1 was filled to capacity. Our Group derives much satisfaction by seeing that, in our growing audiences, our efforts attract an increasing proportion of the younger adherents to geoscience and engineering.

Judith, as Senior Environmental Consultant with Land Quality Management Ltd. (LQM), has wide experience of the work of investigation, assessment and remediation of contaminated land and her lecture was based on the practical courses she provides in this realm.

Contaminated Land Management involves the examination of sites with past industrial uses like factories, gas works and petrol stations where soil and groundwater may contain harmful substances such as petroleum residues, chlorohydrocarbons and heavy metals. Information is sought on former uses, samples are taken, risk is evaluated and the final clean-up is designed.

Fundamental to the work is the study of pollutant linkage - the pathway a pollutant takes from its source to a receptor in danger of being harmed. The link is all important because, above all, if there is no linkage then there is no risk either.

So, in this context, what is a Conceptual Model? It is a scientific method of assembling all that is known about a contaminated land site and adding new data as it comes to hand until all relevant facts can be presented in a form readily understandable to scientist and layman. This is a thoroughly common sense pen and paper exercise rather than an immediate rush to a keyboard, although the way in which it assembles the facts makes for the easier production later of sections, 3D diagrams and the like by computer.

LQM uses two worksheets of A3 size called Conceptual Model Pads (CMP), blank copies of which were handed out. The first CMP faces you ready to list all the potentially contaminative activities by contaminants, migration/exposure pathways and receptors. With ample space for sketch diagrams, the second CMP reminds you that the fundamental object is to define links: Sources via Pathways to Receptors. It also contains aide-memoir lists of all the typical contaminant pathways to look out for and all potential receptors to bear in mind.

The Conceptual Model also embraces Site History, Current Use, Proposed Use, Geology, Hydrogeology, Contaminant Source Areas, Likely Pathways and Potential Receptors. Besides text, it can take a variety of forms - pictorial, sectional, block diagrams, network diagrams and matrices. Its especial importance and usefulness lies firstly in its ability to condense all that is known of the site's surface and subsurface, secondly to guide cost effective investigation and thirdly to provide a tool for discussion and understanding.

With many maps and illustrations, Judith packed an interesting hour describing several practical applications based on her own experience and that of her company.

As well as its use in contaminated land work this modelling method is well worth the study of anyone faced with a problem where it can help to assemble all the information in a logical way.

For further reading, the LQM web site is : www.lqm.co.uk

Gareth Jenkins gave a speech of thanks.

Using the Late Palaeozoic Sedimentary Record to Investigate Climate Change over Geological Time

Report by Geoffrey Jago

Initiating a suite of three meetings focussing on late Palaeozoic rocks, our speaker on 31st May, 2006 was Dr. Sarah Davies of Leicester University and member of our Group committee, who spoke on a division of her work devoted to detailed analysis of the rocks spanning the late Devonian to Permian ages with particular reference to the Carboniferous. Dr. Davies' summary is as follows:

'The Carboniferous is important as one of the critical stepwise transitions of the Earth System when rapid changes in climate and atmospheric composition (rise in O₂/CO₂ and pO₂) coincided with key events in biological evolution (proliferation of land plants) and increased rates of plate reorganisation. Over this time, early Palaeozoic greenhouse conditions were replaced by icehouse conditions. Geological data from a wide range of sources (sedimentology, stable isotopes, the plant record) locations suggest that the onset of glaciation and variation in ice cover in the southern hemisphere at this time are time-equivalent to major changes in sedimentation observed in the palaeo-equatorial regions (e.g. the northern UK). This talk looks at how familiar Carboniferous successions from the Peak District, Yorkshire, Ireland and Scotland could hold some of the vital clues in understanding the drivers of global climate change on geological timescales.'

With inter-glacial warm periods, the period was a very prolonged ice age, especially during the later Carboniferous and earlier Permian Systems. The Carboniferous is particularly important in understanding big changes in the Earth's system on geological time scales which can throw light on whether the present era is one of rising or falling temperatures.

The study focussed on UK & Irish sediments to reveal what they tell us in a global context. Dr. Davies used many excellent graphic diagrams to explain how the various techniques now available to geologists can disclose broad landscapes of changing sea levels, developing and receding ice sheets and erosion patterns in shallow and deep seas as well as on land. Questions remain to be answered. What was controlling climate cyclicality? Is there a link between glaciation and carbon-burial? Can we correlate northern and southern hemisphere change? Can glaciation and variation in ice cover in the southern hemisphere match the rest of the world? Australian records point to a reasonable correlation.

In summary, the work progresses towards improved chrono-stratigraphic records. Well constrained correlation allows key questions to be addressed and multi disciplinary studies can document high resolution diagnoses.

The years before the second millennium will be remembered as the time when the peoples of the Earth woke up to the fact that their own activities were making profound changes to the only place they had to live, so discovering everything possible about climate change is of paramount importance. While geological science has always studied the present as a key to the past, in instances such as this the past can disclose a clearer picture relevant to ameliorating present-day problems. As ever, geology comes to the rescue.

By way of a bonus, this inspiring evening provided clearer understanding of the history of the rocks to be examined in our Group's forthcoming July field trip to Mam Tor in Derbyshire.

A speech of thanks was given by Judith Nathanail.

Landslides and Ground Deformation in Derbyshire

Dr Laurence Donnelly (Halcrow)

Report by Vanessa Banks

Background

The focus of the presentation was primarily the famous Mam Tor Landslide, with some reference to other Derbyshire Landslides and to the significant amount of research that is still required. The growth of knowledge of the geological setting of Castleton and Mam Tor since the 1960s has largely been derived from British Geological Survey mapping, Trevor Ford and Peak District Historic Mines Society. Mam Tor is unusual in that it is an inland landslide, which has been studied in considerable detail. It is one of approximately 8500-recorded landslides. Areas of current interest with respect to landslides include: the South Coast, South Wales, Norfolk and Scarborough.

Geology, Mineralization and Geomorphology

The geological setting of the landslide comprises Namurian shales and sandstones, immediately to the north of the Dinantian Limestone outcrop. The geomorphology is a reflection of Pleistocene activity. Glacial Till has been attributed to the Anglian, later glaciations have been identified in Lancashire and York, but there is only evidence of periglacial activity during this period in the vicinity of the Peak District. The landslide was initiated in

the order of 4000 years ago. In considering a section across the Derbyshire Dome there is a transition from Carboniferous reef deposits to lagoonal facies. The reef dips to the north and southeast and occasionally is intruded by basaltic lavas and magmas, as seen in Caves Dale for example. During the Namurian there was a sediment influx from the North, which resulted in the deposition of mud (Edale Shales), then proximal turbidites (Mam Tor Beds) and then the sand of the Kinderscout Grits. Subsequently, the sandstones were subject to erosion. The Limestone is mineralized, with epigenetic minerals including: calcite, barites, sphalerite and galena. The deposits are found in a variety of forms including scrins, pipes and rakes. The remains of the former lead mines, where fluorite, barites and calcite formed the gangue minerals, have been reworked and now the lead is discarded. Calcite is used in industry. The purplish blue colour to the fluorspar is unique to the area and the finding of a vase of this fluorspar in Pompeii has confirmed the Roman use of the fluorspar. Treak Cliff Cavern has been fenced off due to a roof boulder fall. Behind this the hydrocarbons (of which at least 30 have been identified) still seep from the limestone. It is the presence of the hydrocarbons that has caused the discolouration of the fluorspar. Dirtlow and Odin Rakes have been worked out. Recent working at Dirtlow revealed a crushing circle. Above Castleton there is evidence of underground mining and there are a number of shafts that have been capped in a variety of ways.

Mam Tor Landslide

The landslide is near Odin Mine Vein, but there is no evidence that the underground mining caused the slide, although it may have influenced reactivation of the slide. The landslide has been divided into four zones, which are described in turn below.

1. Backscarp. The footpath up Rushup Edge crosses the remains of a prehistoric rampart, which has been dated to the late Bronze/Iron Age. The backscarp cuts across this feature, indicating that it post-dates it. The backscarp is 70 to 80m high. At the top the Mam Tor Beds (shale siltstone and mudstone) are exposed and are unstable. Within the turbidite sequence sandstone blocks protrude and occasionally are subject to toppling failure, such that there is an accumulation of toppled blocks at the base of the slope. Following heavy rain there debris flows are generated. At the base, on the east side of the landslide the Edale Shales are exposed (these are at a similar stratigraphic level to the Mam Tor Beds), therefore there must be a fault between the two. The Edale shales are unstable and on weathering generate ochreous acidic water.

2. The rotational slip (upper slip), which incorporates toppling and flow. Where the road passes over this area on-going phases of road repair have exacerbated the instability.

3. Transition Zone. This comprises ridges, compression zones, ditches and water. Material type influences the form of the deformation, for example the road behaves very differently to the Edale Shales, which flow and buckle.

4. Debris Flow. In the lower part of the road active fissures are evident and the bitumen has been subject to several phases of repair. Beyond the transition zone flow debris occurs within the landslide and the edge of the landslide comprises an escarpment of up to 2m in height. The presence of a fence and Blacketlay Barn, which is slowly being encroached provide markers against which rates of movement can be assessed.

History of Investigation

In 1989 Skempton oversaw a borehole investigation, which identified a slip surface (in the order of 0.10m thick). Subsequently the rock types, failure and deformation types were characterized, for example stretching in the translational zone was observed. In addition pollen was taken from the slip surface in one of the boreholes and this dated the slide to 4000 to 3200 years in age. Tony Waltham and Manchester University have monitored the slide and shown that it is still moving, modelling 320m of movement since its initiation. Studies of climatic data have shown that movement tends to occur following increased rainfall events (>210 mm). Current remedial works for landslides elsewhere incorporate the use of soil nails and rock bolts, but this is not feasible at Mam Tor. Attempts were made to drain the slope; these worked initially, but then became blocked. A record of ground movements, road stabilisation and the influence of man on the landslide has been recorded by Waltham and Dixon and subsequently modified by Donnelly. The monitoring and measurement has improved with time. Mam Tor is likely to be active for another 4000 years.

Other Derbyshire Landslides

Others that have been studied in north and central Derbyshire include Landendale and Saddleworth Moor.

Mapping by the British Geological Survey primarily directed at improving the knowledge of the stratigraphy has also identified landslides, particularly during the last 5 to 15 years when the interest in landslides has grown. So, now we have records regarding the landslide areas, but little is known about them. Derbyshire is associated with fault reactivation; in Bolsover this was associated with mining activity. Other landslides have been shown to be active for in the order of 8000 years, hence the prediction of a further 4000 years of movement at Mam Tor. The stable angle for slopes would seem to be in the order of 11 degrees. Evidence for the slides comes from escarpments at the top of the slopes, often 1-2m high and in the order of 1 km long, comparable with features seen in the glacial valleys of South Wales. The slides can often be related to valley cambering, evidence for which is confirmed by folding in the mudstones. At Saddleworth Moor large regional slips have been identified with evidence of extensive deformation in the past. The slips are crossed by roads. It is suspected that they will move again. Alport Castle Landslide is recommended for a visit.

Field Trip to Mam Tor Landslide

Saturday, 15 July, 2006

Report by Geoffrey Jago

An exhilarating progress in the magnificent landscape of northwest Derbyshire, to study the Shire's older succession and its mineralisation, rounded off our suite of three meetings devoted to a study of Paleozoic rocks. The geological content has been given in the reports of the two preceding meetings, the speakers at which, Dr. Sarah Davies and Dr. Laurance Donnelly, were our guides today. We met at the end of the road that had been the A 625 from Castleton to points west until, in 1979 after many decades of nudging, part of Mam Tor finally moved it out of the way.

The cloudless sky was decorated with the gaudy canopies of a dozen or so enthusiasts who had leapt from the top of Mam Tor's backscarp into the 150 metres of space above us and were using the facing breeze to keep themselves airborne.

Limestone mineralisation was the focus on the first part of the trip, leading us into the narrow open cleft of the Odin Lead Mine in Dinantian limestone, the original excavation predating Roman times. The discourse included speculation on the genesis of the vein minerals, chiefly galena, barite, fluorite and calcite. Remaining from more recent lead recovery work we were then shown a disused lead mine shaft and, nearby, the steel track of an ore crushing circle which operated by horse power in the same way that apples are mashed today by cider-makers. The Odin Mine worked until 1869, its deeper reserves being reached when it linked to two drainage tunnels driven at depth in the limestone. Exerting a positive effect on ground stability, the Knowlegates Sough lowered the water table by over 30m. In 1712 followed in 1822 by the Trickett Sough which lowered it another 40m.

Our next stop was to a point on the flank of the landslide material to inspect a source of ochreous water and its rusty deposits, the iron content derived from several tonnes of pyrite leached annually from the shales. Then a rough tramp down around the flank of the slip itself led us to the toe which creeps obdurately along at a rate of up to half a metre a year, in no hurry to complete the destruction of Blacketlay Barn.

Panting back from this area, an inspection of the remains of the main road provided a few minutes to regain breath. As an example of very modern stratigraphy, the road surface, cracked and faulted into huge slabs by active displacement, exposes its layers of tarmacs and coarse sub-bases laid down in successive work since the road's inception under a Turnpike Act of 1802. Of relevance to the study of building foundations, Laurance drew our attention to the processes affecting this material as the ground moved.

After a picnic lunch the salient details of the geology and rock structure of the backscarp, which are described in the foregoing report, were pointed out and we had an opportunity to dig over the dark weathered scree from the Edale Shales before climbing to the Upper Road to examine a rock exposure where a few minutes search revealed hydrocarbons.

A speech of thanks to our guides and organisers for this stimulating visit was given by Judith Nathanail.

Field Excursion to Lathkill Dale, Derbyshire

Report derived from the Excursion Guide by Vanessa Banks and Gerry Shaw, itself providing references to 19 works.

On Sunday 22nd October, 2006 one of the best beauty spots in the glorious limestone scenery west of Bakewell was the destination of our Group, their second field trip in 2006, this time in association with the Open University to which our thanks are due as well as to Natural England (formerly English Nature), who manage the Dale, and to its warden Mr Ben Le Bas.

Vanessa Banks and Gerry Shaw were guides to the upper section of the River Lathkill, a five kilometre strip from near Monyash descending to Over Haddon. The subjects were its geology, geomorphology, hydrogeology and mineral workings.

The Beds

The river cuts into the axial region of a Carboniferous Limestone syncline with the Eyam limestone overlying the Monsal Dale limestone, both beds being exposed including a marker bed of brachiopods (Lathkill Shell Bed) and, towards the eastern section and interbedded with the basal beds of the Monsal Dale limestone, two volcanics (Conkesbury Bridge and Lathkill Lodge lava members). The limestones were laid down in clear shallow seas, the Eyam limestone containing reefs with local colonies of brachiopods and some crinoid 'thickets' on the flanks.

Metal Mining

Most of the carb lime of Derbyshire contains mineral veins, historically a rich source of lead in the form of galena, but associated with barite, fluorite, calcite and occasionally sphalerite, the lead having been worked in the eastern half of the study area in the thirteenth century but worked out by the end of the nineteenth century. The source of this mineralisation is likely to have been fluid expulsion from adjacent gulfs or basins in late Carboniferous times, the liquids filling strike slip faults or fissures. The printed handouts provided to those attending contain many details of past mining activities, including grid references of sites of interest. Bearing witness to the dedication and ingenuity of the 'Old Miners' in their lust for mineral, the handout includes two pictures of a line of tall piers, since demolished, which sustained a nineteenth century aquaduct feeding a water wheel powering a mine pump.

Caves

The handout also includes a map of a linear solution cave, surveyed for over 400 metres, which follows a winding east-west route. With an impressive Cascade cavern and a side passage beneath the branch valley of Ricklow Dale. This lies a kilometre and a half east of the village of Monyash. In all there are about 3 kilometres of natural hollows locally and it is considered that they are phreatic (sub water table) caves, the particular horizons determined by specific physical or chemical characteristics.

Hydrogeology

The River Lathkill lies almost entirely within the carb lime and largely coincident with the Monyash Syncline. Its form suggests the valley was inherited from an eroded shale cover. Fed by groundwater mostly from the southern bank and resurgent springs, the river disappears upstream of a point named Bubble Springs in dry periods. In the headwaters, springs formerly serving Monyash and Flagg have failed. This regional fall in groundwater levels may be owing to rainfall changes, down cutting of natural caves or by drainage by mine workings and their underlying drainage tunnels (soughs).

And Meteoric Water

In an attempt to improve the subsurface water regime, the threatening clouds hovering in the morning eventually drained themselves onto the heads of the travellers but only after most of their ten kilometre-plus walk was complete.

Life on the Costa del Cromer: early human occupation and complex patterns of environmental change in central eastern England during the Early-Middle Pleistocene transition.

Report by Geoffrey Jago

Once more, our Group's thanks are due to British Geological Survey, Keyworth for providing a comfortable meeting room. On the evening of 28th November, 2006 Dr. Jon Lee of BGS spoke on the studies he and his colleagues had made of the young rocks in East Anglia. New information has been gained on the age of human occupation and whence the glaciers brought their material.

Climate change has had a big effect over eastern England over the last 2.6 million years and BGS, by linking strata to climate effect, have made a revised stratigraphic model.

Strata groups here are difficult to map but a stratigraphic approach has proved valuable: climate dictates geological processes which themselves drive the geological product. Thus, working backwards, studying the geological products tells us the geological processes and from this palaeoclimate can be inferred. Dr. Lee explained the erosion cycle of weathering rocks, transport, river sorting and coastal / estuarine sedimentation. Cold periods leave fingerprints that differ from warm ones. Frosty times lock up water and sea levels fall. At the same time there is little vegetation to impede run-off and, with lower seas, fast-flowing rivers result in higher erosion. Come the lazy hazy crazy days of a warm spell, river flows slackened firstly because of more vegetation and secondly because of higher sea levels; and this meant less erosion.

During the study period climate change had a 100,000 year periodicity, with cold periods slowly intensifying, each followed by a warm spell, of probably shorter duration than the cold, before the frost began to freeze the bones again. Modern photographs taken in other areas illustrated the likely landscapes, varying from scenes of frosty and gravelly tundra, then glaciers with only high ground visible and then balmy Mediterranean coasts of the Costa del Cromer.

Based on fossil evidence including that from pollen, molluscs and vertebrates, a new more detailed succession of beds have been identified. From top down, these have been named as Holderness, Britons Lane, Sheringham, Lowestoft, Happisburgh, Wroxham, Cromer Forest Bed and Wroxham Crag. Some marine sediments near Norwich and Pakefield were deposited during times of high sea levels.

Previous thinking had named Scandinavia as the source of glacial tills; but detailed analyses now point to the north east coast of Britain as their source.

Britain and Europe were joined by land spanning over 300 Km from west of the Isle of Wight to north of the Wash with two rivers, each with moderate energy, bringing material from afar as they drained into a smaller North Sea. The Thames took a more northerly path than at present and had a parallel to its north in the then mighty Bytham which flowed from Stratford via Leicester and Spalding. On the southwest side of the land bridge the Solent River may have shared a valley with the Somme.

So it has been shown in East Anglia that stratigraphic schemes were driven by environmental change, that there is a link between shallow marine and fluvial sediments and that there were extreme fluctuations in climate.

And what of man in these times? Stone tools, some discovered in the course of this work, provide evidence of human occupation for 700,000 years which prove that the Island Race arrived some 200,000 years earlier than previously believed!

In fact, well before we were an island race.

These continentals would have migrated northwest during the several warm spells of 700,000 million years; but, if personal experience of a local northeaster is valid, when the icicles grew thicker they would have retreated. Arrivederci Cromer.

Judith Nathanail gave a speech of thanks to Dr. Lee for an excellent evening.

The Earth, an Intimate History

EMRG Meeting at British Geological Survey, Keyworth, 14 December, 2006
Report by Geoffrey Jago

What more prestigious way could our Group's work in 2006 have been rounded off than by hearing Society President Dr. Richard Fortey FRS speak on how the early geological researchers built up our knowledge of how the rocks of the Earth came to be as they are. As could be expected, many people attended.

Readers are reminded of Dr. Fortey's work at the Natural History Museum and his authorship of such widely read books as *Trilobite!* and *Life: an unauthorised biography*. Under the Society's 2007 Bicentennial Celebrations, he is also the initial speaker of the Shell London Lecture Series at Burlington House.

This precis can include only a few of the points made in an hour's extraordinarily comprehensive exposition.

Planning a Book

Dr. Fortey said he found that books on geology were strong on theory but little had been published on the processes the Earth undergoes. Because the history of the world is about process, a pilgrimage to the 'holy' sites of geology was planned.

Earlier Authorship

Dr. Fortey began by looking at the writings of the first relevant authors. A slide of a silver dollar reminded us that a strong stimulus to learn what lay beneath the surface was to seek valuable metals. A woodcut from the renowned book *De Re Metallica*, which remained in print for hundreds of years and concentrated on practical mining methods rather than theory, illustrated how Agricola disseminated knowledge of metal mining in central Europe.

Volcanism dishes out evidence of what lies below without requiring any human action and the eruption of Vesuvius in AD 79 is an example of early study which Pliny recorded, from a safe spot across the bay.

Charles Lyell's '*Principles of Geology*' is a foundational work by a past President of our Society. Its frontispiece pictures temple pillars lunched on by a marine clam from which Lyell concluded that the Earth suffered major changes of land level within short time spans.

In a long and well-informed work '*The Face of the Earth*', the Austrian Edward Suess sought to write down the history of the Earth. Coining the name Gondwana, he deduced that the earth had changed in level and space; and half a century later, after World War II, ocean floor research proved his and A.L. Wegener's hypotheses of continental drift.

Foreign Studies

Dr. Fortey went on to describe his studies in Hawaii (great for plate tectonics) and the Eastern Alps (contortion, overthrust and inversion). The Alps had given rise to one of the earliest plate tectonic theories - a slide showed how the French geologist Beaumont, believed for some time, had tried to fit areas into pentagrams.

Bell island in Newfoundland presented an interesting puzzle. The eastern side contains trilobites that match those in the USA while quite different trilobites found on the western side of the island match those in Europe. Tuzo Wilson's hypothesis of the lifespan of ocean basins (the Wilson cycle) concluded that an ancient ocean, the Atlantic of Palaeozoic times, had once separated the two areas before the assembly of the continent of Pangaea.

Digging for Gold

Having started his talk on the subject of metal mining, Dr. Fortey concluded with an anecdote from a more modern source of metal, one of the Australian gold rushes. The diggings had unearthed a boring mineral resembling pyrite which had proved of some use for road surfacing. That is until someone identified it as the mineral Calaverite, a telluride of gold and silver. An intriguing use of the term road metal. Possibly the ensuing road works were completed in less time than the current variety.

An Appreciation

Amongst several points contained in a speech of thanks, Professor Martin Culshaw said that while geologists had always communicated with each other, sometimes to the point of obsession, there was still a fundamental need for geological information vital to public well-being to be more widely presented. An example highlighted in the slides was the necessity to warn of building too close to geohazards, and indeed rebuilding after an event!