East Midlands Regional Group Meeting Reports 2001

Man-made Seismicity - Friend or Foe?

Ths was the title Peter Styles, Professor of Applied and Environmental Geophysics at Keele University, gave to his talk to our Group at British Geological Survey, Keyworth on 10th January, 2001.

Worldwide, small earthquakes are commonplace with over 100,000 of magnitude 3 every year. On average there are 15,000 of force 4 each year, 300 at force 5, 100 at force 6, 20 at force 7 and two at force 8 each year. The graph of the logarithm of number of earthquakes per year against their magnitude approximates closely to a straight line.

We were shown a map from the GS web page representing seismicity in the UK. Those occurring in the UK, about one or two a year, are mercifully of low power. In Britain there is no strong correlation between earthquakes and geology but there is a clear correlation with areas where coal has been worked.

Professor Styles' work has taken him to several coalfields where mine working has been suspected of causing earthquakes. When small ones of magnitude 3 or less were recorded in north Nottinghamshire it was suggested that colliery workings may have been the cause and staff at the National Coal Board consulted Professor Styles. An area spanning 10 by 10 Km was installed with seismometers and it appeared that the cause lay with workings at two adjacent collieries. Work of microseismic monitoring lasted a year and, although the maximum magnitudes of the earthquakes was only 2.5 to 3.0, it was clear that mining was to blame. As it happened, the NCB had already sunk boreholes in which sondes were installed as part of a scheme to predict the continuity of coal seams in advance of the face. Professor Styles was able to make use of these installations, with results that were significant although different from data derived from underground. At Cynheidre Colliery, South Wales, a knowledge of seismicity was able to help with another colliery problem known as coal face outbursts. In longwall mining the working area of the coalface is a narrow excavation behind the coal face, supported for only a short time by hydraulic props. With the advance of the face, the props are removed and the roof is allowed to collapse behind. Occasionally, in certain collieries, the unworked coal bursts with almost explosive force, filling the working area with finely divided coal. A noise called pouncing, resembling the sound of a motorbike, sometimes precedes outbursts and Professor Styles was consulted to see whether seismic detection could provide better advance warning. Seismic detectors were installed in past working galleries around the mine and data was collected. Many 'impulsive' anomalies were recorded (rapid onset events) showing clear P- and S-waves which are produced as the roof collapses. However, before an outburst or gas emission a different wave known as a harmonic tremor, resembling an organ note of single frequency, is recorded. In situ, the anthracite at Cynheidre contains large volumes of compressed methane and there is a close correlation between methane on the coalface and seismicity. The gas emanates from tiny fractures which form in the coal as excavation changes the pressure on the seam. Before an outburst the solid coal becomes extended by microcracks filled with expanding methane which is released into the working voids after an outburst.

Work on a technique known as 3-component data monitoring brought Professor Styles to Asfordby mine near Melton Mowbray. This method is used to show the direction of origin of seismic waves and it allows origin points to be plotted in three dimensions. At Asfordby the coal measures are overlain unconformably by water-bearing Triassic rocks. Seismic anomalies in the Triassic Sherwood Sandstone were observed which migrated downwards with time and were useful in monitoring working conditions including the prediction of roof falls, a very large one of which eventually closed the mine.. Professor Styles' work continues both in evaporite mines in the UK, near which small microseismic activity is being observed, and in Australia. In other UK coalfields small earthquakes caused by mining are still being observed. In the Keele area for example forty coal seams have been mined and the earth will continue to creak for many years.

A vote of thanks was given by Martin Culshaw.

Report by Geoffrey Jago

Pieces of the Past: Meeting of 14th March 2001

At a meeting held jointly with the Thoroton Society and to an audience that filled Meeting Room One at British Geological Survey, Keyworth, Mr. M. Bishop described the work of Nottinghamshire County Council[1]s Planning Initiative Team which promotes the identification, recording, protection, management and understanding of the county[1]s archaeological heritage. The County has a large number of archaeological sites spread across the whole area with a particular density lying along the Trent valley and to the southeast. Indeed, owing to the density of sites of historical interest, some areas have been declared out of bounds on the County Minerals Plan. The districts of Basford, Newark and Rushcliffe contain the most sites. Dates range from 40,000 B.C. at Creswell Crags to modern structures like Papplewick pumping station and wartime pill boxes. Part of the county[1]s history endures in buildings of which some, like churches, are in good repair while others, like Newark castle and Norman motte and bailey castles, li partially in ruins.

There are many sites of abandoned mediaeval villages, the traces of which are visible only from the air at certain seasons when differential growth in crops shows up hidden foundation, ditch and road features. Wind-blown crops pictured from the air at Cossall clearly display the remains of shallow coal workings by pitting. At Gamston, evidence was found of human settlement covering many centuries from the Iron Age. Car Colston, lying as it does near the Fosseway, contains Roman remains as well as the mediaeval Hall Close, a moated site which embraced a fishpond complex on its western side. Excavations at Newark revealed the remains of defence trenches dug in the Civil War. The Trent flood plain holds evidence of many ancient habitations. Because the Trent has always been a very mobile river many old river channels have been discovered and alluvium from flooding, down the years, has obscured some sites of deserted villages. Much valuable sand and gravel lies in the valley and before any extraction proceeds it's important to record as much archaeological data as possible.

The County Sites and Monuments Record is maintained as a central collection of details of historic environment and its components from prehistoric to modern times. Held on computer, a new database is about to come on stream. Information is provided to the public and all interested bodies. This includes advice on policies, planning, management, archaeological work, discoveries and any general queries, all as part of the work of the County[1]s archaeological team.
A large amount of the work of Mr. Bishop[1]s team relates to development proposals. Significant aspects are the importance of the site, the effects upon its archaeology of the proposals, mitigation proposals, Planning application recommendations, the monitoring of Planning conditions, archaeological investigation and expert witnessing. Every development proposal is appraised and evaluated to provide informed decisions and to permit adequate design of mitigation measures. Mitigation can involve preservation to an appropriate level either in situ or by record.

The Archaeological Unit[1]s role also includes providing information to the public via press releases, exhibitions, publications, lectures, school visits and so on. Each year the Unit advises upon 1500 development proposals, 85% of the costs of which are funded by developers. As an example of emergency work, when human remains at Whatton were discovered under a patio, the coroner could be assured that even should the death have been violent, it occurred in the Bronze Age.

A vote of thanks was given by Alf Whittaker.

Report by Geoffrey Jago

Information Technology in Teaching Geoscience

East Midlands Regional Group Meeting held at the University of Derby, Wednesday 14 February 2001

Convenor: Ian Penn

Notes: Mike Rosenbaum

Speakers: Professor Peter Hill, Professor Don MacKenzie and Dr Peter Reagan of the University of Derby

The meeting was chaired by the Head of Department, Peter Hill, who introduced a session of interactive computer material developed for assisting students learn geoscience. A number of modules have been completed, but their development is on-going, refined in the light of the student experience. Peter Reagan introduced the module on igneous petrology, focussing on volcanoes, and Don MacKenzie introduced the geological mapping session.

The igneous petrology courseware forms an integral part of the First Year syllabus, whose allotted teaching time has been reduced four-fold in a decade. Extensive use is made of external sites to enable the student explore more deeply into the volcanoes world, and to investigate links through the literature once their enthusiasm has been whetted. The use of small group projects focussing on a theme chosen by the students, but guided by tutorials with staff, encourage discussion whilst ensuring individual attention through periodic on-line assessments. The assessment was an important aspect of both the student learning experience and the practicalities of providing fair and thorough feedback when dealing with very large class sizes, of the order of 100 students. Various aspects of feedback and marking were covered, including award of fewer marks for inaccurate responses and negative marks for guesswork.

Don MacKenzie then took over the floor to present the mapping module, which provides an introduction to the fieldwork programme. This ensures that students are equipped with appropriate maps before arriving at their first field location, and know both where they are and how to record that position! An impressive demonstration of the use of 3-D representations to drive home the concepts of stratum contours and geological sequences followed. For students with a difficulty of spatial perception, such material is invaluable.

An extensive discussion arose from the sessions, covering issues ranging from the future of the classic undergraduate teaching programme in higher education through the commercial viability of courseware development to the capacity of web servers.

The appreciation for a fascinating and masterful insight was expressed through the warm vote of thanks by the EMRG chair and the ensuing round of applause.

Access to the first year (introductory level) courseware material on the GeoNews web site of the University of Derby is open to all, and may be accessed at:
http://www.derby.ac.uk/seas/geology/Geonews/geonews.html

The Derby pages need Authorware Web Player to be installed (free), available from:
http://www.macromedia.com/software/authorware/productinfo/webplayer/

However, access to more advanced levels is only permitted to registered students of the University.

Links to the national GeoCal software may be found at: http://www.man.ac.uk/Geology/CAL/index.html

GeotechniCAL, for geotechnics, is available from:
http://www.uwe.ac.uk/geocal/

with some specific projects built on this at:
http://www.dur.ac.uk/~des0dt/cal.html

June Meeting Report

As our chairman Professor Martin Culshaw commented, in giving a vote of thanks to the speaker at our meeting of 14 June 2001, exceptional advances have been made in the field of geophysics over last 20 years. It was our privilege therefore to listen to an interesting update by Dr. Jonathan Thomas, Senior Geophysicist of TerraDat Geophysics. Standing in for his colleague Dr. Rusill who was unable to be present, Dr. Thomas spoke on recent developments in applied shallow geophysics for engineering & environmental site applications.

Used increasingly in industry, the discipline covers a suite of scientific techniques to provide shallow subsurface data. TerraDat operates a full compass of methods for shallow geophysical work including ground conductivity, microgravity, seismic reflection, resistivity, magnetic and self potential. Work begins with a desk study followed by a site visit and initial simpler tests. Requiring only light equipment, site operations are non-invasive and confer the further benefits of cheapness, low risk and low environmental impact.

Recent advances include improved software analysis, smaller instruments, digital storage, real time display, faster acquisition, accurate mapping by global positioning satellites (GPS), and improved software analysis.

Engineering targets include water regime levels, ground water flow as well as man-made items like foundations, buried basements, old mine workings, drainage channels, pipes, cables, drains and buried rails. Shallow geological targets include buried valleys and karst surfaces, solution limestone or gypsum cavities and bedrock profiling. For opencast mining an assessment can be made of the ripability of rocks.
While it is important to be aware of any limitations and to realise that geophysics is not a substitute for invasive techniques, recent technological developments have provided great accuracy, speed and efficiency allowing the optimisation of design. In ever wider use, geophysics is becoming a standard tool ; and its total site coverage reduces the risk of targets being missed. Integrated methods have resulted in better interpretation and understanding.

TerraDat Geophysics lists many famous companies amongst its clients and when television archaeologists call for "the geofizz" you may have seen them helping Time Team.

Report by Geoffrey Jago.

Joint meeting of the East Midlands Regional Group of the Geological Society and the East Midlands Geotechnical Group held on 21 May, 2001 in Meeting Room 1, British Geological Survey, Keyworth

Subject: *Some Aspects of the Revised BS 5930 - Code of Practice for Site Investigation*
Speaker: David Norbury of CL Associates.

The aim of the meeting was to highlight the modifications to BS 5930 developed by the Site investigation Steering Group, a substantial update of the previous (1981). It was noted that BS5930:1999 is not a full rewrite of the earlier version. Significant amendments include the inclusion of sections on safety legislation, planning and personnel.

The speaker began by reminding everyone that the British Standard is by no means perfect but it is the best system we currently have. It is extremely difficult to update such a large document in a short space of time, and updates are almost always out of date as soon as they are printed. Attention was drawn to the fact that Section 6 (Soil description) and Section 7 (Reporting) have the wrong references!

Contaminated Land (Annex F)

It was also noted that it is difficult to completely separate contaminated land investigations (BS10175:2001) from engineering ones. Hence, there is much overlap between the documents. Annex F has been produced to provide guidance for Site Investigations on Contaminated Land. It has been designed to provide general information on contamination as well as showing how ground investigations should be carried out.

Ground Investigation (Section 2)

Amendments to this section include chapters on Safety and Quality Management. Safety is relevant to all aspects of site investigation and is the responsibility of all involved parties. Relevant legislation is highlighted along with EC directives and safety management systems. Risks associated with particular hazards should be assessed and provision made for safe working in the site safety plan.

Quality management involves the development of a managerial plan to ensure that the site investigation meets the required levels of accuracy and presentation. A series of written procedures cover equipment, testing, personnel and audits.

Reports and interpretation (Section 7)

In the revised BS5930:1999, two distinct types of reports exist factual and interpretative. Updates to the reporting of site investigations include information on groundwater conditions and contamination aspects.

Question and answer session

It was noted during the presentation that there was a lack of description of made ground in BS5930:1999. Mr Norbury¹s reply suggested that this standard may not be the most appropriate place for such information. Perhaps, a Man-Made ground section could be incorporated in the next edition or in BS10175.

Meeting report by Mike Rosenbaum.

Field Excursion of 11th July, 2001: Parking on the Jurassic

Report by Graham Lott and Geoffrey Jago.

In part of the entry for Geology in his Devil's Dictionary, the American journalist Ambrose Bierce stated that "The Primary, or lower formation, consists of rocks, bones of mired mules, gas pipes, miner's tools, antique statues minus the nose, Spanish doubloons and ancestors." The science has moved on a step or two since the time of Bierce whose career ended in 1911 when, aged 71, he departed for Mexico and was never seen again. No such mysterious fate befell your correspondent when he sought practical knowledge of the Jurassic on our field trip, although, severed from the main party by traffic lights part-way into the tour, he watched the train of cars disappear into the far bush, leaving no trace.

The company was soon regained in Gregory's Quarry, one of the sites where the beautiful Ancaster stone, (Upper Lincolnshire Limestone) beloved of masons and sculptors, is excavated. Led by Graham Lott and Mike Sumbler of British Geological Survey, the evening meeting began at Ancaster Church, six miles northeast of Grantham, where we were given descriptions of virtually all the building stones of the east Midlands from Charnian to chalk, illustrated by photographs of typical buildings. Also of the party, Alan Brandon, who led our 1999 field trip to the Trent gravels, described the geomorphology of the region with its changing river systems since the great ice caps melted, the dry valley of the Ancaster gap where deposits remain from the original river which was captured from the west, and the extensive Ice Age erosional feature of the escarpments of the hard Jurassic limestones which sweep from the north of England to the Cotswolds and beyond.

At Gregory's Quarry, and later at Real Stone Quarry, as well as inspecting the oolites and small shell debris which make up Ancaster stone, we were able to view its overburden of dark interbedded mudstones and shales with a marine band.

A vote of thanks to the leaders was given by David Entwisle and the thanks of our Group go to the quarry owners and staff for their help.

The weather remained kind for a very instructive excursion, the enjoyment being rounded off by a meal with a glass of good beer in Ancaster village.

The following text on Ancaster Stone was kindly provided by Dr. Lott:

In the East Midlands generally the most important sources of building stone are the upper and lower divisions of the Lincolnshire Limestone Formation, which have been worked since Roman times. The formation, which is restricted to the Midlands area, crops out continuously from Kettering to just north of the Humber. It comprises a lithologically diverse succession of pale yellow, cream, reddened or buff limestones (when weathered) which are blue-grey or blue-hearted when freshly quarried from beneath the weathered zone The limestones may be coarsely shelly, oolitic or finely micritic and silty in character. They have been extensively worked for building stone under a plethora of local quarry names, including: Weldon, King's Cliffe, Barnack, Colleyweston Slate, Wittering Pendle, Ketton, Edith Weston, Stamford, Casterton, Clipsham, Heydour, Ancaster, Cathedral, Hibaldstow, Newbold and Cave Oolite. Most of the older buildings in villages along the outcrop, the 'Cotswolds' of the East Midlands, are constructed of Lincolnshire Limestone. Houses and cottages of lower status are commonly constructed of uncoursed rubblestone while the more substantial houses are built of finely cut ashlar block. It is likely that the rubblestone was obtained from numerous local pits whereas the sawn, ashlared stones were probably supplied by a few better established local quarries.

Ancaster Stone - Geology of the stone

Three beds of stone are quarried for building stone. However, there is considerable inconsistency in the way each of these beds have been defined in the literature over the years.

The uppermost building stone bed, forming the top of the formation in this area, immediately beneath the clays of the Rutland Formation (formerly the Upper Estuarine Series), is known as the Weatherbed or Ancaster Rag. This unit is coarsely shelly, commonly reddened, hard-wearing limestone and was used for rough block (Red Weatherbed 4-5ft of Purcell 1967). Underlying this bed is the Brown Weatherbed (6-7ft) also hard, coarsely shelly and used in the past for paving. In the quarry sections these units are both strongly cross-bedded.

Beneath the Weatherbed, and included with it in some descriptions but with the underlying bed in others, is a paler, hard, well-cemented, oolitic limestone bed known as the Hard White (c. 4ft). The hardness of this stone enabled it to take a marble-like polish and it was used decoratively for wall-linings, staircases and fireplaces.

The beds of the Weatherbed sequence commonly show a lenticular core of blue-grey limestone. This blue-hearted limestone is unweathered stone in which the finely dispersed pyrite has been protected from weathering and consequent oxidation giving the more characteristic cream, yellow or brown colouration. The lower part of the exposed quarry sequence comprises the main Ancaster Freestone bed (20-24 ft). This limestone is cream to pale brown in colour and is predominantly oolitic and provides the main ashlar block stone.

Quarrying of the Stone

In Gregory's Quarry the traditional Plug and Feathers wedges are used break the blocks from the bed. Holes are drilled in the bed surface about nine inches apart and one to one and a half inches in diameter. The holes are drilled, using compressed air drills, about half to one third the depth of the bed; a pair of (iron) feathers (thin wedges) are then placed in each hole and wedge-shaped iron plugs driven gently between them starting at one end and working along the line of feathers until the rock splits. In earlier times the holes were 'drilled' percussively using an iron 'jumper' bar and the wedges used were of wood which were, after insertion in the holes, soaked with water causing them to expand and split the stone from the bed.

The stone from the Gregory Quarry is currently transported to cutting facilities at the Rare Stone Group quarries in Mansfield for sawing and shaping into decorative mouldings etc.

The Block Stone Ltd. quarry (Thompson's Quarry) is part of a larger group of quarries with their HQ in Chesterfield, Derbyshire and cutting of their block stone also takes place at one of their other sites.

Some buildings constructed of stone from the 'Ancaster' quarries (Purcell 1967; Alexander 1995).

Medieval: Numerous local churches including St Martin at Ancaster, St. Mary Magdalen at Newark, St. Wulfram at Grantham, St. James at Louth, various Norwich churches and stone dressings at Tattershall Castle.

Wollaton Hall (16th century), Belton House (17th century), Numerous colleges in Cambridge (19th century - see Purcell 1967 for details)

Further afield, the stone in included in Hull Town Hall, Holborn Town Hall, the University of Nottingham's original buildings on Shakespeare Street, Lincoln's Inn, London (for various reconstructions) and St. Pancras Station, London (stone dressings).

Other Uses

Not every abandoned quarry seen in the Lincolnshire Limestone was a building stone quarry. Although not matching modern standards for roadstone as it is too soft and porous, Lincolnshire Limestone from these and other quarries in the area was used extensively in the past for local road making and extensively for the building of many of the Lincolnshire airfields used in both the First and Second World wars.

Transporting Ancaster Stone (Purcell 1967; Alexander 1995)

Stone from the Ancaster quarries can be transported country wide with ease by the modern road and rail network. In the distant past, however, transporting the stone to markets other than those in the local area was quite a logistical problem. Unlike many successful early quarries, the Ancaster Quarries are not ideally located being some way from major navigable waterways, the main method of transporting bulky items like stone. The earliest evidence of the methods and routes used is provided by the 'churchwardens' accounts book for Louth church (1500-24): 'stone was carried on barges or flat bottomed boats by way of the River Slea and a short section of the Roman Carr Dyke to Appletreeness on the Kyme Eau. From there it went to Dogdyke (at the junction with the River Witham) and Coningsby for storage until needed at the building site, to which it was carried in creaking carts by wretched tracks to Louth' (Purcell 1967; Alexander 1995).

The stone for the Norwich churches is believed to have followed the same delivery route to the Kyme Eau which links with the River Witham. The major sea port of Boston was then easily reached and further shipment of the stone was probably by sea to Yarmouth and up the River Yare into Norwich.

Once the stone had reached the River Witham there was also the opportunity to take the stone northwards along the river to the Foss Dyke canal, which was constructed in Roman times, at Lincoln and thence to the port of Torksey on the Trent (Alexander 1995).

Selected references:

- Alexander, J. S. 1995 Building Stone from the East Midlands Quarries: Sources, Transportation and Usage. Journal of the Society for Medieval Archaeology, XXXIX. 107-135.
- Lott, G. K. 2001. Geology and building stones in the East Midlands: Mercian. Geologist.16.
- Purcell, D. 1967. Cambridge Stone. Faber and Faber Ltd.

Lead Mining in the Derbyshire Peak District, by

Professor Trevor Ford.
Report by Geoffrey Jago

It is well known that mining in Britain played a principal part in the Industrial Revolution. Large machines were born of the need to dewater mines and, of the British mining fields, those in the Pennines played an important role. Derbyshire metal mines are historic both in the realm of machinery invention and even in the development of geology as a science. In the latter respect, predating William Smith's much more comprehensive studies, mining work by John Whitehurst in 1778, George Tissington in 1767 and Thomas Westgarth showed their understanding of stratigraphy by drawing sections of the alternating lavas and limestones and the overlying Edale Shales in Derbyshire.

Lead Mining in the Peak District was the subject for East Midlands Group's meeting of 12th September 2001 which was held jointly with the Institution of Mining and Metallurgy at British Geological Survey, Keyworth and our speaker was Professor Trevor Ford of Leicester University

The pale blue Carboniferous limestone on the Derbyshire geological map defines the area where lead has been mined and smelted since the Bronze Age.
These Derbyshire limestones are the host rocks for mineralisation. 310 to 330 m.years old, they were laid down in shallow tropical seas where the crinoids were abundant but corals rarer. Shaly partings, called "wayboards", of clay or volcanic dust, are common and some, of shallow water deposition, attracted plants. Where the deposition was coastal, poorly bedded reefs formed, largely via algae and other microscopic organisms. Massive reefs are seen near Castleton, Matlock, Dovedale, Wirksworth and the White Peak.
Thick interbedded volcanic tuffs (toadstones) are basaltic, deposition altering the lavas to sticky green clay with little mineralisation. The limestone was buried under 2.5 to 3.5 kilometres of Millstone Grit, following which the strata arched up over the Pennines and the overlying beds were eroded to expose the present-day inlier. The basement rocks may be Tournasian (Waulsortian complex). There is no known granite.
Confined to the limestone, lead veins are common between the latitudes of Brassington in the south to Castleton in the north. They are closely bunched along the eastern boundary of the exposure while becoming more widely spaced westwards.

The formation of the intrusive mineral takes several forms, the primary one being near-vertical veins. In general the bigger veins trend E-W, while a secondary trend is NW-SE. While the sequence of events is still under discussion, some fractures are postulated to have occurred in limestone times, others during Millstone times, others later. The mineralisation is mostly late Carboniferous with some as late as Triassic. Movement appears to have gone on before, during and after mineralisation.

Lead as galena was the primary metal deposited, with zinc also important (sphalerite) and copper (chalcopyrite) recovered to the west around Ecton in Staffordshire. Five times as much lead as zinc was recovered. Nickel is also present.

Major fractures are called rakes which can extend up to five kilometres. Thin veins are called scrins rather than rakes. The Matlock area contains many E-W trending scrins. During and after deposition some veins were brecciated. Near horizontal interbedded mineralisation called flats also occur, usually under lava sills, but sometimes on top. A pipe is the miner's name for any source of mineral deposited in a cavity. After uplift, solution caves later filled with mineral by replacement with lead and gangue (ancillary) minerals. In such filled cavities, galena almost always occurs on the borders. It is now realised that a lot of ore dropped off the roof and sides of caverns and was concentrated alluvially, often being mixed with rotted basalt and fluvio-glacial material. Known as gravel ores, these were the first mineral that the old miners took and the remains of their washing operations can still be found. In places sinuous cracks have suffered movement giving rise to bellies and stringers and these are known as fracture veins. Slickensides are sometimes seen where two walls ground against one another, leaving little room for mineralisation. Splits occur in some rakes, Dirtlow Rake south of Castleton being one, where chunks of limestone, called "riders" by some and "horses" by others, lie within veins.

The main gangue minerals are fluorite, barite and calcite. There is a distinct trend for each of these: along the eastern border of the limestone fluorite is dominant giving place somewhat to barite eastwards which in its turn declines in favour of calcite which is dominant on the western side The typical banding in fluorite, determined by grain sizes, is shown in the semi-precious Blue John. By virtue of its density, barite is used for oil-drilling muds and, during the period of drilling for North Sea oil, Derbyshire supplied significant tonnages.

Derbyshire mining law is a study in itself, much of it administered by the ancient Barmote Court which still sits annually at Wirksworth. The old laws dictated that a shaft must be sunk on each plot, called a 'mere', commonly of about 32 yards extent; but often shafts were spaced at 16 yards. For most Derbyshire mines, all that now remains to be seen without venturing underground are surface dumps. It is estimated that the county contains up to 100,000 shafts virtually all being oval and of small diameter, many traversed by climbing via side footholds. To avoid sterilisation, mining law forbade their being backfilled but many were capped with sleepers at a time when Dr. Beeching's policies provided a ready source. Industrial archaeologists inspecting the many areas of interest and given to be heavy footed are well advised not to jump up and down too vigorously.

How much lead was mined? There are 2000 named veins and many smaller ones. Best estimates indicate a total tonnage of three to four million tons.

Golconda Mine, northeast of Brassington, worked intermittently from around 1750 until 1953 for lead, then barite. With over six kilometres of tunnels, rail track transport of 10-inch gauge was latterly employed. The important Mill Close Mines, Darley Dale, had fifteen kilometres of tunnels and extended under the shale cover to find N-S trending veins and many NW-SE scrins. Millclose produced half a million tons of galena plus 120,000 tons of zinc concentrates while its pumps replaced 5000 gallons a minute into the Derwent. In the 1970s its waste tips yielded a quarter of a million tons of fluorspar together with some barite.

Water is nearly always a problem for miners. Early pumping was carried out arduously by hand but in the 1780s steam pumping came in. The practice of driving drainage levels (soughs) from the nearest valley bottom was common practice because once a sough was completed all the workings above became self-draining and lower workings had only to be pumped to sough level.

Despite slow progress in tunnelling at least a hundred separate soughs were driven, several extending to a length of ten kilometres. Before gunpowder shot-holes were adopted in the 1670s, progress in limestone was only two to four inches a day; but eighteen inches a day was possible in shale. In some early workings fire-setting was employed when the working face was heated by brushwood fires and, when hot, drenched with water. Such tunnels assume a characteristic profile. Some early hand-cut levels kept to a coffin-shaped profile to minimise work in the hard rock - a double groove was hand-cut and the rock in between broken out, the remarkable pick-work remaining to be seen in the side walls. Of the working areas (stopes) some are so narrow that ore could only have been removed by long rakes, or perhaps by children; but many stopes widened to vast voids.

The galena was all smelted locally and, as with many mining fields, the smelters made more money than the miners. Early smelting could only use ore in fairly large pieces with poor metal recovery. Later techniques allowed fine galena, called smitham, to be smelted; and concentration of the ore by washing methods (buddling and jigging) became worthwhile. A number of stone-built buddles and ore crushing areas still remain.
Some of the lead was destined to be sent abroad The ship 'Hollandia' which was wrecked on the Scillies yielded 200 pigs of lead exported from Hull and bound for the Dutch East Indies.

A vote of thanks was given by A. Nickless, President of Nottinghamshire Branch of the Institution of Mining and Metallurgy.

- For detailed and well illustrated further reading on this subject, "Lead Mining in the Peak District", edited by Trevor Ford and J.H. Rieuwerts, published for the Peak District Mines Historical Society, is highly recommended.

Geologists in Space - The Aster Programme
Report by Dr Anthony Cooper

Presented by Dr Stuart Marsh, British Geological Survey at the British Geological Survey, Thursday 18th October 2001

Geology from space and the ASTER Programme were the subject of a lively talk given to the East Midlands Regional Group by Dr Stuart Marsh, the head of the British Geological Survey Remote Sensing Group. Dr Marsh outlined the evolution of remote sensing from the earliest pigeon-borne camera though conventional air photography to stereo air photography, false colour infra red photography and the latest developments in satellite and airborne imagery.

The first effective publicly available satellite information from 1970's was Landsat imagery with a coarse resolution (80m on the ground for each pixel) and a limited spectral range. This was followed in the mid 1980's by the Thematic Mapper which included a wider spectral range up into the near and short wave Infrared parts of the spectrum. The resolution was also higher with a pixel equating to about 30m on the ground. At this specification, satellite imagery was already showing its capabilities for differentiating some mineral and rock types from the spectral responses. The Japanese Earth Resources Satellite followed (JERS) which split the short wave IR band into three, had a higher resolution, radar and a stereo capability. The ASTER Programme stands for the Advanced Spaceborne Thermal Emission and Reflection Radiometer

It is the first truly geologically orientated satellite. The manufacture was carried out in Japan, the launch was by NASA and the United States Geological Survey (USGS) governs the data collection and distribution. It is a satellite with a refined capability over the JERS satellite and has sensors that split the short wave infrared into five bandwidths capable of differentiating many types of minerals. The satellite has 14 spectral bands with resolutions ranging from 15m in the visible down to 90m in the thermal wavebands with and a stereo capability. Its functionality makes it ideal for stereo-imagery and terrain modelling. The resolution in the thermal IR bands also makes it possible to use it to discriminate rocks on the amount of silica in them allowing the identification of carbonates, basic and acid rocks. Iron oxides, clays and sulphates can also be mapped using the visible, near and short-wave infrared bands.

The ASTER programme is scanning the world as part of a five-year programme, but coverage is not complete and new areas for research can be requested with an appropriate science case. Verified pre-processed data is available from the USGS with information via their website

Other developments in remote sensing include hyperspectral scanners that can discriminate individual minerals. This technology is currently airborne in the form of the Hymap 126 waveband scanner utilised in the EuroGeoSurveys' MINEO programme, with details on their website

Developments to look forward to include wider access to the new satellite sensor Hyperion with 220 spectral bands and a 30m ground resolution. Remote sensing has come a long way from a pigeon with a camera strapped to its chest!

FROM BULLETS TO BATTLEFIELDS
Report by Geoffrey Jago

The occasional brown bullet shaped remains of a belemnite is not difficult to find on east coast beaches but in some fossil beds they are so closely and neatly bunched as to form what are known as "belemnite battlefields". When he wrote his paper for Greenwich University's Inaugural Lecture Series, this gave our speaker on 14 November 2001, Peter Doyle, Professor of Geosciences at the School of Earth and Environmental Sciences, Greenwich, the idea to combine the study of these fossils with one of wartime battlefields of the 20th century. Two widely differing subjects indeed; but then, geology extends to a wider span than most sciences. To quote Professor Doyle, "Geology has influenced the arts: the visual arts of the landscape painters and illustrators; the poetry and prose of our finest authors; and the music of composers and musicians. Direct links can be made to the geological landscapes of the Giants Causeway, of the Grand Canyon, or of the beauty of the fells in the English Lake District. And ultimately our towns and cities are geological machines ... they are built by geology (bricks, stone, concrete and glass), constrained by geology (foundations, hazards, slopes), consume geologically derived materials (fuels, raw materials, agricultural products from the land) and produce wastes which are more often than not contained by geology (in landfills, for example)."

Belemnites

Belemnites are extinct cephalopod molluscs, having three part shells. With a normal physiology they were very like modern squids complete with ink sacs. Both predators and predated, they ate other mollusca and crustacea in shallow seas and were themselves eaten in turn by pliosaurs, pterosaurs and sharks. Although ammonites, with their large shell remains, have stolen the limelight, belemnites can claim equal importance in the world of paleontology. The better fossil specimens preserve the three calcareous parts: the bullet-like rostrum, the chambered phragmacone at its base (in the final chamber of which the animal lived) and the pro-ostracum, the thin shield that protected the soft forward parts. Behind the pro-ostracum lay the head and finally the arms, lined with vicious hooks. An illustration was shown of a fine National History Museum specimen from the Oxford Clay. Belemnites lived from the lower Jurassic, where they are uncommon, to the end of the Cretaceous. The largest belemnites extended to 2 m. (Ju rassic) but most were 300 - 500 mm long. Five types can be recognised, some having blade shaped cones rather than the commoner bullet shapes,. All paleontologists are grave robbers, so studying fossil formations involves interpreting the living animal, understanding postmortem processes and considering how burial took place. The conditions that led to the intense concentration of the belemnite battlefields is the subject of speculation. In the battlefield concentrations the fossils are all adult, lined up very closely packed and all the same species. Catastrophic events being uncommon, physical concentration is the more likely cause of these packs; and this depends upon the sedimentation rate and the speed of reproduction of the animals. Post-spawning mortality whereby the animals died on a continental shelf and were then washed down into a sediment in deeper water is the most probable circumstance. However, feeding grounds could account for some assemblies which could be the stomach contents of sharks or, mo re probably, regurgitations.

Geology and War

In military strategy, geology is always an important determinant and especially so in trench warfare because the trenches themselves are a geo-engineering problem. Geological assessment of terrain for military purposes, for mobility, position, water supply and ground resources plays a vital part in military planning, an aspect which was initially neglected in World War 1. In those battlefields three lines of trenches were usually dug: front, supply and reserves lines. Belgium has chalk hills and quaternary lowlands, the latter being very muddy and it was soon found that tanks could cope only with the chalk. Nowadays simple clear geological maps are produced to distinguish soft areas from those that can sustain traffic. Because of the extensive use of horses in WW1, supply of drinking water was especially crucial and the geologist King did valuable work to define the local water tables. Where the western front was muddy, Gallipoli was dry and dusty and shortage of potable water was again a major factor. Military mining, carried out in WW1 required a good understanding of the geology. Tunnels from the western front of WW1 still exist as voids and an illustration was shown of one still charged with explosives! Other tunnels are supported to this day by original close timbering, but as this rots foundation problems can be expected. In Belgium some buildings have already collapsed into voids.

For further reading see Professor Doyle's paper of 14th March, 2000 in the Inaugural Lecture Series of the University of Greenwich: "From Bullets to Battlefields" and, in these pages, the report of our Group's lecture of 16th June 1999: "The Geology of War" by Professor Mike Rosenbaum. Once again we were indebted to British Geological Survey, Keyworth for providing our meeting place for a very interesting evening.

A vote of thanks was given by Mike Rosenbaum.

The Globalisation of Engineering Geology, 6 December, 2001.

Have fun, do a good job and learn something new.
And earn a reasonable profit so that you can afford to write a proposal to do all three. Profit is not a four-letter word but Loss is. This positive personal philosophy was offered by Professor Keith Turner whose lecture entitled *Geological Engineering on Both Sides of the Pond* followed our East Midland Group Annual General Meeting and rounded off 2001 in a very comprehensive and satisfactory manner.

Dr. Turner, who is Professor at both Delft University in Holland and the Colorado School of Mines, USA, began by defining an Engineering Geologist as one who must be able to evaluate the geological records and then predict the effects of geological factors on engineering works, or the impact of engineering works on such processes. Evaluation involves geology, and *prediction* involves social sciences and engineering.

From earliest times individuals have offered counsel on excavations, site conditions and construction materials. Were they engineers, geologists or engineering geologists?

In the first century BC, Vitruvius in his *Ten Books of Architecture* advised on the proper way to prepare foundations. In 1442 John Hobbys was paid for overseeing the selection of building stone for Gloucester Castle. The advent of the industrial revolution with its need for canals encouraged geology and engineering and William Smith fathered the science of geology from his work on canal construction.

In 1839, when overseeing the construction of the Erie Canal, James Hall, New York State geologist, evaluated contractor's claims based on an engineering classification of hard rock and weak shale. Alexandre Collin, 1808-1890, oversaw French canals, studying clay slope failures in both cut and embankment, and published "Landslides in Clays" in 1846.

The US transcontinental railway was completed using only one power shovel. All the remaining excavation was manual, mostly by Chinese and Irish labour. Built across unpopulated areas in harsh environments in 1863-69, the project drew on civil war experience and the doctrine of "build it fast and cheap and fix it later".

The value of geologists took time to sink in. In 1894, Dr. Cornelius Lely, Netherlands Minister of Works, said in a Dutch Parliamentary debate: "...the Government has made inquiries from a few geologists who know the local situation with the purpose of informing the engineers about the special qualities of the soil there... of course it is not certain that the advice of the geologists could be or had to be followed... The building of a railway is not the work you can trust to a geologist..."

In the early 20th Century, when the Panama canal was constructed, the policy was to keep shovelling with increasingly powerful machinery in the belief that "natural problems could be overwhelmed". Not far from Los Angeles, the need for more scientific expertise was brought tragically to the foreground in 1928 when the St. Francis dam, built without geological advice, failed catastrophically and left six hundred dead.

In 1929 recognition was given to the parallel necessity for clear report writing when Charles P. Berkey (1867-1955) published *Responsibilities of the Geologist in Engineering Projects* and an American civil engineer described him as "the only geologist I can understand".

Dr. Turner turned next to external social and economic trends. World population, over 6 billion in 2000, is expected to rise to 11 billion in 2100 with 95% of this increase predicted to be in the third world. Problems will include water supply, the rise of megacities and the use of marginal sites. On globalisation issues, world economies are becoming interdependent and while infrastructure is crumbling, recent decades have seen low investment in repair.

Since 1970 we live in a world of digital design. Compare 19th century geological maps with modern 3D diagrams. Before 1970, when slide rules held sway, engineering was heavy and rather over engineered; but nowadays, with the availability of digital methods, the demand is for more detailed subsurface quantification which produces designs that are lighter, more complex and much bigger.

Environmental awareness is eminently necessary and environmental concerns encourage new techniques and approaches. The best sites are already taken up, leaving only the marginal ones. Geohazard identification and mitigation is compellingly important.

In the field of academic training, universities in North America and Europe alike are under financial pressure. Input of geological students in the US peaked in 1996 and has declined since then, although the proportion of female students has increased. In the US, study takes 9 years: 4 years for BSc, plus 2 years MSc plus 3 years PhD. BSc is a very minimum qualification, with MSc the minimum to allow a rise above junior level, and increasingly only doctorates are selected for senior levels of management. At the same time, US oil companies expect to lose 40% of their work force within five years - a terrific loss of experience.

In North America professional registration is strictly controlled by state laws. About half the States in the USA require National Association of State Boards of Geology (ASBOG) qualification. Of those who take this obligatory examination (graduates) only 57% pass! European professions are generally more self-regulating with credentials tied to professional societies.

The especial usefulness of field experience during study was stressed for its value in problem solving, for practical illustration of classroom theory and for adding experience that is not "in the book". Most field trips are held in fine weather; but wet weather presents much better training because failures like floods, landslides and wave erosion occur in bad weather. So pack the oilskins, sou' westers and waterproof pencils, citizens - and don't straddle tension cracks.

An optimistic view was taken of the future, which looks promising because society demands sustainability; and there is an increasing perception of the need for geoscience with the intensifying interest in water and the environment. New infrastructure must be environmentally friendly and requires new techniques such as improved 3D modelling.

The US provides courses for both Geological Engineering and Engineering Geology. So how do they differ? Geological Engineering includes knowledge of the mathematics of rock slopes, engineering science, engineering design and social concepts. Engineering geology is multidisciplinary and involves data translation, proper display and communication of information to ensure that geological terms are understood by laymen.

An increasing press awareness of the significance of our science is now discernible; and lectures like Dr.

Turner's play a substantial role in highlighting the vital importance of both disciplines.

A speech of thanks was given by Professor Martin Culshaw whose work continues to include Chairmanship of E.M.Regional Group. The meeting was convened by Professor Mike Rosenbaum.

Report by Geoffrey Jago.