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Front cover: Triassic sandstone forming the cliff on the southeastern corner of Castle Rock, Nottingham, with Mortimer's Hole behind the left door; see p. 37. Photo: Tony Waltham.

Back cover: A geological map of Nottingham from the 19th century; see p. 51.

Contents

GEOBROWSER

When did the Earth first chill out?

There seems little doubt that soon after its accretion the Earth was a highly energetic body, but are the theories that it began with a prolonged Hadean or ‘hell-like’ episode extending from 4400 to 4000 million years (Ma) ago correct? Unfortunately, no rocks go back farther than about 4000 Ma (*Contributions to Mineralogy and Petrology, 1999, p.69)*, but older *minerals* are known, in the form of 4404 Ma zircon crystals found in Archaean rocks at Jack Hills, Western Australia. This find is fortunate, because zircons provide reliable Oxygen 18 measurements, and the occurrence of this particular isotope in relative abundance is believed to be an indicator of magmas formed from the melting of rocks that had been in contact with low-temperature hydrous fluids – in other words these precursor rocks had experienced significant alteration or weathering. The high ^{18}O values (c.7.5%) in the Jack Hills zircons could be due to a number of other factors, but the only theory to survive rigorous examination is the crystallization of these zircons under conditions more appropriate to the ‘cooler’ Earth system that existed much later in the Archaean, 3800-2600 Ma ago (*Geology, 2002, p.351)*. If this is the correct interpretation, it follows that water may have existed on an Earth that had stabilized well before about 4000 Ma. Furthermore, there could not have been a prolonged ‘high energy’ period of meteorite bombardment between 4450 and 3900 Ma, as some have suggested; instead there may have been a single, relatively short-lived meteorite ‘spike’ at about 4000-3800 Ma, followed by reversion to quieter conditions.

Ever - changing climates

The current debate about human involvement in triggering climate change is increasingly being balanced by research into the many natural causes of such fluctuations. The time-scales at which these factors could have operated are equally varied, as three recent articles show.

• On a geological time-scale, it has been proposed that since the Precambrian (543 Ma ago) at least 66% of the variance in palaeotemperatures may be due to the galactic cosmic ray flux (CRF), caused by our solar system passing through the spiral arms of the galaxy *(GSA Today, 2003, p.4)*. This hitherto unperceived astronomical factor might mean that we are today overestimating the influence of the long-term global CO_2 greenhouse effect.

• On a much shorter time-scale, one of the most important predictions is that Arctic ice sheet melting could very rapidly cut off the supply of warm tropical water to the North Atlantic, triggering the onset of more ‘continental’ climatic conditions in the UK. This is now supported by studies of clay minerals recovered from Atlantic drill cores *(Quaternary Research, 2003, 243),* which demonstrate the operation of this process at least twice in the recent geological past. The oldest recorded Atlantic meltwater pulse, at about 130,000 years ago, probably resulted from ice sheet collapse. The younger event, 77,000 years ago, was of shorter duration and may have been caused by the sudden discharge of water from Siberian ice-dammed lakes.

• An added complication to short-term global temperature change, at least during the Holocene epoch, was the periodic release of large quantities of methane that is otherwise locked up in seafloor sediments – the ‘clathrate gun hypothesis’ (see also, Geobrowser in Mercian 2003). Methane release is a consequence of sediment instability caused by continental-slope failures, and studies of methane contents in ice cores have shown that over the past 45,000 years there have been two main episodes – 15,000 to 13,000 years and 11,000 to 8000 years ago (*Geology, 2003, p.53)*. These are both glacial-interglacial transition periods, but the underlying causes of the slope failure were rather different. The older event followed a deglaciation and occurred at low latitudes; it resulted either from warming of the ocean or from enhanced rainfall causing vast loads of sediment to be conveyed to the continental slope, which then became unstable. The younger slope failures were high latitude ones, and were probably caused by the destabilizing effect of isostatic rebound following retreat of the ice sheets.

K-T extinction: more complications

Previous Geobrowsers (*Mercian, 2000, 2001)* have reviewed the development of ideas about what really caused the end-Cretaceous (K-T boundary) event that wiped out the dinosaurs, and many other types of animal. Since those issues, further detailed examinations of bolide ejecta layers, iridium layers and faunal changes have been carried out across the critical Cretaceous/Tertiary transition strata, and a multicausal scenario now looks very appealing. One of the most recent contributions *(Earth-Science Reviews, 2003, p.327)* favours the following event sequence in the Central American and Caribbean regions:

1. At the very end of the Cretaceous (but before the actual K-T boundary) the first impact occurred, at 65.27 Ma. This was the Chicxulub meteorite. In association with on-going voluminous Deccan volcanism, which lasted from 68.1 to 61 Ma, it contributed to rapid global warming and the consequent terminal decline of planktonic foram populations.
2. The actual K-T boundary impact, at 65 Ma, is not well represented in many sections, due to intraformational erosion; it marks a major drop in primary productivity and the extinction of all tropical and subtropical foram species.

3. A third meteorite impact occurred in the earliest Tertiary, and is tentatively dated at about 64.9 Ma; it contributed to the marked delay in recovery of productivity and evolutionary diversity.

Some of the more doom-laden prophecies about what might happen to the human race under such a bombardment may, to some extent, be erroneous. Calculations based on the composition of the Chicxulub ejecta layer (*Geology, 2002, p. 99)* do not bear out the original scenarios that featured the shutdown of photosynthesis during a succession of 'impact winters' caused by volcanic dust. In fact, more than two orders of magnitude more fine dust than was kicked up by that meteorite would have been necessary to do this. So if not dust, then what caused plants to cease growing? One of the two most likely theories is that this resulted from soot caused by global fires *(GSA Special Paper, 1990, p.391)*. Research soon to be published, however, will suggest that there is a remarkably low amount of charred plant remains in strata at the K-T boundary. If correct, this would leave only the second theory as viable – that widespread plant death, and consequent destruction of the whole terrestrial ecosystem, was due to acid rains produced from sulphate aerosols released from gypsum deposits that happened to be present in the Chicxulub target rock *(Journal of Geophysical Research, 1997, p. 21645)*, a unique combination of circumstances that was unlucky for the dinosaurs but is perhaps unlikely to be repeated.

Silverpit update – controversy

The 20 km-wide Silverpit 'crater' could be considered England's own Chicxulub, buried as it is beneath younger strata in the North Sea about 150 km off the Humber Estuary. This impressive circular feature, detected on the basis of oil company seismic reflection profiles, was attributed to deformation that occurred about 60 million years ago as a result of the impact of an extraterrestrial body (*Nature, 2002, p.520)*. This suggestion is now challenged, however, by another explanation - that it could be the result of tectonic deformation within a complex fault zone *(Journal of the Geological Society, 2004, p.593)*. In essence, this argument suggests that torsional stresses caused by strike-slip faulting may have been transmitted upwards into a 1100 m-thick Permian evaporite deposit which then thinned in response, causing a circular salt-withdrawal syncline to develop at the base of the overlying Triassic strata. The latter subsided, and overlying Jurassic mudstones 'flowed' into the void created, at the same time deforming around a radial thrust-fault system. The effect of all this on overlying Cretaceous rocks was to cause subsidence around a complex system of circular, 'caldera' faults, with Jurassic material forced up into the centre, causing a diapir-like structure that mimics the central upheaval of a meteorite impact crater. The tectonic theory seems complicated, but is attractive in that it could also explain the origin of similar circular structures, such as the Upheaval Dome of Utah and the Compton Valence structure of West Dorset, both featuring highly deformable evaporitic sequences associated with strike-slip fault systems.

MERCIAN NEWS

Cave art at Creswell Crags

Long known for the archaeological material in its sediments, Church Cave, in the Permian limestones of Creswell Crags, has now been found to have artists' impressions of about 90 animals etched into its roof. Partially covered with stalactite, they are genuinely old, and are thought to date from 13,000 years ago, even though the caves were also occupied long before then. The eroded bas-relief images have only just been found, because they are only visible in the strong sidelight reflected into the cave from the morning sun. Details are in *Antiquity* v77, pp227-231, or on their website http://antiquity.ac.uk/ProjGall/bahn/

Mam Tor still on the move

The East Midlands home-grown landslide at Mam Tor continues to creep downwards (see *Mercian Geologist* v15, pp54-55). Prof Ernie Rutter, Christine Arkwright and colleagues at Manchester University have taken the research another step forward with further monitoring and with their analysis of strain fields within the slide debris; they also relate rates of movement to climates past and present. Read the full story in the *Journal of the Geological Society* v160, no5, pp735-744, or an excellent summary in *Geology Today* v19, no2, pp59-64, both published in 2003.

Geopark for Derbyshire?

With the new Geopark in the Abberley and Malvern Hills featured in this issue of *Mercian Geologist*, it is timely to consider the potential for a Geopark in the White Peak. There have already been informal thoughts and discussions on this, and the limestone area around Matlock and Wirksworth can certainly be justified in terms of both its natural geology and its mining heritage. Designation could raise the profile of the Peak District National Park, and could provide a welcome boost to conservation measures.

Editorial

Readers will have seen that our Geobrowser column remains uncredited, so it is up to the Editor to thank John Carney for continuing to produce these fascinating extracts from the geological literature.

And apologies to Ben Le Bas, warden of the Lathkill Dale NNR, whose name had a phonetic and incorrect spelling in the last issue of *Mercian Geologist*.

FROM THE ARCHIVES

An archive photograph of East Midlands geology from the British Geological Survey collection

Greetwell Ironstone Mines

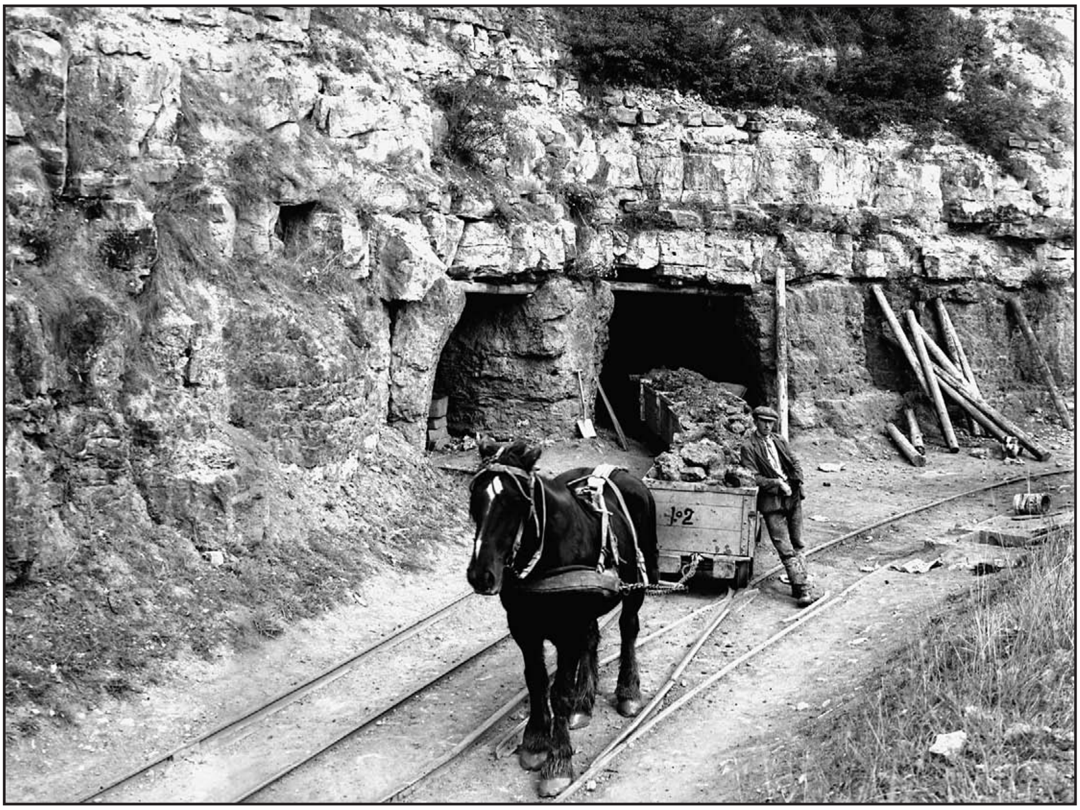
From the far east of the East Midlands region, the ironstone mines in the Greetwell area, east of Lincoln, feature in one of a series of BGS photos taken in 1933 by the Survey photographer, Jack Rhodes.

Ironstone was worked in the Greetwell district for at least 60 years, using both underground pillar-and-stall and opencast methods. Mining commenced around 1878 and ended just before World War II, although the opencast mines remained in operation throughout the war as a source of 'hard core' and 'pitching stone', which was obtained from the Lincolnshire Limestone overburden and was used for roads and aerodrome runways.

Geologically, the ironstone was worked from the Northampton Sand Formation of Aalenian age (in the early Mid Jurassic). The entire formation is about 3.5 m thick, with workable ores occurring as sideritic ironstones with berthierine ('chamosite') ooids, interbedded with sideritic and calcareous sandstone. In the Greetwell area, the Lincolnshire Limestone unconformably overlies the Northampton Sand Formation in most places. The Grantham Formation (formerly Lower Estuarine Series), which separates these formations farther south, is mostly absent, though is represented locally by about 0.3 m of iron-stained sandstone with plant remains. At shallow depth, the ironstone weathers into a limonitic, 'boxstone' structure, and was obtained in this form from the opencast workings. This ore was blended with the less oxidised, blue-green ores won from the underground mines, and was sent to the ironworks at Scunthorpe, where it was usually mixed with the Frodingham ores before smelting. The overlying Lincolnshire Limestone was also worked for use as a flux in the smelting process.

The photograph shows ore-laden trucks emerging from the Long Harry Mine, which was entered by several adits dug into the sides of the opencast workings. The contrast between the darker coloured ores of the Northampton Sand Formation and the paler coloured, well-bedded Lincolnshire Limestone can be clearly seen. The working face was about 2.5 m high, leaving a bed of ironstone 0.3 m thick to form the roof. The main roadway was excavated in a northwest direction from the adit mouth, with pillar and stall workings extending underground for about 2km north-east from the roadway. A substantial fault, which throws down to the northeast, formed the boundary of the workings. Faulting, together with facies change along strike to the north, effectively constrained the extent of workable resources at Greetwell, with all viable reserves exhausted by the late 1930s, despite the imminent demands of World War II.

Andy Howard, British Geological Survey



Long Harry Mine, Greetwell, Lincoln, in September 1933 (BGS photograph # A00733, © NERC).

Bibliography of the Geology of Leicestershire and Rutland
Part 2: 1971-2003

Keith Ambrose and Frank Williams

In 1973, Trevor Ford and colleagues published a detailed bibliography for the geology of Leicestershire up to, and including, the year 1970. This very thorough document has provided researchers in local geology with a valuable starting point, and this follow up paper aims to build on this and provide details of modern references. The opportunity for compiling this bibliography arose through the award of a contract to the British Geological Survey (BGS) by the Minerals Industry Research Organisation using monies from the Aggregates Levy Sustainability Fund provided by the Office of the Deputy Prime Minister. The work focused on geodiversity in Leicestershire and Rutland with education being the primary theme. One of the project deliverables was a website of local geological information, for which this bibliography was compiled. Time and financial constraints meant that the work was not subjected to the rigorous checking that Ford et al. (1973) were able to undertake. We have also had to restrict the bibliography to only papers referring to the two counties. Wherever possible, papers discussing broad topics were checked for references to the counties for inclusion, but inevitably some will have been missed.

We have also found a number of references that did not appear in Ford et al. (1973) and these are listed in Section 1 of this paper. Some of these are relevant to Rutland only and thus did not appear in the original published bibliography. Others, such as the book *The Geology of the East Midlands*, have been split up to include all the component sections in the book as separate entries. All published maps from BGS (and its predecessors) have been added, including all the various editions and reprints. The long list of published County Series, 1:10,560 and 1:10,000 scale geological maps have not been included. Anybody requiring information on these can contact the BGS Enquiries Service or visit the BGS website at www.bgs.ac.uk.

Recent work by BGS in Leicestershire and Rutland, involving remapping of the Loughborough, Melton Mowbray and Leicester 1:50,000 geological sheets has formed the basis for compiling this reference list, drawing on the reference lists compiled for the various publications associated with these maps. These references then formed the basis for checking for other relevant papers. This paper is presented in the same format as the original, with references arranged alphabetically by the year of publication.

As with the first part of this bibliography published in 1973, there will doubtless be some references that have been missed. The authors would be very grateful if readers could bring to their attention any missing items. Please contact Keith Ambrose at British Geological Survey, Keyworth, Nottingham NG12 5GG or e-mail kam@bgs.ac.uk with any omissions.

Acknowledgements

Thanks are extended to Gill Weightman and Dr Roy Clements of Leicester University Department of Geology for invaluable assistance in compiling the bibliography, in particular Roy who supplied a comprehensive list of all theses on Leicestershire and Rutland produced in the university. Grateful thanks also to the staff in the BGS library without whose help some obscure references would never have been traced. This paper is published with permission of the Executive Director, British Geological Survey (NERC).

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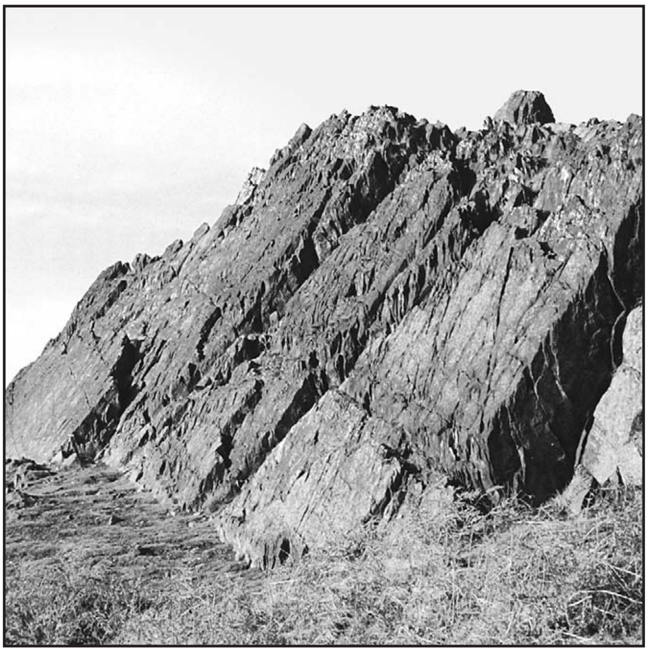

Charnian Supergroup (Precambrian; Neoproterozoic III); volcaniclastic siltstones of the Hallgate Member (Bradgate Formation) c. 5 m above Sliding Stone Slump Breccia. The bedding plane contains numerous frondose and discoid fossil impressions. Near Memorial Crag in Bradgate Park, Charnwood Forest. (Photo: John Carney, BGS © NERC)

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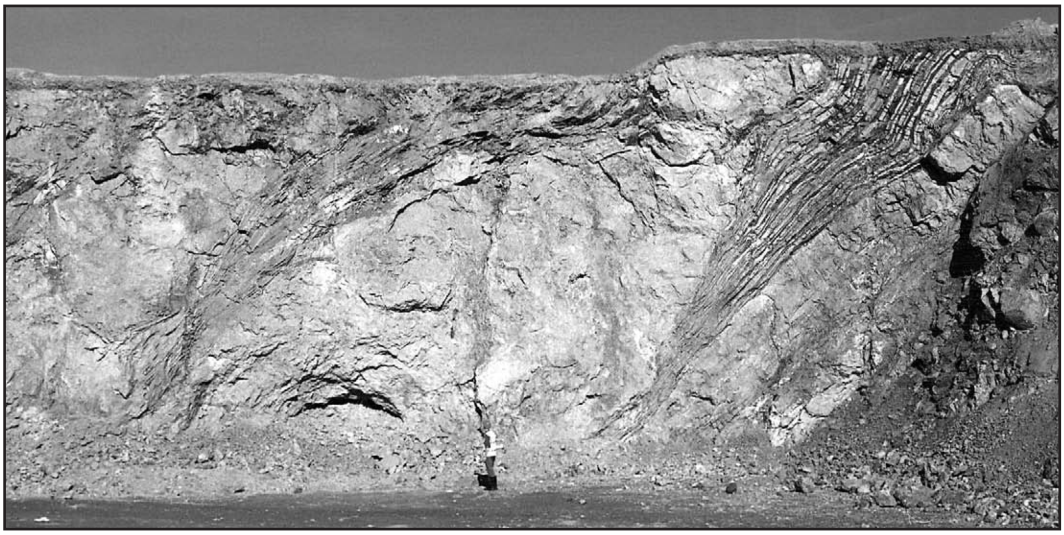

Well bedded dolostones of the Cloud Wood Member, Cloud Hill Dolostone Formation, with a probable slumped mass of massive mud mound reef dolostone; in Cloud Hill Quarry (Photo: Keith Ambrose, BGS © NERC)

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Cloud Hill Quarry. (Photo: Tim Cullen, BGS © NERC)

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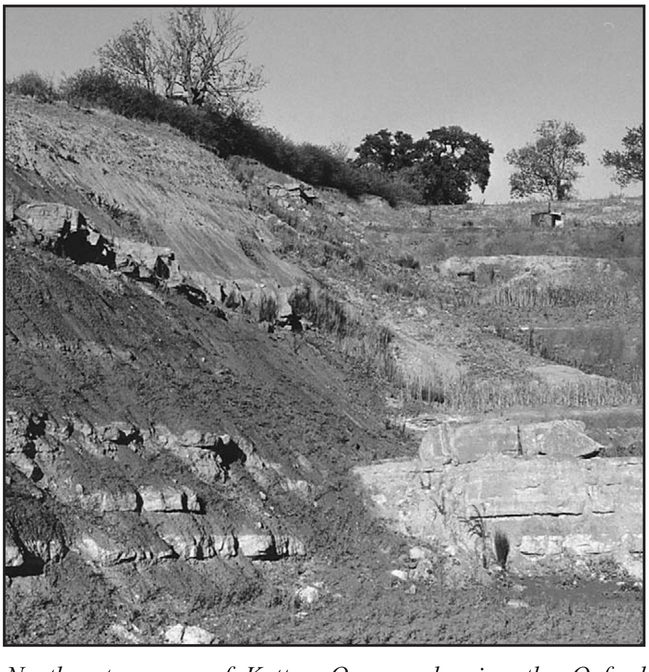

Northeast corner of Ketton Quarry showing the Oxford Clay, Kellaways, Cornbrash, Blisworth Clay and Blisworth Limestone formations. A fault downthrowing to the west (left) lies down the corner between the faces. (Photo: Keith Ambrose, BGS © NERC)

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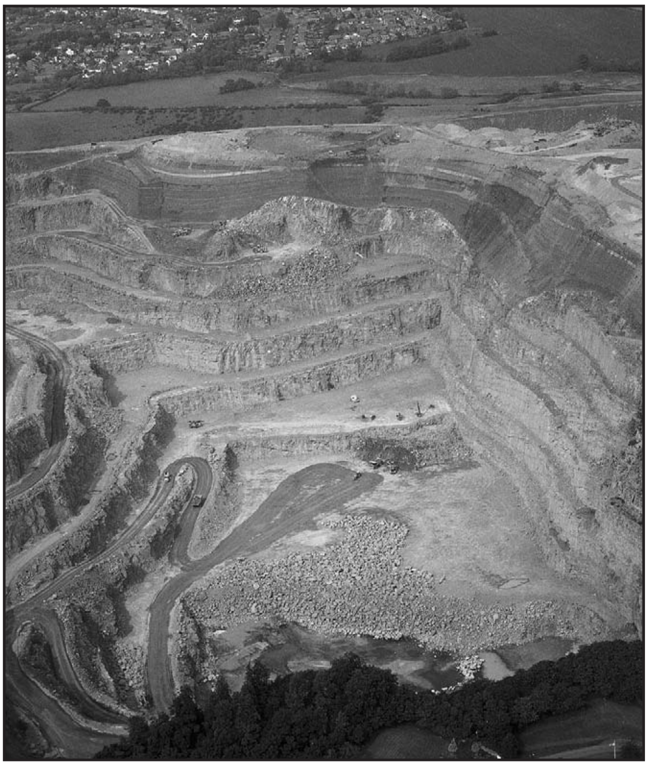

Aerial view of Croft Quarry showing the pale grey South Leicestershire Diorite that is worked for aggregate, overlain unconformably by darker Triassic mudstones of the Mercia Mudstone Group that are infilling wadis (Photo: Tim Cullen, BGS © NERC)

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Cross bedded and trough cross bedded glaciofluvial outwash gravels in Shawell Gravel Pit. (Photo: Keith Ambrose, BGS © NERC)

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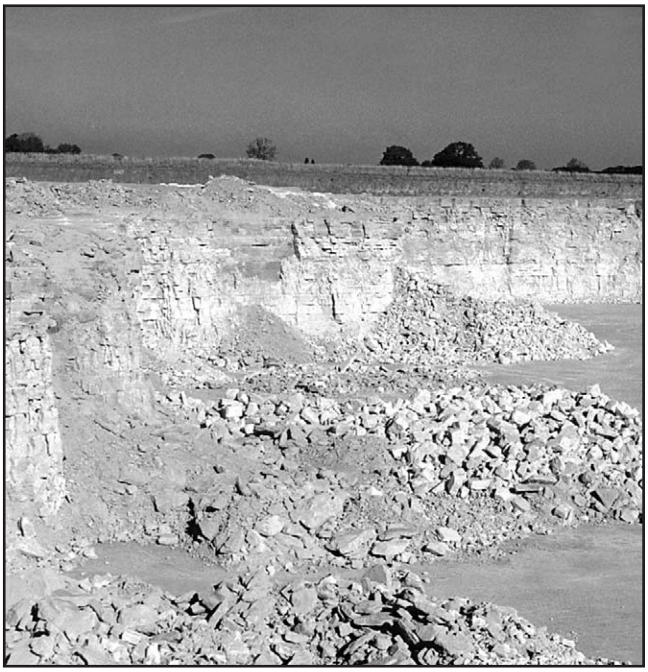

Ooidal grainstones of the Upper Lincolnshire Limestone, in Clipsham Quarry. (Photo: Keith Ambrose, BGS © NERC)

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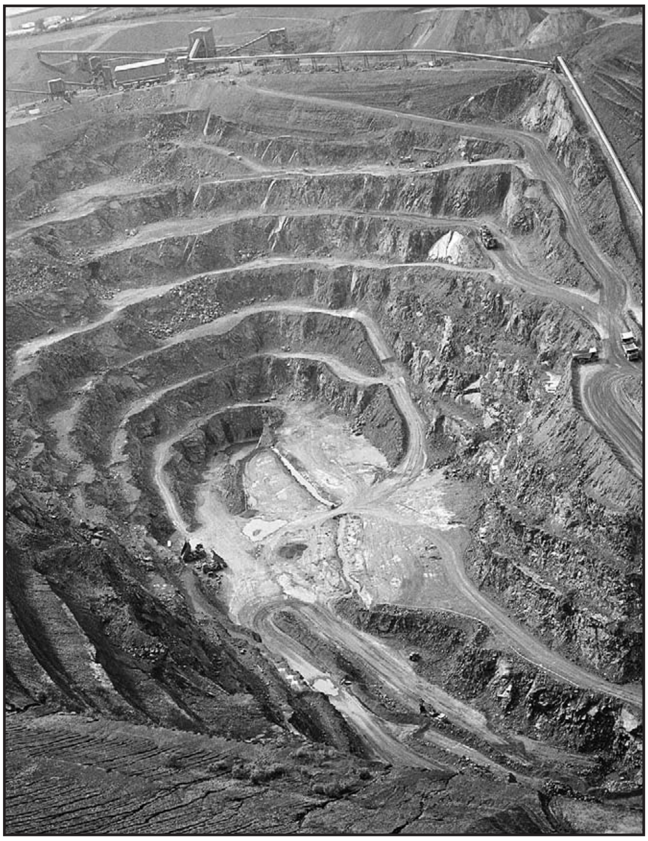

Aerial view of Cliffe Hill New Quarry, working South Leicestershire Diorite. (Photo: Tim Cullen, BGS © NERC)

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Triassic palaeovalley fill of Mercia Mudstone Group, in sharp contact with the Charnian basement, which shows crumbly weathering ('sanding') within c.1 m of the unconformity; south face of Bardon Hill Quarry, Charnwood Forest. (Photo: John Carney, BGS © NERC)

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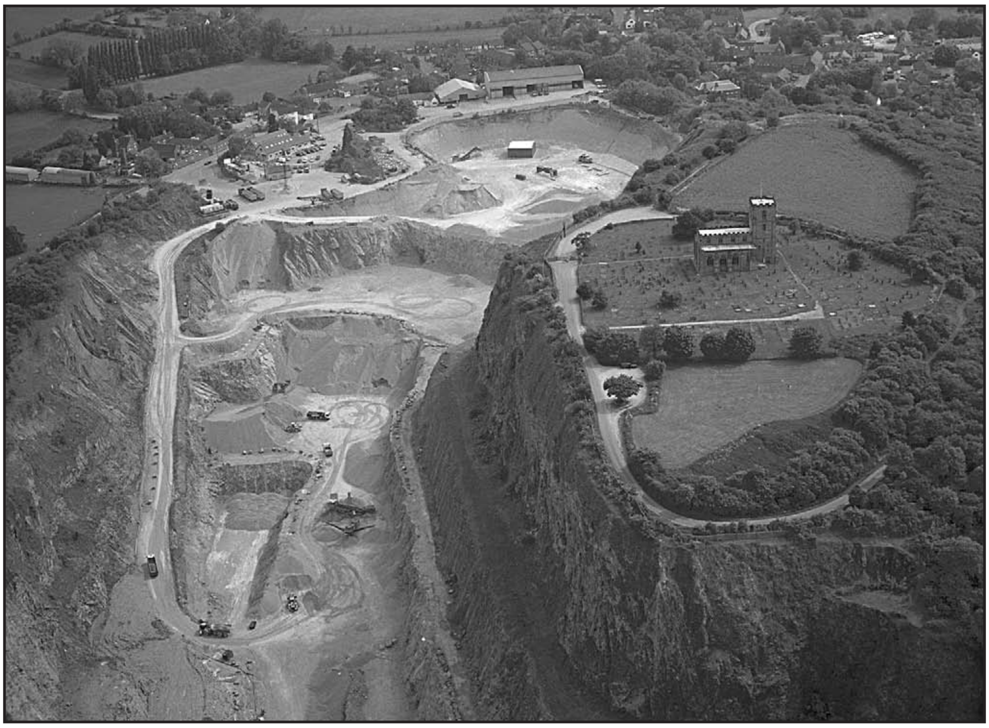

Aerial view of Breedon Hill Quarry. (Photo: Tim Cullen, BGS © NERC)

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East Midlands Geological Society, 40 years on: memories of the early years

John Travis

The Society celebrated its 40th anniversary with a lecture and dinner meeting, after an introduction by Neil Aitkenhead, on February 7th, 2004. The current president, Ian Thomas, gave his presidential address, followed by a dinner at which a number of earlier presidents and officers were gathered, including Trevor Ford who gave a toast to the society, its future and forty years past. Frank Taylor, Dorothy Morrow, Ian Sutton, Neil Aitkenhead, Sue Miles, Richard Hamblin, and Tony Morris were past presidents also in attendance.

The Society that was founded 40 years ago has gone through interesting times, especially in the earlier days when new investigative techniques and their results gave explanations of long-standing observations and confirmation of what once were controversial geological theories. What follows are a few personal memories of some of the events, people and features during that period; many of them may be read about at greater length in the pages of the Mercian Geologist. This was not written as a detailed historical description of the early years, which was covered in an excellent article by Frank Taylor (1989).

Probably the last working quarry within Nottingham City, around 1966 and just before it ceased extraction of Mercia Mudstones at Mapperley brickyard. Today, the quarry floor is a housing estate, and the skyline has a car sales court fronting onto Woodborough Road, where the factory was.

Background

The East Midlands is an area with much geological diversity, and has a long history to its economy, which at times had considerable, even major, contributions made by extraction and working of the wide variety of rocks, minerals and ores that occur in the area.

There have been centuries of mineral extraction in the East Midlands, with a limited list ranging from building stones, brick clays, dredged and quarried fluviatile sands and gravels, to open-cast and deep-mined coal, gypsum and ironstones. Ores of lead and copper, and later zinc, have been mined. Other minerals, including fluorite, barite and calcite, that were originally waste products of lead mining, became important in their own right in the 20th century, while lead has become just a by-product of their production.

Also quarried and mined, are high-grade limestones for the chemical, glass and sugar industries, as well as for agriculture. Dolomites, both Carboniferous and Permian, have similarly been extracted as refractories, as well as a pioneering but short-lived attempt at magnesium metal extraction in Derbyshire. Much larger quantities of some hard limestones, along with various igneous and metamorphic rocks, have been quarried for aggregates, used as roadstone, in concrete and as railway ballast, besides input to the still important cement industry.

Various clays have been quarried and even mined underground to produce bricks, sanitary ware, pipes, pottery, refractories and other materials. Largely, but not exclusively within Nottingham's suburbs, very large quantities of Mercia Mudstones have been turned into bricks over the last 200 years; the quarries left huge scars that are now partially healed and largely full of houses and industrial buildings.

There has also been lesser extraction of other minerals for pigments, abrasives and semi-precious stones for jewelry and ornaments. Except for Derbyshire's Blue John fluorite, all have long since ceased. Oil extraction started relatively late, to make a small but valuable contribution during World War Two, and extraction in Nottinghamshire and Lincolnshire continues to this day, along with some methane from coal seams.

Development of an idea

With this diverse geology-based industrial heritage and local interest in geology (clearly seen in the popularity of geology evening classes in the late 1950s and 1960s, it was perhaps surprising that there was no local public society devoted to geology, such as existed in Manchester, Yorkshire and several other places. There were societies, and groups within them, that had members with geological interests, including the Peak District Mines Historical Society (formed in 1959), the Nottingham Field Club, various college and university clubs and societies and a variety of other more historical societies, such as the Leicester Literary and Philosophical, the Russell Society and others further afield .

When the late Prof. W.D. Evans, later Lord Energlyn (Elliott, 1986; Sarjeant, 1987), took his post as head of the geology department at Nottingham University in the late 1940s, he tried to form a local geological society, but was disappointed at the lack of response and failed to establish anything. He frequently remarked on this when he saw the success of the EMGS some years later.

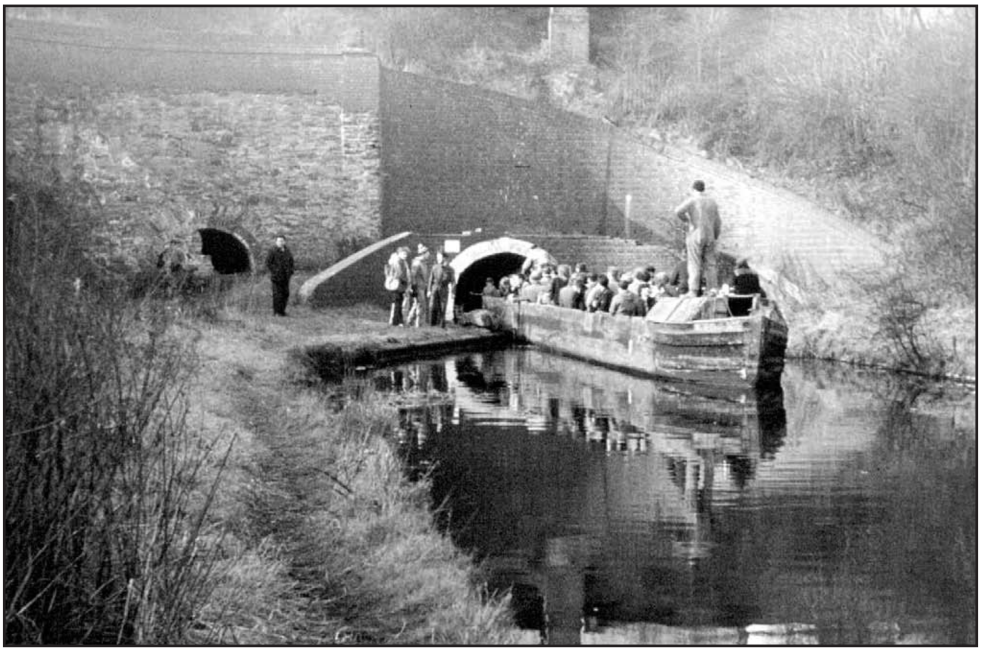
The popularity of the geology evening classes in the early 1960s was beginning to give rise to thoughts and informal discussions about the formation of a local society. There was apparently considerable enthusiasm and talk for several years, according to some members of the classes, but no one seemed to be taking any positive action. This interest was certainly present in evening classes run locally by Bill Sarjeant, Phillip Speed and Frank Taylor, and this was remarked on by Bill Sarjeant in his opening editorial in the first issue of Mercian Geologist. There was also increasing enthusiasm from the influx of younger staff members to the university geology department. However, it was Bill Sarjeant, with Frank Taylor and some of their colleagues from that department, who eventually took the necessary vital steps in the process of bringing enthusiastic people together.

Sometime in December 1963, after discussing this among their colleagues and evening class members and canvassing opinion from friends at Leicester and Sheffield Universities, they approached several people including the writer and his wife, whom they knew had interests in geology as members of Peak District Mines Historical Society, and asked us if we were interested in attending a small meeting to discuss the possibilities of forming a local Geological Society. So on Saturday January 4th, 1964, a group met in Bill Sarjeant's room at Nottingham University to discuss the proposal and decide what the next steps should be. By courtesy of Frank Taylor (who appears to have had some formal record of the event) those present were Bill Sarjeant, Frank Taylor, Peter Stevenson, Miss F.I. Brindley, Miss N.C. Stewart, Mr Cobb, Mrs E.M. Palmer, and John and Josie Travis.

Discussion quickly showed there were plenty of potential members for a proposed society, from evening class students, from colleagues in departments of geology, mining, civil engineering and geography at various colleges and universities, and from other bodies such as the Nottingham Field Club. Right from the beginning, it was stressed that the new society should be open to all, and not become just a society of professional geologists. Certainly as a publication platform, mainly but not exclusively for the professionals, Bill Sarjeant was very enthusiastic about producing a journal for papers of local and wider interest, even before we had a society.

It was decided that were clearly enough potential members to form a good nucleus of a society, so local press advertising for an inaugural meeting would probably bring in a good few more. The meeting ended with plans to book a venue and to advertise the meeting in the Nottingham Evening Post and by flyers to colleagues. Then the inaugural meeting to discuss the formation of an East Midlands Geological Society was then held at the University Adult Education Department on Shakespeare Street, Nottingham, on Saturday afternoon, February 1st 1964.

Society council meeting late in the 1960s. Left to right, Bob Morrell, Frank Taylor, John Travis (standing), Lynn Willies, Phillip Speed, Dick Elliott, Bill Sarjeant, Dorothy Morrow. The happy look on members' faces is due to the after-meeting activities - education in the fine art of whisky tasting, courtesy of Bob Morrow (not pictured) and Bill Sarjeant who were particularly learned in this art.



The Society's first field trip, May 1964, with one of two narrow-boats full of members about to enter one of the Dudley Canal tunnels at the Tipton portal.

Foundation

On the chosen day, a large crowd (variously remembered as 55 or over 100 people) turned up at the hall, where the proposal to form a local Geological Society was enthusiastically received. Alternatives names were offered, but the first name of "East Midlands Geological Society" was never really challenged. An interim council was formed to draught a constitution and to fix a date for the next meeting, where this would be presented for discussion, and be followed by a lecture. The meeting ended with a feeling of satisfaction that it was looking very promising for a much larger potential membership than had been originally envisaged.

The interim council met and a draught constitution was prepared. It was submitted to the next meeting of the society at the same venue on Saturday 7th March 1964. After the formal business, Dr Frank Taylor gave an illustrated lecture on the geology of Derbyshire. The hall was packed to capacity for the meeting, with probably about 150 people, not all of whom became members on that occasion, but enough to be very gratifying for a first meeting.

The very next day, Sunday 8th March 1964, the Society's first field trip was held, when around 80 people travelled mainly by coach to the Tipton portal of the Dudley Canal Tunnel in the West Midlands. This was partly out of geological interest, but was more in the nature of urgent support for a preservation group fighting a proposal by British Rail, to block one end of the system, in order to fill part of it and build an embankment above rather than erect a more expensive bridge. The meeting, urgently organised by Bill Sarjeant and the secretary Bob Morrell during the previous week, was a great success both in terms of turnout and its help to the preservation group (Sarjeant, 1964). It was a joint venture, and in addition to EMGS members, included some 30 others from the Peak District Mines Historical Society and from the Swinnerton Society at Nottingham University's Geology Department.

Our support was in the form of our presence, and in traversing the tunnels (nearly 3km long) in narrow boats to demonstrate that people were interested in keeping open the tunnels and canals of the area. This was just before the canal networks became popular for leisure cruising, and old industrial canals were not widely regarded as the assets that they are now. The excursion did leave the boats at some open-air basins to study Silurian limestone and shale exposures, and some excellent fossils were collected, mostly from loose debris in what was at that time a rather derelict industrial landscape. The Society's support was undoubtedly significant, and the canals and tunnels were subsequently kept open, and are still used today for canal cruising. The geological interest is still present, as the canal tunnels enter the old limestone mines that have now been turned into a tourist feature to compliment the adjacent Black Country Museum.

The Society's second indoor meeting, on Thursday 23rd April 1964, was held in the Nottingham and District Regional College of Technology (that later became Nottingham Trent University). This was a collectors' evening, where some 17 collections or exhibits of various types, ranging from synthetic diamonds and natural gemstones to collections of minerals, fossils and problematica, displayed by members of the Society. It was a great success, and allowed people to see what a diverse range of geologically related interests members had; it was also a great opportunity to socialise. This was the last meeting of the first indoor season, and the Society's first year continued with a series of five field trips by coach. These were mainly local, and were intended to give the members a broad overview of the geology and

Society visit to a quarry before the days when hard hats were required; in steeply dipping limestones, near Waterhouses, Staffordshire.

geomorphology of the East Midlands. Affectionately known as Cook's Tours, they were very popular but sometimes resembled the geological version of American tourists doing Europe in a week, with the leader and other contributors often giving nonstop microphone commentaries on the fly.

The Society membership did not then contain so many professional geologists, and the majority of lay members were not well versed in field techniques of extracting and trimming specimens from exposures. For several years, the sight of coaches disgorging anywhere from 30 to 80 people wielding a motley collection of domestic hammers and chisels, wearing no eye protection or hard hats, and vigorously attacking everything that was not moving in a quarry or exposure filled the writer with dread. Splinters of rock flew around like battlefield shrapnel, and some potentially good specimens were reduced to piles of useless rock chips simply through lack of demonstrations of good technique. Perhaps this was where the Society failed somewhat in its professed educational role, especially as there were some very able teachers among the professionals. Fortunately if there were any injuries they were relatively trivial.

Progress

The second season of indoor meetings began in November 1964, some of which set a pattern for the next few years by being held outside Nottingham; venues were in Loughborough, Derby, Matlock, Bakewell and Newark, often jointly with other societies. In council, Bill Sarjeant was already putting forward ideas for which he became a tireless advocate, sometimes in the face of opposition from the rest of the council. Some members thought that he was trying to get the society to run before it could walk, but he constantly put forward interesting and radical ideas that seeded lively and sometimes noisy discussions.

His enthusiastic plans for a journal, to be called the Mercian Geologist, came to fruition early, with the first issue published in December of that first year, and it has been a great success ever since. Like the society membership, it was always intended to be open to papers contributed by amateur geologists, and not be just a publication for the professionals.

A few other ideas from Bill Sarjeant were not opposed in principle, but one turned out to be too expensive at the time and has still not materialised. He proposed that a gold medal should be presented to selected people who had made outstanding contributions to geology; it would be known as the Founders Medal or the Shipman Medal to commemorate a local pioneering geologist (Morrell, 1966). It was not the cost of the gold that was prohibitive, but the cost of making the dies to mint the medals. An initial model was designed before reduction to press dies, as one of our members, Phillip Hanford, was an artist-sculptor who gave valuable advice to Bill Sarjeant when investigating the project.

Other projects were launched successfully, including local groups, some of which did very valuable work, mainly with input from the amateur component of the membership. They included the detailed examination of the Rhaetic and adjacent beds in a recently disused railway cutting at Barnstone by J.H. Sykes, J.S. Cargill, and H.G. Fryer (Sykes et al, 1970; Sykes 1971, 1974, 1977). Dick Elliot had a project on the local Keuper (Mercian Mudstone), and Peter Steveson was investigating a glacial channel at Sproxton, Leicestershire (Stevenson, 1967).

Frank Taylor also had an ongoing project collating geological information gathered from local temporary exposures, including pipe trenches, building sites and new road cuttings and sent in by members (or examined by Frank himself when notified of the location). Most impressive of these was the wonderful opportunity to see great lengths of virgin exposures when the M1 motorway was built through the region, and this was also the subject of an excellent, and unrepeatable, Society field trip. Another local development that revealed extensive exposures, but in shorter sections that had to be collated into a whole, was the clearance and replacement of 19th century housing in the St Anns and lower Woodborough Road parts of Nottingham over several years in the 1960s.

A notable event in 1966 was the annual meeting of the British Association for the Advancement of Science that was held in Nottingham in early September. The Society and many of its members participated in the geology section of the activities, and gained some valuable publicity during the event. Dr Frank Taylor was local secretary for the Geology section of the meeting, and other members organised exhibits of the Society's work.

The Mercian Geologist

The production of the Mercian, with initially two issues per year, was a major event for the society, both in financial and social terms. Before the days of word processors and desk top publishing, production was a long hard job of gathering papers, peer-reviewing them, retyping them into a standard format, proof reading, correcting, printing, and finally the great social event that was the collating!

Frank Taylor leading one of the popular "Cook's Tours", this one to Shropshire area. The formal dark suit and tie were common among our leaders at the time. Bob Morrell and Dorothy Morrow are in the foreground.

Not long after the first couple of issues had been produced, Bill Sarjeant, as editor, had examined the costs of production at the University printing department. It was the largest job they undertook at that time, their normal output being small runs of exam papers, so they were not equipped to collate an entire Mercian Geolologist. They had to collate by hand, so wanted to raise the price, and this frightened the editor into looking at alternatives. He eventually decided that the Society could save significant costs if the journal was self-collated, so that just printing and binding were paid for. The scale of the task was probably not quite appreciated at this stage.

The first self-collation was Part 1 of Volume 2. The sight of nearly 40,000 sheets of printed pages was almost frightening, spread over numerous benches of the Geology Department rooms, waiting to be assembled in a single weekend into about 500 copies of the journal of 133 pages, plus reprints for authors. Collation was by a small army of volunteers, working by hand (and driven mainly by Frank Taylor, whip in hand) for periods of anything from an hour to the whole weekend, and every minute of voluntary labour was valuable and greatly appreciated. Included among the personnel on collating weekends was Wilfred, a rescued pigeon looked after for many years by Mrs Dorothy Morrow; Wilfred never collated anything, but he was a good talking point and a surprise to newcomers. After much soul-searching, the Mercian was changed to A4 paper, with the start of Volume 4. This reduced the collating workload as the larger page size meant dropping from over 100 pages per issue to about 80, saving some 5000 pages of collation.

A collating weekend was always a considerable social occasion, with the task in hand that was variously perceived as either relatively relaxing or totally mind-numbing. Each gave the opportunity for much conversation as members walked up and down along the piles of pages, collating them first into separate articles, then into the complete journal. Reprints were stapled, trimmed and bound by the collating team, but the main journal went outside to be trimmed and bound as the University printers could not then handle such a large publication. However, the system of hand collating worked well, and only ceased in the 1980s when reliable collating machines became available. This produced mixed feelings, as many saw it as the loss of a welcome social occasion twice a year.

In the early days, printing quality was not consistent, especially of photographs on the glossy paper, and an important but boring part of the collation was checking every page for defects, before every assembled journal was checked again before going to the binders. This epic of Society voluntary labour was still not the end of work on the Mercian. The membership list was held in a box of file cards, which were used for many years to hand address the envelopes, for both the Mercian and the newsletters.

When this had been done, many members picked up their copies at a meeting, but if they did not, many copies were hand-delivered by volunteers who each covered an area near their homes, once again saving considerable amounts of Society money on postage. It was only in the mid 1970s that Frank Taylor accessed the university mainframe computer to create a database for label printing. This was typed in by Susan and Marian, both of the Taylor family, and saved hours of work in subsequent years.

The finished Mercian Geologist has been largely uncontroversial but has occasionally produced critical comments to the Society. The issue that caused the loudest mutterings, particularly among some of the lay membership, was Volume 2 Part 2, which was in its entirety (112 pages) a bibliography of the geology of the Peak District up to 1965. A valuable piece of work to researchers, academics and amateurs with an interest in the region (supplements were published later), it was considered a waste of space by some of the lay members who felt they had been robbed of a normal issue of the Mercian. They were not even placated when it was pointed out that the bibliography had been published with a grant, at no cost to the Society, whose funds therefore grew that year. Grumblings resurfaced when a bibliography of the geology of Leicestershire was published as the whole of Volume 4 Part 4 (and has a supplement forming just a part of this issue). Bibliographies do not make light reading, but they are a valuable contribution to research that a local Society journal can make.

Characters

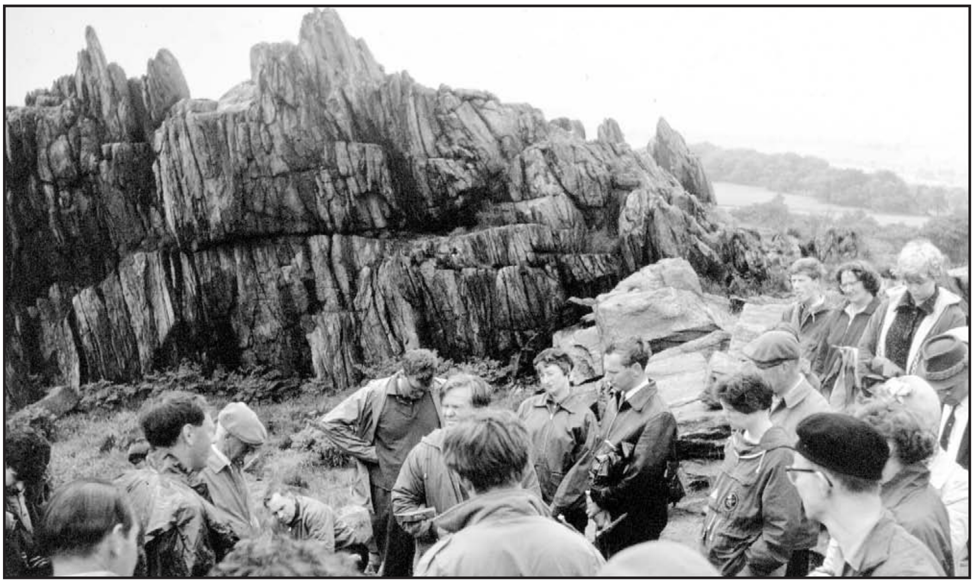
The Society's early membership was a very diverse collection, with an age spectrum significantly younger than it is today, and with a fewer professional geologists, as it was before the days of the British Geological Survey at Keyworth. There was however, a professional component that hardly now exists due to the decline in the coal industry, railways and other local industries that employed geologists, besides the geology teaching departments that closed in the late 1980s. Surprisingly, there was a time when it seemed that a significant part of the membership was either employed at, or retired from, Boots the Chemist, and some of the society social gatherings were more like Boots reunions. The company itself had little to do with geology other than using some talc, a few limestone products and pyrolusite in their manufacturing, but they seemed to have numerous staff with an interest in geology. Despite the title of the Society, the membership has always come from a wide area. Some notably dedicated members (including the Beaumont family from Huddersfield) consistently travelled 60 miles each way to most of the indoor and field meetings, while others regularly came from Peterborough, Stamford and distant parts of Leicestershire.

The Society's first treasurer, Edmund Taylor, was a notable character (Morrell, 1978). President of the Nottingham Cosmopolitan Debating Society, he could be very vociferous at council meetings on subjects that had nothing whatever to do with the geological matter being discussed, but he was always an interesting conversationalist. During the mid sixties, the writer attended a college geology course, when he was able to recruit many younger members. Some stayed with the Society for several years, one recruited mature student, H.R. Potter, eventually became president of the Society. Frank Taylor (1989) paid tribute to many more of the quiet but dedicated workers who ensured success in various fields through the early years of the Society.

In terms of membership recruitment and indoor meeting attendances, the greatest event for the Society was the relocation of most of the British Geological Survey to what had been the campus of the Mary Ward Teacher Training College at Keyworth. This move brought a large influx of professional geologists and academic excellence to the area, and it swelled the Society's membership and attendance at meetings at a time when original members were becoming fewer.

Anyone observing the current Annual General meetings, with elections of officers and council largely on the nod from the President, would scarcely believe the politicking that occasionally went on at times in the early years. Some of the elections were hotly contested, for reasons long since forgotten, but usually over something to do with one of Bill Sarjeant's radical proposals. Bill Sarjeant was a well-loved character, whose personal presence around the Society was greatly missed after took up a post in Canada, and left Nottingham in 1972. The Society was just one of his many achievements (Anon, 2002).

Ron Firman describing distant geomorphology on a weekend excursion to the Lake District in the late 1960s. Dorothy Morrow, Josie Travis, Emily Ramsell and Mina Beaumont are among others in the picture.



Field trip to Charnwood Forest, with Trevor Ford.

Landslides, disasters, frost and dinners

There were a few incidents that lightened the Society's early days, some of geological note, others more meteorological. The Society has usually had a programme of around six field trips through the summer field season, including half-days out, regular full-day trips, weekends, several full-week excursions, and more recently the very popular midweek evening trips during the longer light evenings around June.

The 1966 January indoor meeting was held jointly with PDMHS, at Matlock, on the 8th of the month. Additional to the advertised lecture, Trevor Ford spoke on the recent arrival of a fairly large stony meteorite which had broken up in the atmosphere and landed in the vicinity of Barwell in Leicestershire; he showed photographs, and also had a small fragment of the meteorite that showed to the audience, so fresh it was almost still warm. Later the same weekend, and following a period of heavy rain, there was a large landslip on Dale Road at Matlock (Taylor, 1966), which caused the demolition of two cottages beside the road that we had travelled from Nottingham to the meeting only 24 hours earlier.

During the autumn of 1967 a nationwide outbreak of Foot and Mouth Disease restricted access to large parts of the countryside, and eventually caused the relocation of the January 1968 lecture from Matlock to Nottingham. Starting in January 1966, it has been the custom to organise a dinner for members, usually to coincide with the December meeting or the Foundation Lecture in the February. Various venues were used, including the Nottingham University Staff Club, for these very pleasant social occasions. The 1968 event was thrown into chaos when, between going into the lecture and coming out 90 minutes later to go for the meal, freak weather had left everything glazed with clear smooth ice when a shower of rain was followed by a sharp freeze. To say it made the journey up the hill to the Staff Club difficult is a major understatement. Attempts to drive up were largely abandoned following various incidents that made the car park and road look like a pantomime on ice. Walking was little better until off the paved areas, and the evening featured scratched cars, bruised anatomies and a delayed start to the dinner.

Field trips were not without their own noteworthy incidents, usually related to getting there or back, the weather or falling rocks. An early and very popular trip (that needed two coaches for members) was to examine rocks and mineralisation at the base of the Triassic of Leicestershire and Derbyshire, with Trevor Ford and Bob King (King & Ford, 1969). Unfortunately travelling between two of the stops, one of the coaches had a breakdown somewhere on the M1. Before the days of mobile phones, there was no way that the leaders on the other coach could know what had happened. The driver realised his coach problem was terminal, but, by a rare coincidence, an empty coach from the same firm was spotted and flagged down, and members were able to hitch a ride and catch up with the rest of the party. The rest of the trip was excellent.

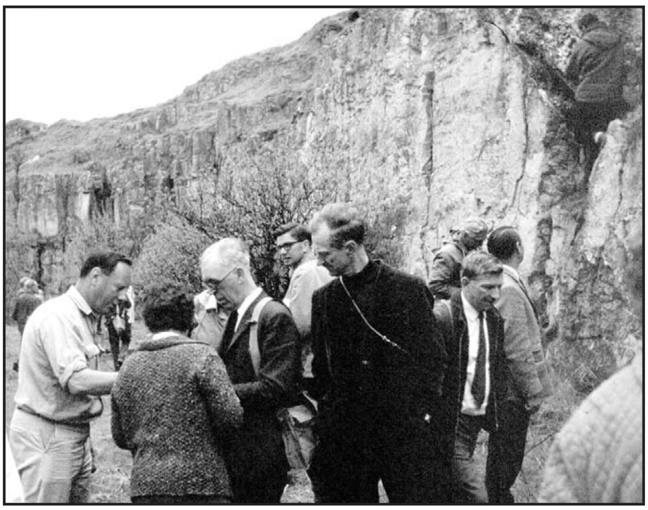
In a second incident, the Society's hired transport was near the top of the Winnats Pass at Castleton, and about to descend into the Hope Valley, when the driver stopped unannounced, peered under the coach for a few minutes, declared there was a problem with the brakes, and asked "Had anyone got any sticking plaster or insulation tape?" As a fix for a brake problem, this request was viewed with some alarm, but someone produced the requested item, something was done with it, and 15 minutes later a safe but nervous descent was completed to the valley floor. On a more positive note, tribute must be recorded to the drivers from the local coach companies, who have taken the Society up lanes far too narrow in order to reach a remote rock exposure; only occasionally did a new driver prove to be a "jobsworth" and leave members with rather more walking to a site.

In 1967, the University Geology Department moved to larger premises, which thanks to the late Prof W.D. Evans became what was later described by the then secretary, Dorothy Morrow, as the spiritual home of the Society for many years. It was also the venue for most winter lectures, until increasing attendances necessitated a move to a larger lecture theatre. This was in the Life Sciences Department, and the link with the Geology building was finally broken in the late 1990s, a decade after the Geology Department itself had ceased to exist. But while it was still extant, the Department's founder and the Society's first Honorary Member, Prof H.H. Swinnerton died in 1966, aged 91(Evans, 1967).

Reflections local

The 40 years of the Society's history have seen many good times and also some sad times. Geology-based industries, which contributed so much to the local economy in the early years of the Society, have declined dramatically. Who would have predicted at the Society's foundation in 1964 that two new coalfields would open, at Asfordby and Selby, and that one would close before it entered full production. Problems at Asfordby were unique to British coal mining, and were the subject of a lecture attended by many Society members at Loughborough University. Along with the closure of most collieries in Nottinghamshire, and all of the Derbyshire and Leicestershire coalfields, several of the Trent Valley coal-fired power stations that took their output have also closed down. Apart from short-lived opencast sites, Britain's coal industry has been decimated in the face of cheap imports and changes in coal usage.

The once-extensive iron ore mines in the East Midlands, some visited by the Society, which fed the steelworks at Holwell, Corby, Stanton and Scunthorpe, have long since closed, as have the steelworks at all except Scunthorpe. The orebodies were practically worked out, but the demise of local mining was largely due to changes in steel manufacture and to imports of cheaper and higher-grade ore, mainly from Brazil and Australia). In contrast, gypsum mining does continue in the East Midlands, albeit on a reduced scale.



Trevor Ford in demonstration mode in Manystones Quarry, in the Peak District.

In the early days of the Society, Derbyshire had been a producer of fluorite, mainly for the chemical and steel industries, for the larger part of a century, but this declined in the face of cheaper imports from the Far East. Cavendish Mill, where most of it was processed and upgraded, would have been closed but for a management buyout; had it closed, it may well have been the end of fluorite mining in Derbyshire. Barite extraction has had a chequered history, boosted briefly then dropped by failed expectations as an ingredient of radiation-shielding concrete in the nuclear industry, but then given another outlet in drilling mud for the North Sea oil industry. Most production was from numerous small-scale operations, sometimes one man working old mine dumps and opencast sites, feeding their output to various refiners for upgrading.

The only mineral extracted in undiminished quantities throughout the life of the Society is limestone, extracted largely for aggregate but also to supply the chemical and glass industries and agriculture. Quarry output was boosted in the early days of the Society to supply huge quantities of aggregates for construction of the M1 motorway through the region in the mid 1960s. An irony of the quarrying over the last 150 years is that many of the spaces left behind have become more valuable as landfill sites than the extraction that created them in the first place. The downside to this is the loss of valuable geological exposures, many of which were visited by the Society in the early years.

Reflections wider

On a more positive note, the science of geology made huge advances in the early years of the Society. Despite the local name of the Society, lectures on many of these advances have tended to be about geology on a worldwide scale. Around the time of the Society's formation, much of the scientific data and observations were maturing to confirm the once-controversial theory of continental drift and boost its evolution into plate tectonics. This revolutionary model of our dynamic Earth so neatly explained the many geological features that were previously the subject of wildly differing ideas, theories and arguments about their origin. Though these advances in our understanding of our Earth were about geology on a planetary scale, they explained features of East Midlands geology including the tropical environments of local Carboniferous coal deposits and the extensive volcanism in past eras. While such are now taken for granted, they were argued about and even scoffed at by some of the conservatives of the 1960s.

Geophysical exploration with Vibroseis on a country road near Radcliffe on Trent.

Significantly, a lecture in 1969 by Professor Runcorn on the subject of continental drift drew the largest attendance the Society had ever had up to that date, and the venue had to be changed to a larger lecture theatre before proceedings could start. There was a further lecture on the subject, this time under its newer title of plate tectonics, only a year later, by J.E. Prentice. Then in February 1977, Bill Cummins gave his first presidential lecture entitled "Is plate tectonics the only answer?". He delivered this to another packed audience, and concluded that the alternatives were not viable, and that the plate tectonics model was still the one that best fitted the observations and evidence.

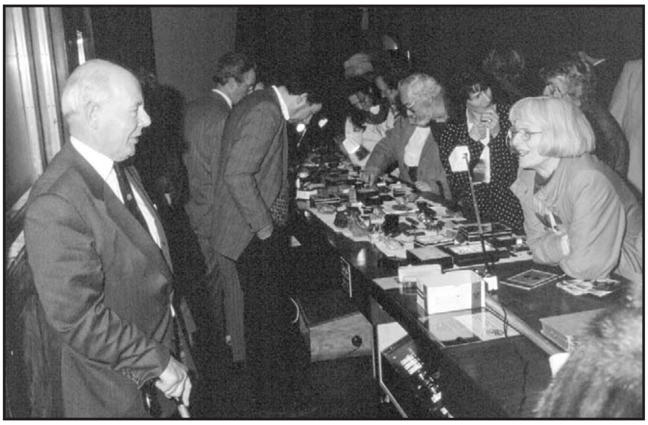
Geophysics also took giant leaps forward, largely from the increased capacity of computers that could analyse the mountains of collected data. Society members may recall from the late 1970s and early 1980s seeing strange vehicles vibrating large steel plates on the surfaces of the East Midlands highways. These were Vibroseis equipment that generated trains of ground vibrations, in place of shock waves from explosives, and picked up the subsurface reflections on lines of geophones that reached up to 5 km along the sides of the roads. Computer discrimination of the complex of received signals was then used to produce structural maps of the subsurface geology, largely in order to locate likely oil and gas traps. Seismic and gravity geophysics have also given proved useful in the prediction of imminent volcanic activity (in areas outside the East Midlands), sometimes enabling pre-eruption evacuations of endangered towns. The Society had lectures about most of these topics, but one of the speakers booked for a lecture tragically lost his life in a volcanic eruption in Columbia.

Other advances in geological science have been closer to home. A Society member, Dick Aldridge, solved the long-time puzzle of the origins of conodonts, the fossils so important to stratigraphy, and he has given no less than three lectures to the Society on the progress of this fascinating research. Earlier, Bill Sarjeant solved the geological puzzle of the Xanthidia (Sarjeant, 1967), when he brought together a mass of work dating back over a century, and made sense of long-standing debates about the relationships of yet another group of useful microfossils. Bill Sarjeant did some of his practical work, examining and drawing prepared microfossil specimens by using a powerful optical microscope, long before the scanning electron microscope made subsequent work so much easier.

Research on the orogenisis of the South Pennine orefields (Mostaghel & Ford, 1986) produced ideas that changed significantly through the early years of the Society. Since further refined, they bear little resemblance to ideas current at the time of the Society's formation.

These are but four examples of events that occurred in the early life of the Society since its foundation 40 years ago. However, the life of the Society has not all been just geological, but is about its enthusiastic members, without whom it would not exist. Sincere thanks must go to all those who have over the years given thousands of hours of their time to organise the Society lectures, run the field trips, produce the Mercian Geologist and the circulars, man the exhibition stand and work at countless other tasks.

Special mention must be made of the first officers and council who were finding their way with the new Society. Having discovered in the first few years some of the problems and inadequacies of the initial set-up, the routine organisation of the Society was quietly refined by Frank Taylor, at times with a little (but very significant help) from resources of the University Geology Department, to whom the Society is for ever grateful. His contribution does not in any way lessen what many others have done over the years, and he made reference to some of the key early members in his Roll of Honour and acknowledgements in his paper "EMGS: the first 25 years" (Taylor, 1989).



Prof Howie with his display of specimens being examined by Society members, after his lecture on gemstones at the 25th anniversary celebrations.

The Society celebrated it 25th anniversary in 1989 with an entertaining lecture on gemstones by the flamboyant Professor Howie, waving his sword-stick around to let members know that he was willing to defend his valuable collection of gems on display at the meeting! Now 40 years on, the Society continues to be entertained and informed by a succession of very welcome lecturers.

The East Midlands Geological Society has clearly fulfilled a local need, if the continuing large attendances at indoor meetings is anything to go by, and it retains a healthy and steady membership list. Geology-based local industries may have declined, but advances in the techniques of geological science have yielded a much clearer picture of Earth processes, both on the large scale and within the East Midlands. Society members have contributed to this by means of their research and publications, and that is part of the ongoing success story of the East Midlands Geological Society.

Queen for a night! Society President, Madge Wright, crowning herself with Prof Howie's replica of one of the crown jewels at the 25th Anniversary meeting. Judy Small appears to be Lady in Waitng.

Acknowledgements

Inspiration for this presentation came from a suggestion by Alan Filmer. I am grateful to Ian Sutton for critical comments, and to Michael Frost and especially Dorothy Morrow for their help editing the text. These are but a few personal observations and memories of some of the early days of the Society; they are not intended to be a detailed history, of which the first 25 years were well covered by Frank Taylor in 1989. A few memory joggers have come from a variety of Society sources, mainly the Mercian Geologist and council minutes. Apologies are due for any errors or omissions; memory of events 30 or 40 years ago are not always totally sharp.

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LANDMARK OF GEOLOGY
IN THE EAST MIDLANDS

Castle Rock, Nottingham

To many observers, Castle Rock may appear just as the lump of ground that the castle or its successors stand on. But the rock itself is a major geological landmark in the city, with its bare sandstone cliff rising 38 m to the castle terrace.

Nottingham owes its location to its geology, where the topographically resistant Triassic sandstone has survived as a bluff of high and dry ground that overlooks a shallow crossing point of the River Trent, which was itself a key transport corridor. The original Saxon settlement was on the more accommodating plateau now occupied by the Lace Market, while Castle Rock was first utilised very soon after 1066 when the Normans installed their military stronghold on its crest. Only the details have changed since.

Geology of the sandstone

Not surprisingly, Castle Rock is formed of the Nottingham Castle Sandstone, a formation of pale brownish sandstone that is about 65 m thick in the Nottingham area. Formerly known as the Bunter Pebble Beds, this is now regarded as a sub-division of the Lower Triassic Sherwood Sandstone Group, dated at about 250 million years old. It overlies the deep red Permian Lenton Sandstone, and in turn is overlain by the red-brown mudstones and sandstones of the Triassic Sneinton Formation (previously known as the Waterstones), part of the Mercia Mudstone Group.

The sandstone is a splendid example of a continental sedimentary rock with clear fluvial origins. It is mostly medium- to coarse-grained with particles dominantly of quartz up to about 1 mm across, but there are many horizons rich in well-rounded pebbles of quartzite or vein quartz. Sediment was derived from denudation of the contemporary uplands, notably the Variscan mountains that lay to the south of what is now Britain. Deposition took place in a huge braided river system that spread across the semi-arid inland basins occupying much of southern, north-western and north-eastern England. The rivers flowed only periodically, in response to seasonal rainfall on the Variscan mountains. Each flood season brought new sediment, and the replenished rivers shifted their channels, leaving banks of sand and spreads of pebbles across the floodplain. Much of the deposition was in sand bars between channels, and in point bars inside meanders, where horizons rich in pebbles and mud-flakes preserve the onset of each flood event. When the sand bars were finally buried by further sedimentation, their complex internal structure of inclined lamination, or foresets, was beautifully preserved within cross-bedded units typically a metre or so thick.

Most of the main cliff faces around Castle Rock expose rather unexciting and homogeneous sandstone, and are anyway rather inaccessible for casual study. But there are two splendid exposures of note. Lenton Road lies in a deep cutting round the north of the castle walls, beyond the gate, and its southern face exposes cross-bedded pebbly sandstone in units about a metre thick, with foreset beds dipping into the cutting face. A rounded embayment exposes what appears to be a channel structure with convergent

***Figure 1**. Castle Rock seen from the southwest, with vertical joints defining the serried buttresses of the sandstone cliff.*

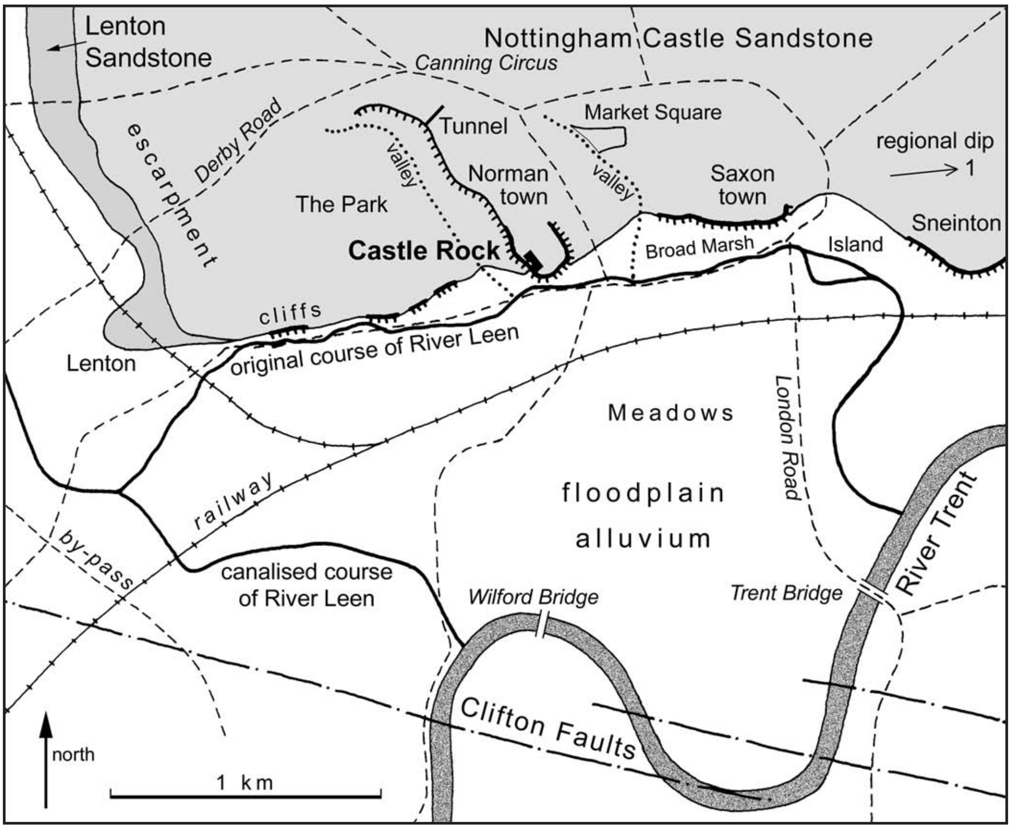


Figure 2. The geology and surrounds of Castle Rock, showing the River Leen in its original course along the foot of the river-cut cliffs that fringe the Trent floodplain where it breaches the sandstone escarpment.

dips, but these are merely apparent dips in uniformly inclined foresets, viewed in rock faces at different orientations. The most splendid example of cross-bedding within a single sand bar is exposed farther north in the clean vertical wall on the north side of the lower exit of the Park Tunnel (Fig. 3), and there is a wealth of other sedimentary structures exposed in and around the tunnel.

The Nottingham Castle Sandstone inherited its gently dipping tectonic structure from its position on the eastern limb of the Pennine Anticline, which was uplifted by tectonic movements on the periphery of the Alpine orogenic belt. It now dips eastwards at about one degree, but otherwise exhibits remarkably little deformation. The sandstone is a weak rock; it has a sparse cement of clay particles that bridge between the quartz grains (Fig. 4), and the many open pores were formerly occupied by a primary calcite cement that was dissolved away by circulating groundwaters (the cement survives in the same sandstone formation at depths of hundreds of metres). The sandstone gains its mass strength from the scarcity of its fractures. Major bedding planes are widely spaced, and joints are mainly restricted to a single system aligned roughly NNW-SSE, and dipping steeply to the west; these have a mean spacing of about 15 m along the Lenton Road section. Joints in the same system are spaced more closely within a belt immediately west of the Castle, creating the unstable rock slabs on the southwestern side of Castle Rock (Fig. 1).

Geomorphic evolution of the Rock

Castle Rock stands at the southern end of the west-facing escarpment of the Triassic sandstone. This extends beneath the city centre, then northwards through Nottinghamshire, forming sandy hills with soils so poor for agriculture that they were left as the woodland growth that formed the core of Sherwood Forest. In Nottingham, the scarp face of this landform has been reduced by steady denudation to a gentle slope on the eastern side of the Leen Valley, while the short dip slope is rapidly lost beneath the Mercia Mudstone cover on the east side of the city. Castle Rock itself forms a ridge that merges into the dip slope around Canning Circus. On either side there are valleys. The valley to the west drains down through the Park Estate; the valley to the east drains down the dip and is where the original Nottingham market place was established, separating the Saxon and Norman towns on their respective hills (Fig. 2). Both are now small, dry valleys in the permeable sandstone, that may have supported considerable run-off during the last (late Devensian) glacial period when the ground was permanently frozen. It would be tempting to describe the Park face of the ridge either as a subsidiary escarpment created by a stronger band within the sandstone or as a minor fault scarp that breaks the dip slope, but neither structure has yet been recognised.

The entire sandstone escarpment extends no farther south than Castle Rock, although the sandstone itself extends below the Trent valley alluvium as

***Figure 3**. Current bedded sandstone exposed by the entrance to the Park Tunnel.*

far as the Meadows, where it is terminated by the Clifton Faults. These pass almost east-west beneath West Bridgford, Wilford village and the Nottingham University campus, and throw the sandstone vertically down to the south, displacing its outcrop way to the west.

The steepness of this southern edge of the sandstone upland, including the face of Castle Rock, is largely due to erosion by the River Trent and its precursors. Prior to the major Anglian glaciation, which ended about 450,000 years ago, drainage patterns in central England were radically different to those of the present day. At this time, the present course of the Trent between Nottingham and Newark, known as the Trent Trench, did not exist. Instead, drainage from the southern Pennines is believed to have flowed south-eastwards along a proto-Derwent tributary and joined a main proto-Bytham river north of Leicester, which flowed eastwards along the course of the present Wreake valley towards the Wash. During the Anglian glaciation, much of England and Wales was buried beneath a thick ice sheet that suppressed all pre-existing river drainage. On de-glaciation at the end of the Anglian period, new glacial deposits or areas of stagnant ice blocked the former Bytham river valley, and meltwaters were forced to find new channels. The Trent Trench was a new drainage course, cut across a former watershed by highly charged meltwaters as they found a new route to the Lincoln Gap. At the upstream end of the Trench, the meltwaters cut into the southern edge of the sandstone escarpment, along the line of the Clifton Faults. Although ice sheets associated with more recent glaciations have never reached the Nottingham area, at least two major episodes of periglacial conditions have led to further downcutting and widening of the Trent Trench to more than 2 km across. During these cold climatic periods, the Trent was highly charged with sediment and formed a complex, braided channel system with a gravelly floodplain. During warmer interglacial periods, including the last 10,000 years, the Trent has formed a single main channel meandering across its floodplain and depositing layers of silt and mud during floods. These slow but constantly shifting channel positions have eroded the valley sides back to a line of bluffs, with the highest and steepest section forming the southern tip of Castle Rock.

Historical changes on the Rock

By Saxon times the River Trent was established fairly well along its present course upstream of Trent Bridge, so that it had fallen back to just over a kilometre from the foot of Castle Rock. Fluvial

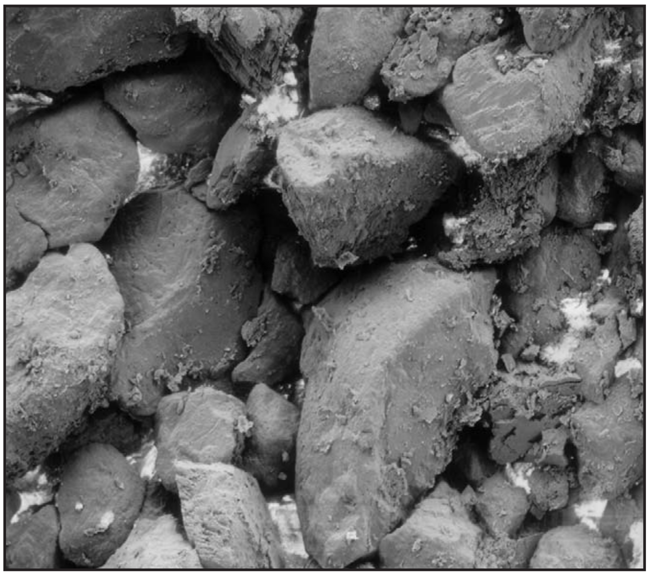


***Figure 4**. Nottingham Castle Sandstone, with quartz grains bonded by a minimal clay cement; an image from a scanning electron microscope; field of view is 4mm across*

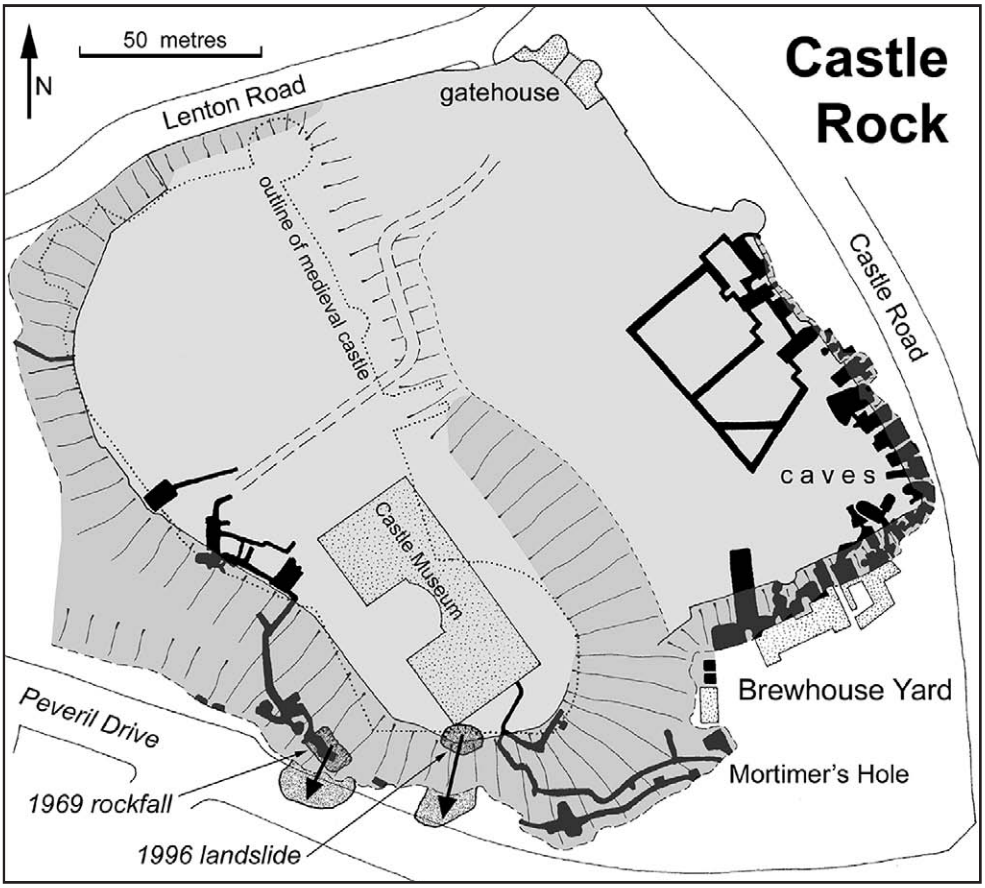


***Figure 5**. The caves and features of Castle Rock.*

undercutting of the Rock was still in progress by the River Leen, which flowed against the foot of the sandstone cliff until it was progressively more artificially controlled around the time the Beeston Canal and wharves were built in front of the Rock in 1793. Then in 1884, the river was finally diverted into the canal with an overflow into the Trent via the Tinker's Leen across the Meadows. Finally, works that were completed in 1973 diverted the Leen into the Trent upstream of Wilford Bridge.

When nature ceased to undercut the Rock, man took over. The sandstone is almost the perfect medium for excavating cave houses, or cave rooms for any other purpose. Very few of Nottingham's hundreds of sandstone caves were actually dug out as dwellings, because a dank, dark room down a flight of steps from inside a house could be a very convenient storage cellar but made very unattractive living space. The main exceptions were along the Trent Valley cliffs where rock houses could be cut horizontally into the cliff face, with doors and windows to let in light.

The first rock houses may have been cut into the foot of Castle Rock in Saxon times, but nothing survives that is recognisably from that era. Mortimer's Hole may date back to 1194 as a supply route from the civilian merchants in Brewhouse Yard to the garrison high above. The tannery cave, intersected by the Western Passages, is likely to be more than 600 years old, and was almost certainly not the first cave in the site. Most of the caves set into the eastern foot of the Rock are from later times, they include the beer cellars behind the two inns, and a series of rather featureless rooms that must have formed the back rooms of houses and workshops fronting on Castle Road (*Mercian Geologist*, 1992, v13, p5-36). Behind the northernmost of these, the linear caves forming a grid are among the youngest in Nottingham, having been excavated as air-raid shelters around 1939 (Fig. 5). Worthy of note is the Park Tunnel, cut through the ridge that extends behind Castle Rock. Excavated in the 1850s to allow access for horse-drawn coaches into the Park Estate, it was soon demoted to a footpath when new roads were built round the south of Castle Rock. But its geological benefit remains with the excellent exposures of sedimentary structures in the clean vertical faces cut in the sandstone (Fig. 2).

With respect to Castle Rock's present appearance, the key question is how much the cliffs have been modified and undercut artificially in connection with the caves. A natural sandstone cliff normally degrades to little more than a "very steep slope" when an undercutting river takes a different course elsewhere. In Saxon times, erosion by the River Leen was probably maintaining a fresh face on the steep crag at the southern tip of Castle Rock. But the rest of the perimeter, including that facing the present site of Castle Road, was probably just a steep bank up which it was possible to scramble; comparisons with the western perimeter overlooking Peveril Drive, or with the slopes further north in the Park are appropriate.

The toes of the sandstone ramparts were probably cut back in order to create a low vertical face so that a house could be built against it with cave rooms extending back into the rock - in the style of the Trip to Jerusalem Inn and the Brewhouse Yard Museum buildings. Furthermore, each successive generation of buildings was probably cut further back into the cliff to remove weaker weathered rock and also to remove any old caves that might be declining in stability; cut-off remnants of caves are clearly recognisable in some of Nottingham's other cliffs. The net effect of man's activities has been to make the sandstone cliffs steeper and more dramatic at the back of an excavated sandstone platform around the site perimeter.

Castle Rock today

The castle atop the rock has evolved substantially from its Norman original, and the building now in place is a mansion dating from the 1670s and largely rebuilt in the 1870s. Its surrounding terrace is formed by earth behind a masonry perimeter wall. The "Christmas Day landslide" in 1996 occurred when water pressure from a burst pipe caused the retaining wall to fail. Castle Rock itself was unscathed by this event, when only the soil and wall collapsed over the stable sandstone (*Mercian Geologist*, 1997, v14, p53-57). Rockfalls in 1939 and 1969 did, however, incorporate the sandstone bedrock, when large joint-bounded slabs fell away from the cliffs on the south-western corner of the site. In the later event, an almost vertical rib of sandstone, about 8 m high and long but only a metre wide, collapsed over the entrance to the Western Passages (Fig. 6). Precautionary engineering works after the 1969 event left the concrete buttresses and plugged fissures that are still visible above Peveril Drive, along with concealed rock anchors that stabilise the rock within this zone of joints (Fig. 6).

The main cause of instability now threatening Castle Rock is the growth of tree roots that reach down the sandstone fissures in their search for year-round water sustenance. The dominant weathering process on Castle Rock is the heaving out of joint blocks by expanding tree roots, while face retreat on the intact rock is extremely slow. One sandstone buttress outside a cave beside Castle Road was destabilised by tree roots opening up a joint within it (*Mercian Geologist*, 1997, v14, p61); the trees were cut down, but the roots were left alive. Further

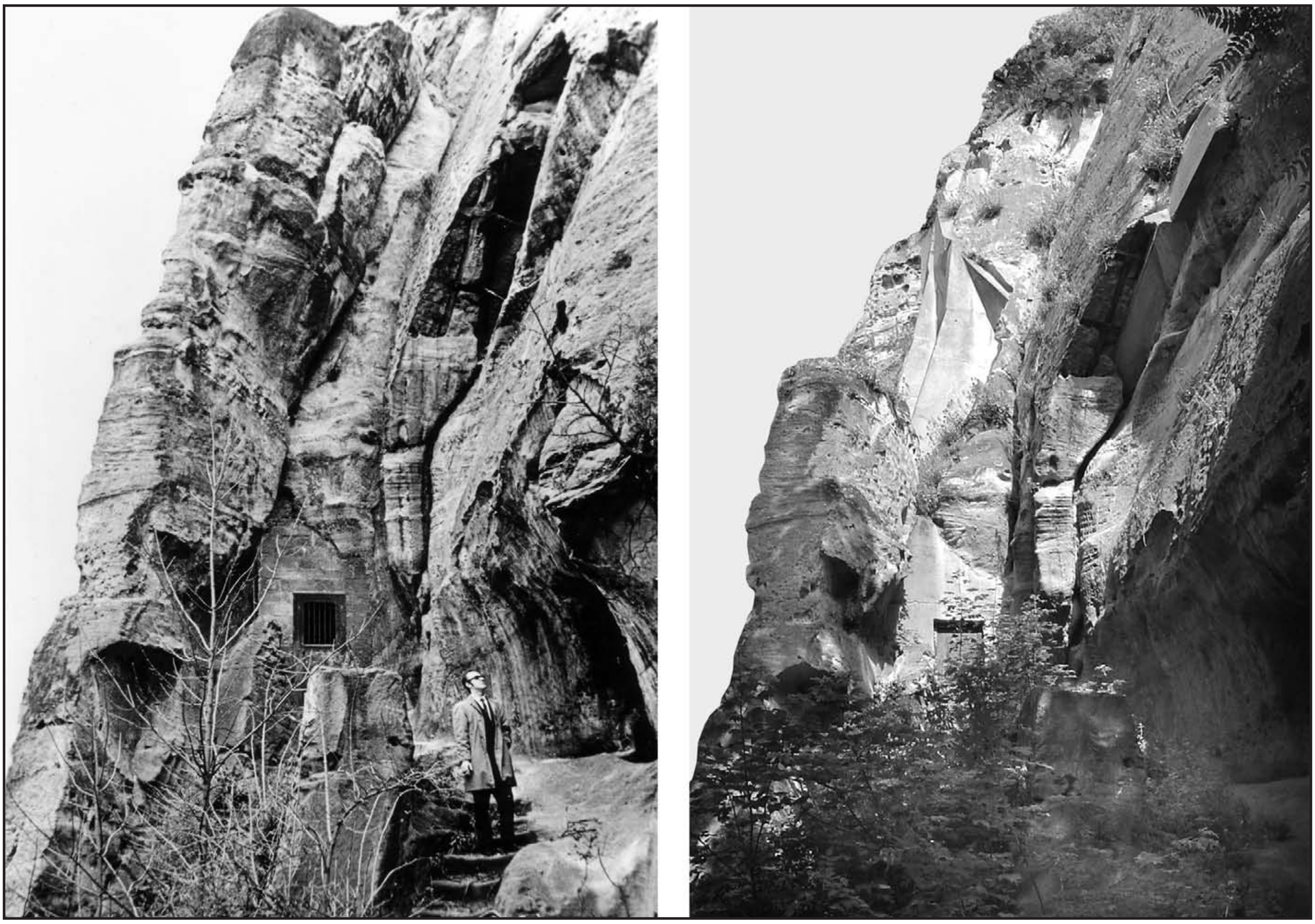


Figure 6. *The heavily jointed western face of Castle Rock, over the lower entrance to the Western Passages caves. The photo on the left, probably taken in 1937, shows the intact outer buttress, before its demise in the 1969 rockfall. The photo on the right shows the massive concrete ribs installed after the rockfall to support the remaining rock.*

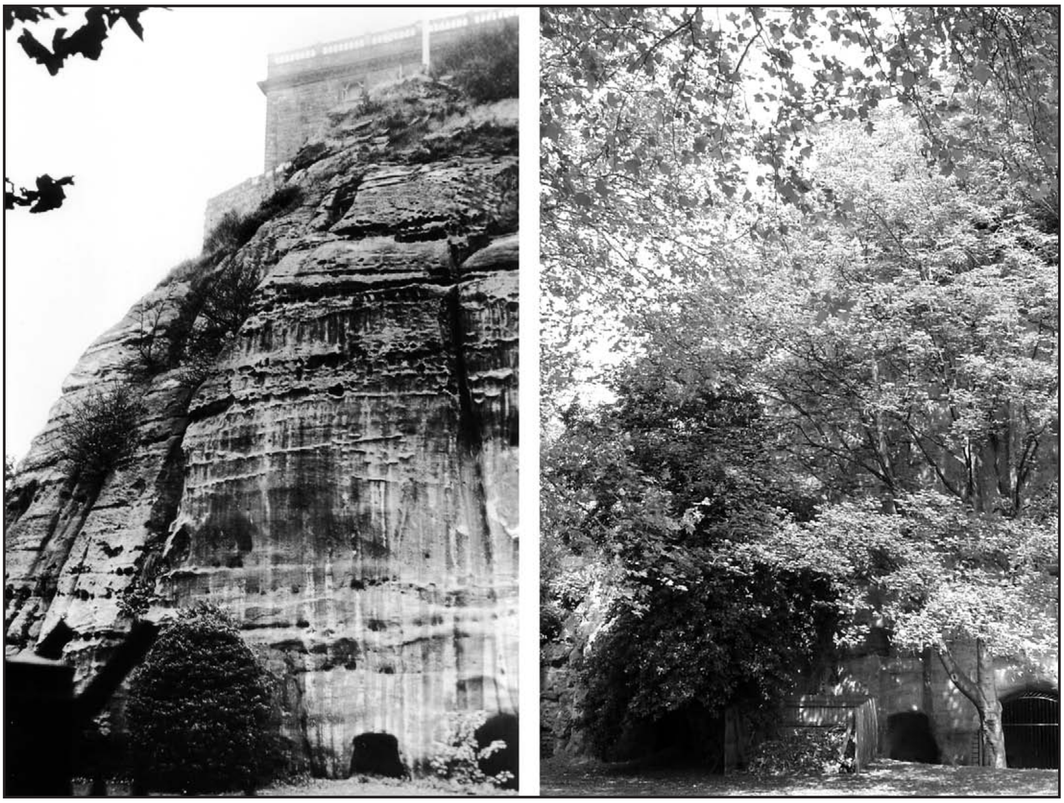


***Figure** 7. The steep southwestern face of Castle Rock, devoid of trees in 1958, and almost lost to sight behind the greenery in 2004.*

remedial works were therefore needed and a steel frame was built inside the cave, so that the rock was anchored to it when coated with reinforced plastic that is almost undetectable because it has an outer surface embedded with sand grains.

Debate still continues between the environmentalists, who delight in a greening of the rock by natural tree growth, and the geologically minded, who prefer the boldness of bare rock. The low cliff above Castle Road has been deforested, but action was too late, and the rock rampart (below the castle walls and above the cave entrances) is still covered by unwelcome scrub undergrowth designed to hold a soil blanket on the less steep slopes. Meanwhile, newly planted trees and rampant ivy are steadily obscuring the fine rock exposure beside Lenton Road. Bare rock does survive on the high cliffs south of the castle, and successful remedial work on some parts has included a protective coating of glass-reinforced polyester that is almost invisible due to the sand incorporated in it. But these faces are steadily being lost behind trees that grow ever taller in front of them (Fig. 7). The future may be brighter, as growing tourist interest in the caves and Castle Rock is leading to wider appreciation of Nottingham's geological heritage. Consequently, it is to be hoped that a new management plan of the Castle and its Rock, due to be completed by Nottingham City Council within the next 18 months, may lean towards the geological conservation aspects (a rebuild of the castle terrace, lost in 1996, is due within the same time frame). The city lost its castle landmark during the Civil War, and it would be a tragedy if the Castle Rock landmark was lost 400 years later behind a screen of trees.

Tony Waltham, Nottingham Trent University
Andy Howard, British Geological Survey

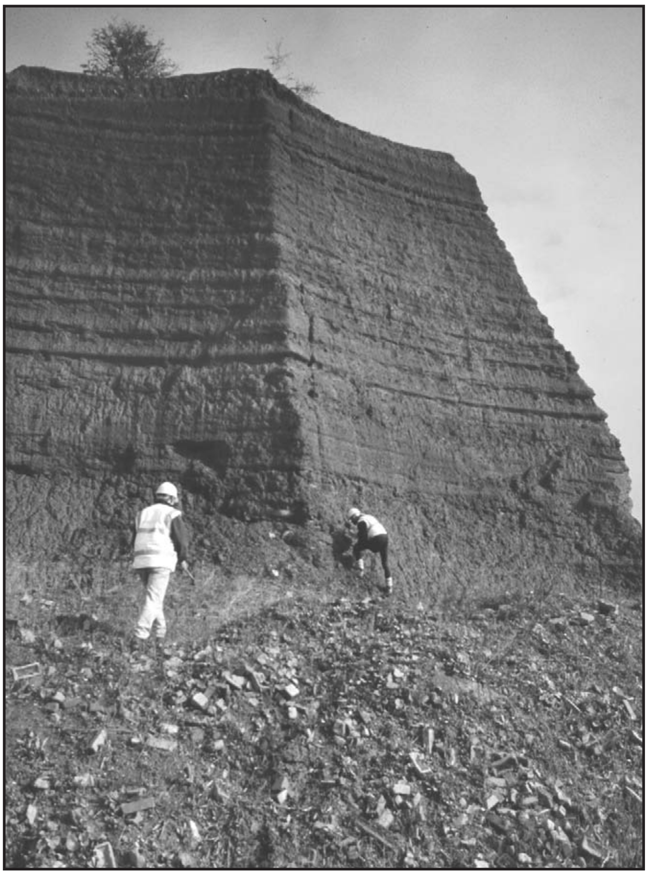
REPORT

Leedsichthys problematicus

Fish remains are not uncommon in the Oxford Clay, and are associated with the marine reptiles and invertebrates which abound in this material. The largest of the fishes was first recorded in the 1890s by Alfred Leeds, after whom the fish is named.

Alfred Leeds and his brother Charles lived at Eyebury Farm, near Peterborough, and collected widely from the local brick pits (Knot Holes) in the Oxford Clay. In 1898, Alfred Leeds excavated the caudal fin of *Leedsichthys*. This was huge: the measure from tip to tip of the tail was 3.6 m. The fin rays bifurcated at intervals until, at the distal end, they were no more than needle thickness. It is recorded that, having assembled the bones, Leeds swore never to tackle another excavation.

In the summer of 2001, two students from Portsmouth University were working on their field projects in the Oxford Clay at Whittlesey. They found a bone projecting from the clay face and reported the fact to members of Stamford and District Geological Society. Further investigations revealed a line of bone ends stretching for a distance of some nine metres. One piece was extracated and set for identification. It turned out to be *Leedsichthys*.



The quarry face in Oxford Clay where the fossil was found.

The quarry, now disused, had been worked on a shale planer. This machine scrapes the face of the quarry directly on to a conveyor belt, and it was obvious that some part of the skeleton had gone for ever. However it was deemed likely that much more could be buried further into the cliff. The line of bones exposed was some 6 m above the quarry floor, but it was accessible up a slope of fallen scree. Unfortunately, there was a further 15 m of clay above the bones. It would have been extremely dangerous to excavate without removing the overburden.

Work on *Leedsichtys* was already being carried out by Jeff Liston, researching his PhD in Glasgow University. He had assembled and was studying most of the known material in Britain, and had examined the collections in most of the European museums. Jeff was delighted to hear of the discovery.

After some thought, it was decided to try to find the funds to carry out an excavation. This task fell to Dr Dave Martill at Portsmouth University, and by early summer 2002 it was possible to hire an excavator to remove the superficial clay.

It took five days to remove some 10,000 tonnes of clay. An area the size of a tennis court was cleared to a level some 100 mm above the bone bed. A brown shell bed at the level acted as a marker horizon. It also yielded an abundance of fossil material – mostly invertebrate. The sides of the excavation had to be graded to an angle of about 45° to obviate the risk of rock falls on to the workers on the site.

Next, a work force had to be assembled and housed on the site. About 20 students, mainly from Portsmouth, were involved. A tent camp was erected for their accommodation. Working together, the students and the members of Stamford Geological Society were now able to begin the delicate business of exposing any bone which lay beneath the shell bed.

Leedsichthys bones on a bedding plane in the clay.

The temporary shelter against rain and sun hastily built over the exposed site.

Work continued for about three months. The camp site became quite a social gathering point. Situated alongside the railway line it soon became known to the regular train drivers, who sounded their hooters in response to the waving arms. Much to the relief of Messrs Martill and Liston it soon became obvious that there was a considerable spread of bone over a wide area. Excavation and mapping progressed.

Mapped, recorded and numbered, each bone was consolidated by painting with Paraloid B72 in acetone before it was lifted. The smaller bones were laid out on sand trays for transport. Larger bones were encased in a Plaster of Paris jacket before lifting.

Inevitably it rained – hard. The site was flooded. Drainage channels were dug around the perimeter and a pump was employed to clear the water. A shelter was erected over the site, covered by plastic sheeting. Needless to say it never rained again, but the shelter from the heat of the sun was appreciated by the workers. It also prevented too rapid drying of exposed bone. Hanson Brick made available a pre-fabricated building to store the bone until it was ready to be taken from the site.

It was realised that we had the fore-quarters and skull only of the beast. If any more had been there, it had already gone down the conveyor to become bricks. Two large fins were revealed. Each more than a metre long, they were the central portion of the fin. The proximal ends were found detached elsewhere, and the distal ends bifurcated repeatedly until they were but needle-thickness or absent. Numerous gill rakers were found, indicating that the creature was a filter-feeder, rather as today's whales and basking sharks. Did *Leedsichthys* shoal as whales and sharks do? A number of large flat plates were found – possibly the platy covering of the skull and gills.

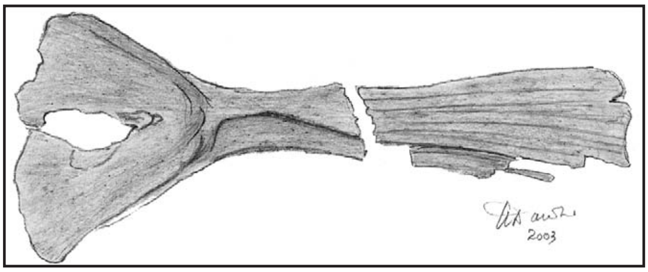
Cleaning, conservation and preparation of the bones was commenced at Peterborough Museum, but at the end of the 2002 operation the whole collection, amounting to some 2,500 bones, was taken to Portsmouth University. The intention was to employ a preparator to work on the bones, but no funding was available. The bones are currently being returned to Peterborough Museum in small numbers for two or three volunteers from Stamford Geological Society to continue the work of preparation. Every bone is

Working with the plaster to encase isolated blocks of clay that contained most fish bones.

A plaster-reinforced block of clay ready for lifting.

broken into numerous small pieces. As each is cleaned, re-assembled and glued it is given a supporting cradle of fibre-glass resin and recorded by drawing to full size. We hope the structure of the skull and gill region can be calculated by Jeff Liston in the Hunterian Museum in Glasgow.

Local interest in the find grew as information spread around. Organised visits were arranged for local groups, schools and university groups. The whole operation was recorded for television over a period of several weeks. Local children were filmed searching for fossils, and a programme titled “The big monster dig” was broadcast in the summer of 2003.

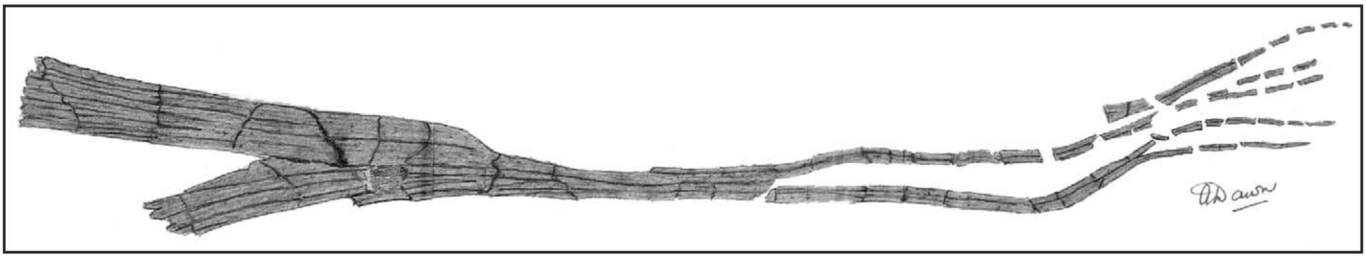


Main limb of a fin, drawn originally life-size, 500 mm long.

The site was closed down for the winter in September 2002, and was re-opened for further work in 2003. There appears to be more bone in the clay face not yet excavated and it is hoped to get a machine back in 2004 to clear more of the overburden. Meanwhile the task of preparation, slow and tedious, proceeds bone by bone in Peterborough Museum. Each bone requires hours of work, even days on the large ones. It will take years to complete them all.

This is by far the most complete assemblage of bone from the forequarters of *Leedsichthys* ever found. Successful reconstruction will greatly enhance our knowledge of the creature. What is not certain is the total length of the fish. No vertebrae have ever been found. It is thought that they were cartilagenous and so not preserved, as ossified bone would be. Estimates, based on small, supposedly related, species, are from 10 to 20 metres long. This fish is truly whale-size.

Alan Dawn
Stamford and District Geological Society



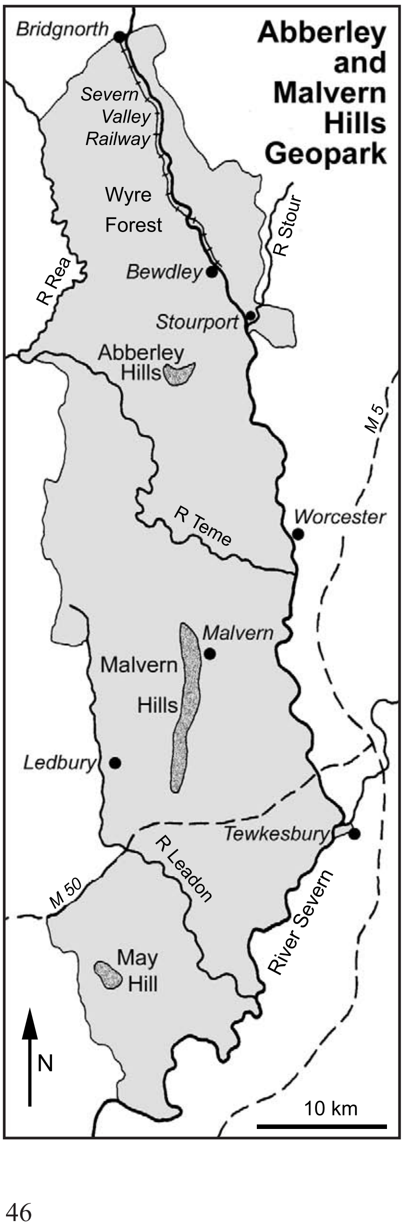
Distal part of a Leedsichthys fin, drawn originally at life-size, 1200 mm long (P.M.A.G. F174-73).

REPORT

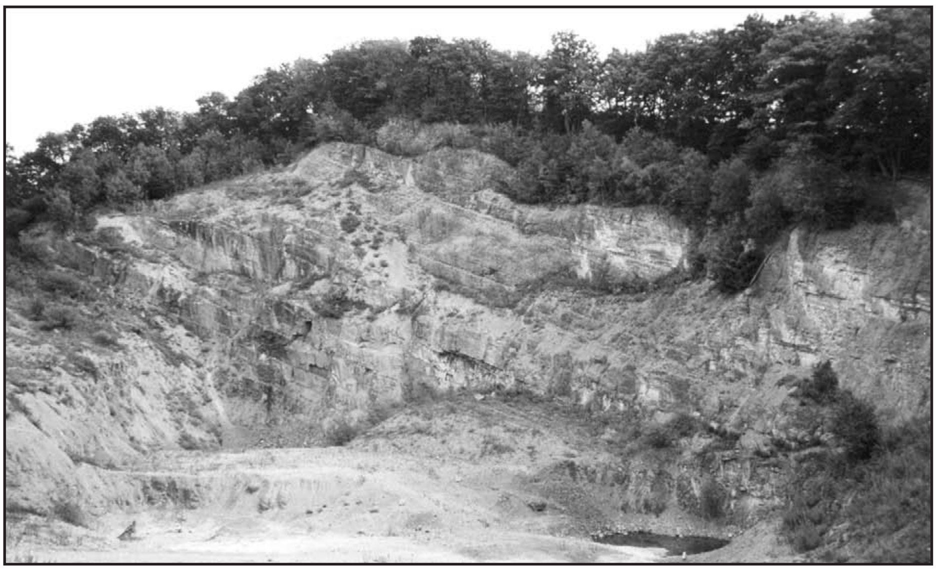
Abberley & Malvern Hills Geopark

A new feature of Midlands geology is the Abberley and Malvern Hills Geopark, which now covers an area of 1250 km^2 within the counties of Herefordshire, Gloucestershire, Shropshire and Worcestershire. In October 2003, it became the 17th member of the European Geopark Network. The international importance of the Earth heritage of the area has therefore been highlighted by its designation as a Global Geopark. UNESCO created the Global Geoparks Network in February 2004, and the European geoparks then merged with eight already established in China. The partnership that founded the Abberley and Malvern site, and now takes the project forward, consists of the Abberley Hills Preservation Society, English Nature, the Forestry Commission, Gloucestershire Geoconservation Trust, Herefordshire and Worcestershire Earth Heritage Trust, Scenesetters and University College Worcester.

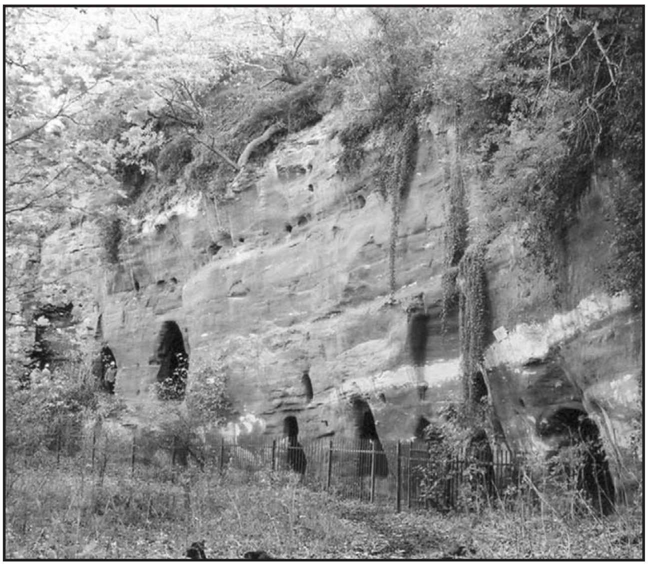
The Abberley and Malvern Hills Geopark represents one of the classical areas of British geology, where the geological and geomorphological significance of the area has formed the basis for research and mapping from the works of Roderick Murchison through to the present day. The two lines of hills form the backbone of the Geopark to illustrate over 500 million years of Earth history. Stratigraphy from Precambrian to Jurassic, and also the Quaternary, is represented, including almost complete successions from the Silurian and Triassic periods. A fine range of igneous, metamorphic and sedimentary rocks is exists, with some nationally important exposures. The geological map quickly illustrates the strong structural influence on the area. The underlying Precambrian basement with its associated faulting and folding has a major north-south influence on the geology of the Geopark. Its impact can be seen from the southern margins of the Silurian May Hill pericline inlier, through the surface expression of the Precambrian of the Malvern Hills, to the nearby Silurian hills of Ledbury and Suckley and onto the



The Malvern Hills, formed of Precambrian basement rocks, in the view north from British Camp on Herefordshire Beacon.



Whitman's Hill Quarry, near May Hill, exposing limestones and shales that represent a complete succession through the Silurian Wenlock and Ludlow Series.



Redstone Rock, at Arley Kings, west of Stourport, with its old hermitages in the Triassic Wildmoor Sandstone.

Abberley Hills themselves. The associated major faulting then continues in to the Carboniferous rocks of the Wyre Forest. This geological backbone is flanked by a full Triassic succession to the east and by a significant part of the Lower Devonian to the west. Furthermore the glacial and fluvial history of the Quaternary is written in the deposits and terraces of the Rivers Severn, Teme, Rea and Leadon.

In the nine months since Geopark designation, the Abberley and Malvern Hills Partnership has been working closely with the active and well established Earth heritage groups that are located within the site, to create an environmentally sensitive programme of geological investigation and conservation. This is complemented by a programme of public and educational awareness that is aimed towards fostering a greater appreciation and understanding of Earth heritage and also making the links between geology and the natural landscape. The programmes include rock and fossil roadshows, public lectures, guided walks and self guided trails. There is an established series of geology, landscape and building stones trails within the geopark; trail guides and interpretation panels not only provide information about Earth heritage but also focus on the associated archaeological, ecological, cultural and industrial heritage of the Geopark. Locations with public access are used, and the trails and sites can be used by schoolchildren as part of their work in the national curriculum. They have also been used in undergraduate degree courses at University College Worcester. A notable success has been the use of an existing guide by the Severn Valley Railway Education Department. This vintage steam railway company now produces a programme for schools using the guide, which explains the geology and landscape along the route. The geology is explained as the train travels along and also at various stations in the Wyre Forest coalfield and along the entrenched valley of the River Severn.

Geoparks in Europe

Copper Coast, Ireland - coastal scenery
Marble Arch Caves / Cuilcagh Mountain, N Ireland - karst
North Pennines, England - moorland scenery
Abberley and Malvern Hills, England - stratigraphy
Cabo de Gata, Spain - mines and Neogene volcanics
Maestrazgo, Spain - stratigraphy and structures
Rouchechouar, France - Jurassic astrobleme
Haute Provence, France - stratigraphy and fossils
Vulkaneifel, Germany - volcanic cones and craters
Nordlicher / Teutoberger, Germany - dinosaur trails
Bergstrasse / Odenwald, Germany - sandstone and granite
Kamptal, Austria - stratigraphy and fossils
Eisenwurzen, Austria - alpine terrains
Madonie, Sicily, Italy - limestone caves
Roccade Cerere, Sicily, Italy - old mines
Lesvos Petrified Forest, Greece - Neogene fossil trees
Psiloritis, Crete, Greece - structural geology and karst

Geoparks in China

Shilin,Yunnan - stone forest karst
Huangshan, Anhui - granite mountains
Lushan, Jiangxi - Quaternary stratigraphy
Yuntaishan, Henan - mountain scenery
Shongshan, Henan - Precambrian stratigraphy
Danxia, Guangdong - sandstone mountains
Zhangjiajie, Hunan - Quartzite pinnacles
Wudalianchi, Heilongjiang - basalt volcanics

Designated Geoparks, with their main geological interests.

To celebrate the importance of geology and geodiversity throughout Europe, the Geopark Network co-ordinated a series of events within each member's territory. This proved to be a great opportunity to raise awareness of the importance of geology on both national and international levels. A series of well-attended events celebrating the geological heritage of the area ran through May and June, 2004, with an inaugural lecture by Professor Aubrey Manning, president of the Geopark.

What is on the horizon for the Abberley and Malvern Hills Geopark? The geopark is participating with eleven other European Geoparks in a public awareness and education initiative, and there are proposals to twin with one of the Chinese Geoparks. The management team also have plans for an earthquake observatory, for a regular 'geological activity' bulletin and for a holiday geology and geotourism programme within the Abberley Hills. It is also a prime task to foster good working relationships with parish councils and community groups, landowners, local authorities, museums, universities, schools, and country parks. All this is aimed to bring geology to as many people as possible and to protect it for future generations to see.

Cheryl Jones
University College Worcester

HOLIDAY GEOLOGY

Earthquakes, ancient and modern, in the region of the Dead Sea Rift

The Dead Sea Rift lies between the Sinai and Arabian plates on a transform fault about 1000 km long, linking the Red Sea spreading boundary with the continental collision zone of the Taurus-Zagros mountains. A family of faults was formed in the Cenozoic and there is about 105 km of sinistral displacement of the Arabian plate. Several pull-apart basins developed along the Rift, and the Dead Sea basin is one of the largest and deepest, bounded by the Jordan and Arava strike-slip faults.

Depressions within the trough are filled by Neogene and Quarternary sediments, mainly fluvial and lacustrine, overlying marine evaporites. The most extensive of the paleo-lakes, Lake Lisan, the precursor of the Dead Sea, reached about 220 km from the Sea of Galilee in the north to Arava in the south from about 60,000 years until 18,000 years BP. There was then almost complete desiccation (Begin et al, 1974), before the water level rose again to form the Dead Sea. During its highest stand, Lake Lisan reached about 200 m above the modern level of the Dead Sea and covered most of the marginal faults. Its deposits, the Lisan formation, consist of soft marls with alternating laminae, a few mm thick, of white aragonite and darker detrital material containing fine grained calcite, dolomite, aragonite, quartz and clays. These varve-like paired laminae are thought to be seasonal precipitates of aragonite in summer with darker detrital flood inputs in the winter.

The combination of a seismically active region with unconsolidated sediments, which can amplify the seismic effects, provides archaeological and geological evidence of historical and pre-historical earthquakes. The region has been populated for thousands of years and there are records throughout the period, of seismic events. These range from the mythical and religious writings of the early inhabitants to recent seismological records. A study of 4000 years of historical records concludes that the mean return period of strong earthquakes along the Arava, Dead Sea and Jordan River Valley section of the Rift is about 1500 years (Ben-Menahem, 1981).

The earthquake record

Modern earthquakes are well documented. Seismological observations in the area show that large events align with the traces of those transform faults with a predominantly sinistral movement. Micro-seismicity occurs over a wide area, with both normal and strike-slip faulting (Marco et al, 1996).The last major earthquake (M 6.2) struck the area in 1927, from an epicentre about 25 km south of Jericho, and caused many casualties with widespread damage in Nablus, Bethlehem and Jerusalem (Fig. 1).

Historical earthquakes are interpreted from biblical accounts, and seismic phenomena may underlie some of the well-known stories in the Bible. There is geological evidence that the destruction of Sodom and Gomorrah (Genesis 19: 24-28) resulted from an earthquake in the Dead Sea area (Neev & Emery, 1995). This involved the bituminous marls and limestones of the late Cretaceous that were buried within the rift, as well as overlying organic-rich, poorly consolidated sediments of the Dead Sea Group, producing seismic epiphenomena with an outburst of smoke and a rain of sulphurous fire. The structural geology and geotechnical properties of near-surface sediments may be related to seismicity, and it has been suggested that the cities of Sodom and Gomorrah were located near the Lisan Peninsula, and their destruction was due to earthquake-induced liquefaction in the poorly consolidated sediments (Harris & Beardow, 1995). The cities' disappearance beneath the waters of the north basin may be the first recorded liquefaction event in Judaeo-Christian history, and a tsunami-like wave stranding a block of salt on the newly formed shoreline may have given rise to the story of Lot`s wife!

***Figure 1**. Remains of the Winter Palace Hotel in Jericho, after the 1927 earthquake.*

Prehistoric earthquakes are interpreted from evidence within the Lisan Marls. In the area about 2 km east of Masada, deep canyons about 50 m deep give good exposures in the Lisan marls (Fig. 2), where earthquake deformations and sedimentary structures are well preserved. Decollements with separation of microfolds from undisturbed subjacent laminae are prominent though individually limited in areal extent (Fig. 3) and these have been ascribed to minor seismic events. Larger and more widespread mixed layers of pulverized and fragmented laminae occur in association with syndepositional faults of about 0.5 m vertical slip; they have been attributed to slip events on the faults, producing major earthquakes, of M > 5.5, with total disruption of beds at the sediment water interface (Marco & Agnon, 1996). The sedimentary record indicates a mean recurrence rate of ~1600 years for historical earthquakes of such magnitude, a figure comparable with that estimated for recent earthquakes.

Archaeological sites with earthquake impacts

For the interested geotourist, there is evidence of earthquakes during the historical period that may easily be viewed at the many archaeological sites along Highway 90, which lies along the Jordan Valley and the Dead Sea shore.

Bet Shean was an important site of population for 6000 years, becoming a Roman city and the capital of the province of Palestina Secunda. A major earthquake in AD 363 destroyed the Roman city, though Byzantine builders reutilised the Roman stones and columns, and the city was destroyed again in AD 749 by another earthquake. The collapsed main street of Bet Shean remained untouched after this event, until recent excavations exposed fallen columns lying in a general northwesterly direction, which is interpreted as the orientation of seismic first motions (Fig. 4). Enthusiastic reconstruction of the old city by Israeli authorities will soon remove the splendid confusion of the seismic shock aftermath.

***Figure 3**. The Lisan Marls show mm-thick banding of aragonite and detrital layers which have been folded and detached from subjacent laminae before being overlain by undeformed layers.*

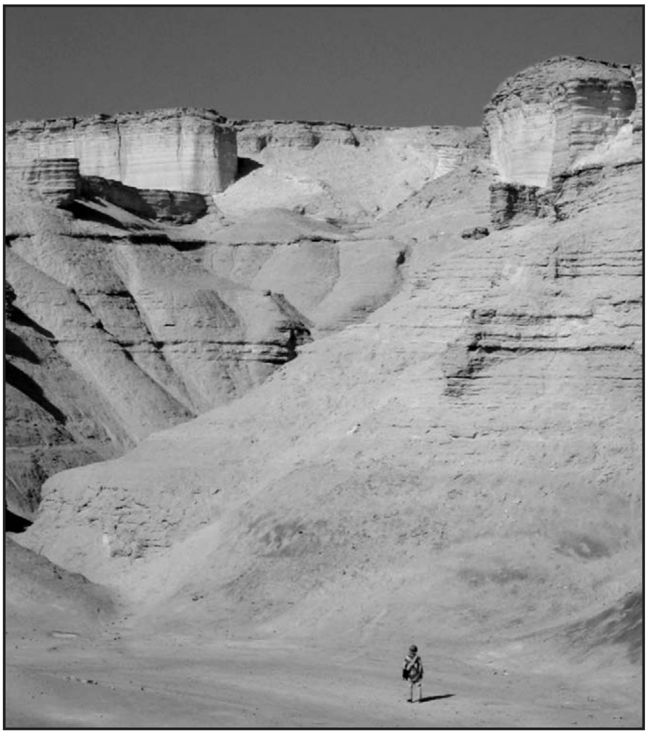


***Figure 2**. Deep canyons with walls up to 50 m high cut through the soft Lisan marls at Masada.*

Jericho has been inhabited for more than 10,000 years. The eastern edge of the ancient Tel is sited by the Spring of Elisha, which rises from its limestone aquifers through the fractured rocks of the East Jericho normal fault. Jericho offered major advantages for settlement and farming, but also a disadvantage for the fortifications that have collapsed several times through earthquakes. It is possible that the collapse of the walls during the siege by Joshua (Joshua 6: 1-16) followed an earthquake since it was associated with an earlier failure of flow in the Jordan River (Joshua 3: 13-16); this may have been due to primary seismic effects, in tilting or subsidence, or due to damming upstream by mudslides as occurred in 1927 (Nur & Ron, 1996). About 5 km north of Jericho, Hisham`s Palace was partially destroyed by an earthquake in AD748 while still under construction. This was probably the strongest seismic event in Palestine in the last 2500 years, with estimated magnitude of M>7 (Ben-Menahem, 1981). Distortion of the building structures from rectangular to rhomboidal shape was due to sinistral shearing stress between two faults with similar trends (Reches & Hoexter, 1981), and not as previously ascribed by archaeologists to shoddy builders and surveyors.

Figure 4. *Fallen columns in the main street of the old city of Bet Shean, which was totally destroyed in AD 749 but is now being reconstructed.*

Qumran, on the northwest shore of the Dead Sea, was the home of the Essenes, an ascetic sect who paid great attention to ritual bathing and purity, and included the authors of the Dead Sea Scrolls. Clean living was, alas, no safeguard. In 31BC, an earthquake destroyed buildings and in particular ruptured the vital water system, forcing the inhabitants to abandon the site. Archaeologists have exposed faulted stairs in the cistern (Neev & Emery, 1995; Nur & Ron, 1996).

Masada is a fortress built on a horst of the rift margin halfway along the Dead Sea flank, and is the site of the alleged mass suicide of its defenders against the Romans. Tilted walls, disturbed floors and aligned fallen masonry are ascribed to earthquake damage of the first century (Karcz et al, 1977), but it is difficult to distinguish this from military action and the depredations of later occupants. Better evidence of seismic effect may be seen in the storehouse walls which have collapsed as a unit (Nur & Hagi, 1996).

We thank Dr Shmuel Marco, Israeli Geological Survey, for introducing us to the Lisan Marls at Masada, and also Fr J. Murphy-O`Connor O.P. for many archaeological trips in both Israel and the Occupied Territories. We thank Elia Photo-Service for permission to use figure 1. Their shop in the Old City of Jerusalem is well worth a visit.

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Gerard and Brenda Slavin

REPORT

Blue-collar Geologists

Back in the 19th century, men who were appointed “Borough Engineer” were expected to perform in the roles of architect and property surveyor and the new profession of “civil engineer” - and last but not least to act as someone who was geologically aware. This was a range of skills that few had on appointment, but many acquired eventually by practical, and sometimes painful, experience. To some extent, Brunel might stand as the example, but he was exceptional in his confidence if not in his real background knowledge.

There were, however, several men who deserve to be recognised for their achievements. In London, two names stand out. One was Joseph Bazalgette, chief engineer to the Metropolitan Board of Works, the supreme authority then overseeing planning and construction in the capital. It fell to him to engineer both the supply of clean and safe drinking water and also the disposal of the dangerous wastes of the growing city and its suburbs; this was in the years following the notorious 1858, known widely as the Year of the Great Stink, when the normally polluted Thames became excessively stinking, Bazalgette solved the problem by embarking on the greatest exercise in tunnelling and pipe-laying ever seen in London. His collecting sewers took waste to the processing plants at Crossness and Becton, while his water mains traversed all the newly expanded suburbs.

In the process, he gained an awareness of the Paleogene rocks of the London Basin, to an extent unrivalled in earlier surveys. His engineering was set up in fullest awareness of the problems posed by fat clays, pyritic clays and, above all, the challenge of water-logged sand lenses that were virtually quicksands. The massive granite walls of the London Thames Embankment were his most visible legacy. A contemporary Surveyor to the City, William Haywood, acquired his geological experience when he bridged the notorious Fleet River with the massive Holborn Viaduct supported on its deep-founded piers of granite from Ross of Mull.

All of these men were following approaches to work set down by William Mylne, the last of a long line of Scots mason-engineers extending back to the time of James I as royal appointments. In London, Mylne specialized in water supply, channelling the streams and springs of Middlesex and Hertfordshire to the needs of the expanding city, preparing the way for Bazalgette. In sinking deeper wells, surveying the lines of acqueducts and pipelines, Mylne gained a knowledge of subsurface outcrops and their facies variations within a short distance. His data was collaged to create one of the best maps of London geology, published in 1856 as *Geological Map of London and its Environs* (with revised editions in 1858 and 1871). On a scale of 1.43 inches to the mile, and using a combination of hachures and shading, his first edition map is still the best to use when trying to explain to non-geologists the relationship between geology and topography in the core area of London. In 1856, much of north and southeast London was yet to be covered by new housing and factories. With the benefit of his access to trenches and tunnels, a modern geologist, armed with state-of-the-art geophysical equipment, would be hard pressed to achieve Mylne’s detail. Mylne was invited to join the Committee of the Geological Society set to revise and update the Society’s Geology Map of England and Wales, initiated by Greenhough and then in its third edition. Elected a Fellow of the Royal Society in 1860, he remained a Fellow of the Geological Society until his death in Amwell, Hertfordshire, in 1890.

Geological map of Nottingham

All the above is preamble to drawing attention to similar geological awakenings in Nottingham at about the same time. With a great similarity to the work just mentioned by “engineers” in London, Arthur Brown, Borough Engineer, and Frederick Jackson, Civil Engineer, produced a very clear map, which they entitled *Plan of the Borough of Nottingham showing surface levels by contour lines and geological formation* (see back cover of this journal). The map is at the unusual scale of $3^{1}/_{3}$ inches to the mile, with the scale divided into chains and yards. We are told that “the geological features are from the ordnance plan, re-surveyed and amended in detail by J. Shipman of Nottingham and approved by W. Talbot Aveline FGS &c”. The map was published as an appendix to the *Report of the Health Committee of the Corporation of Nottingham, 1882*. It was referred to in a description of the sanitary conditions of Nottingham, where another map showed the distribution of deaths by diarrhoea and dysentry (257 out of a total of 4588 deaths in 1882, with two more deaths from cholera).

The map is undated, but is much earlier than 1882. The base map of the streets of Nottingham dates to around 1850, and is one of various maps prepared at the behest of Jackson around that time. The geology is straight from the Geological Survey, and almost matches that on the One-inch Sheet 126 until the new 1:50,000 appeared in 1996 after the resurvey by Messrs Howard, Ambrose, Charlesley and Brandon. Aveline was the field mapping officer of the Survey at the time, while Shipman was assistant editor of the Nottingham Daily Press, “an exhaustive worker on Nottingham geology, and was always on hand at any temporary exposure” (Morrell & Sarjeant, 1964). Much of his data would have gone into publications of the Nottingham Naturalists’ Society, but much may have found reached this map of the Borough Engineer.

Like the Mylne map of London, the Nottingham map is contoured at an interval of 30 feet, giving a good impression of the topography that is trenched by the River Leen and by the Daybrook Stream. Bold print records clearly the district names and the plots that would be important to a Borough Engineer. These include the Union Workhouse, the Lunatic Asylum, cemeteries and burial grounds, the gasworks, Sanitary Wharf(s), reservoirs at Belle Vue and Bagthorpe, the prison and the original University.

The geology offers coverage mainly within the Permian and Triassic succession. The name Triassic does not appear in the legend of the map's key, but its Bunter and Keuper are bracketed as New Red Sandstone (though this excludes the Permian red beds). Lithological comments on superficial deposits are scattered across the map, so that there are "drift clay, sand and pebbles" and "drift clay and quartzite and magnesian limestone pebbles" at Radford Woodhouse. Several quarries are marked in Bulwell, along with two brick yards and a large brick works. It would have been the business of the Borough Engineer to have the fullest awareness of what was where as the city expanded. Strangely, however, there is no note of the sand mines and sandstone caves for which central Nottingham has become well known. Cave cellars beneath individual houses were probably never recorded. Rouse's sand mine on Mansfield Road was probably sealed off, lost and forgotten in the 1850s, but it is surprising that there is no mention of the mines and quarries between Mansfield Road and the Forest. The Park Tunnel must have offered a wonderful new exposure when it was being excavated at about this time, but it was opened in 1855, so could just post-date this map. But details of the sandstone do seem to be a remarkable omission from this record of geology in the East Midlands.

A Nottingham geologist abroad

The other local government officer-geologist of whom Nottingham can be justly proud is Felix Oswald (1855-1958), who in his life did several adventurous things, mainly climbing and mapping in the Caucasus Mountains of Armenia in the last years of Queen Victoria's reign. He entered the Civil Service with a BA degree of the University of London when that was possible as an external degree, possibly taken in Nottingham. On his own initiative and inclination he studied botany, geology and zoology, and he achieved a BSc to add to his first degree. His geology was serious, as we find him providing coloured illustrations of rocks in thin section for Teall's *British Petrography*, the standard for petrological descriptions until Hatch and Wells' textbook came along (with the pen-and-ink drawings that we all copied for style).

It was his interest in rocks which took Oswald to Armenia in 1898 with the traveller H.F.B. Lynch. Later, he went in company with Douglas Freshfield to make mountaineering first ascents, including parts of the formidable volcano Nimrud. Those climbs saw them making their own geological maps, having previously completed the topgraphical surveys. Their map was presented at a meeting of the Geological Society in London in 1906 and was part of the reason for his gaining a DSc of London University.

His privately printed book, *The Geology of Armenia*, summarising his several expeditions in the company of Freshfield, won him the Murchison Fund of the Geological Society for 1907, their Centenary Year. A copy of the map of Armenia was deposited with the Geologists' Association Library before the First World War, was seen in the 1950s, but sadly was lost in flooding of the store at a later date. It would be interesting to learn whether other copies survive in collections in Nottingham.

Oswald's work overseas, which extended to East Africa before the outbreak of the 1914-1918 war, was all undertaken while he held the post of Probate Officer for the East Midlands, which saw him living in Nottingham up to his retirement in 1926. He collected fossils from the Tertiary clays of the Kavirondo Gulf in Kenya, combining with specialists from the British Museum in their description in the Quarterly Journal of the Geological Society in 1914 (Volume 70, pp 128-162). Domestic duties were suspended in 1914 to allow him to return to the Caucasus on behalf of the pre-Revolution Government of Russia to lead the search for oil inland from the producing fields along the Caspian shore. At this time, Professor Serge Tomkeieff, later of Armstrong College in Newcastle (later King's College), was also engaged by the British Government as a liaison between this country and the interim administration.

To Tomkeieff, Oswald was a first rate geologist, with a good grasp of that part of the mountains. Oswald clearly fits the image of the polymath, living up fully to that role with the detachment which characterises scientists of that era. Having achieved completion of work in one field, he turned to meet the challenge of something quite different. His early fascination with petrology became an attention to palaeontology. In his later years in the East Midlands, a continuing interest in geology was eventually part displaced by serious studies of the archeology of the Roman Fosse Way; and this took his name into recognition in the files of the Society of Antiquaries, probably allowing him to fulfil his Probate duties more assiduously. Local Government and the Civil Service must have been more lenient at those times, but in the process, allowed a talent just a little less than that of Sorby to blossom. Add the contribution of Douglas Freshfield, and Nottingham was making a significant contribution to British science at the beginning of the last century.

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Eric Robinson

HOLIDAY GEOLOGY

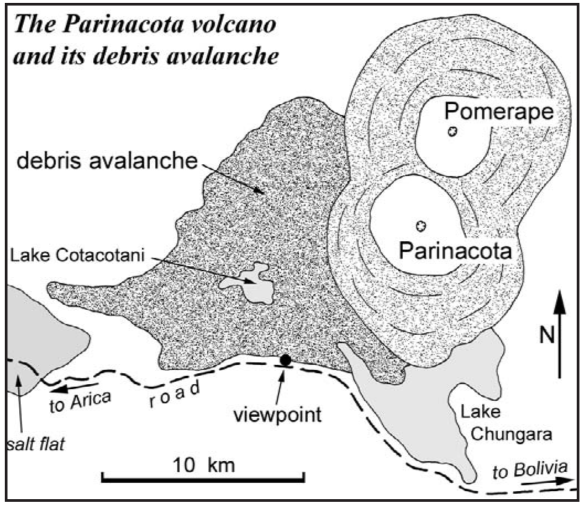
Parinacota, Chile

Where the crest of the High Andes is sandwiched between the altiplano and the Atacama Desert, travellers have a plethora of geological splendours that are beautifully exposed with little or none of the vegetation that is such an inconvenience in regions of more temperate climate. One of the many highlights is the Parque Nacional Lauca in the northern tip of Chile - where Parinacota and Pomerape are lovely volcanic cones astride the Bolivian frontier. And Parinacota is worth the entire journey, just to see its debris avalanche.

Until 1980, the scale, processes and significance of lateral collapses of andesitic and dacitic volcanoes had not been widely appreciated. But then Mt St Helens erupted, and the full story of the flank collapse, the debris avalanche and the lateral blast was revealed. The same had happened on Bezymianny just 24 years previously, but nobody saw much of that in the remote wilderness of Kamchatka. But then prehistoric debris avalanches were recognised below explosive volcanoes all over the world, and the process was seen as a recurring and major feature in volcano evolution.

Parinacota has one of the finest debris avalanches anywhere. It is a beautiful volcano with a snow-capped cone that rises to 6348 m. But the entire cone, that stands 1700 m above the surrounding highlands, is Holocene. An even larger predecessor on the same spot collapsed about 8000 years ago. Its western side failed completely - to produce a massive debris avalanche that swept down and away to the west. Over 6 km^3 of rock debris were spread out over 156 km^2 of land, with a maximum run-out of 23 km. The head-scar of this giant landslide is buried beneath the later volcanic cone, but the debris is hugely impressive. Within it, hills up to 400 m across and 80 m high are single blocks of rock that came off the original volcanic edifice. The rest is a chaos of rubble - that the guidebooks describe merely as lava rubble; it may be all lava and tephra, but the best thing about it is how it got there in a truly fantastic landslide event. When the huge debris slide filled a valley, the shimmering Chungara Lake was impounded just to the south. Its waters still filter out through the permeable debris, on their way feeding the Lakes of Cotacotani stranded in hollows in the centre of the debris.

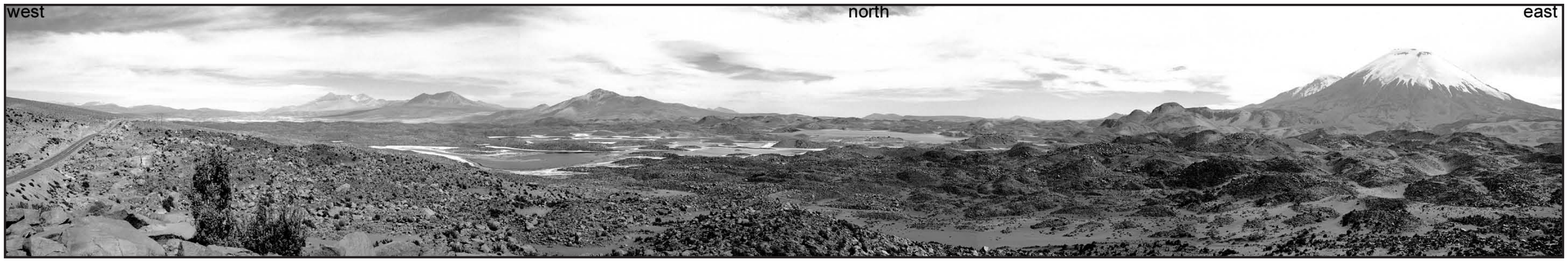
There are a host of flank-collapse debris avalanches spread below the Andean volcanoes. The largest is beneath Sotocompa, and this extends to over 600 km^2, but it lies on a remote section of the Chile-Argentina border.



The Parinacota volcano and its debris avalanche

Parinacota is smaller, but it is so very accessible - right beside the main road from Arica to La Paz. The view from that road (the panoramic photograph below) is awe-inspiring. Every feature of a giant debris avalanche that you could ever hope to see is laid out in front of you. This is geology big-time. So call by the lovely coastal town of Arica, rent a car, drive inland through the incredibly barren Atacama, and just go for Parinacota - or stay overnight in Putre, and view the volcano and its splendid debris in early morning light.

Tony Waltham



salt flat *distal avalanche* *avalanche blocks* *Pomerape* *Parinacota*

road to Arica *Cotacotani Lakes* *main debris avalanche* *hummocky terrain of debris avalanche*

HOLIDAY REPORT

Fossil dwarf elephants on Tilos

The Greek island of Tilos is reached by tourists in three hours by ferry from Rhodes. Around 50,000 years ago, during a period when sea level in the Eastern Mediterranean was much lower, a number of African elephants swam from what is now the Turkish mainland to the island of Tilos. Isolated there, they developed in to smaller creatures in response to the conditions on the island.

In 1971, Prof. Symeonidis from Athens University visited the island to investigate reports of human bones found in rocks on a beach near the capital of the island, Megalo Horio. He was told of bones in the nearby Harkadio Cave, since when, ongoing digs each summer by staff and students of Athens University have revealed partial and damaged skeletons of over forty elephants. These have a maximum height of 1.5 m, compared to the normal height of an African elephant of 4.0 m.

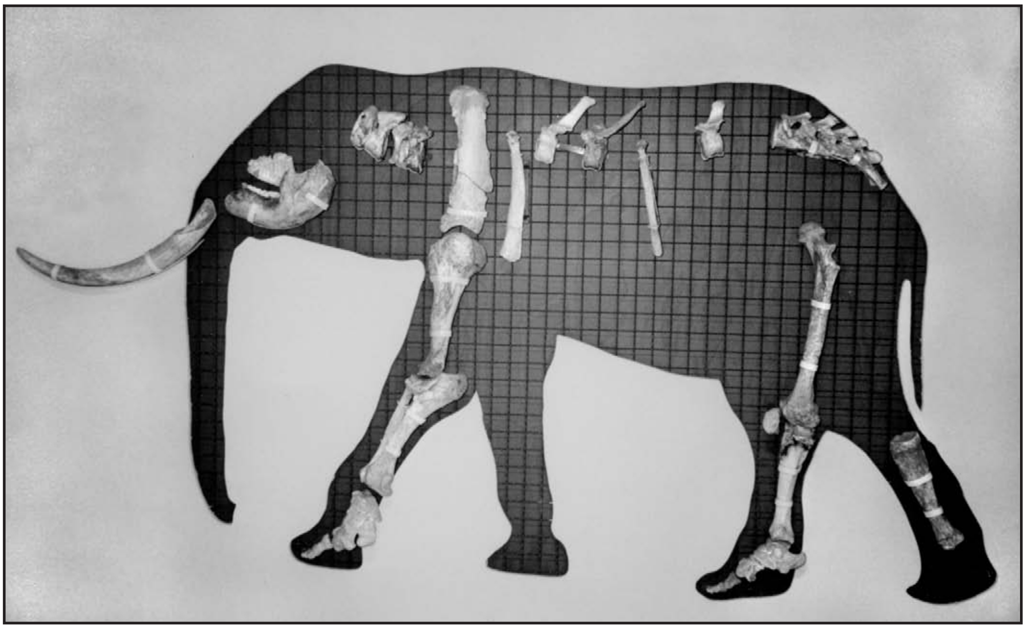
The Harkadio Cave can only be visited if the geologists are present, but in nearby Megalo Horio there is a small museum under the Town Hall devoted to the finds from the Elephant Cave. It is opened by request at the Town Hall, when Vicky will enthusiastically give a guided tour of the museum and its exhibits providing an English translation of the Greek text. If time is available she will follow this up with a tour of the adjacent Church and give a talk on the history of the island from the Neolithic to the present day. Most of the bones have been taken to Athens University for study but the partial skeletons of one adult and one juvenile are imaginatively displayed along with information about the finds and background. A purpose-built museum is under construction adjacent to the cave, and it is hoped that more of the material in Athens will be brought back to the island when this is opened.

It is thought that the elephants were sheltering in the cave when a roof collapsed, probably due to an earthquake, and killed them around 3000-4000 years ago. Their remains were then buried by a deposit of pumice erupted from the neighbouring island of Nysiros. The eruption and earthquake events could well have been connected. It is surmised that the loss of a part of the elephant population, possibly including the matriarchs, resulted in the colony becoming extinct. However, there is evidence that man worked the bones at the same time, so human involvement in the extinction of the elephants has not been ruled out.

The geology of the island appears to be limestone unconformably over volcanics, all now very strongly folded. The limestone is metamorphosed and altered, with crystalline bands following the bedding, and much of both the limestone and its veins are bright red. There are some local drift deposits of pumice that is thought to have come from an eruption on Nysiros about 8000BC. Soils filling voids in the limestones are bright red, and similar material containing limestone blocks is being exposed in ravines re-excavated by modern streams. The writer would like to know more about the geology of this fascinating island.

Tilos is very small and quite mountainous, rising to 651 m. It is unusually green and well watered for an island in the Aegean. In spring there is a wealth of wild flowers and abundant birds. With a little help from the island bus it can be thoroughly walked using old donkey paths in about a week.

Alan Filmer



Fossil bones of the dwarf elephant that have been recovered from the Harkadio Cave on Tilos.

EXCURSION

Bradley Fen Brick Pit, Whittlesey

Leader: Neil Turner (Nottingham Natural History Museum, Wollaton Hall)

Sunday, 1st June, 2003

An interesting day was spent looking for fossils in the Middle Jurassic Oxford Clay at Bradley Fen Brick Pit (NGR: TL237979) followed by a visit to the geology displays at Peterborough Museum that include marine reptile skeletons from the brick pits. Bradley Fen Pit is the only site still working for brick clay in the Peterborough area, and is run by Hanson Brick. We were very grateful to Chris Boyles, the Works Manager, who came along on the day and gave us access to the site. We were also grateful to members of the Stamford and District Geological Society who came to the brick pit and then later, at Peterborough Museum, talked about the fossil finds in the Peterborough area over the years.

Due to the unstable nature of the Oxford Clay, we could not collect safely from the steep quarry faces, but there were numerous piles of clay spoil all over the quarry floor that were rich in fossils and where we were able to collect. After an initial threat of rain as we arrived, the weather was fine and dry for the rest of the day. Many invertebrate fossils were found in the brick pit, including ammonites, particularly Kosmoceratids, belemnites and bivalves. A few recovered vertebrate fossils included two vertebrae thought to be of the marine crocodile, *Steneosaurus*. Peterborough is famous for its brick - making industry, and many brick pits have been dug to extract the clay since late Victorian times. Many fossils have been found over the years, and a belemnite brought along from the Nottingham Natural History Museum's collections was just like those being found on the day, but had been collected from a brick pit at Whittlesey 100 years beforehand.

After we had searched for and found numerous fossils, even though a complete and well-preserved crocodile skeleton still eluded us, we made our way to Peterborough Museum to view their informative display of the geology of the Peterborough area on the First Floor. This includes large skeletons of Middle Jurassic marine reptiles like *Steneosaurus,* with which we were able to compare the vertebrae that we had just found at Bradley Fen, *Cryptoclidus eurymerus* and *Opthalmosaurus*. Also, on display was the small pliosaur, *Pachycostasaurus dawni*, that could be seen to have thickening of the rib cage and vertebrae, and is thought to be a benthic-feeding carnivore (Cruickshank et al, 1996). The museum's geology exhibits have already been described in the *Mercian Geologist* (Dawn, 1997). After we had looked at the displays we were shown the geology workshop by members of the Stamford and District Geological Society where, among other things, they make casts of fossils for sale in the museum shop. The day was a great success, made the more interesting by the help we received from everyone involved.

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Collecting from the Oxford Clay at Bradley Fen Brick Pit, between Peterborough and Whittlesey

EXCURSION

Lincolnshire Wolds

Leader: John Aram
Sunday 6th July 2003

Morning worshippers leaving West Keal church on this summer Sunday found their car-park occupied by more than twenty members of the Society and their leader, John Aram, at the start of their day in the Lincolnshire Wolds. The unusual location was used to examine the local Spilsby Sandstone used in the construction of the church, and to enjoy the view over the fenlands to the south of the Wolds.

The poorly cemented, greenish coloured, badly weathered stone of the church exterior was contrasted with the less weathered stone inside the porch, where it showed blue and brown mottling with fossil bivalves clearly preserved. The small grains of green glauconite that are characteristic of the Spilsby Sandstone proved difficult to find, even with the aid of a hand-lens. Traditionally this sandstone has been considered as Cretaceous in age, but detailed studies of the fossil content have shown that it crosses the Jurassic to Cretaceous boundary.

From the edge of the churchyard the steep slope covered with soliflucted and down-washed weathered sandstone concealed the unconformity between the Spilsby Sandstone and the underlying Kimmeridge Clay. To the south, Boston Stump could be seen, with the route of the main road towards it following the slightly higher ridge of the clay-rich Stickney moraine (which separates the lower, flatter East and West Fens on silts and peats to either side). The moraine is an important marker of the southern inland limit of the last ice-sheet that passed down the eastern side of the Lincolnshire Wolds, into the Wash embayment and across to North Norfolk during the Devensian.

From West Keal, the route north crossed a dissected upland with reddish sandy soils developed on the Spilsby Sandstone, with clay-floored valleys where streams had cut through to the underlying Kimmeridge Clay. A few of the higher areas had a capping of very chalky till, remnants of a more widespread glaciation prior to the Devensian, when ice completely covered the Wolds.

The excursion continued to the Snipedales Country Park and Lincolnshire Wildlife Trust Nature Reserve. The opportunity was taken to inspect a small exposure of Spilsby Sandstone in the valley side, where its rapid rate of weathering was readily appreciated, while its permeability was illustrated by seepages and springs at the junction with the impermeable Kimmeridge Clay of the valley floor. The main valley has a west to east orientation and is asymmetric in cross-section. Earlier investigations by students have shown that the shorter, steeper slopes occur on the north-facing side of the valley, while the opposite slopes were longer and less steep. Auger holes across the valley revealed a much greater depth of weathered material below the soil on the south facing slopes in comparison with that on the opposite sides. It is suggested that this contrast was initiated during a period of severe climate when there was little or no cover of soil or vegetation. South-facing slopes thawed out and froze again more frequently than those in the shadow on the north facing side, hence slope processes were more active and slopes receded more rapidly on that side.

After lunch, the excursion continued northwards, climbing the scarp of the Chalk at Tetford, before turning northwest along the Bluestone Heath road. A short stop was made in a scenic lay-by with a geological interpretation board; this was an opportune reminder that the Lincolnshire Wolds is designated as an Area of Outstanding Natural Beauty, and that much of its distinctiveness arises from its varied geological framework.

Pleistocene till exposed at Welton on the Wolds.

The next stop was the Lincolnshire Wildlife Trust Reserve at the appropriately named Red Hill, where the Red Chalk occurs at the base of the White Chalk. Beneath the Red Chalk the under-lying Carstone could also be identified in the sides and floor of a narrow sunken footpath. Fossils weathered out of the Red Chalk were found in the scree below the exposure; specimens found included brachiopods, the characteristic small belemnite *Neohibolites minimus*, sponges, burrows and other trace fossils. The possible causes of the red colouring were discussed, the older explanation of lateritic soils being compared with the more recent theory that it derived from the 'red-beds' in the North Sea Basin, where Permo-Triassic beds had been exposed by erosion by the Upper Cretaceous.

The day ended with a guided tour of part of a geological SSSI in a former sand and gravel pit at Welton Le Wold, near Louth. A section in glacial tills above the gravels was available for study, having been cleared of vegetation and weathering debris in 2001, with the aid of Facelift funding from English Nature. The significance of the site related to the discovery between 1969 and 1972, by Chris Alabaster and Allan Straw of both large mammal remains and flint hand-axes in a stratified context in the gravels. The finds include the teeth and tusks of *Palaeoloxodon antiquus* (straight-tusked elephant), while the hand-axes were recognised as of Acheulian type.

Details of the Welton finds were published in the Proceedings of the Yorkshire Geological Society in 1976, where the gravels were given a suggested Hoxnian age, with the overlying tills allocated to the Wolstonian glaciation. Since then, the Midlands type site for the Wolstonian has been discredited, with the suggestion that there are no Wolstonian glacial deposits on-shore in Britain, where glacial tills are either Anglian or Devensian in age. The lower tills at Welton then become an anomaly since they are overlain by Devensian tills to the east, but must be younger than the gravels containing the human artefacts. Archaeological records of the presence of hominids in Britain during interglacial periods have also now been revised as a result of studying sites in East Anglia. If the lower tills at Welton are Anglian, then there is evidence of humans in Lincolnshire before half a million years ago. In 2003, Heritage Lincolnshire were successful in their bid to English Heritage for Aggregate Levy Sustainability Funds for a re-analysis of the artefacts and mammal remains from this site, and for a short programme of boreholes to obtain samples of the gravels from ground adjacent to the back-filled area in the former quarry. Discussion at this site in particular benefited greatly from the observations and contributions of Society members.

Footnote. Eleven boreholes were drilled at Welton shortly after this excursion took place, and a report of the findings for English Heritage is being collated by Heritage Lincolnshire. John Aram continues his investigation of the tills as part of a research degree at Royal Holloway, University of London.

REPORT

Palaeontological Association Meeting,

Geology Department, University of Leicester

The 2003 meeting of the Palaeontological Association was held in the Geology Department at Leicester University between the 14th and 17th of December, and was attended by well over 200 delegates, who arrived from all parts of the world. The talks were, as usual, wide-ranging, and are summarized as a series of abstracts on the Association's website (www.palass.org). Palaeontology, like all academic pursuits and many other things, is subject to the vagaries of fashion and at any one time there are many 'hot' themes buzzing around, but perhaps this was one of the most generalised meetings for some time, when anyone with something worthwhile to say had a chance to do so. Cladistics and phylogeny, which so polarise the palaeontological community, couldn't be left out of things of course, and on the Sunday before the main meeting began, there was a seminar on stem groups. That was well attended and the six talks provoked suitably lively debate.

As for the main programme on Monday and Tuesday, variety was proved yet again to be the spice of life, as talks ranged from the usefulness of Quaternary tree rings, via Miocene frogs, to more conventional subject matter such as brachiopods and a range of molluscs, and ending with the decidedly controversial topic of Ediacaran fossils and whether some or maybe all of them are just the creations of microbes. At the close of normal talks on the first day, delegates decamped to a larger lecture theatre to hear the Annual Address by Professor Mike Benton. I hope Mike will forgive the recollection, but it doesn't seem so very long ago that one of us (AS) first encountered an earnest but shy postgraduate on a mission. The mission may yet await full realisation, but the postgraduate has now blossomed into one of the most assured palaeontologists in this country, and the audience got full value on the topic of *Palaeontology and the future of life on Earth*. Those looking for East Midlands themes in the talks at the meeting were fated to be disappointed, but the Palaeobiology Group at Leicester University kept the EM flag flying by presenting a number of talks.

The Palaeontological Association Annual Dinner is one of the highlights of the year for those of us who spend our time amongst the life of the past, but rarely can details be revealed for fear of embarrassing eminent and respected palaeontologists. However, 2003's event was another splendid 'do' and can the cleaners really have been surprised to encounter people still in the bar when they came in to do their morning stint on Tuesday?

On the final day of the meeting, Helen Boynton and John Carney led a field excursion to two of the internationally famous Precambrian fossil localities of Charnwood Forest. Participants appreciated the weather, which was freezing but sunny, and many still savour the memory of the double-decker bus-ride through this very distinctive part of Leicestershire.

At the first stop, the 65 members of the field party warmed up with a march to the summit of Ives Head, on the fringe of Charnwood Forest just south of Shepshed. It is doubtful whether so many people had been assembled here before (see group photo), and their presence was fully justified because the Ives Head fossil impressions are the oldest to be seen in Charnwood Forest and may yet prove to be the earliest examples of organised Life on this planet. The fossils occur on a bedding plane in strata of the Ives Head Formation (Blackbrook Group), and the delegates saw several bold impressions, which were ideally highlighted in the oblique rays of the midwinter sun. Helen Boynton discovered these forms and described them in recent issues of the *Mercian Geologist* (Vol. 13, 165-183; Vol.14, 2-3 and 197-201). They include the lobed form *Ivesheadia lobata*, an impression with a combination of lobes and segments named *Blackbrookia oaksi*, and a palmate form *Shepshedia palmata.* There was much debate among the delegates concerning the affinities of these impressions – do they, like certain other Charnian fossils, represent primitive medusoids, are they microbial colonies, or are they a form of Precambrian life that has yet to be recognised and categorised? Perhaps there will always be speculation about their origins and the last word is best left to one expert from Canada, who described them as 'beautiful and bewildering'.

After a pub lunch in Newtown Linford, the party entered Bradgate Park at Hunt's Hill and made their way up to the spectacularly fossiliferous exposure at the Memorial Crag. Here, the fossil impressions occur on a bedding plane just above the Sliding Stone Breccia, at the base of the Bradgate Formation, some 2 kilometres higher in the Charnian sequence than the Ives Head fossil bed. Many of these fossils (see *Mercian Geologist* Vol. 13, 165-183) are typical of the latest Precambrian Ediacaran assemblage that has been recognised worldwide, in that they contain discs and also many *Charnia* fronds, including one form, *Charnia grandis*, that may have been a metre in length. Helen also pointed out an extremely small example of *Charniodiscus concentricus,* only 15 mm long. Other impressions, consisting of complex bundles of fronds with a central disc (*Bradgatia linfordensis),* have not been recognised elsewhere in the World and they underline the uniqueness of the Charnwood Forest occurrences – and the need for them to be investigated further. The fossils at Memorial Crag are best seen in low, oblique sunlight and as the sun set, the party was treated to one of the best views ever seen of these vastly important fossils, a scene which generated real excitement.

Late in the afternoon, the group descended from the Old John Tower in the gathering gloom, over ground that was rapidly hardening. Many will have been introduced to a totally new type of palaeontology, involving species at the very start of organised life, that belong to no obvious or long-lived evolutionary tree, and which are in many cases only faintly visible under certain lighting conditions. A Field Excursion Guide on the day's outing is available from the British Geological Survey (Boynton and Carney, 2003: BGS Occasional Publication, No.3).

John Carney and Andrew Swift

Cold day on Charnwood for the PalAss field trip

LECTURE

The geology of bottled water

Summary of the lecture presented to the Society on Saturday 11th January 2004 by Prof. John Mather of Royal Holloway, London University.

As a hydrogeologist, I am often asked about the benefits of drinking bottled water rather than water drawn directly from the kitchen tap. Apart from the fact that the smell of residual chlorine is absent from bottled waters, is it worth either the money or the effort to stock up with water at the supermarket?

Most bottled waters are marketed in the UK as "Natural Mineral Water" or "Spring Water", the use of both names being regulated by the European Commission. A "Natural Mineral Water" is defined as a microbiologically wholesome water, originating in an underground water table or deposit and emerging from a spring tapped at one or more natural or borehole exits. It must be clearly distinguishable from ordinary drinking water by its nature and original state. Both these latter characteristics will have been preserved because of the underground origin of the water, which has protected it from all risks of pollution. In other words a "Natural Mineral Water" is an untreated groundwater. A "Spring Water" comes from a source which has either not applied for recognition as a "Natural Mineral Water" or does not meet the conditions laid down. However, regardless of this it is likely to satisfy the requirements of the regulations which cover the quality of public water supplies. Again a "Spring Water" will be groundwater but might have been treated in some way. Waters marketed with neither of these titles may, for example, be desalinated waters or waters derived from Canadian glaciers, however, most of the bottled waters available in Britain originated as groundwater.

The ultimate source of most groundwater is atmospheric precipitation, rain and snow melt, although deep groundwater may reflect contributions from other sources such as fluid inclusions or formation waters. Much of the chemical character of groundwater is then established within the soil and the unsaturated zone, above the water table. Although there may be little change in total mineralization within the saturated zone, below the water table, it is here that exchange reactions and other processes slowly modify groundwater chemistry.

The composition of rainfall is controlled by the dissolution of atmospheric gases, particularly oxygen and carbon dioxide and by the wash-out of components derived from the sea, land and pollution sources. Thus rain is essentially a dilute solution of carbonic acid and a sea-salt aerosol, plus a variable mixture of sulphuric, nitric and hydrochloric acids. The acidic rainwater has low dissolved solids and rapidly dissolves carbon dioxide which occurs in the soil as a result of root and microbial respiration and the oxidation of organic matter. The carbon dioxide-charged water is very effective in dissolving minerals. The most common reaction involves the dissolution of calcite. Where there are no carbonates, the chemistry will be controlled by the dissolution of silicate and aluminosilicate minerals, but these are relatively insoluble. Minerals such as gypsum are also dissolved, and pyrite is oxidized to introduce sulphate into the groundwater system.

Within the saturated zone, if groundwater is not yet in equilibrium with carbonate, silica and aluminosilicate minerals, these will continue to dissolve, proceeding towards equilibrium with those minerals available for dissolution. Soluble salts such as halite will dissolve, and a sequence of redox reactions will occur along the flow system. The latter control the hydrochemistry of metals such as iron and manganese and carbon, nitrogen and sulphur species. Cation exchange reactions occur, the most important of which are those taking calcium out of solution and replacing it by sodium, reducing the hardness of water. The sodium generally comes from exchangeable sodium held within clay minerals.

The natural chemistry can be masked by impacts from urban and industrial developments and modern intensive agriculture. The latter is responsible for the major increase in nitrate concentrations seen in many groundwaters over the last three decades.

It is clear from the above that groundwater achieves its composition through a number of interacting factors. However, certain geochemical characteristics, such as the magnesium/calcium ratio, will be determined by the host rock; chloride concentrations may be controlled by atmospheric inputs, and sulphate and nitrate concentrations by man's activities. An understanding of these various factors enables the hydrogeologist to unravel the geochemistry of a bottled water and say something about its origin.

Waters derived from upland springs, including those in Cumbria or Dartmoor, have relatively short flow paths and there is little opportunity for water/rock interaction to occur. In consequence, such waters are low in dissolved solids and are often close to rainwater in composition. Waters from limestone terrains generally have high bicarbonate and calcium concentrations and are simply rainwater that has dissolved the host limestone. Elevated nitrate concentrations in such waters show that their source is intensively farmed agricultural land. Waters derived from tuffs and lavas in the Scottish Midland Valley have higher concentrations of magnesium and lower concentrations of bicarbonate. In these areas, rainfall has dissolved aluminosilicate minerals rather than carbonates. Some waters, such as those from Buxton, contain no nitrate suggesting that they have a deep-seated origin. In the East Midlands, the waters at Woodhall Spa contain ammonia and are highly mineralized, suggesting that they are old groundwaters with a long flowpath and plenty of time for extensive water/rock interaction to occur.

In Britain, bottled water is drunk because it is thought to be better or “safer” to drink than tap water. However, this is not the case in many overseas countries, where bottled water is often consumed because of its medicinal properties. Many of these waters are high in dissolved solids and have diuretic properties. Consequently, British holiday-makers travelling abroad need to be careful to buy bottled waters that are comparable with the water they drink at home, otherwise problems may ensue.

The question posed at the beginning of this summary was whether or not it was worth buying bottled water? Certainly if your local supply is over-chlorinated, or if the water smells musty (because of algae growing in your storage tanks), it is probably worth buying water for drinking or for diluting that after-dinner glass of whisky. However, in most cases the bottled water is unlikely to be any improvement on your local supply, and certainly no safer.

LECTURE

William Smith (1769-1839) and the search for raw materials 1800-1820

Lecture presented to the Society on Saturday 13th December 2003 by Prof. Hugh Torrens of Keele University.

This lecture, recounting Smith’s career as a canal engineer, land and mineral surveyor, cartographer and geologist, was originally presented as the Geological Society’s William Smith Lecture for 2000. As such, it can be read in the Geological Society Special Publication 190 (2001) *The Age of the Earth: from 4004BC to AD2002* (pp. 61-83). It also appears as supplementary material (pp. 153-192) in the Bath Royal Literary and Scientific Institution’s 2003 reprint of John Phillips’ 1844 *Memoirs of William Smith, LL.D.* This reprint, which also includes an *Introduction to the Life and Times of William Smith* especially written by the speaker (pp.xi-xxviii), was published in a limited edition of 600 copies (ISBN 0 9544 9410 5). It is not available from bookshops, but a few copies may still be available at a cost of £15 (+ p & p); enquiries should be directed to the Bath Royal Literary and Scientific Institution, 16 Queen Square, Bath BA1 2HN, or by phoning 01225 312084.

LECTURE

Life and work of Alfred Wegener

Summary of the lecture presented to the Society on Saturday 3rd April 2004 by Dr Clare Dudman, freelance author.

In 1968, J. Tuzo Wilson declared that the recent revolution in geology should be called the Wegenerian revolution in honour of its chief proponent, Alfred Wegener. Yet Alfred Wegener remains little known, in spite of having a surprisingly full life of geographical and scientific discovery.

Alfred Wegener was born in 1880 in Berlin. He was the youngest of five children, two of whom died before adulthood. At eighteen, he entered the Friedrichs-Wilhelms University in Berlin to study science, graduating with highest honours with his dissertation on the astronomical Alfonsine tables. He then joined his older brother Kurt as an assistant at the Prussian Aeronautical Laboratory. His work was to examine the nature of the atmosphere and this led to the brothers staying aloft for 52.5 hours in a hydrogen balloon, which was then a world record.

As a result, Alfred was asked to go on a Danish expedition to Greenland as meteorologist in 1906. The expedition lasted two years, and Wegener helped map the northeast coast, took the first colour photographs on an expedition and took various innovative photographs of arctic mirages and ice. Significant was his expedition to Sabine island, an island off the coast of East Greenland, where he measured the longitude and found that it appeared to be rather more to the west than where it had been recorded about 40 years previously.

On his return to Germany he became a private lecturer in Marburg, on astronomy, meteorology and cosmic physics. In 1908 he gave a lecture at Hamburg and met his future wife Else Köppen in the audience. He then wrote *Thermodynamics of the atmosphere* (1911), in which he explained the now-accepted theory of rain drop formation in temperate latitudes.

At Christmas 1910, he noticed that the coastlines of Africa and South America interlocked, an idea which he at first dismissed, but a few months later was forced to reconsider, when he came across a compendium of fossils which listed the similarity of fossils of the Carboniferous in South Africa and Brazil. Rejecting the established theory of the time of land bridges, Alfred realised that a far better explanation was that the continents had once been joined and then had drifted apart. He was immediately convinced he was correct, and a few months later presented his ideas to the newly formed Frankfurt Geological Society. There was an immediate outcry, but by this time Wegener had already escaped to Greenland again.

In Wegener's 1912-13 expedition to Greenland, he became one of the first people to overwinter on the ice sheet, and the first to cross it from east to west with ponies. After almost losing their lives several times his team was rescued when almost starving to death.

He returned to marry Else in 1913 and then was almost immediately sent out to the trenches of the Great War. He was wounded twice, the last wound ensuring he was unfit for active service, and was also shell-shocked. He used his recuperation to revisit his idea of continental drift and wrote the first edition of *The Origins of the Continents and Ocean*. The rest of the war he spent as an itinerant meteorologist, also doing revolutionary work on meteorite impact craters on the earth and on the moon.

At the end of the war, in December 1918 he at last obtained his first permanent academic post by replacing his father-in-law, Vladimir Köppen, as a professor of meteorology at Hamburg. During his time there, he wrote two further editions of *The Origins of the Continents and Ocean*, incorporating new evidence, and also, with Köppen, wrote *The Climates of the Geological Past*, which showed how the map of the world looked in past geological ages. His books were translated, and so his ideas came to the attention of a wider audience, and caused yet more controversy and ridicule.

In 1924, the family (he now had three daughters) moved to Graz, where he became professor of meteorology and geophysics. Since he had now accumulated more evidence, he wrote the last edition of *The Origins of the Continents and Oceans*, and in 1926 his ideas were ridiculed at a New York meeting of the American Association of Petroleum Geologists. After this, interest in the theory died down and his work was disregarded. Further meteorological work was followed by two expeditions to Greenland (a preliminary in 1929 and the main one in 1930) to establish three scientific stations across the widest part of the ice sheet.

The last expedition was beset by delays. At the end of September Wegener decided to lead a final sledge party to supply the central station. He arrived at the end of October in atrocious conditions. A couple of days later he set off back to the coast with an Inuit companion called Rasmus. It was the last time anyone saw them alive.

The following summer, Wegener's body was found, sewn into his caribou sleeping bag by his Inuit companion and buried in the ice. It was supposed that he had died of heart failure. His Inuit companion was never found.

Following magnetic exploration of the oceanic floor Wegener's idea was revived in the 1950s and 1960s. But instead of the continents behaving like icebergs pushing through a sea of sima, as Wegener had proposed, it was now suggested that the Earths' crust consists of a small number of plates which constantly move against each other. In this way, Wegener's theory of Continental Drift evolved into the theory of Plate Tectonics.

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Rasmus Villunsen and Alfred Wegener ready to set off from Eismitte in the middle of the Greenland icesheet, in November 1930 - the last time anyone saw them alive. (Photo: Alfred Wegener Polar and Maritime Institute)

ESSAY REVIEW

Ecton Copper Deposits, Staffordshire

The recent publication of *Ecton Copper Mines under the Dukes of Devonshire 1760-1790* by Lindsey Porter (2004) has yet again raised the difficult question of the nature of this famous copper ore deposit, as well as throwing light on many related matters.

Four years ago the writer reviewed the geological settings of the mineral deposits throughout northeast Staffordshire (Ford, 2000) and summarized the state of knowledge of these deposits, which have been under water since mining ceased in 1856 at Ecton Mine and in 1889 at Clayton Mine. Each of these two mines worked a "pipe" of copper, lead and zinc minerals, in effect a vertical, roughly cylindrical ore-body. The term pipe is used at Ecton with a completely different meaning from its use in the rest of the South Pennine Orefield. In the latter a pipe is generally defined as an elongate orebody roughly parallel to the stratification and usually nearly horizontal, often centred on palaeokarstic features, or formed along the contacts of limestone with either dolomites or lavas. At Ecton, the pipes have a more or less vertical cross-cutting relationship to complexly folded strata, with no palaeokarst, dolomites or lavas involved. As no description of the deposits based on direct observation by a geologist is known, reliance has long been placed on the somewhat vague and incomplete accounts from the late 18th to middle 19th century.

Lindsey Porter's excellent book contains chapters on the geology and on contemporary visitors' accounts, with quotations from several writers including Banks (1767), Harpur (c.1767-1770), Efford (1769), Hatchet (1796), and Mawe (1802). While these were largely concerned with the experiences of the visitors, with mining methods or the minerals found, they included some observations on the geological setting - in the days before geology was established as a science. Taking these observations together with the much later contribution by Joseph Watson (1860), Porter has been able to deduce somewhat more about the nature of the deposits than my conclusions in 2000.

In short, Ecton Mine's "irregularly cylindrical" ore-body was worked over a vertical height of about 1400 feet (420 m), down to 300 m below river level, and the Clayton orebody was worked over a similar depth some 250 m to the south. Neither bottomed the stratigraphic sequence of Carboniferous Limestone beds. Most of the ores were hosted in the Ecton Limestones-with-Shales, but it seems likely that the workings penetrated the Milldale Limestones beneath.

The pipes were in or close to the ill-defined axis of the Ecton anticline (Prentice, 1952; Aitkenhead et al, 1985), though the 18th century writers did not recognize it as such. Indeed, an unsigned and undated section (shown as Figure 2.1 in Porter's book) shows the structure of the hill as a monocline facing east, though no evidence for such a structure is known. The anticline plunges northwards, so that the apparently regular sequence of limestone divisions dipping at about 20° south, as shown on some mid 19th century diagrams, is contrary to modern geological analysis. Instead, the incompetent nature of the mass of thin limestones with intervening shales overlying more massive limestones appears to have resulted in concertina-like and often discordant folding of the former on both flanks of the anticline. If these folded beds are regarded as lying on each side of a tight upfold, the pipes may in fact lie mostly within the Ecton Limestones-with-Shales, particularly with the tightly compressed core of the fold. The folded limestones are well seen in Apes Tor at the northern end of Ecton Hill, where they display north-south axes resulting from east-west compression. Equivalents to the Apes Tor folds are also visible in the presently accessible adits where the anticlines are generally some 10-20 m wide and high (Critchley, 1979). Critchley's diagram of the folds seen along Clayton adit (reproduced as Figure 5 in Ford, 2000) show that the western flank is almost flat-lying with tight upright folds only in the vicinity of the pipes. Some of these tight folds are visible in the walls of the Clayton Engine Chamber and are illustrated in photographs in Porter (2004) and Ford (2000).

In the only detailed discussion of the folds found so far, Watson (1860) referred to the anticlines as huckle saddles and the synclines as trough saddles. He noted the presence of double saddles. He also said that ores were present in saddle joints, i.e. axial fractures in both anticlines and synclines and also along the bedding forming "wings" on each side. While Watson provided a good description and a diagram, he unfortunately cited no specific localities, and it is not known whether he ever saw such structures in the Ecton pipe, as that began to fill with water four years before his paper was published. Saddles were, however, found in the Clayton and Good Hope Mines at Ecton, though no full description of their mineralization features is available. A saddle has also been found in Royledge Mine, some 5 km to the west; Watson may have projected ideas from these other examples to formulate a general idea for all the Ecton mines, but his paper is not clear on this matter. Lindsey Porter has suggested that if the axial joints in anticlines and synclines, i.e. huckle and trough joints, were aligned in the stack of eight groups of folds (see below) they would provide linked lines of weakness for the movement of mineralizing fluids.

Reading between the lines of Efford's, Hatchet's and Harpur's writings, Porter has deduced that there were eight arrangements or groups of saddles in the depths of Ecton pipe, each having been mined out to leave a succession of voids stacked on one another. The voids were recorded as "vaults", giving the

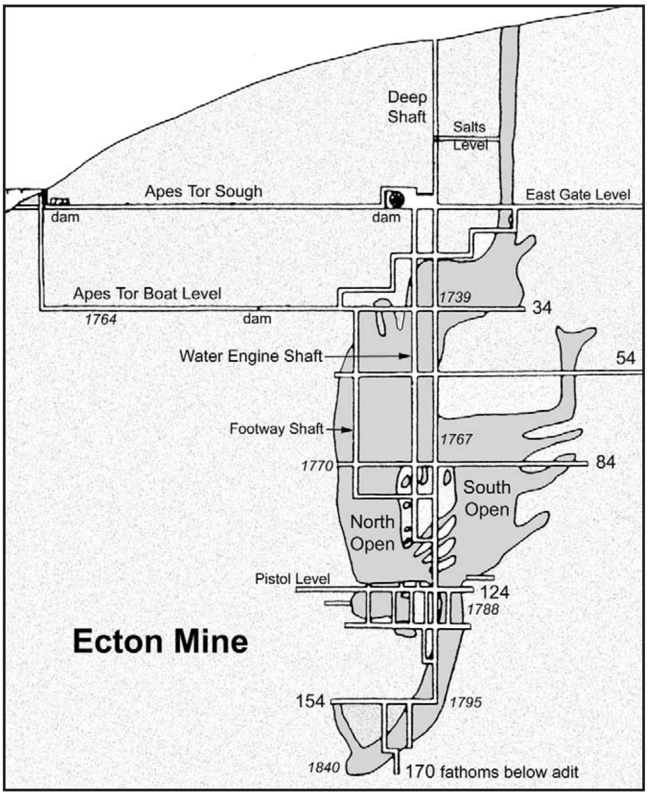

__Figure 1__. Diagrammatic section of the Ecton pipe, redrawn after a mid-19th century prospectus; numbers in the larger font indicate depths in fathoms below adit level at the Apes Tor Sough, and numbers in the smaller italic font indicate dates of the advancing workings.

misleading impression of natural caverns. Some saddles were said to be capped by "pipes" of the traditional Peak District type, but details are unknown. The "stacked voids" do not agree with the arrangement of "opens" in a mid-19th century prospectus diagram (Fig. 1). Only those parts of the mines at or above adit level, i.e. above the level of the River Manifold, are still accessible and details of the folding in some adits were admirably described by Critchley (1979), some of whose diagrams were reproduced in Ford (2000). The details of folds in other adits remain undescribed.

The pipe was noted to have been squinted in places, i.e. offset by faulting ("squatted", according to Watson, 1860), and the mineralized pipe was lost at the lowest levels perhaps by the same type of offsetting. Double saddles were mentioned in mid-19th century reports in the *Mining Journal*, apparently due to folds crossing at right-angles, though this seems strange in the tectonic regime of east-west compression. In the pipes the ores were found in large and small masses between limestone blocks of similar size, sometimes with clay admixtures. Structures known as "lums" were apparently similar aggregations of limestone blocks with much clay: a presumed example is visible today in the adit of the nearby Dale Mine that was worked for lead.

Clayton Mine was apparently of similar nature, but it was worked by a different company of adventurers (= shareholders) and no 18th century archives are known to have survived. A few mid-19th century diagrams were attached to company prospecti. Both the detailed nature of the deposit and the history of mining are poorly documented.

Though mining peaked with the Duke's activities of the late 18th century, there was a long history of previous mining. Indeed the discovery of an antler pick and hammer stones in old high level workings indicates that mining took place in Bronze Age times (Barnatt & Thomas, 1998). Specimens of copper ore collected in the 1690s are in the Woodwardian Collection of the Sedgwick Museum, Cambridge. The somewhat patchy early 18th century history was summarized by Barnatt (2002)

The overall impression gained is that the orebodies were large masses of mineralized crush-breccia developed in tight folds in the incompetent Ecton Limestones-with-Shales. Ore-fluid movement is likely to have been largely lateral, with an upward component, out of the Cheshire basin, as discussed by Ford (2000). There were several other pipes in the area (Ford, 2000; Porter & Robey, 2000) but none was exploited to anything like the same extent and none has been studied in modern times, and it may well be that there are further ore-deposits comparable with Ecton which have never been found.

Lindsey Porter's book gives a detailed account of this major mining enterprise in the late 18th century (much enlarged from Porter & Robey, 2000). Nominally conducted by successive Dukes of Devonshire, who were happy to receive the profits and spend them on various projects such as buildings in Buxton and at Chatsworth, the actual management was left to the agents, a few of whom Porter reveals to have been rather less than honest. The enterprise involved up to 300 miners, plus some of their wives, the latter mostly on surface ore-dressing, as well as their children. In an otherwise sparsely populated agricultural region, such a work-force drew in many immigrants, and it needed considerable back-up of housing, food and beer. Porter's analysis of thousands of documents in the Duke of Devonshire's archives at Chatsworth House has revealed the complexity of operations.

Most of the smelting was done at Whiston some 15 km to the southwest and this required teams of pack-horses and mules to transport the ore; these in turn required fodder, and tons of hay were required in winter to alternate with pasturage in summer, doubtless a considerable boost to local agricultural revenues. The Duke's agents minimized costs by building dedicated roadways to avoid paying tolls on turnpikes. Coal for the smelting furnaces was obtained from the Duke's own collieries near Whiston. Some coal was brought back to Ecton on the return journeys, for use in a steam winding engine, in smithies, lime burning, domestic heating and a limited amount of smelting of both copper and lead. Vast quantities of timber were needed both within the mine and for buildings outside, and woodlands were all but stripped for miles around. Great quantities of nails were obtained from forges in the Belper area. Machinery and other metal equipment also had to be brought in, sometimes necessitating teams of horses for heavy loads. Fluorspar was shipped in from the Matlock area for use as a flux in the smelting process. Clay was brought in from the Pocket Deposits (Brassington Formation) at Newhaven for use in water-proofing ponds and for lining furnaces; bricks were imported for building furnaces; the list goes on.

While copper was the main product, considerable quantities of lead ore were raised. As Ecton was outside the main orefield, it had no Barmaster and no lead records were made. Zinc ore was obtained too, but its use in brass-manufacture was largely a 19th century phenomenon and the 18th century miners took little note of it. The marketing of these different ores was a complex business, and several clerks were employed dealing with wages, merchants, supplies and shipping. It is their records which have provided such a mine of information on what was one of the largest mining operations in Europe in its day.

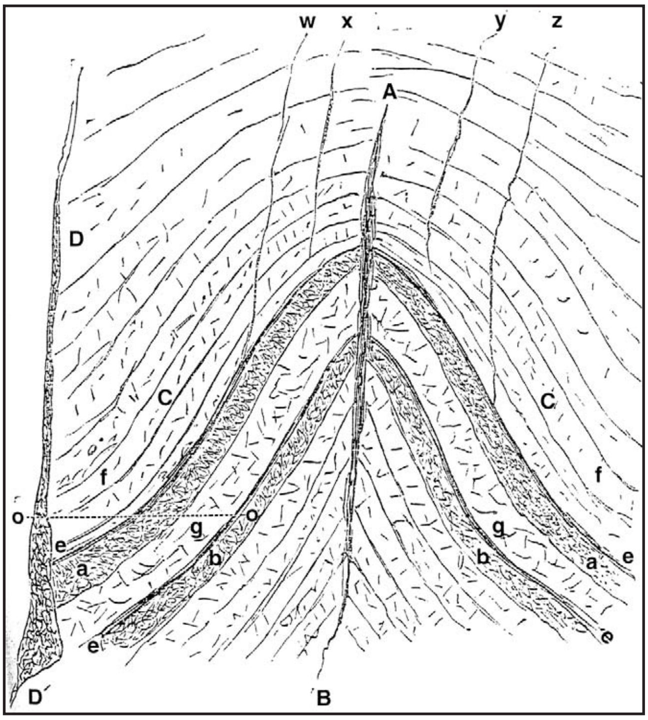

***Figure 2**. Joseph Watson's 1860 diagram of a saddle (reproduced from Porter, 2004, page 21). A is the crown or huckle of a saddle; A-B is the saddle joint; C and C are the wings; D-D is a trough joint, usually more productive of ore than a saddle joint; w, x, y and z mark fissures, which ran up to a pipe vein; f and f are troughs rich in ore, particularly at a and a; e and e are soft decomposed limestone, taken to be guides to ore; o-o marked a cross-cut to reach the wings and troughs.*

In recent years part of Ecton Mine has been developed as an educational resource by Geoff Cox, and it is to be hoped that this arrangement will continue after his recent death. It is also to be hoped that someday a research grant will make it possible to pump out the flooded workings and see those geological details which have been hidden for nearly two centuries.

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REVIEW

An atlas of Carboniferous basin evolution in northern England. A J Fraser and R L Gawthorpe, 2003. Geological Society, London, Memoir 28. 96 pp large format, ISBN 1 86 239135 1, £55.

Traditional accounts of the Carboniferous of Northern England (ie north of Leicester) have commonly relied on the integration of surface geological studies with deep borehole data. However, within the last 20 years or so, our understanding of these strata has been extended into the subsurface dimension by a number of articles that link the borehole evidence into a vast network of seismic reflection profiles. These were created as a culmination of 70 years of exploration that has resulted in the discovery of 75 million barrels of recoverable oil reserves in Northern England. The authors have been at the forefront of the most recent work, and in this atlas they present a 'unique collection of onshore seismic data', mainly derived from the now-fragmented seismic database of British Petroleum. This is amply supplemented by interpretations, to produce a highly readable account of the complex interplay between plate tectonics, sedimentation and structure through Carboniferous time.

The layout of this atlas takes into account the needs of 'browsers', and of those who wish to build up their knowledge step-by step. Following the Introduction, Chapter 2 discusses the regional structural framework, commencing with a synthesis of the Precambrian and Caledonian structures that determined the locations of many important Carboniferous faults. Along such structures the Variscan tectonic cycle proceeded, creating rifted basins, burying them beneath sediment, and eventually uplifting or 'inverting' them. These events relate to a tectono-stratigraphic model, which divides the Carboniferous strata into three megasequences: syn-rift, post-rift and inversion, each desposited during a specific phase of the Variscan cycle. Megasequences are in turn subdivided into lower-order seismo-stratigraphic sequences, their boundaries recognised on seismic profiles by depositional breaks or by their pinching out along basin margins.

Chapter 3 is devoted to Carboniferous basin development, and it summarizes the siesmo-stratigraphic sequences developed within several basins. The format of the atlas (405 x 305 mm, ring-bound) comes into its own here, because some of the interpreted seismic sections are very long when pulled out. East Midlands geology is well represented, with the Widmerpool Gulf chosen as the type example of a Carboniferous rifted basin. A useful tectonic synthesis correlates strata between different basins, from the East Midlands to the Tweed, setting their development within a time frame constrained by fossils found in boreholes through the various sequences. Formations exposed at the surface, and named on geological maps, are mentioned where possible, but the seismo-stratigraphic approach does not lend itself easily to integration with conventional lithostratigraphy.

Geologists working with exposures or borehole material, and attempting to interpret depositional environments, should find Chapter 4 of most relevance, since it discusses the palaeogeography and facies evolution, through time, of the tectono-stratigraphic sequences. This account utilizes large-format palaeofacies maps showing much new detail. Some of these would have been better in full-colour, and in places the print is rather small and difficult to read.

The final Chapter (5), on play fairway analysis explains why all of this research has been done, because it is through the integration of structural and seismic sequence analysis that hydrocarbon fields are nowadays identified. The chapter takes the reader through the various hydrocarbon targets, or 'plays', that developed at different times within these basins as the Variscan tectonic cycle proceeded, analysing them for attributes such as source-rock, cap-rock and reservoir potential and structure. This is not just about the Carboniferous, however, because at the end of that period the Variscan uplifts inverted many of these basins, destroying existing oil accumulations and arresting further generation. In fact, the oil and gas exploited today was re-generated from Carboniferous strata as a consequence of their burial beneath an insulating blanket of Mesozoic (Triassic, Jurassic, Cretaceous) strata. This interplay between Mesozoic burial, oil generation, and the distribution of remnant Carboniferous basins is illustrated with a series of maps, the outcome being a play assessment making it clear that 'the geological history of the East Midlands, compared to the rest of northern England, is most favourable for the development of an oil province'.

At £55 this is not the cheapest of publications, but it is reasonable enough to be purchased by the libraries of all universties and organisations that include geology as a significant activity. The authors hope that the atlas will not only provide a paper record of a now-fragmented seismic data holding, but will be of value to researchers, to many in the oil industry, and to all those seeking to understand or to teach the concepts of basin tectonics and seismic sequence stratigraphy. Given that this is not an inordinately large publication, the attainment of all these objectives has been successfully achieved.

John Carney

REVIEW

The Geology of the East Midlands, by Albert Horton and Peter Gutteridge (compilers), 2003. Geologists' Association Guide 63. 128 pages of A5, 29 figures, 13 photos. 0-900717-89-0, £8 (£6 for EMGS members).

This guide was produced through a joint collaboration, written and prepared by members of the East Midlands Geological Society and printed and published by the Geologists' Association. It is a very welcome and much needed guide to an area encompassing a wide extent of country with geological exposures of great interest, ranging from the Precambrian to Recent. The guide had a prolonged gestation period, but now that it is safely delivered, the parent organizations can relax; all is well, and the authors, compilers and editor are to be congratulated on a job well done.

The guide is divided into three sections dealing with the Precambrian, Carboniferous and Permian- Jurassic periods. Each section is introduced by an essay setting out the geological history of the region in that period and setting the context of the excursions. For newcomers to the region these essays are a valuable introduction and geological orientation. The excursions of course are the substance of any guide. Though there may be differences of opinion as to the best choice of sites within such a wide and varied region as the East Midlands, these are generally well chosen and will take readers to eleven representative areas of great interest.

Each itinerary is well organized, with a preamble describing objectives and logistics for the trip, including useful telephone numbers to gain authorised access. The geological descriptions are lucid, sufficiently detailed and, useful for the beginner; all except one draw conclusions from the visible evidence as to the processes that underlie the geology. As on all geological field trips, points for discussion and dissension arise. Your reviewer should like to have listened to a discussion between Dr Editor Gutteridge and Dr Peak District Ford as to the stratigraphic placing of the mud mound at Locality 5 on the excursion to the Stone Centre. Where does it lie with respect to the Monsal Dale / Eyam Limestones boundary? A pleasing feature of all contributions is the close correlation made between the geological setting and the local industrial history that has provided the wealth of the region. In this respect, John Marriot`s contribution on Holymoorside and that of Andy Howard on the Permo-Triassic of Nottingham are particularly enjoyable.

Illustrations are important in guidebooks and, not least, Tony Waltham`s cover photos will surely attract buyers at the counter. In the text the photographs are generally of good quality, but some lack scale markers, others are perhaps past their "sell-by" date, and the cleavage refraction is poorly demonstrated in Figure 7. The black-and-white line drawings and maps are excellent as are the coloured paleogeographic maps (though the colour coding in Figure 30 is wrong). There is an inconsistency in captioning of figures; some usefully indicate the location numbers, but others do not. This is inconvenient and confusing when the figure and the location it illustrates are five or six pages apart, as in the Middle Jurassic excursion.

The text is supported by a short glossary of geological terms used and highlighted in the text. In general these are succinct, one-line explanations and are helpful and informative for beginners, but their brevity leads to some problems. The definitions for dip and strike are so mutually circular that their meaning becomes elliptical, and the bald definition of epiclastic is hardly helpful. Zones of the Dinantian, not referred to in the text, are explained in the glossary; goniatite zones of the Namurian which feature in descriptions of several locations are not. It would have been helpful to have had a simple explanatory table(s) for these in the body of the text, much as in Wolverson Cope`s G.A. Guide 26 to the Peak District.

There is a good further reading list for readers to follow up, but looking back through old G.A. guides there seems to have been a change in presentational style during the 1990`s with replacement of formally referenced articles by a reading list. Perhaps there is something to be said for this in general terms, but your reviewer finds the older practice of specifically referenced articles more useful when going to the library, and points to G.A. Guide 44 on the Late Precambrian Geology of the Scottish Highlands as a model. Perhaps for future guides, a compromise might be reached with a short general reading list complemented by specifically referenced itineraries, and the Guide Series Editor may wish to consider this.

Two particular points for comment arise. The reference to Ford and Rieuwerts' *Lead Mining in the Peak District* indicates a new edition in preparation to replace the 3rd; but the new 4th edition was published in 2000, preceding this guide by almost three years and perhaps evidence of its prolonged gestation. Figure 15, a sketch map of the Stone Centre is drawn after Gordon Walkden, but no reference is made to Walkden`s publications in the reading list. This omission is a pity, for they remain important and valuable accounts of the Wirksworth area .

This is an interesting and valuable guide which achieves its purposes well**.** Any infelicities are minor. It will serve to inform and enthuse those new to geology, and will induce those more experienced, to revisit sites and explore again with new eyes. Like all successful ventures, it raises the question "what next"? The East Midlands is surely big enough for a second volume, and this idea is commended to the parent bodies.

The prices of the Guide through the Society, to members at £6 and to non-members at £8, are remarkable value, particularly compared to the GA members' price of £8-50 and a retail shop price of £15. For once, the north-south divide is working in our favour, but then we don`t have an office in Piccadilly opposite Fortnum and Masons! At EMGS prices, buy two copies, one for your library and one for wet field days.

Gerard Slavin

REVIEW

The practice of British geology 1750-1850, by H S Torrens, 2002. Variorum Collected Studies, Ashgate Publishing: Aldershot. 356 pp, ISBN 0-86078-876-8, £59.50.

This review is particularly appropriate in view of Professor Torrens' recent lecture to the Society on William Smith's practical geological activities. It is a collection of thirteen of Hugh Torrens' research papers (two with co-authors) on matters relating to the early evolution of geological science. The chapters are facsimile reproductions from other publications without any later editing and with original type-face and pagination. It is useful to have them all in one place, as some appeared in obscure overseas journals or conference papers. One chapter is in French and another contains several quotations in Italian: translations would have helped the reader.

The Mineral Surveyors of the late 18th and early 19th centuries were, broadly, prospectors who advised landowners on any rocks or minerals worthy of exploitation. They contributed to the advance of geology, but, as few of their reports were published, they have generally been overlooked by historians of science. The surveyors were often in financial difficulties, particularly after the Napoleonic wars when a general depression discouraged investment. A conflict with the gentleman geologists of the Geological Society of London led to much of the practical men's work being belittled if not ignored.

From intensive searches of contemporary correspondence and business records, Hugh Torrens has presented us with an intriguing survey of the activities of some of the Mineral Surveyors. The Irishman James Ryan invented the core drill for obtaining much better samples of the strata penetrated than the percussion drills used beforehand. He also founded a School of Mining in Montgomeryshire, possibly the first such school in Britain, though little is known about it. The Welshman John Williams and his part in coal prospecting are discussed in detail, especially his involvement in an abortive venture in Italy. Arthur Aikin's ambitious Mineralogical Survey of Shropshire (1796-1816) is described, though it was not completed and remained unpublished until Murchison used some of it in his *Siluria* in 1839. Not surprisingly William Smith, canal engineer, mineral surveyor and "Father of English stratigraphy", with his problems in getting both his stratigraphic ideas accepted and his great map published, come into the story, and there are frequent references to the role played in various projects by John Farey, author of the *General View of the Agriculture and Minerals of Derbyshire* (1811). Ford and Torrens' biographical introduction to the 1989 reprint of that great work forms chapter VI of the present collection.

Other early mineral surveyors discussed include J.H. Fryer, who was sent out to Peru to supervise British investment in the Potosi mines (before they became part of Bolivia), but seemingly never got there owing to political problems. There is a section on W.E. Logan, whose intimate knowledge of the South Wales coalfield was later incorporated in Henry De La Beche's early Geological Survey reports; subsequently Logan effectively founded the Canadian Geological Survey almost single-handed. Another section covers James Buckman who surveyed the Guyandotte coalfield of West Virginia where the investors found it difficult to believe the local geologists' reports.

Much of the mineral prospecting and mining material in the book is concerned with coal mining, a subject which Hugh Torrens referred to as being "papyrophobic": in its early days the mining fraternity was not keen on putting anything down on paper, particularly failures. The Mineral Surveyors were also much concerned with adventurers sinking trial boreholes and shafts in places where there was never any likelihood of finding coal, such as Bexhill in Sussex and Malmesbury in Wiltshire. It was not unknown for such boreholes to be "salted" by dropping lumps of coal down at dead of night!

This book should be on the shelf of all interested in the early development of both geology and mineral prospecting, particularly coal mining.

Trevor Ford

REVIEW

Northamptonshire Stone, by D.S.Sutherland, 2003. Dovecote Press: Wimborne. 128 pp, ISBN 1-904349-17-X, Softback £12.95 (+ £1.95 p & p from Dovecote, Stanbridge, Wimbourne, Dorset BH21 4JD).

Northamptonshire is a county entirely on Jurassic strata with many different limestones, sandstones, mudstones and ironstones dipping gently eastwards so that they crop out in narrow strips trending roughly SW to NE and along the sides of river valleys. A sheet of boulder clay covers the interfluve areas.

In earlier times almost every village had its stone quarry that provided building material for castles, stately homes, churches and other buildings. Diana Sutherland has here carried out a thorough survey of which stone was used where, often in combinations for decorative purposes.

The stones are treated in stratigraphical order from the Liassic limestones up to the Upper Jurassic Cornbrash, and geological maps are provided for each group. She describes the petrographic details by which we can recognize the stones used, and records the locations of about a hundred quarries. Regrettably many of these were destroyed by ironstone working in the 20th century and others have been back-filled so that only a few are accessible today. Some of these are still producing stone though mainly for aggregate.

Special treatment has been given to the Collyweston Slate, a fissile sandy limestone mined in northeast Northamptonshire. Similar “slates” were obtained elsewhere, as at Duston, now beneath a Northampton housing estate. There is a chapter devoted to the Saxon church at Brixworth wherein various rocks from the Precambrian of Charnwood Forest were used, some apparently “recycled” from the ruins of Roman Leicester.

Details of quarrying and stone-working methods are somewhat hidden in locality descriptions. Weathering properties are noted, but nothing is said about physical properties such as crushing strengths. The latter would have been an unknown factor to mediaeval masons, and it is a testimony to their skill that so many buildings have survived.

This attractive book is liberally illustrated with colour photographs, and the printers have made a fine job of reproducing the subtle shades of brown, red, cream, white and grey. A glossary and index are included.

Trevor Ford

REVIEW

Geology of the Melton Mowbray district, by J N Carney, K Ambrose and A Brandon, 2002. Sheet Explanation of Melton Mowbray, England & Wales Sheet 142, Solid & Drift Geology 1:50,000, British Geological Survey. 34 pp A5, ISBN 0-85272-436-5, £9 (Map is £11, or a pack with both map and Explanation is £18).

This part of our home ground was resurveyed in 1997-99 by three BGS surveyors well known to most EMGS members - John Carney, Keith Ambrose and Allan Brandon. All three were EMGS members at the time, gave lectures or led field trips for Society members, and contributed to the Society’s *Geology of the East Midlands* which includes this area.

The Melton sheet adjoins the Nottingham Sheet to the south and covers Melton Mowbray, Keyworth, NE Loughborough and the Vale of Belvoir. It follows the same format as the Nottingham sheet, so that both maps show an enormous improvement in clarity and amount of information compared to the older series. The geological map is accompanied by a very comprehensive generalised vertical section for the whole sheet. There are three cross sections on the map and a further three in the Sheet Explanation. Small scale Bouguer gravity and aeromagnetic anomaly maps of the sheet and surrounding area are included plus a schematic model illustrating the spatial relationships of the Quaternary deposits.

The 34 page Sheet Explanation, compiled by John Carney, is clearly and concisely written to provide a wealth of useful information. There are colour photographs of landscape features and of Lias group fossils and ten tables covering topics from the Carboniferous rocks to the Quaternary deposits, fossils and mineral deposits. The new map and its accompanying text will greatly enhance the understanding and appreciation of the area by any Society member who is interested in any aspect of the natural environment of the area.

Alan Filmer

REVIEW

Grand Canyon Geology, edited by S S Beus and M Morales, 2003, second edition. Oxford University Press: New York. 432 pp, ISBN 0 19 512299 2, paperback £29.50.

The book is a revision of the edition published in 1990, which was a successor to the book *Geology of the Grand Canyon* edited by W.J. Breed and E.C. Roat, published by the Museum of Northern Arizona in 1974. Curiously this is not mentioned, nor is it listed in the bibliography of the new edition. It may seem unusual for an author to review a book to which he has contributed, but the writer is only one of 37 authors, who has had no contact with the others, did not see their chapters until publication, and had no communication with his co-author, who revised the draft supplied several years ago.

Anyone touring the American Southwest, is bound to have visited the Grand Canyon probably seeing it from the viewpoints along the south rim. The first impression is of almost horizontal strata lying parallel for as far as one can see, but this is misleading, for there are many gaps in the stratigraphic record. This book presents a summary of many years of research. Down in the bottom of the canyon are several stretches, known as the Upper, Middle and Lower Granite Gorges, that provide the only accessible sections of the "basement" rocks in the region. They consist of gneises, schists and granite intrusions that are 1.8-1.4 billion years old, and this edition provides a new analysis arising from detailed research in the last 15 years. The rocks are of Older Proterozoic age and have been buried to a depth of at least 20 km by crustal processes. Subsequent uplift led to the erosion of the top 10 km yielding a Great Unconformity beneath the younger, unmetamorphosed, Precambrian sediments, which have ages of around 1200-800 million years, i.e. considerably older than our own Charnian rocks.

The details of the younger Precambrian indicate a range of environments from desert to lacustrine, and shallow to deeper marine. The marine beds yield a variety of fossils; the Chuar Group in particular contains thick shales, some black, with many microfossils (acritarchs). These shales are potential source rocks for hydrocarbons, but any accumulations near the Canyon would obviously have seeped out through the walls to be lost. Further away, such Precambrian hydrocarbons may still be trapped in structures beneath the Colorado Plateau but they have not yet been found.

The rest of the Grand Canyon walls are composed of Palaeozoic beds resting on the Great Unconformity that was noted by J.W. Powell on his historic boat trip through the Grand Canyon in 1869. However, there are many stratigraphic gaps. Above the thick Cambrian sequence, there are no Ordovician or Silurian beds, indicating a long period of emergence.

The eastern Grand Canyon, seen from Desert View; most of the middle ground is younger Precambrian sediments capped by Cambrian Tapeats Sandstone; the lower part of Marble Gorge is on the far right.

Devonian rocks are largely limited to fills of channels cut into the Cambrian, but they merge into a continuous dolomitic horizon in the western Canyon. Both Cambrian and Devonian are covered disconformably by Mississippian (Lower Carboniferous) limestones, but these represent two advances and regressions, with gaps representing non-deposition. Filling deep channels cut into the limestones are beds of the Surprise Canyon Formation, roughly the age of the British Millstone Grit, seen mainly in inacccessible cliff sections in the western Canyon. The Supai Formation, of Pennsylvanian age (roughly the same as the Coal Measures) at first sight looks like similar cyclothems though without the coals. However, the sandstones are mainly aeolian, not deltaic, and there are thin conglomerates marking the start of each transgression after breaks with no deposition. The highest beds are Permian, ranging from the massive aeolian Coconino Sandstone to red beds and dolomites, together not unlike the British Permian succession. All these Palaeozoic beds show evidence of thickening to the west and an increasing approach to a shoreline to the east.

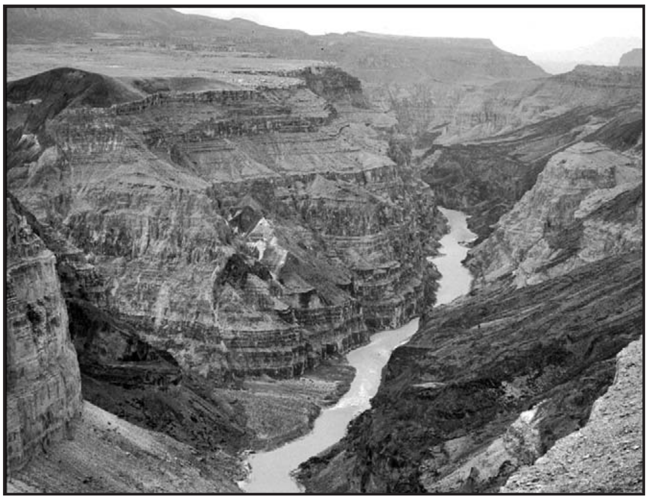
Thick Triassic, Jurassic, Cretaceous and early Tertiary strata once lay above the Canyon's strata but these have been eroded off. They can still be seen in nearby Zion and Bryce Canyons and in the Painted Desert. The structural relationships to the basin-and range province to the west and to the rest of the Colorado Plateau to the east are well-known, and are admirably summarized in this new edition. Thus the first half of this new book provides a comprehensive survey of the present state of stratigraphic knowledge in the Grand Canyon.

The second half is more concerned with the geomorphological evolution of the Canyon. The establishment of the drainage system across the

Colorado Plateau can now be dated more accurately at starting close to the Miocene/Pliocene boundary, around 6 million years ago. The Canyon had been eroded to its present depth in less than 5 million years, before the time of the volcanic eruptions whose earliest lavas tumbled into the western Canyon about 1.4 million years ago. Lavas from several eruptions filled the western Grand Canyon to depths of up to 420 m, thereby damming up lakes, at least one of which stretched the whole length of the Canyon. The lava dams were the sites of waterfalls higher than Niagara, and were eroded away remarkably quickly, possibly with catastrophic collapses and floods over a period of less than half a million years, except that sediment deposited behind the dams had to be eroded away as well; sediment relics survive in a few side canyons. The final chapters are mostly concerned with the origin and hydraulics of the famous rapids and with debris flows from the walls.

While this book provides a fine summary of the basic geology, there are gaps. There is no chapter on mineral deposits and mining (as there was in the Breed & Roat book of 1974). Asbestos was mined from metamorphosed dolomites above the Proterozoic sill above Hance Rapids; copper was raised from fault breccias at some two dozen localities, mostly in the early 20th century. Copper and uranium were obtained from breccia pipes resulting from solution collapse, one pipe being worked up to the 1950s. Guano mining from Bat Cave in the western Canyon is not discussed, nor are there descriptions of other caves, though karstic drainage affects much of the surrounding area with massive springs discharging into the Canyon or its tributaries. Massive movements of rock waste are described as debris flows but, surprisingly, the chapter does not cover rock falls or landslides. Discussion of the latter is in the wrong place, having been tacked on to the regional tectonic chapter, as are valley anticlines (usually known as valley bulges in Britain).

The central Grand Canyon, showing Upper Granite Gorge in the floor, walled by Mid-Proterozoic metamorphics and granitic intrusions that are overlain by horizontal Cambrian and Mississippian beds.



The western Grand Canyon, with the remains of two lava dams, just downstream of Toroweap Overlook.

Rock falls are not discussed though they can be spectacular – a joint block some 100 m high fell off the Coconino Sandstone near the South Rim village while the writer was there, and the raft trip operators report some twenty such falls each year. During one overnight camp after a heavy rainstorm, your scribe could hear rocks falling from the adjacent cliffs – an alarming experience when sleeping on a beach in the line of fire! Spring-head sapping at the base of permeable strata is not discussed as a factor in causing rock falls. Travertine deposits are widespread through the Canyon and its tributaries, but the only ones mentioned are those forming waterfalls in Havasu Canyon, and there is no comment that these tumble over the eroded ends of the sediment fill arising from the lava dams.

The book is liberally illustrated with black-and-white photos though Figure 21.12 is inverted. Typographic mistakes are few though *uncomformity* appears throughout Chapter 5. Finally, I looked in vain for a list of addresses or affiliations of the contributors. Some I know nothing about: others range from senior academics or USGS geologists to Masters students at Northern Arizona University. Notwithstanding the deficiencies, this is a fine book and well worth investing in if you are going to the American Southwest or wish to know more about what you saw on your study tour.

Trevor Ford

THE RECORD

Like my predecessor Alan Filmer I would like to use this report to address the various aspects of the Society's work and also acknowledge at least some of the individuals who have given up a great deal of their time for us all.

The Society has now celebrated its 40th anniversary and, I suspect, this last twelve months have been one of its busiest. At the beginning of 2003, membership stood at about 377, and I now understand this to be around 366.

The Society has changed the way it does some of its business and I apologise to anyone who initially might not have received all or part of any correspondence or publication. The Society has placed increasing emphasis on the internet and we are grateful for the work of Rob Townsend on the Society's website. Alan Filmer, who has retained his dealings with new members, advises that most of the new member enquiries come via the website, and other enquiries include those from students on particular geological problems, orders for publications and even where someone might find employment as a professional geologist.

I am grateful to Andy Howard, Tony Waltham, Ian Sutton and whoever else I might have forwarded such enquiries onto; and to Alan Filmer for dealing with most enquiries for purchases of publications, including copies of the Mercian Geologist.

The *East Midlands Field Guide* is now in circulation and has received excellent reviews. However, it was noted in one as being expensive, but then the copy reviewed was issued by the GA - who initially charged significantly more. Council decided to act independently on price, advising itself of the Society's objectives. The Society's publications continue with the forthcoming *Building Stones and Geological Walks of Nottingham* and the *Sandstone Caves of Nottingham* continues to sell well.

Field Meetings 2003

Special problems this year concerned the funding of transport and the feasibility of actually getting a bus or coach to some particular venues.

June was a busy month with a day trip to the Bradley Fen Brick Pit near Peterborough, led by Neil Turner, and evening trips to both the Ashover area with Colin Bagshaw and the quarry at Dorket Head with Andy Howard.

July provided a day in the Lincolnshire Wolds with John Aram, and also the season's weekend excursion to Shropshire with Ian Sutton.

Last but not least, September took us to see the ever-popular building stones of churches in Derbyshire and Leicestershire with Albert Horton.

Indoor Meetings 2003-4

These started with the 'Geology of New Zealand' by Dr Ian Sutton, straight after the 2003 AGM, followed by the 'Geological map of southern Britain' with Dr John Cope in the April.

Prior to our own new field season opening, we shared a lecture at Derby University by Dr Trevor Ford on the 'Geology of Speedwell Mine and Cavern' in May, and then continued in the autumn with the 'Early Cretaceous: from Lincolnshire to Argentina' with Professor Peter Rawson and 'Geology in the city' with Professor Martin Culshaw.

Prior to the Christmas Buffet, we heard from Professor Hugh Torrens on 'William Smith and the search for raw materials', followed by the January lecture from Professor John Mather on the 'Geology of bottled water'.

In February the Society helped celebrate its 40th anniversary with a talk by the President entitled 'The East Midlands – a geocentric view' followed by the Annual Dinner.

As many as 65 members and guests at a time attended these talks; such numbers not only impressed the speakers but also proved the popularity of the Society.

We are very grateful to all our speakers and to both Ian Sutton and Beris Cox for organising the Field Meetings and Indoor Meetings respectively.

Council

Sue Miles kindly took over publication of the Circular which had previously been the work of the Secretary. But in taking over this role there was no way I could do all that Alan Filmer had done before. I am also grateful to Alan and Sue for the way they have supported me and, indeed, to all of Council. Members are encouraged to receive their copies of the Circular by e-mail wherever possible; and I am sure you will agree they continue to become even easier to follow.

Those of you who are able to visit the Society's website will see there is now also a Latest News page on which we can place early items. Recent examples were a job advert for a geologist and news of the refurbishment of the Wollaton Hall Museum Geological Section. Council, Secretary and the WebMaster, Rob Townsend, will endeavour to ensure that the website continues to uphold the Society's charitable objectives; members' comments on its content are always welcome.

Council met formally on six occasions and have this year nominated three members for Honorary Membership; these are Ron Firman, Trevor Ford and Neil Aitkenhead, who therefore join Frank Taylor, Madge Wright, Jack Fryer and Dorothy Morrow. I am stepping down after one year as your Secretary and Janet Slatter, already on Council, has kindly offered to stand in my place.

John Wolff, Secretary 2004

NOTES FOR CONTRIBUTORS

Scientific papers. These are accepted on the understanding that they have not been published (or submitted) elsewhere. Papers may be of local or wider interest (normally where the author has some local connection). Shorter reports, news items, reviews and comments are all welcome, especially where they have a local interest.

Submissions. Material should be submitted as hard copy of all text and figures; please send two copies of papers, but one copy suffices for short reports. The text is also required in an electronic file in either Word or Wordperfect, either sent as attached to an email or mailed on a disk. Please follow the style used in *Mercian Geologist*; the e-file should have a minimum of formatting, which is set by the editor.

Figures. These are essential to almost any paper, and are of prime importance because they are conspicuous and so tend to be studied more frequently than their parent text. Please take care over preparation of maps and diagrams, and follow the guidance notes in the adjacent panel. Electronic files as .psd, .tif or large .jpg are preferred, and may be sent as email attachments (less than 10 Mb per email) or on a CD. All e-files of figures must be in images at least as large as their intended print size and at 300 dpi. Each figure or photograph must be in a separate file, and must not be embedded in Word documents

Photographs. These are mostly printed in black-and-white, but colour is generally available on a limited number of pages. Requirements for sending in electronic files are as for figures, above. Good photographic prints or 35mm slides can be scanned.

Abstract. Scientific papers should start with an abstract that states the essential themes and results.

References. Text references should be in the style of (Smith, 1992) or related to work by Smith (1992); use (Smith et al.; 1992) for more than two authors. All references are cited in an alphabetical list at the end of the text; please copy the style that is already used in *Mercian Geologist*, and cite journal titles in full.

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Offprints. 25 complementary copies of papers and reports are provided to authors.

Correspondence and submissions. All items should be addressed to the editor, Dr Tony Waltham, 11 Selby Road, Nottingham NG2 7BP. The editor welcomes queries and discussion concerning any intended submissions; phone 0115 981 3833 or email <tony@geophotos.co.uk>.

PREPARATION OF FIGURES

Size and shape. Each illustration should be of a shape that reduces sensibly to one or two columns width in the *Mercian Geologist* format and then has a size that reflects its importance and its amount of detail. Avoid large blank spaces within any diagram; place the key to create a good shape; north should preferably be at the top of maps – but this is not essential if rotation improves the shape. Maps and diagrams are normally only printed in black-and-white.

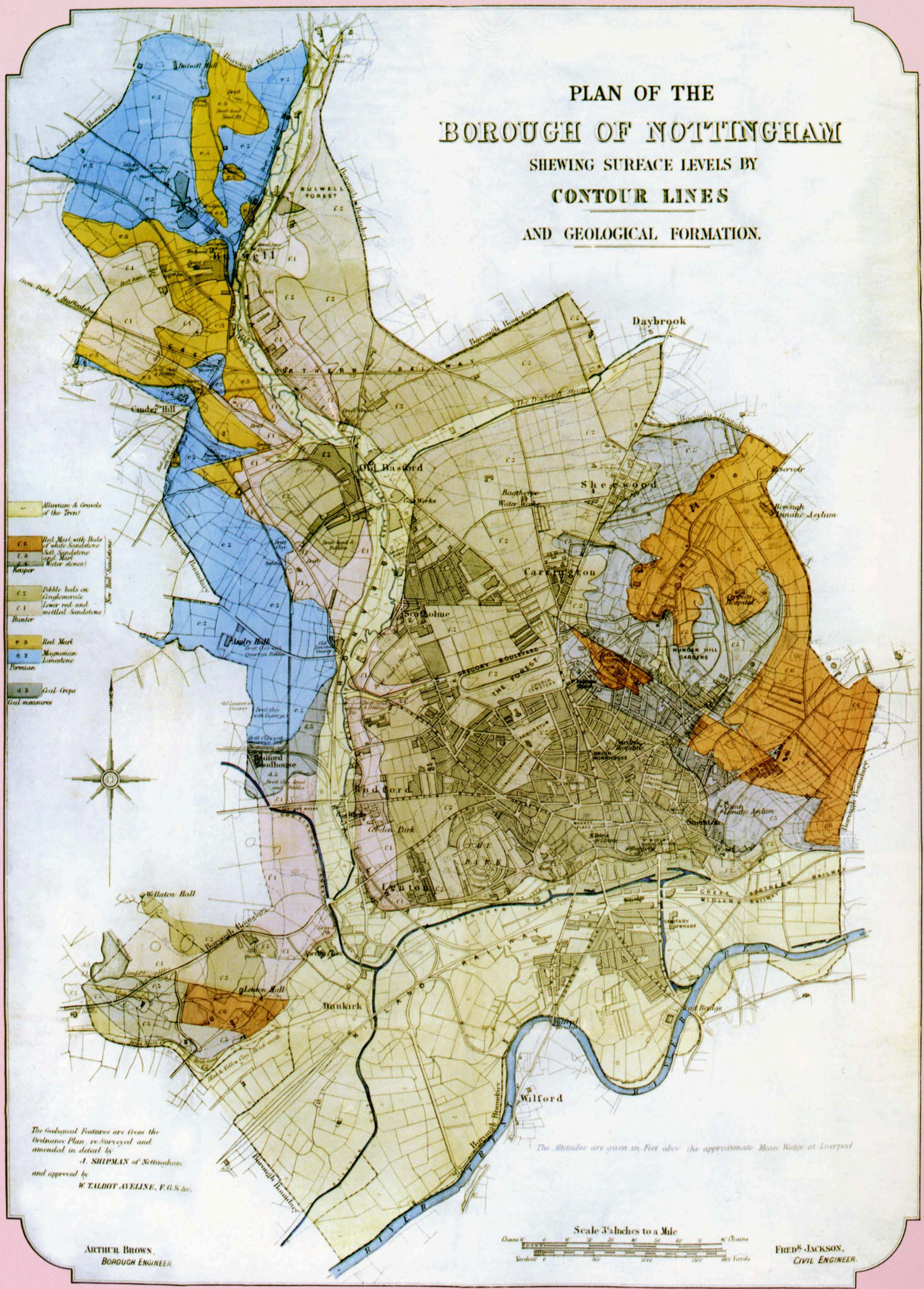
Drawing. Figures drawn by hand should be at least 150% of final print size. Draw them in black ink on good tracing paper. Pay attention to line weight; using Rotring pens, lines should be in the range 0.2 to 0.8. Each drawing must be enclosed in a frame; contours, roads, boundaries, etc. should reach to the frame.

Lettering. All lettering must be machine produced, preferably by computer on a scanned image. Lettering should be in sizes that will reduce to 6-12pt on the printed copy; use size and/or bold face to indicate importance; there should be minimal or nil use of upper case lettering. Arial is the preferred font.

Ornament. Carefully hand-drawn ornament can be very effective. Alternatively add by computer; tones of 20-50% are easily placed by filling in Photoshop. Where ornaments are used, lithologies should keep to convention; shales/clays/mudstones = dashes; sandstone = dots; limestone/chalk = brickwork; igneous = x, + or v. Dot sizes and dash lengths allow variations for multiple stratigraphic units of comparable lithology. On cross sections, dashes or bricks must follow the bedding; therefore they may best be drawn by hand unless morphing software is available. Tones must not be added to drawn artwork as they cannot be scanned, but are useful in figures prepared on a computer.

Digital preparation. Figures are best scanned into a computer file before adding symbols, tones and lettering. The completed files should be saved as .psd, .tif or .jpg (save at 10 or 12) at 300 dpi at image size larger than that to appear in print; other software (including Corel) cannot be accepted.

Help. Figure drawing is normally the responsibility of the author. Where facilities are unavailable, the editor may be prepared to offer assistance. In such cases, the author should still prepare clean drawings of all the lines, preferably with hand-drawn ornament, in black ink, on tracing or white paper; then send these to the editor, together with a photocopy of each line drawing with the lettering added by hand (at the approximate suggested size and in correct position) and with any additional ornament clearly indicated.


PLAN OF THE
BOROUGH OF NOTTINGHAM
SHEWING SURFACE LEVELS BY
CONTOUR LINES
AND GEOLOGICAL FORMATION.
Alluvium & Gravels of the Trent
Red Marl with Beds of white Sandstone
Soft Sandstone and Marl (Water stones)
Keuper
Pebble beds or Conglomerate
Lower red and mottled Sandstone
Bunter
New Red Sandstone
Red Marl
Magnesian Limestone
Permian
Coal Grops
Coal measures
Daybrook
Bulwell
Bulwell Forest
Old Basford
Sherwood
Carrington
Cinder Hill
Basford Woodhouse
Radford
Lenton
Gregory Boulevard
The Forest
Mapperley Hill Gardens
Sneinton
Wollaton Hall
Lenton Hall
Dunkirk
Wilford
River Trent
The Geological Features are from the Ordnance Plan, re-Surveyed and amended in detail by
J. SHIPMAN of Nottingham
and approved by
W. TALBOT AVELINE, F.G.S. &c.
The Altitudes are given in Feet above the approximate Mean Water at Liverpool
Scale 3¼ Inches to a Mile
ARTHUR BROWN,
BOROUGH ENGINEER
FREDK JACKSON,
CIVIL ENGINEER.