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East Midlands Geological Society

Correspondence
The Secretary, E.M.G.S., 100 Main Street,
Long Whatton, Loughborough LE12 5DG
01509 843297 secretary@emgs.org.uk

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Front cover: Chatsworth House, in Derbyshire, seen beyond its bridge across the River Derwent. See the report on page 27. Photo: Tony Waltham.

Back cover: A few of the ornamental stones, building stones and minerals from Chatsworth House, taken from the report on pages 27-42.

Contents

MERCIAN NEWS

Cave pearls

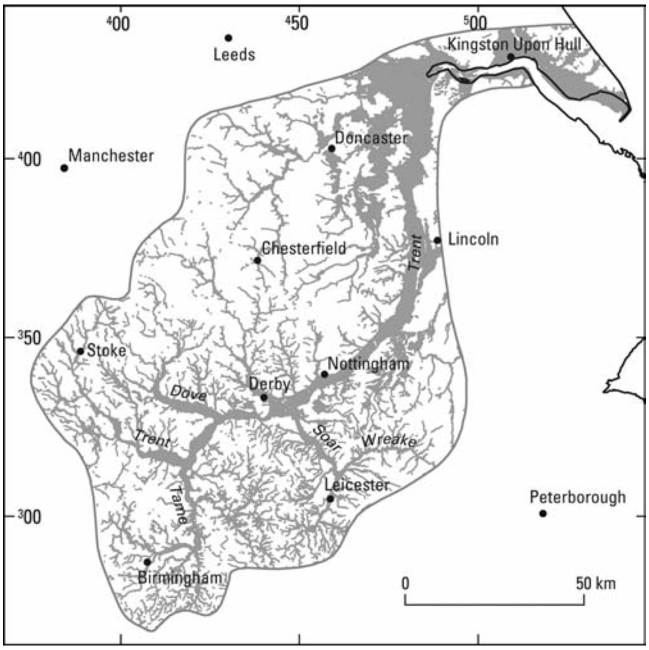
Many members of the Society have commented on Paul Deakin's splendid photograph of cave pearls that appeared with little further information on the front cover of the supplement with the *Mercian*'s last issue. Cave pearls are concretions of calcite, with an internal structure of concentric bands around a central grain. They form in shallow pools of lime-saturated cave water, and are close to spherical because they are rotated during their growth, due to regular disturbance of the pool water by drips from above. They are often found in pools beneath tall dripping shafts. These in the Golconda Mine lie in a pool within a flowstone cascade in a section of natural passage about 10 m tall. The larger pearls are 10-15 mm across, which is a good size for cave pearls. When they become too large to be rotated by the dripping water, they tend to lose their shape and become cemented to the floor, and this has now happened to the Golconda pearls - since their photograph was taken in the early 1980s.

Notes for authors

Guidance notes for authors are no longer printed in the *Mercian*. They may be retrieved from the Society's website at www.emgs.org.uk or are available on paper by request from the Secretary.

Erratum

Members and readers may have noticed that the Trent basin was singularly devoid of alluvial deposits in the map that was Figure 1 in John Carney's paper in the last Mercian (v16, n4, p231). This was due to a gremlin in the digital file, for which the Editor apologises. A more informative version of the map, defining the floodplains by the extent of alluvium and floodplain terrace deposits, is reproduced here.



Churchill Fellowship

Congratulations to Ian Thomas, immediate past president of the Society and Director of the National Stone Centre, who has been awarded a highly coveted Churchill travelling Fellowship to study traditional building craft training in the context of sustainability and modern building regulations. In the main, he will be focussing upon the use of stone. He plans to begin his seven-week tour later this year in Norway, travelling south through Sweden to the Danish island of Bornholm, then back into Sweden and across to Finland. The second leg of his journey will take him from Austria through Germany to Belgium.

Sandstone Caves of Nottingham

The Society's best-selling book on Nottingham's caves, started life as a paper in the *Mercian*, when it was penned by the current editor. It is now in its third edition (and on its seventh print run), as a book aimed at a wider readership. The new edition, published late in 2007, is in full colour, with 52 of the author's photographs, and also 23 maps or plans. It is fully up to date, including information on recent discoveries. The caves' geology, varied histories and current uses are all explained, along with their conservation issues. The book is essential reading for anyone with an interest is the history of Nottingham or with responsibilities for the city's conservation and development.

GEOBROWSER

Global climate change - a puzzle solved

The controversies over global climate change have generally revolved around two important aspects: a) is the Earth really warming up? and b) if so, what is causing it? Those in denial about the first question have so far been able to cite the fact that temperature readings taken from weather balloons and satellites have, according to most analysts, shown little if any signs of progressive warming when compared to surface measurements. If these weather balloon temperatures are truly representative of the situation, then most models that predicted global warming are wrong. This paradox has now been resolved by measuring changes in winds, which are tied to fluctuations in temperatures and would be a more accurate gauge of true atmospheric warming than the thermometers (*Nature Geoscience, May 2008*). Measurements on thermal winds, based on the motion of weather balloons at different altitudes in the atmosphere, show that temperatures at heights of 10 km in the Tropics have risen by about 0.65ºC per decade since 1970. This is probably the fastest rate of warming anywhere in the Earth's atmosphere, and is in line with other predictions of global warming models.

Problems with methane

The possibility that (geologically) sudden releases of methane, a powerful greenhouse gas, could help to ‘tip’ the Earth’s climate towards unbridled warming has been mooted for some years (e.g. *Geobrowser 2004, and talk by John Rees in November, 2005*). Such an event would be devastating, but its onset is difficult to predict; possibly for that reason, many non-geologists prefer to largely ignore it, and instead base their models on smoothly-curving extrapolations of recent global temperature increases. It is therefore up to geologists specialising in palaeoclimate changes to point out the danger. They can do this by going back into ‘deep time’, reversing Hutton’s principle of uniformitarianism by suggesting that the past may be the key to what is happening in the present.

In very deep-time….

With increasingly sophisticated methods of isotopic and geochemical analysis, we can now go back a long way and suggest that an abrupt release of methane may have occurred in latest Precambrian times, about 635 million years ago (*Nature, May 29, 2008*). This could have contributed to the chain of events that ended what was possibly the last "snowball" ice age, the Marinoan glaciation (see also *Geobrowser, 2005*). The mechanism involved is suggested to be the abundant release of methane from clathrates - masses of methane that form and stabilize within lattices of water molecules frozen in sea floor sediments beneath ice sheets under specific temperatures and pressures. When the Precambrian ice sheets became unstable and collapsed, they released pressure on the clathrates, which began to degas. The finding could explain many things, including the abruptness of the glacial termination, changes in ancient ocean-chemistry, and unusual chemical deposits in the oceans that occurred during the snowball Earth ice age. The researchers warn that we are currently witnessing an unprecedented rate of warming, with little or no knowledge of potential instabilities that lurk in the climate system and how they can influence life on Earth. But much the same experiment had already been conducted 635 million years ago, the outcome is preserved in the geologic record and this shows the planet’s potential to undergo an abrupt and catastrophic change from a very cold, seemingly stable climatic state to a very warm and stable climate, with no pause in between.

And the terrestrial dimension?

Methane out-gassing from terrestrial sources is another of the mechanisms suggested to advance the process of climate change towards the ‘tipping point’. We only need to go back to between 11,000 and 12,000 years ago, to the end of the last glaciation, to establish the potency of this phenomenon. American and Russian scientists have found that from 8000 to 12,000 years ago, the vast area covered by northern hemisphere peatlands increased dramatically, and methane levels -resulting from the decomposition of organic material and its release upon thawing - rose to 750 parts per billion by volume, a level they would not be reached again until the Industrial Revolution. Temperatures over Greenland likewise jumped an additional 7ºF, reflecting a period of warming, which in turn thawed more ice, particularly in North America, and freed up more land for bog formation. Today, with global warming proceeding apace, methane is once again being rapidly released from the northern tundra and in the near future will boost the present level of atmospheric carbon, possibly by several billion tonnes (*New Scientist, August 2005*).

Further evidence corroborating the importance of terrestrial out-gassing has come from studies of core samples from the Greenland Ice Sheet Project II. These ice cores, from the last 40,000 years of Earth history, show a rapid increase in methane, and while some researchers believe that clathrates were responsible, others believe that the methane was generated in wetlands. (*Science Daily, February 2006*). By studying the ratio of the heavier isotope of hydrogen, deuterium, to the normal hydrogen it was found that a contribution from clathrates could be ruled out, leaving only two realistic candidates - changes in wetland systematics and/or increased natural gas emissions during the glacial period. The former of these explanations is thought to be the most likely, since it is compatible with models predicting that, as climates warmed, and the area occupied by wetlands expanded, methane emissions increase.

The study of terrestrial carbon out-gassing is relatively new, but is now being applied to much earlier geological records, as recent analysis of British Tertiary peat bog material has shown. These fossil wetland deposits, belonging to the 55 million years old Cobham Lignite, were intersected during the construction of the Channel Tunnel. Their geochemical composition (*Science Daily, September 2007*) shows that carbon isotope values of hopanoids - compounds made by bacteria - suddenly decrease in a manner that can only be explained by switching to a diet of methane. This indicates that methane emissions must have increased, suggesting that 55 million years ago there was a massive release of carbon into the atmosphere that coincided with, and probably enhanced, global warming. In *Geobrowser* (2003), this event was attributed to a combination of out-gassing by volcanism and methane hydrates, but the new study suggests that there was a knock-on effect, causing environmental changes in wetlands. It is perhaps the earliest example of how terrestrial ecosystems millions of years ago were affected by rapid warming-induced changes in climate, and is therefore a further salutary lesson on how they could respond to warming in the future.

Good news for Nottinghamshire coal

Amid much fanfare it was revealed in April this year that UK Coal is considering re-opening Haworth colliery, in the village of Bircotes, 15 km south of Doncaster. This mine was mothballed 20 months previously, with 'geological problems' being cited as the cause, but even care and maintenance is expensive and last year it was marked for closure. All that changed with the doubling of world coal prices in the past year. The planned opening will not happen until seismic surveys and boreholes are completed, the company cautioned, but this could lead to an investment decision to re-open the mine. The last new mine to open was at Asfordby in Leicestershire 20 years ago, when the coal industry was still nationalised - and that pit was already being closed down (*Merciant, 1998*) by the time UK Coal bought the English coalfields in the 1994 privatisation. It is also reported that record coal prices have already encouraged UK Coal to invest £55m at Thoresby in Nottinghamshire and Kellingley in Yorkshire, extending the lives of those deep mines by a decade.

The company remains Britain's biggest producer of coal, despite falling output, but it supplies just 15% of the coal burned in Britain - while Russia, South Africa, Colombia and Indonesia account for most of the rest (*UK Government: figures for steam coal imports in 2006*). The concern for the security of supply is obviously very significant for government and consumers. One problem to further investment is that the three big customers - the electricity generators - signed fixed-price contracts with UK Coal, and are still buying cheaply. The company's average price last year was little more than half the market level and there are still 13M tonnes - 18 months' output - to supply under those contracts (*various reports, including the Daily Telegraph*).

The Humber Stone - a misapprehension

Media reports (*Leicester Mercury and* BBC'*s East Midlands Today*) during April heralded the placement of an information board at the site of this large boulder, which is located near to the traffic island at the intersection of Thurmaston Lane and Sandhills Avenue (SK62410709), north Leicester. These reports correctly identified the stone as being a glacial erratic of Mountsorrel granodiorite, but fell into the trap of assuming that the stone was transported to its present site as a result of ice movement during the last glaciation, which ended only about 12,000 years ago. In fact, no ice reached here during this Last Ice Age - it stopped well short, in Derbyshire, Staffordshire and along the Norfolk coast. Instead, the erratic owed its journey to a much earlier and more widespread glaciation, which occurred about 420-440,000 years ago during the Anglian Stage of the Quaternary. Very good corroborating evidence for this is provided by the newly published BGS map of Leicester (Sheet 156, with Sheet Explanation). This shows that the Humber Stone lies squarely within an outcrop of Thrussington Till, a boulder clay deposited by an Anglian ice sheet that, originating as it did in the Pennines region, would have travelled across Mountsorrel, picking up the stone and dropping it in its present location about 10 km to the southeast.

The Humber Stone. The trench surrounding this stone was constructed about the year 1900 - perhaps an early example of geological conservation in the East Midlands.

Another first for Charnwood Forest?

In this issue of *Mercian*, as in many others, deserved prominence has been given to the internationally important Precambrian fossils found in Charnwood Forest. The story behind their first recognition, by the then-schoolboy Roger Mason in 1957, has been recounted many times (Mercian 2007, p.280 for example). It was an event of tremendous importance globally, because it constituted the first find of large fossils in rocks that were conclusively of Precambrian age – in other parts of the world it had always been assumed that 'old' but undated rocks with fossils must be of Cambrian or Ordovician age.

If we examine the literature prior to Roger's discovery, we find that disc-like impressions in Charnwood Forest were occasionally mentioned, but were dismissed as being of inorganic origin. Recently, however, a very early reference, and the first to assign an organic origin to the discs, has been unearthed by Frank Ince, who brought it to the attention of Mike Howe, Chief Curator at the BGS. In 1868, a lecture on Charnwood Forest by R. A. Eskrigge (reported as an article in Transactions of the Manchester Geological Society, 7(5), 51-57) carried additional comments by a 'Mr J Plant'.

Plant stated that in April 1848, he and a colleague had 'discovered' on the rocks ring-like impressions, 6 to 12 inches [15-30 cm] in diameter, and had communicated this find to Professor A C Ramsay. The latter's opinion, as relayed by Plant, was that these circles originated where 'large seaweeds had been rooted, and probably by the action of the seaweed bending round by the force of the water, scooping out the mud in concentric circles'. Today this remains a most prescient conclusion, remarkably comparable to certain more recent suggestions. Although parts of the interpretation can be questioned, there seems little doubt that both Ramsay and Plant were convinced that these were the impressions of large, rooted organisms (modern seaweeds comprise several groups of multicellular algae, but also organisms of the kingdom Protista). Plant went on to say that no impressions of this type have been found in the 'Cambrians of North Wales', and here he may have been taking a sideways swipe at those who thought that the Charnian rocks were younger than Precambrian in age.

Unfortunately, we do not know the date of Ramsay's pronouncement, and it was presumably communicated in a letter or verbally, rather than being immediately published, but it probably occurred very shortly after 1848 and so could pre-date the accounts by Salter (1856) of organic impressions in Precambrian strata of the Long Mynd. If so, the Manchester article may document the earliest recognition of fossils in England's oldest rocks. In the communication, 'J Plant', stated that he had conducted '....many years careful exploration (in Charnwood Forest) before I came to Manchester'. This biographical note makes it fairly certain that the discoverer was John Plant rather than his brother, James, who also contributed on the geology of Charnwood Forest around that time.

REPORT

The National Stone Centre

The National Stone Centre stands on a dramatic site in old limestone quarries, overlooking Wirksworth, in the southern Peak District. Half of the 20 ha is a Site of Special Scientific Interest on account of its unique assemblage of carbonate mud mounds and shark remains. The Centre aims to tell the story of stone in all its aspects, including geology, geomorphology and geodiversity, also its historical use and applications in art and the man-made landscape. It is an independent charity managed by representatives of industry, government and academia, but is self-sustaining and draws no regular revenue from government or industry, relying on grant aid only for larger capital work. Main activities are sustained by income from commissioned work, much of this based on support from the Aggregates Levy Sustainability Fund.

Most of the geo-trails around the site have been recently improved, where a new series of interpretive panels cover earth science, history and ecology. New trail guides describe the site itself and nine, off-site, circular walks in areas between Stanton Moor and Whatstandwell. These recount the quarrying and mining history as well as their geology, and were supported by Countryside Agency, Heritage Lottery and Aggregates Levy funding. Work has also resumed on the "Geosteps", forming a small amphitheatre for use in outdoor presentations, with each step in stratigraphical sequence, upwards from Precambrian greywackes of Radnorshire at the base. The highest layers are still being sourced, but each step will be topped by local Hoptonwood limestone for seating. Longcliffe Quarries Ltd are supporting this work.

In the Centre's educational programme, volunteer leaders assist school visits with fossil casting and with demonstrations of rocks, minerals and soils, as well as walking the trails over the site or to overlook the nearby Dene Quarry which still produces aggregate. The Centre offers training courses related to stone; some are organised directly, while others are collaborations, including those in lime mortar and rendering, masonry, dry stone walling and stone carving.

The Centre generates income to sustain its other activities, by providing data on uses and sources of stone; it has created viewpoint panels for 20 quarries and geological sites across the country, and locally for Darlton, Dene, Crich and Ballidon quarries. It has also conducted a review of the Derbyshire and Peak District RIGS, and has worked on historical research of Mendip quarries. With the BGS, it has completed an investigation into the demand, supply and planning issues of aggregates to support major development in Milton Keynes and the South Midlands, and it is involved in the preparation of regional strategic policy documents for aggregate quarrying in the East Midlands and in Wales.

Ian Thomas

THE RECORD

We welcome any members who have joined the Society within 2007. Regrettably, the level of membership of the Society seems to be falling slightly at the moment.

Indoor Meetings

The subjects discussed during this year's indoor meetings have been as diverse as ever. They began with a very successful members' evening that was held after the AGM in March. Under the chairmanship of Gerry Slavin, Vanessa Banks spoke on Derbyshire springs as a water supply, Alan Dawn on reptiles from the Oxford Clay, Alan Filmer on Big Bend National Park in Texas, Tony Morris on a geological visit to Hungary and Gerry Shaw on the geology of Orkney.

Also in March, as part of the Geological Society's Bicentennial Local Heroes initiative 'Engineering Geology through the Centuries', was the annual joint meeting with the Yorkshire Geological Society at the BGS at Keyworth.

April's lecture had a medical theme when Gerry Slavin related Geology to Disease

The winter programme began in October with 'The History of Scafell Caldera: a dramatisation' by Professor Peter Kokelaar.

In November Keith Ambrose gave us 'Geodiversity and Education in Leicestershire and Rutland'.

In December Dr Richard Hamblin took us away for 'Ultimate Quaternary - the geology of Hawaii', followed by a well-supported Cheese & Wine evening.

In January Dr Howard Falcon-Lang spoke on 'Sex, lies and fossil plants', which revealed the life of Mary Stopes and her major contribution to Earth Science.

During this year's Foundation Lecture in February Professor Monica Grady had us 'Looking for Life on Mars'.

Once again we are grateful to Beris Cox for organizing such a varied programme of speakers, all the more so because this has been her final year as Indoor Meeting Secretary. Her place will be taken by Richard Hamblin who has a hard act to follow.

Field Meetings

A day trip to see the new exposures in an extension to Ketton Quarry, led by Alan Dawn, was the first of the season's field meetings in May. Evening visits were made to the Hemlock Stone led by Gerry Shaw in June, and to the Manifold Valley led by Colin Bagshaw and Ian Sutton in July. Also in July was a visit led by Keith Ambrose to Cloud and Breedon Quarries.

In early September a weekend in East Anglia was led by Richard Hamblin. Later in the month saw a visit to Stanage Edge with Fred Broadhurst.

The programme of Field Trips was as usual organised by Ian Sutton to whom we give our thanks. We are also grateful to all the field trip leaders for the hard work they put into both the preparation and on the day.

The details of this summer's visits will be advertised in forthcoming circulars and on the website.

Council

Council met formally on six occasions during the year. Thanks are due to Mrs Sue Miles for producing the Circular that keeps members up to date with the Society's activities and provides information about other relevant events and organisations. New members continue to find out about us via the website, and now half the membership takes the circular via e-mail.

This year has seen the publication of the new colour edition of the ever-popular Sandstone Caves of Nottingham, and also a reprint of the successful East Midlands Field Guide. Gerry Shaw's leaflet 'Rock Around the Campus' highlighting the geology to be seen at Nottingham University has been well received, and the Society is looking to producing similar ones for other local sites - suggestions and/or help would be welcome.

Thank you to members who are passing on older editions of the Mercian Geologist that are no longer required; this has been very helpful.

Rock Boxes are now available for donation to Primary Schools, and we would like members to spread the word to any contacts they may have. We thank those members who have passed on specimens for this project, and ask that members continue to bear the project in mind when they visit appropriate localities.

The Society continues its interest in Geodiversity issues. Representatives of the Society this year visited Crich Quarry to discuss with the company geologist and site manager proposals to extend the quarry and how to preserve some of the old workings. A watching brief is kept at Dirtlow Rake and the Society is hoping to contribute to the East Midlands RIGS project.

The web site continues to bring us new members and geological enquiries, and informs the public about the Society's work. We are grateful for the work Rob Townsend puts into maintaining and developing it.

In conclusion I would like to thank all those not specifically named in my report whose hard work enables the Society to flourish.

Janet Slatter
Secretary

MEMBERS' EVENING 2008

The second Members' Evening was held on 8th March 2008, when four presentations were made. The instructions to the presenters were simple: *show us your interests and infect us with your enthusiasm*. It is hoped that other members, whether amateur or professional, will continue the success of the Members' Evenings in future years.

The Thulean Basalt Province

Alan Dawn

In the late Cretaceous, North America and Greenland were attached to Eurasia as part of Laurasia which had separated from Gondwanaland in the break up of Pangaea. Then, at about 63 Ma, in the early Tertiary, the North Atlantic began to form with rifting between North America, Greenland and Western Europe accompanied by voluminous volcanism. The area which is now the Inner Hebrides (Skye, Mull, Rhum, Eigg and Muck) together with the Ardnamurchan Peninsula were buried under massive flows of flood basalts. The rifting developed across mantle plumes (or hotspots), one of which lies beneath Iceland today. The previous track of this plume is traced by the Iceland - Faroes Ridge, with the basalts younging closer to Iceland, leaving the Faroes an inactive site. Above its hotspot, Iceland has been created by continuous volcanism since early Miocene times, c16 Ma. The island nation lies on the mid-ocean North Atlantic Ridge, and this is the only part of the currently active ridge exposed on land.

Water, ice and volcano interactions

There are various interactions between volcanoes and the ice fields. The largest ice field is Vatnajokul, in the southeast of Iceland, under which is an active volcano. When it erupts, huge volumes of meltwater burst from beneath the ice (forming the floods known as *jokulhlaups*) with massive damage to roads and infrastructure on the sandur outwash plains. Huge quantities of rock debris are transported by the floods and extend the coastline seawards.

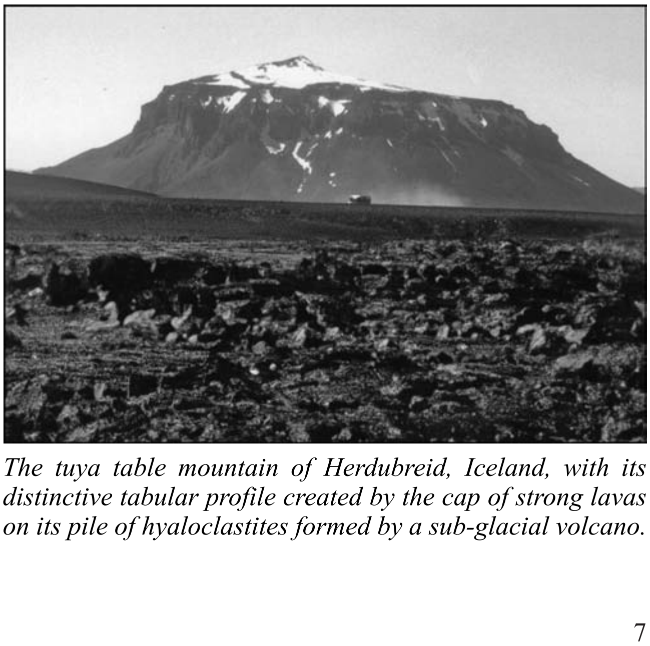
Another feature of eruptions beneath ice is the development of tuyas or table mountains. These form in three stages:

- when a volcanic eruption occurs through a vent covered by very thick ice, magma melts the ice to produce a water-filled cavity, and under high pressure pillow lavas are deposited;
- as the volcano grows, the ice/water pressure decreases and further eruptions are phreatomagmatic, with shattered hyaloclastic tephra (mainly fragments of basalt glass) overlying the pillow lavas;
- with further growth the vents may rise above water level, and subaerial effusive flows then build on the piles of subjacent hyaloclastites, thereby creating the distinctive "table top" appearance of the tuya.

The grand terraced waterfall of Gulfoss cascading over ledges of flood basalt, in southeastern Iceland.

Much of Iceland's scenery is dominated by successive, near-horizontal, basaltic lava flows that produce a characteristic trap or staircase morphology with the development of many spectacular waterfalls.

Because of the increased heat flow associated with the mid-ocean ridge, hot springs abound, and at Geysir the eruption of a hot water spout has given its name to other such features worldwide. Wilhem Bunsen, of burner fame, correctly attributed the phenomenon to meteoric water that penetrates to depths where it is heated geothermally, but then ascribed the eruptions to bubbles of high-pressure steam accelerating in their rise towards the surface. In fact, the key process is "flashing" whereby superheated water converts instantly to steam when pressure declines due to water being pushed out of the underground conduit.



The tuya table mountain of Herdubreid, Iceland, with its distinctive tabular profile created by the cap of strong lavas on its pile of hyaloclastites formed by a sub-glacial volcano.

The zeolite minerals

Iceland's basaltic lavas are commonly amygdaloidal, and the cavities are filled with minerals that include calcite, quartz and feldspars and widespread zeolites. These are tectosilicates, with three dimensional frameworks of SiO_4 and AlO_4 tetrahedra, that are characterised by an open crystal structure with channels and cavities that give space for water molecules. On heating, the loosely bound water is given off without structural collapse - hence the name from the Greek for 'boiling stone'. Zeolites are white, colourless or in pale colours, and many occur as handsome fibrous, acicular, tabular or cubic crystals.

[*This presentation was accompanied by a demonstration of zeolites collected from Scotland and Iceland*].

Zeolites from Jeigerhorn, Iceland.

Rise of the Roddons

Dinah Smith

The Fenland of Lincolnshire and Cambridgeshire is the largest area (4000 km^2) of Holocene deposits in Britain. These are up to 15 m thick and have a complex palaeo-environmental history. Their stratigraphy comprises a succession of interbedded clays (marginal marine salt-marsh environments) and peats (freshwater reed beds), representing greater and lesser amounts of marine influence over the time period from 6000 to 2000 BP.

Microfossils in a washed sample of roddon soil.

The salt marsh clays contain spectacular networks of silt/sand-filled tidal creeks known locally as roddons. These can be seen in many fields in the Fens as very slight ridges with paler-coloured soil, and are best seen after the land had been ploughed.

The roddons host a range of microfossils – especially foraminifera, ostracods and the spines and stereome fragments of echinoids. The latter provide firm evidence for the marine origin of the sediments.

By working out the mechanism of the infill that formed these roddons, by analysis of their sediments and microfauna, a greater understanding of the transgressive and regressive history of the Fenland may be determined. Work has been concentrated on the Thorney area of Cambridgeshire with visits to roddons at Whittlesey in Cambridgeshire and Methwold in Norfolk, and environments have been compared with the modern tidal system at Stiffkey on the north Norfolk coast.

Cross-section of a roddon in a ditch beside the new Thorney bypass (at TF316045), showing the paler soil in the clean-cut, U-shaped channel, beneath the gentle ridge of the roddon.

Water Wheels and Geology at Matlock

Lynn Willies

A major feature of the geology of the Matlock Gorge is a series of east-west anticlines and synclines, plunging to the east at the Carboniferous limestone margin with the overlying Edale Shales (Ford, 2002). The River Derwent cuts the gorge through limestone and associated volcanics, in a sinuous course of about 5 km between Matlock and Cromford, The complex river course is derived partly from superimposition from the overlying shale on to the limestone (with the various folds leading to its sinuous course); it then cut down into the limestone, rather than shifting eastwards in the softer shales, where its course was fixed by projecting limestone reef-knolls. Finally there was a uniclinal shift of the course above hard basaltic lavas and in soft volcanic tuffs at the latter's top surfaces.

The area is one of Missippian-type lead/zinc, fluorite/baryte mineralization with associated minerals, especially calcite, in both fissure veins and stratiform pipe deposits (Ford, 2001). Power sites for mine pumping to exploit the mineralisation are found on the River Derwent, and include from north to south, Dimple Mine 300 m north of Matlock centre, Ladygate at the west end of Pic Tor or Church Cliffs, two sites at Artists Corner, two under High Tor, one near Hodgkinson's Hotel Corner, Matlock Bath and the Hagg Mine at the southern end of the Lovers' Walks, Matlock Bath. This list of water wheel locations is not exhaustive and at least another couple of sites are possible. Contemporary evidence of the sites and their function lies in old paintings of this very scenic area.

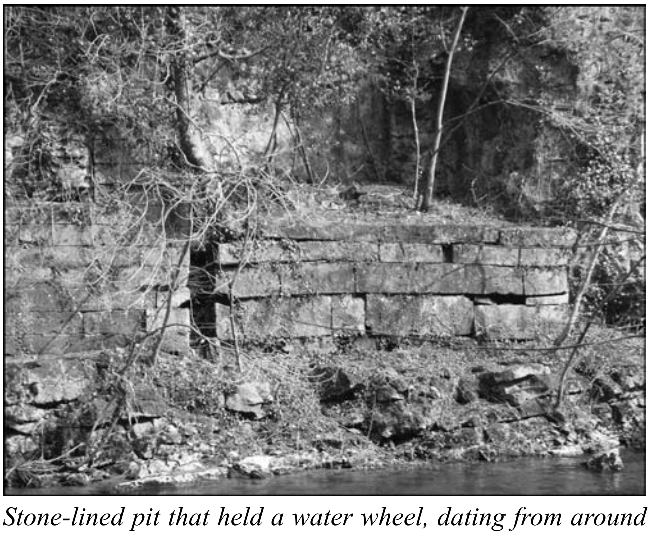
Dimple Mine is on the major Seven Rakes Vein, with a wheel installed alongside the river in the 1760s; a steam engine was installed about 1808 and another a half-century later. One recent result of the documentary information was a forecast of cavernous sub-river workings above the lava and tuff where the vein cuts through. These were drilled for and found above 20 m depth, and reinforced concrete was laid to protect the new section of railway line above. Little remains to be seen today except for hummocks and cinders at the steam engine site next to the river and the outcrop of the vein in the quarry cliff behind the Sainsbury's recycling site. The top of the vesicular lava and the overlying tuff can be seen near the new River Bridge, but is likely to vegetate fairly soon.

Ladygate has a vein of the same name cutting the river and passing through Pic Tor, which is notable for its adjacent reef knoll and very cherty limestone. A water-colour picture of about 1789, of the timber scaffold bridge which carried the pumping rods over the river, is in the Cornwall Record Office. A steam engine followed, suggesting mining to considerable depth, but little came of it. The deep cleft of the vein is obvious today in the cliff and there are remains of the pumping shaft at its base. The water wheel was over the river, apparently fed by an extended leat from the Dimple site.

Ringing Rake ranges north from Artists Corner, and is a southward extension of the parallel veins that make up Seven Rakes; it continues south, being then known over the river as Raddle Rake, forming the huge fissure behind the main face of High Tor. There is a substantial side of the wheel pit south of the corner on the High Tor side of the river, which dates from about 1800. The other side of the wheel pit was in the river, and the wheel could be hauled up when there were heavy floods. A painting shows a section of the rods which ran a short distance upstream and then crossed the river to work a shaft on Ringing Rake, probably near the present public toilets in the car park. It is fairly certain that the wheel and pumps enabled the workings to go under the river for the first time. It is possible to enter this mine and see the fault, volcanics including hyaloclastites, and a range of other features of geological interest.

Raddle Rake is the continuation of Ringing Rake east of the river and up to High Tor face; a sough entry can be seen a few metres above the south side of the river bank, isolated by river-lowering operations in the 1790s and 1970s. The wheel site was across the river on the west or road side, almost opposite the Ringing Rake site, and again presumably operated by rods over the river and up the hillside to a pumping shaft. It was abandoned by 1789 when a little sketch of it was drawn by Turner.

High Tor Mine, worked about 1820, had a huge wheel, 8 m across and of about 80 HP capacity. The weir and leat are shown on Ordnance Survey large-scale plans, but were destroyed in a flood-relief scheme about 1970. However the wheel site and tail race still exist under the paint works that succeeded the mine by about 1850 and still operate. Rods took the power 300 m along a passage under the Tor following the Great Rake, and there are still holes visible that retained support beams for the pumping rods. The lack of appreciation of the depth the old miners worked below river – probably well over 30 m – was part of the reason for the failure of the Riber Mine in the 1950s.



Stone-lined pit that held a water wheel, dating from around 1800, on the High Tor bank of the River Derwent.

South of High Tor, midway between the above site and Matlock Bath Station, was another small weir, from about 1780, shown on a water colour, while there is also a further picture, possibly by de Loutherberg, that appears to have rods looking rather like a post and rail fence going up to what became the site of the 1950s Riber Mine. The picture location is unknown.

By North Parade, at its western end and near the Jubilee footbridge in Matlock Bath, there was a weir across the river probably in the mid-18th century, again seen in paintings. This was near a sough that went under the Heights of Abraham and the Coalpit and Great rakes, though it is more likely that it fed a leat to a wheel working veins on the east side of the river just around the corner.

Hagg Mine was portrayed by de Loutherberg about 1780. His romanticised picture may be seen in Buxton Museum and shows a rather-too-rustic bridge carrying rods and chains running on pulleys across the river. The mine is still enterable, but it is in very soft slippery tuffs. The river-level sough drained almost a kilometre to just beyond the White Lion at Starkholmes, but it is doubtful whether the lower pumping level ever reached that far. A little sketch made by Eric Geisler, a Swedish traveller in about 1773, shows the wheel and rods; the wheel was undershot, on the west side of the river.

In conclusion, historically the veins have been tested well east of the river and the associated geology has been investigated to reasonable depths. Overall, the evidence is that economic mineralisation is limited to the east, and the presence of volcanics makes mining difficulties because of the associated clays. Appreciation of this might have prevented heavy financial losses at Riber Mine in the 1950s. Knowledge of the cavernous substructure beneath Dimple Mine, still had economic usefulness in railway development. One does not actually need to go out and get tired and dirty to study geology – there is much evidence of economic geology available in archives and galleries. In addition try searching for Matlock Bath pictures on the internet and especially the British Library and Picture the Past collections.

Thanks to Roger Flindall who has supplied much data from his extensive researches, and who also searched parts of the area with me.

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Ardnamurchan Macro to Micro

Rob Gill

Correct identification of rocks by their mineralogy and texture is one of the cornerstones of geology, and the desire to be able to achieve this, prompted by a visit to Montserrat and the collection of some rocks from there, was responsible for the creation of Geosec Slides, a small business producing thin sections on microscope slides. Setting up the business involved a move from Lincolnshire (and the East Midlands Geological Society) to Ardnamurchan in Argyll.

Geosec is now located at Achnaha, in the middle of one of the Tertiary volcanoes on the west coast of Scotland. The area is remote, and the scenery is spectacular, with the ring formation that is known worldwide and remains the subject of active geological debate over its formation. One of the main reasons for being in this area is the range of different rock types available nearby for study. The feeling of being within a volcanic structure is more obvious here than in most of the other centres in the Scottish volcanic province; the topography of many others has been modified by ice, to produce a landscape that is more post-glacial than volcanic.

It is not too difficult for anyone with an interest to make thin sections for their own study. Modern cements are easier to use than the traditional Canada balsam; clear epoxy resin, sold for glass and china repair, is fine for cementing the sample to the slide, and UV-setting superglue can be used for fixing the coverslip. Grinding is done on a glass plate with 220- and 400-grade silicon carbide grit, and slicing is with a diamond saw, either a lapidary model or even one of a tile-cutter type. Many rocks, of only moderate attractiveness in hand sample, become objects of beauty when viewed in polarised light; spectacular birefringence colours are displayed, and the structure and mineralogy are revealed, leading to easier correct identification.

Ardnamurchan's Tertiary ring complex, seen from the west.