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THE NORTH WEST GEOLOGIST
(Formerly THE AMATEUR GEOLOGIST)

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Editorial

This issue of *The North West Geologist* is dedicated to the memory of Grahame Miller, editor-in-chief of our journal from 1988 until his death last year. I am very grateful to Derek Brumhead, who worked with Grahame for many years on the Council of the MGA, for writing the leading article for this issue - an appreciation of all that Grahame achieved for our subject since taking up Geology on his retirement. The current status of *The North West Geologist*, recently described by a leading professional journal as, "the best of its kind", is due entirely to Grahame's dedication over many years.

In order to maintain these high standards it is vital that the editorial team is continually provided with sufficient copy. True, the regular features, such as *Conservation Corner*, *The Geological Survey at Work* and the *Field Trip Reports* are self-generating, but the real meat of the journal, the original articles, have recently needed some gentle coaxing from your pens (or should I say "word-processors"). Please contribute ! Please don't wait to be asked - your editors will consider anything (!), and if you cannot manage a full article, please consider writing a book review or a short contribution to *In Brief*....

Your journal depends on you supplying the life blood.

John R Nudds   Sheila Owen   Tom Metcalfe   N C Hunt
Spring 1995

Notes for Authors

Articles and suggestions for future issues are always most welcome and should be sent to either Dr John R Nudds, The Manchester Museum, The University of Manchester, Oxford Road, Manchester M13 9PL, or to N.C. Hunt, Department of Earth Sciences, The University, Liverpool L69 3BX. Articles should be typewritten or preferably on disk, if possible in **Wordperfect**, and may be up to 3,000 words in length. Figures should be designed for reduction to fit a maximum frame size of 180mm x 125mm.

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Back numbers of The Amateur Geologist and The North West Geologist

Limited stocks of most previous issues are held in Manchester and Liverpool and copies can be obtained by application to the editors.

IN BRIEF...

USGS - the end of the road ?

Whatever our worries over the recent retreat of the BGS with its closure of the Aberystwyth Office (see *In Brief....*, last issue, and *The Geological Survey at Work*, this issue), we should spare a thought for our colleagues across the Atlantic who are facing the news that the US Geological Survey and the Bureau of Mines are due for complete closure as part of a package of bills that Republican members of Congress have pledged to introduce in the first 100 days of the new Congress. The reason, like many things these days, is to save money, but as *Geoscientist* (Vol. 2, No. 5) points out, the timing seems rather illogical when you consider the increasing vulnerability of the US "to natural hazards, pollution, land contamination and reliance on unstable foreign sources for oil and raw materials'. President Clinton is apparently committed to maintaining both the USGS and the USBM, but one wonders how long they can survive....

Metamorphism at The Natural History Museum

And, its all change too at The Natural History Museum. Many of you will fondly remember the Geological Museum in South Kensington which a few years back closed its front door and began a sort of symbiotic relationship with its nextdoor neighbour, the Natural History Museum. The Geological Museum became the "Earth Galleries" in contrast to the "Life Galleries" of the old BM(NH). Well its now entering a second phase of metamorphism which will involve a complete re-display of the collections over the next three years. The bad news is that the Earth Galleries have been closed to the public until the summer of 1996 and will not be available in their final glory until 1998. The plans include a huge atrium on the ground floor, opening via an escalator to the upper floor exhibits. In the meantime, visitors to the BGS London Office will have to use the Natural History Museum main entrance on Cromwell Road and collect a BGS Information Office Visitor's Pass from the reception desk. Then follow the BGS signs through Galleries 30 and 40 to the BGS Office in Gallery 50.

Crocodiles in Yorkshire

I know its on the other side of the Pennines, but I thought readers might be interested to hear of the discovery last autumn of a well-preserved and almost complete teleosaurid crocodile in the cliffs south of Whitby. The discoverer was none other than Phil Manning, former research student with Paul Selden in Manchester, later Curator of Geology at Clitheroe Museum (see *Museums Roundup*, last issue) and now researching on dinosaur mechanics in

Sheffield. Phil was actually looking at dinosaur tracks when he discovered the hind portion of the crocodile in the Alum Shale Member of the Whitby Mudstone Formation, actually hanging out of the cliff. The problem was that the animal was projecting head-first into the cliff and excavation was difficult, to say the least. Funding from English Nature and provision of equipment from the National Trust, including a working platform, ladders, petrol-driven rock-saw and a Land-Rover, enabled almost all of the beast to be removed during a 3-day excavation. The specimen, which has been identified with *Steneosaurus* sp., has been given to the Yorkshire Museum and will go on display once necessary conservation work has been carried out.

Baldwin bows out

After 680 million and 25 years Stuart Baldwin is retiring from his fossil replica business and fossil museum. These are being purchased by the Open University and will transfer to Milton Keynes in April this year. The unique museum, which was opened by David Bellamy in 1988, houses some 2,000 fossil and zoological exhibits including dinosaurs, and been a very popular venue for school visits and for the general public. But it is the fossil replica business for which Stuart is best known, and many of us learnt our geology with the aid of his excellent reproductions. I well remember undergraduate practicals in Nottingham in the early 1970s when Baldwin's fossils were new on the market; we used to test his claims of durability by bouncing "Chalk" echinoids off the floor of the lab.! And they passed the test ! The good news is that Stuart's secondhand book business will continue at Fossil Hall in Witham, Essex, possibly on an even larger scale. Meanwhile there is much in the way of equipment, cabinets, fossils, minerals, replicas and books which are to be disposed of. For a detailed list of stock to be cleared send a SAE marked "FH Sale", to Fossil Hall, Boars Tye Road, Silver End, Witham, Essex, CM8 3QA. And, best wishes for a Happy Retirement, Stuart !

(John R. Nudds)

GRAHAME MILLER 1914 - 1994

by Derek Brumhead

Grahame Miller died on 8 May 1994 aged 79. He was a history graduate of Oxford (where he met Eileen) and this grounding left him with a particular interest in archaeology and another subject he soon found to be closely related, geology. Grahame's responsible job with the BBC (he was Head of North Region Programmes) did not leave much time for leisure interest although, as his notebooks of over forty years ago testify, opportunities were always taken on family holidays to observe and record sites of interest, and in the notebooks of the 1950s geological sections, sketches and notes on specimens start to appear.

As retirement approached, he began to prepare for his approaching leisure time by studying geology more systematically. He became an enthusiastic member of the Manchester extra-mural department evening classes in geology. The *Outside the Walls* brochure, for some years unlike nowadays, was then filled with a classic series of classes at all levels run by tutors of the Manchester Department - Broadhurst, Simpson, Pollard, Treagus, Wadsworth, Nicholson, Adams, Nichols and others. Encouraged by them, he joined the Manchester Geological Association in 1972. When he retired in December 1974, he started to attend residential courses such as the Bangor Summer School and those run by other extra-mural departments such as Leicester, Liverpool and Sheffield. He also joined other societies such as the Yorkshire, The East Midlands and The Geologists' Association.

Of course, he regularly attended MGA meetings and his enthusiasm and knowledge resulted in his being invited to join Council in 1979. For some years he was Vice President (1982-87) and he would have been the ideal person to have been President, but, much to the disappointment of many, he was unable to do so owing to increasing concern over his health.

Despite this problem, in 1988 he took over from John Pollard as MGA editor of *The Amateur Geologist*, as it was then called. He was unremitting in his attention to improving and enlarging this publication, pursuing possible authors, assembling material on conservation and reviews of literature, improving the layout, seeing the journal through the press (which meant difficult journeys by public transport to Eccles), extending its coverage, and was instrumental in persuading the Association to change the name to *The North West Geologist*. A very useful innovation was the offprint he arranged of

Murray Mitchell's important lateral key to Lower Carboniferous corals, which had widespread sales. As a result of Grahame's work, *The North West Geologist* became established as one of the best of the small society publications.

His interests in geology were wide, but he specialised particularly in igneous rocks and trace fossils. There was his work on the igneous rocks of Derbyshire and on Arnold Bemrose, a gifted amateur after his own heart; a lecture to the MGA on the Ballantrae Complex; his discovery of the bivalve, *Sanguinolites* at a quarry near Hayfield, and a professional article on the trace fossils of Cracken Edge, near Chinley. Grahame, like all true and informed amateurs, was essentially a field geologist and many of his articles are the results of days and weeks spent in the field at Peak District locations which not many others had visited or even knew about. He regularly travelled into the Peak District sometimes by public transport, but often at the weekends in the car of his friend, Joe Salem, another keen member and supporter of the MGA. Grahame was meticulous in following up lectures and excursions by reading widely, travelling regularly to consult the latest journals in the university library, and by keeping detailed notebooks. The result was that he was always up to date in the subject and at meetings and on excursions could ask the most penetrating questions. As his expertise grew, he became in demand for lectures and leading excursions, although for the latter his luck as far as weather was concerned often appeared to run out.

He was an excellent collector, too, and it is a matter of great pleasure and pride to Eileen that his specimens, all carefully labelled and provenanced, have been placed in the Buxton and Manchester museums. His research files and notes on the Peak District together with photographs and slides have been placed in Buxton Museum. There are also a great number of photo albums and slides from other parts of the country and abroad and these too have been taken up by the museums. He had a fine library of geological books; some, as he wished, have been incorporated into the Manchester departmental library (with a special book plate), and maps, books, and OU videos have been placed in the MGA library. The local school at Furness Vale had already benefited from his gift of what he called his "hands-on" specimens.

We shall miss his kindness and patience with children (always a bag of sweets in hand) and animals (badgers included), his idiosyncratic field gear including a "bushwhacker" hat, his sense of repartee and a quirky sense of humour, of which we are reminded by some of the headings to his articles. In fact, his love of words found expression in a love of poetry and it was appropriate that John Wadsworth should have read W.H. Auden's *In praise of* *[illegible]* at the memorial service last July. A draft of a letter Grahame wrote to a BBC producer shortly before he died included the following:

> "I do hope the Auden venture comes off. When I retired I took up geology in a committed way and I've been working on a little article about Auden as the Geologists' Poet. He knew his stuff, hoped to be a mining engineer, and was fascinated by the minerals and old mines of Weardale."

That is one piece of writing which unfortunately we will not see, but we have enough to remind us that Grahame was one of those special dedicated and expert amateurs who have always graced our subject and inspired others.

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ROCK AROUND LIVERPOOL 1
THE PAVING STONES OF WILLIAM BROWN STREET

by Joe Crossley and Hazel Clark

INTRODUCTION

As Geologists we admire the wide variety of rock types used for building, facing and ornamental stones. Their interest and value is undeniable, especially the *exotic* rocks that cannot be seen readily in the field. However, by looking at the buildings, a wealth of information beneath our feet may be missed! Sedimentary building stones tend to show vertical "cross sections", often exhibiting parallel and cross bedding and lamination, but paving stones tend to show horizontal bedding and lamination planes and their associated features, such as ripples.

Excellent examples can be seen along William Brown Street and its junction with Byrom Street and Lime Street in Liverpool. These paving stones, made of a fine, micaceous sandstone (probably the Haslingden Flags of Upper Carboniferous age), display a wide range of inorganic sedimentary features, with both trace and body fossils.

A quick glance in passing will reveal the obvious, but greater reward can be gained by a careful examination which can, however, cause problems and some embarrassment. Be prepared for people giving you funny looks or worse, tripping over you as you bend down to scrutinise the paving. Your friends and passers-by may infer that you are begging and throw coins in your direction or conclude that you have become very religious and helpfully point out east (these events have actually happened to us), while many people assume that you have lost a contact lens and offer assistance. Determining the position of the stones may also raise a few eyebrows and comments about the Ministry for Funny Walks!

SEDIMENTARY STRUCTURES

Parallel lamination

The best flagstones, because of their ease and evenness of splitting, are composed of parallel laminated sandstone. The rock equivalent of plywood, these flags have thin (millimetres), extensive, sheet-like layers (laminae) of uniform thickness. Most laminae are only a few grains thick and may be characterised by slight grain size differences and/or be separated from one another by an even (thinner), partial or complete layer of mica. The formation of this structure is not fully understood, but it would seem to involve fast, smoothly flowing currents, i.e. laminar flow.

Primary current lineation

This is probably the commonest structure to be seen on the surface of natural flags. Best seen in low angled sunlight, it forms a distinct linear pattern, which on very close, detailed examination is seen to consist of very closely spaced (a few millimetres), low relief (a grain diameter or two) ridges and hollows. It typically occurs on the parallel lamination planes. For this reason, primary current lineation used to be described as the "parting" lineation. Pcl, as it is known in the (sedimentology) trade, is formed by fast flowing, relatively turbulence-free currents. Variations in the current direction can be deduced from pcl in worn flagstones *at the bottom of William Brown Street and the steps leading up to the fountain at the top of William Brown Street.* Divergent pcl can be seen in different laminae in the same flagstone.

Flute casts

These are uniquely displayed *on a grey flag near the junction of William Brown Street and Byrom Street, eight flags north of the black and gold bollard nearest to the tunnel entrance and adjacent to the Merseybus lay-by.*

As the name suggests, these are the casts of elongate, ovoid hollows cut by a turbulent current into an originally soft, muddy substrate. The cast is formed by infilling of the hollows by the overlying bed of sand. The direction of current flow is from the globose, most upstanding end along the gradually declining slope towards the end where the cast merges into the bedding plane.

Groove casts

These occur on the same flagstone as above. They are also casts, but of very elongate, narrow (a few millimetres or less) hollows produced by a small object (e.g. a sand grain or shell fragment) being dragged by the current over the muddy substrate. The examples seen on this flagstone indicate a somewhat different current direction to that of the flute casts. As some are curved, all have a much lower relief than the flute casts and their direction varies, it must be concluded that the "tool" forming the grooves was being moved by a slower, but still turbulent, current.

Cross lamination and ripples

Best seen on the steps of the Walker Art Gallery and at the junction of William Brown Street and Byrom Street. The most straight forward and useful definition of cross lamination is that it is not parallel! It is true that several adjacent laminae may be parallel with one another but not parallel with the overlying and underlying lamination or bedding planes.

In general, flagstones with uneven or rippled surfaces are internally cross laminated. Most of these exhibit cross lamination planes sloping down into the body of the flagstone (c.f. parallel laminated sandstone which have no such sloping surfaces). The alternation of micaceous and quartz rich laminae with primary current lineation, on the dipping cross lamination surfaces, is an unusual combination, which may be seen in a few flagstones.

Cross lamination is formed during the migration of asymmetric ripples; sand grains carried by the current up the gently sloping stoss-side of the ripple accumulate and then avalanche down the steeper lee-side to produce cross lamination.

For further discussion of the above sedimentary structures and what may be gleaned about their environments of deposition see Collinson & Thompson (1982).

TRACE FOSSILS

Various trace fossils are present in William Brown Street and can also be used to make deductions about the palaeoenvironment. Trace fossils are the record in sedimentary rocks of animals' activities. They are perhaps more esoteric and best seen with bright, low-angled sunlight. In general most are either at right angles to bedding (i.e. vertical) or parallel with bedding (i.e. horizontal). When studying the following diagrams, turning the page upside down will reveal the surface of the paving stone. Many of the hollows are filled with parallel laminated sand. Thus the 'top' surface of the cast may be flat as a result of splitting along the partings between laminae.

In many instances it is very difficult or impossible to determine what animal produced the trace fossil. Seilacher (1964) and Ekdale, Bromley & Pemberton (1984) classified them ethologically, i.e. a classification based on the activity the animal was pursuing at the time it was producing the trace fossil. The following broad ethological groupings include the most common trace fossils: **Domichnia** (vertical dwelling burrows), **Cubichnia** (shallow, temporary resting hollows), **Fugichnia** (burrows made by panicking animals escaping (generally upwards) through rapidly deposited sediment), **Fodinichnia** (the three dimensional feeding trace of deposit eaters), **Pascichnia** (meandering or spiral two dimensional feeding traces formed on or just below the sediment surface), **Repichnia** (more or less straight, horizontal tracks and trails formed during directed locomotion), **Agrichnia** (complex three dimensional burrow systems in which animals allegedly feed on trapped organisms or "farmed" bacteria etc. on the burrow walls).

Not all the above groups may be seen in William Brown Street, but the following may be seen:-

Domichnia

(See Moore 1962, Seilacher 1964, Bromley 1994.) These tend to be cylindrical burrows and are generally seen in horizontal cross section, or as a circular protuberance, normally less than 10mm in diameter. The protuberances consist of sand from the layer above which has filled the uppermost part of the burrows. Domichnia are generally typical of high energy environments where both erosion and deposition may be rapid. If the protuberances occur individually they are probably *Skolithos*, but may be *Monocraterion* (Figures 1 and 2). However if they occur in pairs, similar to present day ragworm burrows on the beach, they represent remnants of the vertical, "U"-shaped burrows *Arenicolites* (Figure 1) or *Diplocraterion* (Figure 2) which allowed the through flow of food and oxygen bearing water. Really close examination should enable one to distinguish between the individual genera of the above pairs. The casts of both *Monocraterion* and *Diplocraterion* are distinguished by their tapering conical-shape (Figure 2). *Skolithos* and *Arenicolites* (Figure 1) are normally formed by the erosion of the uppermost funnel-shape and therefore indicate a higher energy episode than *Monocraterion* and *Diplocraterion* where deposition has preserved the uppermost part of the burrow. Where *Monocraterion* and *Diplocraterion* have been buried by subsequent deposition, in favourable circumstances the inhabiting animal extended its burrow upwards, producing spreite in the latter (Figure 2). Consequent erosion may cut through both funnel and burrow to give the form shown in Figure 1 of a central truncated burrow surrounded by the circular trace of the funnel.

Probably the best examples of Domichnia occur in the vicinity of the William Brown Street sign outside the Picton Library. To be more precise they occur *on a small, square flag, 6m from the sign in a direction towards the*

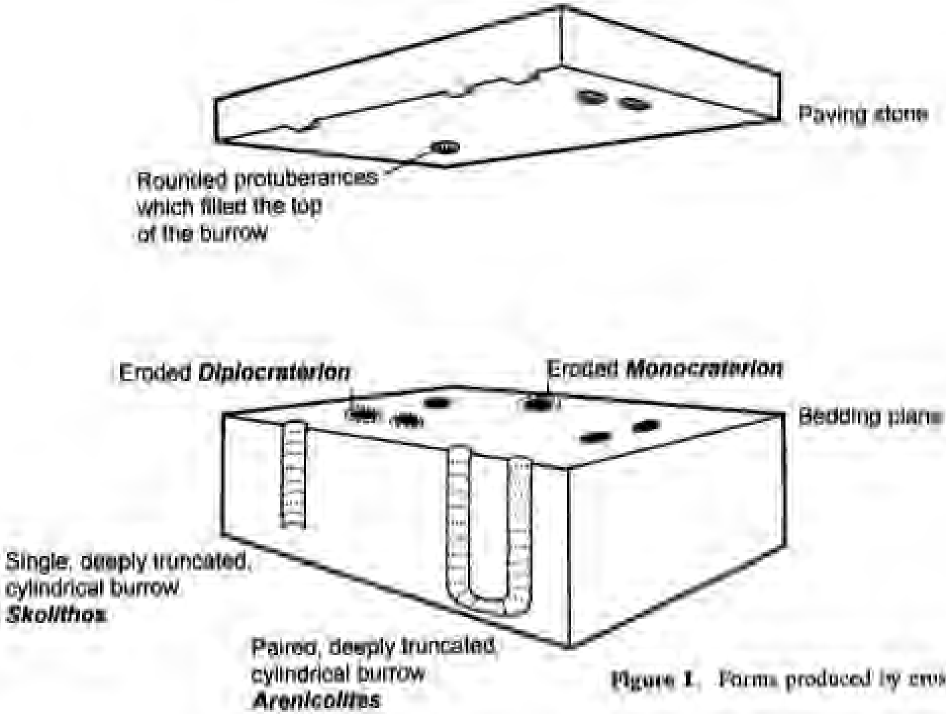

Figure 1. Forms produced by erosion.

Municipal Building's clock tower and on a rectangular, buff coloured flag with a grey area running diagonally across the middle, 1m in front of the sign.

Cubichnia

(See Moore 1962, Seilacher 1964, Bromley 1994.) These are exemplified in the vicinity by bivalve resting impressions, *Lockeia [Pelecypodichnus]*, which when seen upside down form "upstanding", pointed, ovoid shapes which are the casts of the hollows (Figure 2). Some may show alignment, indicative of a fairly gentle, constant food and oxygen supplying current. An abundance of these can be observed on *a buff/yellow tinged, large, rectangular flag, on the Museum side of the road, midway between the balustraded wall, the first tree and the raised ornamental garden at the bottom of William Brown Street.*

Fodinichnia

These burrows are indicative of lower energy environments in which there was little or no erosion (and therefore no need for the animals to burrow vertically downwards) and where organic rich sediment was deposited. The horizontal "U"-shaped burrows of *Rhizocorallium* are also typical of this lower energy environment and may be seen near the corner of St. George's Hall at the top of William Brown Street, *in the fifth flag, 3m in the direction of Lime Street from the statue of Neptune adjacent to a small, double-doored side entrance.* Further examples of Fodinichnia, though somewhat difficult to see, occur *in the darker grey flags in front of the Museum steps and lower, entrance for the disabled and partially sighted.*

Pascichnia

A slower rate of deposition and a less plentiful food supply forces animals to cover a much wider area, more thoroughly in order to gain an adequate food supply. This feeding behaviour produces Pascichnia (Moore 1962, Seilacher 1964). The absence of these traces from the flags confirms that such low energy conditions appear not to have existed during the deposition of the flags. This confirms Sherlock Holmes' opinion that the absence of phenomena is just as, if not more, important than what is present. (Read Conan Doyle's story of the dog that did not bark when its owners house was burgled!)

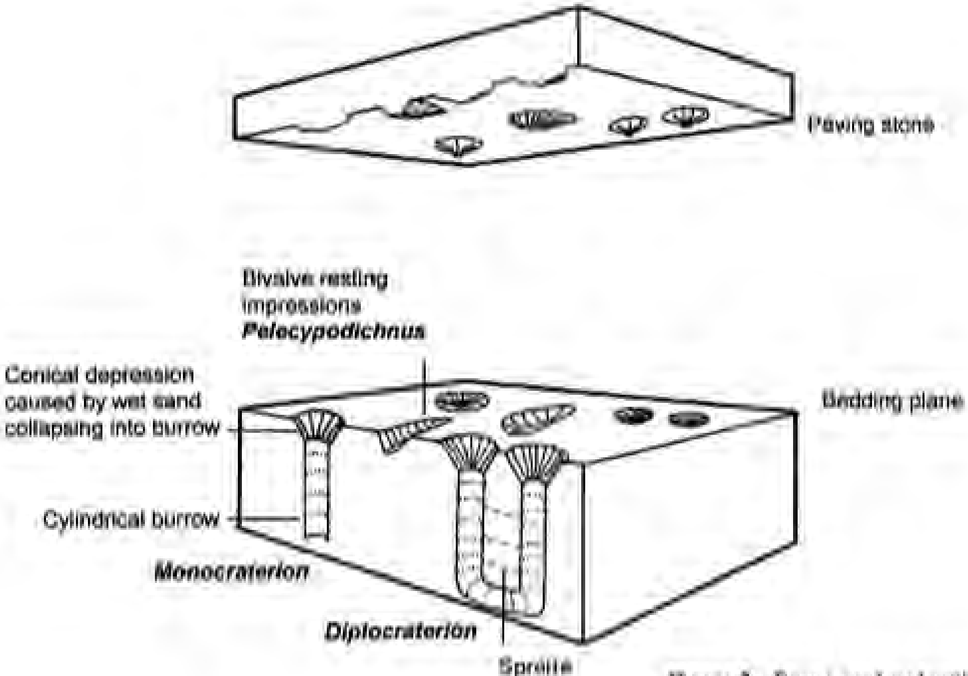

Figure 2 Forms produced with no erosion.

BODY FOSSILS

Body fossils, as opposed to trace fossils, are not as rare as one might imagine. Black carbonaceous plant debris (some of which may have been aligned by the current) commonly occurs on lamination planes in association with mica. Larger plant material, in the form of *Stigmaria (?)*, though extremely unusual, may also be seen *in the middle of the extensive pavement area on the Museum side corner of William Brown Street.*

CONCLUSION

Consideration of our under-used/untrodden resource is particularly appropriate as the paving industry is undergoing a revival. Four acres of modern (laid at intervals since the 1930's), but worn concrete paving, has been replaced recently in Trafalgar Square, on Tower Hill and outside the Houses of Parliament with Carboniferous flagstones from the Huddersfield and Ramsbottom areas. Paving stone has not been sent to London in such large quantities since the late nineteenth century (Wainwright 1992). Westminster Council has given Leicester Square a face lift by importing Rosa Porrino granite from Galicia, Spain for £100 per slab (some of the cheapest granite in Europe) (Robinson 1994). Also prior to the 1950's, the streets of Dublin were paved with stone from the Leinster Massif. The granite was not homogeneous in colour or texture and was a reflection of the variation within the mass of the five or more plutons comprising the Leinster Massif. Over the last three decades the Corporation used concrete to replace worn granite slabs, but recent years have seen a return to the use of Leinster Granite (Wyse Jackson & Robinson 1994).

One of the reasons for the demise of the "modern" concrete flags may be that they are relatively fragile, being only about 50mm thick in comparison with natural flagstones which reach thicknesses in excess of 110mm. Some of Liverpool's larger flags measuring $1m^2$ must weigh over a quarter of a tonne, thus ensuring their intact survival!

The materials described above play an important role in the development of the urban character. The streets of our towns and cities may not be paved with gold *per se*, but they may offer a valuable and interesting resource - the golden (or grey) sandstones of the Carboniferous.

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THE MYSTERIES OF ALDERLEY EDGE

by Tony Browne

INTRODUCTION

Apart from the mythological mysteries of Alderley Edge, regarding the "Wizard" and King Arthur, debate has taken place over many years concerning more worldly matters. Was the area worked for its copper either in pre-Roman or Roman times, and was nearby Mottram St Andrew the type locality of the rare mineral, mottramite, which had been named after it ? Some recent finds have shed light on these puzzles.

THE ANTIQUITY OF THE MINE WORKINGS

In 1874 Professor Boyd Dawkins of The University of Manchester found a number of stone hammers in the Brindlow area, where the ground had been excavated to a depth of eleven feet below the surface (Boyd Dawkins 1875). Mr J.D. Sainter, visiting the site later, recorded stone hammers and in particular, "an old roughly used oaken shovel" (Sainter 1878). Boyd Dawkins considered that the Brindlow Mines had been worked in the Bronze Age.

In 1901 Charles Roeder made visits to the Edge with Mr F.S. Graves of Alderley who had found several stone hammers near the Hagg, and also at Engine Vein and in Dickens Wood. Hammers were also found at Mottram St Andrew. Many of these hammers are now in The Manchester Museum. They were often fashioned from a micaceous sandstone although erratics of igneous rock from the glacial drift were also used. Markings on the side walls at Engine Vein are consistent with the use of stone hammers. Roeder (1901) considered that it was "the Roman colonist" who first worked the area for minerals and not "the original dweller". His reasoning was circumstantial, based on the premises that the Romans, who came to exploit the mineral wealth of Britain, are known to have worked nearby Derbyshire for lead, and that a Roman road passed through the area. Why Roeder named his 1901 paper, "*Prehistoric* and subsequent mining at Alderley Edge...." is a mystery in itself, as "prehistoric" in Britain is assumed to be pre-Roman. Roeder & Graves (1905) described the find of an iron pick in Engine Vein, and from this deduced that the mines were worked by the Romans using British slave labour. However, Carlon (1979) notes that the "pick" is a mass of rusted metal which cannot be dated.

Recently the wooden shovel referred to by Sainter has been the subject of a fascinating article by Garner, Prag & Housley (1994). This tells how local author, Alan Garner, looked after the shovel for forty years hoping one day to convince an authority that it was of the Bronze Age. Dr John Prag of The Manchester Museum took up the challenge and sent it for radio-carbon dating to Oxford, where Rupert Housley obtained a date centring on 1,750 BC, in the Middle Bronze Age. Here we have the first definite evidence that the Edge was worked for minerals in prehistoric times.

When this paper was begun (March 1995) there was still no evidence, however, of Roman activity. However, the finding of an earthenware pot containing some four hundred bronze coins dating from approximately 320 AD to 340 AD has just been made and described in a National Trust press release. This find, by Mr Malcolm Bailey and other members of the Derbyshire Caving Club (DCC), who manage the mines for the National Trust, was made at the top of an infilled shaft some two feet below the original ground level. So there is now evidence that mine workings were in existence in Roman times and that there was some accessibility in mid 4th century.

And what of Mottram St Andrew ? In 1994 examination of the spoil from the digging of a drainage system yielded three stone hammers. The largest of these is dumb-bell shaped with a central groove, made from Ennerdale granophyre, weighing 10 lb 14 oz. It is suggested that this heavy type of hammer was swung by rope or leather. The second is cone-shaped, having a central groove and a transverse groove round the rear end for firmer fixing to a haft. It is of a coarse-grained sandstone, weighing 5 lb. The smallest, a flat, dumb-bell shape, has a central groove and is of a fine-grained, micaceous sandstone, weighing 1 lb 4 oz. These finds support the evidence of other stones from the site of very early mining at Mottram.

MOTTRAMITE

Mottramite [$Pb(Cu,Zn)VO_4OH$], takes its name from the locality of Mottram St Andrew. Henry Roscoe of The University of Manchester, described the occurrence of vanadium in the Lower Keuper Sandstone (now named the Helsby Sandstone) within the Triassic (Roscoe 1868). He obtained vanadium for his experiments from a lime precipitate, which was a waste product of cobalt extraction from sandstone at Mottram by the Alderley Edge Mining Company. Roscoe (1876) gave the name "mottramite" to the mineral which occurred as a "crystalline incrustation [sic] on Keuper sandstone found

Erratum
Line missing from top of page 20 should read, "at Alderley Edge and at Mottram St Andrew...". In the same year another".

vanadium mineral, from a gold mine in the USA, was described by Dr J. Blake as "roscoelite". The suggestion that roscoelite was found at Mottram is a misreading of Roscoe's paper.

Earlier this century Sir Arthur Russell was unable to obtain samples of the mineral from Mottram as access was unavailable. In 1930, however, he was able to collect specimens from the Keuper Sandstone at Pim Hill in Shropshire (Russell 1949). As he considered that there was no authentic material from Mottram, he proposed that Roscoe's mottramite had come from Shropshire on ore destined for copper extraction at Mottram. Since then debate has taken place regarding the provenance of the original samples. Russell's view was supported by Kingsbury & Hartley (1956) on the evidence available at the time.

However, in 1980, Mr P. Ward, with members of the DCC, gained temporary access to part of the old mines at Mottram and found mottramite *in situ*. This material was examined and discussed by Braithwaite (1994). In December 1993 Mr Stephen Mills, also of DCC, was allowed access for a limited period to the same part of the workings. Mottramite was found *in situ* as a black, velvety, botryoidal encrustation on sandstone along the Kirkleyditch Fault, where Wilmslow Sandstone is faulted against the pebbly Engine Vein Conglomerate, at the base of the Helsby Sandstone. Specimens of the mineral were analysed at The University of Manchester and confirmed as mottramite (Manchester Museum accession numbers N.12134-N.12136). Further analysis is taking place on specimens which have a green crust. Access to the working is now impossible due to infilling of the entrance shaft.

So, vanadium is present at Mottram as Roscoe stated, and there is no need to assume that it had come from Shropshire, particularly as Shropshire ore was treated locally near Pim Hill and also at Gallantry Bank in Cheshire which the ore would have had to pass on its way to Mottram.

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THE TRANSFER OF THE SALFORD MINING MUSEUM GEOLOGICAL COLLECTION

by John R Nudds

INTRODUCTION

The Salford Mining Museum at Buile Hill Park, was founded in 1906 in the former residence of the first Mayor of Manchester, Sir Thomas Potter (1774-1845). It was built between 1825 and 1827 to the Greek neo-classical (or villa style) designs of Sir Charles Barry, the architect of the Houses of Parliament (1836) and the Manchester City Art Gallery. It passed into the hands of the Bennett family in 1877 on the death of Sir John's youngest son and was sold in 1902 to Salford Corporation (for £23,000) who opened the house as a Natural History Museum four years later. It is presently a branch of the Salford Museum and Art Gallery.

As Preece (1978) remarks, "although the museum began with displays on natural history, there has always been a strong interest in science....In 1959 the museum extended downwards and, with the assistance of the National Coal Board, Buile Hill No 1 Pit was constructed in the museum cellars. The enormous popularity of this display and the closure of many local collieries over the following decade ensured the increase of the mining collection".

In the early 1970's further mining displays were added on the ground floor, when the "Buile Hill No 1 Drift Mine" was constructed. There were two important implications of this decision; first, the new exhibit encroached upon the space being used for geology storage which thereafter became almost inaccessible. Secondly the further popularity of this display culminated in 1990 in a decision that the Salford Museum would thereafter concentrate its resources purely on its collections and archives relating to the coalmining history of the Lancashire coalfield and to other forms of mineral extraction both in this country and overseas. By this decision the geological and natural history collections were orphaned and the only geological exhibitions now at Salford are those relating purely to the formation of coal and Coal Measure fossils.

In January 1991 a team of natural history curators from The Manchester Museum and Bolton Museum, representing the North West Collections Research Unit (NWCRU), visited Salford to assess the state of the natural history collections and produced a plan to re-locate them. Few of the natural history collections presented any problems; for example, the Abraham Lincoln

Shell Collection was to be transferred to The Manchester Museum Invertebrate Resource Centre for curation; the antiquarian botany books were to be transferred to The Manchester Museum Herbarium, the entomological material was to be transferred to Bolton Museum; the bird egg and bone collections were to be transferred to The Manchester Museum Zoology Department; while the cased vertebrate mounts, several of which were by reputable taxidermists, were too bulky to be accommodated in total by either Manchester or Bolton, and were to be divided between various museums in the north west region.

The fate of the geological collections, however, posed additional problems. All of the material appeared to be worth preserving (at least until a more careful examination could be undertaken under more favourable conditions), but its considerable bulk and the very difficult conditions of the geology stores at Salford dictated that considerable resources would have to be expended in order to rescue this particular collection.

THE SALFORD GEOLOGICAL COLLECTIONS

The geology collections were housed in two main areas of the Salford Museum. The first, a large upstairs room, which also housed the invertebrate, entomology and vertebrate collections, presented reasonable conditions for examination of material. Even here, however, the collections were showing many worrying signs: 10% of material was loose in drawers; 50% had no labels; 50% of labels present were discoloured or stained; 20% of the labels showed signs of mould; all of the specimens were very dirty; 5% had pyrite disease; 5% were showing beautiful examples of salt efflorescence; 20% were splitting or fragmenting etc. etc. But there were clearly some exceptional specimens worth preserving.

The second area of geological storage, however, presented a different story. The room in question was on the ground floor of the museum and was the area referred to above in which the Buile Hill No 1 Drift Mine had been constructed. Part of the floor space of the geology store had been used to accommodate a reconstructed pit head area, complete with a chain haulage system, rails and coal trucks. Consequently the only access now into the store was by crawling down the "gallery" and removing a small wooden trapdoor from the side of the "coal face". Through this small space (10" x 3') one then dropped down a further 2' onto the floor of the geology store. One had to work entirely with torch light or more appropriately with miners helmets, for this room had no light, neither artificial nor natural. The geological collections were stored in open trays on wooden racks with little room between the racks.

Everything was covered in a layer of black coal dust, some of the racking had collapsed so that trays, labels and specimens lay in a heap on the floor. And just to make one feel really happy about working in such conditions, a couple of split sacks of glass fibre were spilling their contents onto the floor of the store room and into the air as one moved about. It was totally impossible to begin to assess the collection under these conditions.

THE ACTION PLAN

It was suggested by the NWCRU report that Salford Museum apply for a Natural Sciences Incentive Fund grant from the Area Museums Service, to permit these specimens to be extracted from this almost impenetrable basement store (a horrendous task in itself), cleaned and placed in card trays *in situ* ready for transfer to The Manchester Museum where they could be assessed. In the end the grant was actually applied for by The Manchester Museum and the project included provision for the temporary employment of a geology graduate, first to remove carefully the many hundreds of specimens from this store whilst preserving any associated documentation, second to undertake a preliminary cleaning and sorting, and finally to transfer the collection to Manchester and to begin its registration.

It was recognised that this project would fit completely with the collections management and conservation strategy of The Manchester Museum Geology Department, whose policy it is to build on its current strength of geological material from the north west region. Moreover, the recently acquired role of the Manchester Museum Geology Department as a HEFCE Regional Collection Centre, requires that it acts as a safety net for such local collections at risk.

As Keeper of Geology I was to oversee and supervise the project in all its stages and the grant for which we applied, and which was granted in full in April 1991, was for a total of just under £1,000, to employ a graduate assistant for four weeks, plus a further sum of £300 to purchase 1,000 cardboard trays.

In September 1991, Wendy Hadleigh, a graduate in Geology/Biology from Manchester University, and a former volunteer museum assistant at both Dudley and Manchester, began work on this project. Conditions in the basement store were so appalling that Wendy had to dress in boiler suit, steel-capped boots, hard hat with petzl lamp and face-mask to avoid firstly, inhaling coal dust and glass fibre, and secondly to avoid skin contact with the latter. A decision was quickly made to spend as little time as possible in this polluted atmosphere and so the cleaning and sorting phase was left until after all the collections had been transferred to Manchester. Within one week all the specimens had been removed from this store with the exception of some very large ammonites. These posed something of a dilemma, it being difficult to find anybody both sufficiently strong to lift them, and yet sufficiently slight of build to be able to negotiate the small trapdoor !

As specimens were removed from the store they were placed immediately into individual cardboard trays together with any associated labels or other documentation. When necessary specimens and/or labels were also placed in polythene bags for added protection and security. We learned from this experience that it was important not only to preserve the collection provenance of the specimen, but also to record the provenance of the specimen within the museum from which the collection is being transferred. For example, often one would have almost emptied a drawer packed with specimens only to find a scrap of paper saying something like, "All specimens in this drawer are from X". Unless one records the exact location within the donor museum's store as the specimen is removed, one risks losing such information. Sometimes one would find a label saying something like, "All specimens in this drawer and in the drawer above come from X". Again, by the time one discovers the label, the "drawer above" has already been emptied. Or you might even come across a label saying, "All these specimens, plus those in the cabinets on the landing, come from X".

We made a decision to overcome such problems by bringing empty cabinet drawers from The Manchester Museum and transferring specimens drawer for drawer as they were brought out of the Salford store. Then, by numbering each drawer and marking them onto a plan of the Salford storage it was possible to retain all such information. These drawers were packed with protective bubble-pack and stacked into the museum's transit van for transfer to Manchester. On arrival at our labs the healthier atmosphere enabled a more considered approach to the cleaning and sorting of the collections. Most specimens were totally black from coal dust and often washing in water was the only way to even decide whether we were dealing with a fossil or a mineral. I don't think this ever caused any damage, except to one or two chalk fossils, but many times such washing revealed real treasures from what had appeared to be amorphous lumps of coal.

THE TREASURES OF SALFORD

Scientifically important finds included palaeobotanical specimens from the Williamson Collection (of which we have the majority already in Manchester), some large trilobites and some Dodo bones from the Plant Collection; specimens from the Prosser Collection; a series of Pleistocene gastropods from Macclesfield listed in the *Macclesfield Geological Memoir* (1906); some large slabs with footprints of the Triassic pseudosuchian reptile, *Chirotherium*, and the smaller *Rhynchosaurus*; and, most important, the topotype (and only the second known example) of the large ?amphibian, *Chelichnus ingens* Binney, from the Upper Carboniferous of Tintwistle in Longdendale, figured by Sarjeant (1974, fig. 23). (These latter examples illustrate one problem which we had not accounted for in the costing of the transfer, and that is the expense of removing such heavy specimens. Our usual removal firm, Maxteds Ltd., who rely purely on a number of very strong men, were for once defeated by the specimen of *Chelichnus* and had to subcontract this job to a firm with a hydraulic crane, eventually costing the Museum £385 to transfer one specimen !)

Other interesting specimens include a fine piece of amber with included insects; a large *Ulodendron* fruit; a piece of Jet carved into leaves; some enrolled specimens of *Calymene*; a piece of blister copper; graphite; a large quartz crystal from Brazil; a petrified Bird's Nest from ?Derbyshire; and some nice specimens of *Titanites*.

ASSOCIATED ARCHIVES

Apart from the specimen labels, which were mostly glued onto wooden or thick card tablets, the only documentation that came with the collection were two bound ledgers, apparently compiled in 1965, and which recorded a number (RM for the rocks and minerals, F for fossils); the name of the specimen; the locality; the geological horizon; the donor; the date of donation; and other remarks. Only 72 specimens were recorded in the RM series, and 450 in the F series. However, these did prove to be invaluable documents in identifying specimens which had been separated from their labels and in identifying old collections, and will be preserved along with our own ledger catalogues.

We were additionally fortunate at Manchester to receive from Salford a considerable geological library which included several extensive runs of bound periodicals including *Quarterly Journal of the Geological Society*, vols 1 (1845) - 126 (1970), *Proceedings of the Geologists' Association*, vols 37 (1926) - 83 (1972), and some early editions of *Geological Magazine*. In addition were included some rare early palaeontological and mineralogical monographs, such as Lyell's *Elementary Geology* (1852), Parkinson's *Organic Remains* (1822), Portlock's *Geology of Londonderry* (1843), Murchison's *Siluria* (1872), Sedgwick & M'Coy's *British Palaeozoic Rocks* (1855), Sowerby's *British Mineralogy* (1811), Captain Brown's *Fossil Conchology* ((1849) and many others.

Many of these apparently came originally from the library of the Manchester Geological Society, founded in 1838, which was transferred to Wigan Mining College in the 1960's and thence to Salford Museum (Williamson 1994). Ironically, it was the associated museum of the Manchester Geological Society, that together with that of the Manchester Natural History Society, formed the nucleus of the geological collection of The Manchester Museum in 1867 when they were accepted by the newly formed Owens College (Nudds & Eagar 1994). The 1991 transfer of the Salford Geology Collections thus reunited the MGS collection with its associated library, which had been separated some 124 years earlier.

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STEREO-OPTICS IN GEOLOGY

by David I. Green

INTRODUCTION

Stereomicroscopes are one of the most used research instruments in university geology departments and museums and are increasingly being taken up by minerals and fossil collectors. They provide a three dimensional (stereoscopic) view at low magnification which provides for detailed examination of specimens. Probably the two most common uses in geology are for specimen identification and for manipulation and examination of materials being prepared for further analysis. For mineral and fossil collectors, however, it is often the beauty revealed in specimens which first attracts attention. This article is written for those who use a stereomicroscope, but are unaware of its limitations, and for those who might require one.

Stereomicroscopes are fundamentally different from the compound microscopes used for biological and polarizing work. Biological or polarizing microscopes may have binocular heads, but the images are laterally inverted and provide no perception of depth. Furthermore, objects must be specially prepared and mounted on glass slides for study. Compound microscopes are not suitable for examining three dimensional specimens and are not considered further.

OPTICS

To appreciate the limitations of any optical system an understanding of the nature of light and how it interacts with transparent media is useful. Visible light forms a tiny part of a spectrum of radiation which ranges from radio waves to X-rays and beyond. It can be regarded as a wave phenomenon, with different wavelengths corresponding to different colours. The human eye is sensitive to wavelengths between 400nm (registered as blue-violet) and 700nm (registered as red). Light registered as white is a mixture of the colours and hence wavelengths between these extremes.

Light travels at different speeds in different media: in vacuum it travels at 3×10^8 ms^{-1}; in all other media its speed is reduced. At the interface between transparent media, light is bent away from its original direction if it crosses at any angle other than perpendicular. The degree to which light is slowed by a particular medium, and hence the degree to which it is bent, is governed by a property known as the **refractive index**. The higher the refractive index the more the light is slowed down. The rule is that when light travels between transparent media with different refractive indices, it is bent towards the normal (perpendicular to the surface) if the refractive index of the second medium is greater than the first, and away from the normal if the index of the first medium is greater than the second.

To complicate matters further, the refractive index of a given medium is not the same for all wavelengths and therefore light of different wavelengths is bent by slightly different amounts. This property is known as **dispersion**.

The fact that light is bent at the boundary between transparent media of different refractive indices makes it possible to produce lenses. These are shaped pieces of glass with polished spherical surfaces which modify the light path to produce images. The images need not display one to one correspondence with the object, they may be magnified, inverted, or laterally inverted (right and left interchanged).

Lens Abberations

Simple lenses almost always suffer from defects known as abberations; they are reduced in optical instruments by combining different lenses with different characteristics. Although not generally pronounced in optical instruments, a knowledge of lens abberations is useful when assessing a stereomicroscope.

Two abberations important to microscopy are chromatic abberation and spherical abberation. Chromatic (colour) abberation results in the fuzzy red and blue haloes seen around a white object: it occurs because the red and blue constituents of the white light are bent by slightly different amounts and so the red image is focused at a different position to the blue image. This is a function of the dispersion of the glass (and is the reason why expensive low dispersion glass is used to make some lenses). Spherical abberation results from the fact that the circular surface of a simple lens focuses light at different points depending upon where the ray falls on the lens surface; it reduces the overall sharpness of the image. Others defects include the globular effect where plane objects appear to be imaged on the surface of a sphere, and coma or astigmatism which produces elongated images of circular objects.

STEREOMICROSCOPES

A microscope in its simplest form has two lenses; an eyepiece lens and an objective lens. The eyepiece lens forms a large virtual image of the real image produced by the objective lens. In a modern stereomicroscope, the eyepiece and objective are made of several elements and there may be a zoom system interposed which alters the magnification steplessly. The only other optical elements in a typical stereomicroscope are the prisms, which are mounted in the binocular head and reverse and invert the primary images produced by the objective to produce erect images at the eyepiece. The prisms also usually modify the light path from the objectives, delivering parallel images to the eyes, reducing eyestrain.

The stereoscopic effect required for examining three dimensional objects, is produced by configuring the optical system such that each eye sees the same magnified image at a slightly different angle. This can be achieved in two ways. The simplest, conceptually, is to arrange two completely separate monocular microscopes side by side at the appropriate distance apart and angle of view. This is known as the Greenough system after the American zoologist who suggested it. The second method uses separate images produced by light travelling slightly off axis through a common main objective lens and is known as the common main objective system.

Greenough System

The Greenough system has the benefit that light passes axially through two separate low-power microscopes on its way to the eyes. It is easier to correct abberations when light travels axially through the lens system and so it is relatively easy to make a well corrected microscope. The objective lenses in the Greenough system must be close together and so they tend to be small and the resultant images are dark, especially at high magnifications. An added complication at higher magnifications is the marginal unsharpness of the separate images which is a consequence of each microscope viewing the object at a slightly different angle.

Common Main Objective System

This uses a single, large main objective to form the primary image. The optical axis of the main objective is perpendicular to the object plane and for this reason the marginal unsharpness characteristic of the Greenough system does not occur. Chromatic abberation is difficult to correct since the light rays do not travel axially through the main objective. This leads to more pronounced colour fringing around contrasting objects, especially at high magnification. The globular effect whereby the image appears to be formed on the surface of a sphere can be a problem with high resolution objectives.

MAGNIFICATION AND RESOLUTION

Few concepts cause as much confusion as the distinction between magnification and resolution. The resolution is the finest spacing which the instrument can distinguish. Assuming all other faults are corrected and the system is working perfectly, the resolution is controlled by the wave nature of light. Beyond the limit of resolution, two points on a test object cannot be distinguished no matter what magnification is used. Magnification is how much bigger the image appears than the object. The magnification of the microscope is determined by multiplying the magnifying power of the objective system (usually engraved on the zoom in modern instruments) by the magnifying power of the eyepiece lens. A microscope with the zoom set at 2.5 and with 10x eyepieces will give 25x magnification.

The limitations of the human eye are important in determining the maximum useful magnification. The resolution of the eye is limited by the spacing between cells on the retinal surface and for an average person corresponds to a spacing of about 0.15mm at the point of closest focus. The maximum useful magnification of a microscope is that at which the image is magnified to such an extent that the finest spacing which the eye can distinguish in the image is equal to the resolution of the instrument.

A theoretical treatment of microscope resolution was worked out by Ernest Abbe at the Zeiss factory in the 1880's. It showed that the wave nature of light governed the resolution of a system through a phenomenon known as diffraction. The resolution of microscopes is governed by a quantity known as the numerical aperture (NA), a property of the objective system. The fine detail of Abbe's theory is still a source of debate amongst microscopists, but his result is often summarized by the simple formula that for someone with average eyesight:

Maximum Useful Magnification = 1000 x NA of the Objective System

The numerical apertures of different stereo systems vary depending on their optical design. Many modern instruments have NA's of 0.08, or thereabouts, leading to maximum useful magnifications of about 80x. For the best stereomicroscopes, fitted with high resolution objectives, the NA can be improved to about 0.2, corresponding to a useful magnification of about 200x and allowing about five times more detail to be distinguished in the image.

DEPTH OF FIELD

There is a direct and unavoidable conflict in optics between the NA and depth of field. The depth of field is the distance parallel to the optic axis over which the object appears acceptably sharp. It depends on the fact that the eye is incapable of recognising small deviations from a perfectly focused image. Instead of an image point, a "circle of confusion" is seen if the focus is not perfect. This becomes larger away from the point of perfect focus as the aperture of the objective and the magnification are increased. The depth of field is consequently shallow at high magnifications. It is worth noting that the accommodating power of the eye contributes to an apparent increase in depth of field. This is the reason why images which appear sharp under the microscope can give poor results when photographed.

Ordinarily, for low magnifications, a high depth of focus and a low resolution is desirable, so that thick specimens can be seen in their entirety. At high magnifications, a high resolution and correspondingly shallow depth of focus is usually required so that the finest details can be studied. Zoom microscopes often have variable numerical apertures depending on their zoom position which go some way to achieving this. Some microscopes are now fitted with iris diaphragms in their optical paths so that the depth of focus can be varied at will.

CHOOSING A MICROSCOPE

The factors outlined above can usefully be borne in mind when choosing an instrument. One important consideration might be the maximum magnification which is required. The very best instruments have a maximum useful magnification of 200x or more, while standard modern instruments might be restricted to about 80x, and less well-designed systems to 40x or less.

Many users find the colour fringing seen around objects, particularly at high magnification, disturbing. Taking instruments on an equal cost basis it is easier to correct the Greenough type than the common main objective type. Most microscope lenses are achromatic, that is they are corrected such that two colours are focused in coincidence. A few are apochromatically corrected, which means that three colours are focused in coincidence. For all practical purposes an apochromatic system will show no colour fringing, whilst an achromatic system will show some, particularly if a common main objective design is considered. Those who find colour fringing disturbing, or who require high quality colour photographs of objects, should consider an apochromatically corrected common main objective instrument or a well corrected Greenough design. Note, however, that the common main objective design tends to give a brighter field of view than the Greenough which may also be important in photography.

The choice between a zoom microscope and a fixed magnification system might be important. A parallel with camera lenses can be drawn: zoom lenses are more versatile than those with fixed focal length, but tend to have slightly lower optical quality overall. This is not to say that fixed systems always deliver better images, but that in general a good zoom system will be more expensive than a good fixed focus system.

The accessories available with a particular system should be considered carefully. Most users will want two sets of eyepieces with different magnifications. Some users will benefit from high eyepoint eyepieces which allow spectacles to be worn. Additional or supplementary objectives may be important to increase the NA of the instrument and hence its maximum useful magnification. A transmitted light stage is useful for inspecting some fossil material, such as insects in amber, and for viewing thin sections. Provision for fitting a polariser and analyzer can equally be useful to petrologists wishing to look at larger scale structures than those visible under polarising microscopes. Those intent on photography will require a trinocular head for attaching a camera. Long arm stands (to view large specimens) are particularly useful in geology, and should be considered seriously. Surprisingly few instruments come with carrying cases as standard, although they are essential for transportation on a regular basis. A final accessory which will be required by almost everyone is an eyepiece graticule for measuring objects.

A good light source will certainly be required for all but rudimentary work. Various types of illuminator are available ranging from angle-poise lamps upward. For geological work, good quality illumination is very important and fibre-optic light sources are definitely the best. They provide good quality, colour-balanced, even illumination which can readily be directed. Most fibre-optic illuminators are supplied with "flex and stay" swan-neck cables. For geological work it is worthwhile considering a ringlight illuminator in addition to or even as a replacement for these. Unlike most other accessories, fibre-optic illuminators are available from independent manufacturers and should not inhibit the choice of microscope.

Before choosing an instrument it is worthwhile spending time looking at as many different models as possible. Long experience has shown that people respond quite differently to the same microscope, and the time taken finding an instrument to suit is well spent. Optical quality may be of prime importance, but if a microscope is to be transported regularly good quality mechanical construction is also necessary. Information on the price of microscopes is rapidly outdated and the reader is referred to the list of suppliers for an up to date guide. Good quality stereo optics do not come cheap, but a microscope properly cared for will give a lifetime of service.

SIMPLE TESTS

The following simple tests should be undertaken on a properly adjusted instrument as a aid to checking optical and build quality. They will rapidly show up any major fault. As a matter of individual choice, however, there is no real substitute for comparing different instruments side by side on a bench.

Adjusting the microscope

The microscope should be properly adjusted for the user's eyes. Most microscopes will have one, or better two, adjustments on the draw tubes, known as dioptric adjustments. For instruments with a single adjustment, make sure both eyepieces are well-seated in their tubes and that the interocular distance (the distance between the eyepieces) is correct for your eyes. Choose a high magnification, close one eye, and focus the fixed eyepiece on a flat object (in the centre of the field) using the rack and pinion. Close the other eye and focus on the second image using the dioptric adjustment. The microscope is then set correctly.

The procedure when there are two dioptric adjustments is slightly more complex, but it allows zoom systems to be set so that they are parfocal, (in focus over the entire magnification range). Under high magnification with the dioptric adjustments to the middle of their range (nominally 0), focus on a flat test object such as a sheet of graph paper using the rack and pinion. Choose a low magnification and without looking through the microscope, alter both dioptric adjustments so that each is extended as far as possible (maximum positive setting). Then look into the eyepieces and slowly rotate each adjustment inward until each image is in sharp focus. Repeat and take an average if necessary. The microscope is now set correctly.

Tests

Use the following tests to check the optical and mechanical condition of a microscope. For a zoom system make the checks at several zoom positions unless otherwise stated.

Choose a white opaque object and arrange it against a dark background. Focus at the highest magnification with x10 eyepieces and look for coloured haloes. Is the level of colour fringing acceptable ?

Lay a piece of graph paper flat on the stage, focus on it, look around the edge of the field of view with each eye in turn; the images should be coincident. Check by rapidly shutting one eye and then the other. If the images are detectably out of coincidence, especially vertically, eyestrain will certainly result.

Still viewing the graph paper, does the field of view seem acceptably flat and in sharp focus right to the edges ?

At high magnification, focus on a tiny particles of dust on a glass slide resting on a black background; there should be small haloes surrounding them. Rack the focus up and down; the haloes should remain uniformly circular.

All of the mechanical components of the microscope should move smoothly without undue pressure. Check for grittiness in both the zoom and focus. Check that the weight of the microscope does not cause the focus to creep. Look at the heads of the screws which give access to the prisms within the binocular head; these should not appear worn. Remember your eyes should not feel unduly tired after using the microscope.

USED INSTRUMENTS

For those on a more limited budget a good used microscope can provide a very satisfactory alternative. These are occasionally put up for sale by members of geological or microscopical societies, educational establishments, or through a limited number of dealers who advertise in photographic magazines. It is doubly important to check the condition of a used instrument thoroughly using the tests outlined above.

SUPPLIERS

Some suppliers of stereomicroscopes in the UK are listed below. Each will provide an up to date catalogue and price list if requested.

Carl Zeiss (Oberkochen) Ltd.
PO Box 78, Woodfield Road, Welwyn Garden City, AL12 1LU
Manufacturer of the SV range of stereomicroscopes.

Finlay Microvision
Unit 6, Southfields Road, Kineton Road Industrial Estate, Southam, Warwickshire, CV33 0JH
Importer of Kyowa stereomicroscopes.

Hampshire Micro
The Microscope Shop, Oxford Road, Sutton Scotney, Hants SO21 3JG.
Suppliers of a wide range of stereomicroscopes.

Leica UK
Davy Avenue, Milton Keynes, MK5 8LB
Manufacturer of the high performance M-series of stereomicroscopes following a recent merger with Wild, the Swiss manufacturer, a takeover of Bausch and Lomb at the same time produced the less expensive stereozoom series.

Lakeland Microscopes
Low Lodge, Rockland Road, Grange-over-Sands, Cumbria, LA11 7HR.
Importers of Russian Stereomicroscopes.

Nikon UK, Instrument Division
Haybrook, Halesfield 9, Telford TF7 4EW
Manufacturers of the SMZ series of stereomicroscopes.

Olympus Optical Company
2-8 Honduras Street, London, EC1 Y0TX
Manufacturers of the SZ series of stereomicroscopes.

Prior Scientific Instruments Ltd.
Unit 4, Wilbraham Road, Fulbourn, Cambridge CB1 5ET
Suppliers of a number of UK assembled instruments.

THE BRITISH GEOLOGICAL SURVEY AT WORK

North-West England and Midlands (T.J. Charsley)

The 1:50,000 geological map for Lancaster (BGS Sheet 59) in two editions showing solid and drift has been published and the memoir has been written for publication in 1995/96. Other work in the area is concentrated on the completion of mapping of the Wakefield area (BGS Sheet 78) and continued mapping on the Bradford (BGS Sheet 69) and Huddersfield (BGS Sheet 77) sheets.

Work to produce reports and applied geological maps providing earth science information for planning and development under contract to the Department of the Environment continues for the Wigan and Bradford Metropolitan Borough Council areas; publication of the results from the former study is due in mid-1995.

Further south, production of maps for the Nottingham (BGS Sheet 126) and Birmingham (BGS Sheet 168) areas is well in hand, with publication anticipated in 1995/96. Field surveying continues in the Loughborough (BGS Sheet 141) and Wolverhampton (BGS Sheet 153) areas.

Lake District and Cumbria (Reproduced from the British Geological Survey Annual Report 1993/4 by permission of the Director, BGS. NERC copyright reserved.)

As part of the Lake District Regional Geological Survey, mapping was completed in the Cockermouth district (BGS Sheet 23) and continued at Keswick (BGS Sheet 29) and Ulverston (BGS Sheet 48). The Ambleside memoir (for BGS Sheet 38) is in preparation. Detailed outcrop studies of the Skiddaw Group and the unconformable overlying Borrowdale Volcanic Group have provided important constraints on the timing of deformation. The regional penetrative cleavage fabric, common to both the Skiddaw Group and the Borrowdale Volcanic Group, is postdated by weaker, domainal crenulation fabrics which continue across the unconformity into the base of the Borrowdale Volcanics, showing that all the cleavage fabrics postdate the volcanism. In the revision survey of the Cockermouth sheet emphasis was placed on a detailed reinterpretation of the Coal Measures and a revision of the stratigraphical nomenclature of the Dinantian sequence. The proposed classification recognises that east of the Bothel Fault the Dinantian succession is similar to the Yoredale facies of the northern Pennines, but that west of the fault Yoredale characteristics are much less evident and the succession most closely resembles the limestone sequence of west Cumbria. In the Whitehaven area a section through Namurian rocks in the Hensingham bypass road has revealed an unusual phosphatised siliceous carbonate bed with abundant spicules and locally pellets of primary glauconite, a mineral not previously recognised in the Carboniferous of Britain.

A sequence of weakly cleaved volcaniclastic rocks, belonging to the Borrowdale Volcanic Group and more than 1,200 metres thick, lies beneath Permo-Triassic and Carboniferous strata in the Sellafield area of west Cumbria. Seven formations have been defined from six of the deep boreholes drilled by UK Nirex Ltd. The rocks are predominantly welded ignimbrites. Abrupt lateral thickness changes and intraformational collapse-mesobreccias characterise the sequence. Deposition is considered to have been within an actively subsiding basin, probably a caldera complex. This is thought to have had an episodic history, with periods of Caldera collapse following eruptions during which an evolving magma chamber was trapped. A Quaternary Characterisation Project conducted on behalf of UK Nirex Ltd. in the Sellafield area established firm glacitectonic evidence for a readvance of ice (the "Scottish Readvance") following the main glaciation of the area.

Wales (Dick Waters)

The last year has seen many changes to BGS in Wales. These largely centre around the announcement by the BGS Directorate in late 1993 that the Regional Office for Wales in Aberystwyth, was to close for financial and operational reasons. Attempts to starve off the closure were marshalled by a steering group including local councillors and the local MP. They sought additional funding for the Aberystwyth Office from the Welsh Office, but sadly, were unsuccessful in their endeavours. As a result the Office at Bryn Eithyn Hall closed in early September 1994 and the building has now been sold.

However, BGS decided to retain one member of staff in Aberystwyth, based at the University with a remit to explore and develop the possibilities for commercial work in Wales, especially with the local authorities. This new "Office in Wales" was established in August 1994 and is staffed by Dr Jerry Davies. Whether it will be a long-term fixture depends entirely on the commercial opportunities for BGS in Wales.

The remaining geological staff, previously based at Aberystwyth, are now widely scattered; one to the Edinburgh office, one to an overseas posting and three to the headquarters at Keyworth. Those based at Keyworth now comprise a new Wales Section within the Central England and Wales Group.

Turning to the mapping programme, this is now entirely concentrated in Central Wales where work is continuing on the Builth Wells (196) 1:50,000 sheet. Last year saw the completion of the mapping of the mid-Ordovician volcanic sequence at Llanwrtyd Wells, in the core of the Tywi Anticline, and the Llandovery shelf-sequence to the east. Maps from Central Wales published last year include solid and drift editions for the Llanilar (178) and Aberaeron (179) 1:50,000 sheets, although the latter is only available as an electrostatic plot.

Other maps published include solid and drift editions of the Montgomery (165) 1:50,000 sheet, a provisional, combined solid and drift edition of the Wrexham (121) 1:50,000 sheet and the bilingual 1:250,000 Map of Wales. A colour satellite image of Wales at the same scale as the Map of Wales is to be published early in 1995. The 1:50,000 Snowdon (119) and Cadair Idris (149) sheets are currently in press; Flint (108) is still in preparation.

The only memoir published last year was that for the Aberdaron and Bardsey sheet (133), which described the results of a team from Cardiff University that mapped the area under a NERC contract. Memoirs in press include Cadair Idris (149) and Snowdon (119), while those for Montgomery (165) and Flint (108) are still in preparation.

Finally, mention should be made of the landslip in the village of St Dogmaels, 1km west of Cardigan. Land movements in February 1994 gave rise to widespread public concern and as a result, Preseli/Pembroke District Council commissioned BGS to advise and investigate the landslip. Prior to this, the landslip had not been recognised, mainly due to the absence of modern, large-scale geological survey maps of the area. The landslip occurs in a 55m-thick sequence of laminated clays, gravels and tills that was deposited in a pre-glacial tributary valley of an estuary of Afon Teifi. The clays accumulated in an ice-dammed lake in front of the advancing Devensian ice sheet. The most recent land movements are the result of the reactivation of an ancient landslip, probably initiated in late-glacial times. The landslip is approximately 800m in length and up to 300m wide. It contains elements of circular, translational and flow types of landslips.

CONSERVATION CORNER

Lancashire RIGS (Chris Arkwright)

Although the RIGS Group in Lancashire was one of the first to be set up in the North West, due to many changes in administration, results have been rather slow. During the past year John Jowitt did much to co-ordinate the efforts of the group, but unfortunately, due to other commitments, was unable to continue his valuable contribution. Lancashire RIGS is now administered by a small committee with an occasional larger meeting to allow for general discussion and approval of any newly surveyed sites.

A preliminary list of approved RIGS has recently been submitted to each District Council in the area to be included in their current planning strategies. This has resulted already in an enquiry re. "the impact of a new road through a drumlin field "! Members will now be able to comment on the siting of this proposed road and hopefully an exposed drumlin section will be the result.

However, we are very mindful that even this limited publication of RIGS is mostly without the landowners knowledge. Consequently, the group's efforts are now being focused on contacting the landowners concerned and we are grateful for the advice and assistance of the County Landowners Association in this exercise.

By the end of September 1995 we hope to have completed the processing of all the proposed RIGS (about 100 in total) which were selected some time ago from the county site records housed at Clitheroe Museum. This includes surveying, documentation, approval or not by the larger RIGS group and contacting all the landowners. We feel that the present smaller committee of local geological society members is better able to control progress and are optimistic of achieving our targets for this year.

Everyone involved in Lancashire RIGS is to be kept informed of progress by an occasional newsletter and, of course, many in this larger group will be helping with the surveying etc. It is also planned to have one or two summer evening field excursions to suitable RIGS, possibly accompanied by the land owner, to promote good working relationships.

The next stage will be to select a few appropriate RIGS for educational use and to produce the necessary explanatory information, in the form of on-site boarding or possibly trail guides. Actual conservation work will also have to be carried out where needed. Anyone wishing to help with Lancashire RIGS should contact: Alan Gur (01254 661548) or Chris Arkwright (01772 39022).

Greater Manchester RIGS (Simon Riley)

Over the last year the Greater Manchester RIGS group have completed the review of all the NSGSD records held at the Manchester Museum. We now have a short-list of the most promising sites with RIGS potential for seven of the districts within Greater Manchester. The remaining three districts are in the hands of Cheshire RIGS. Resurveying the sites on the short-list has started and we are already part way through one of the districts.

To assist in the swift running of the field recording, we have designed and produced our own site recording forms and accompanying guidelines. We are also currently assembling district recording packages which will contain all the relevant maps, copies of NSGSD forms and general information required to survey a given district.

In November, RIGS members, Chanel Johnson, gave a talk to the Oldham Geological Society (OGS) which was followed up with a field recording day looking at the various aspects of site recording. Further field days are planned with a view to OGS members carrying out the field survey in the Oldham district.

There is still plenty of field recording yet to be done; any offers of help would be gratefully received. Please contact: Simon Riley, The Manchester Museum, The University of Manchester, Oxford Road, Manchester M13 9PL (Tel. 0161 275 2636; Fax 0161 275 2676; e-mail simon.riley@man.ac.uk).

Staffordshire RIGS (Keith Harrison)

During 1994 the North Staffordshire Group of the Geologists' Association (NSGGA) has been very active in site conservation. In March the Westphalian C/D boundary at Metallic Tileries, Chesterton, was exhumed by Staffordshire University Enterprises and the NW face at Brown End Quarry, Waterhouses was cleared. In June members visited the construction site of the A50 by-pass at Heron Cross, Stoke-on-Trent and a strategy for Earth Science Conservation in North Staffordshire, was drawn up. In September a letter was sent to the Director of Planning and Architecture, Stoke-on-Trent, regarding the Agenda 21 project to request that they consult the NSGGA before future landscaping so that geological sites are not infilled or covered, and in October a working party at Brown End Quarry cleared vegetation from the front of the quarry face.

Current projects include the maintenance and improvement of the SSSI site at Brown End Quarry, Waterhouses, where publicity is needed to encourage public awareness. The sites at Pot Bank, Hanchurch and Miry, Apedale need official investigation and practical attention to bring them into a satisfactory state. The sites at Cold Meece are in danger of being infilled. Continued work by members of the NSGGA will keep the sites in a good state of preservation. In time the sites can be enhanced to help the visiting public understand the purpose of the site's preservation.

All of the work at the sites will be fully recorded, any findings of geological interest will be noted and the significance pointed out. Specimens collected will be carefully catalogued and stored. When time and finances allow, noticeboards and display boards will be erected at the sites to draw attention to visitors of the significance of what can be seen. Where it is possible, booklets and handouts will be produced and made available at local outlets near to the sites.

Cheshire RIGS (Tony Browne)

RIGS in the Bollin Valley were defended as part of the Cheshire Wildlife Trust's case against the second runway at the Manchester Airport Public Enquiry.

Recorders of RIGS should be aware of the need to draw up site boundaries accurately, and also to search relevant literature, e.g. memoirs, for any reference to the site.

Assistance would be welcomed in recording sites, particularly in the Macclesfield and Congleton areas. Please contact Jill Smethurst of the Cheshire Wildlife Trust at Grebe House, Reaseheath, Nantwich, Cheshire, CW5 6DA (Tel. 01270 610180; Fax 01270 610430).

MUSEUMS ROUNDUP

Geology in UK museums - interactives and multi-media ?

The display of geological and geomorphological objects and concepts in a museum context has long been a challenge to museum curators and designers. It has never been easy to bridge the time-gap between a dull, lifeless piece of black rock and the violent, fiery, colourful excitement of an erupting volcano. And how do you get the message across that a weird impression on the surface of a piece of shale was once a living animal, crawling on the sea bed some 600 million years ago, at the very dawn of life on this planet ?

In Victorian times, when the science was still in its infancy, it was sufficient for museums simply to fill their cases with row upon row of rocks, minerals and fossils, each with a brief, scientific identification, but offering no interpretation. Museums were preaching to the converted and the geological displays existed predominantly for the academics, the scholarly gentry and learned clergy, who, following the fashion of the times, were busily accumulating their own cabinets of curios.

But, the general public today demand and deserve something rather different, and museums are at last waking up to this fact. Television documentary exposure of natural history, coupled with increased available leisure time, has created a generation hungry for further information, and geological curators all over the country are busy trying to ensure that their subject does not get left behind.

There is no shortage of material - a recent survey by the Geological Curators' Group lists over 170 geological museums in the British Isles. In the last two decades many of these have demolished the dusty desk cases of our forebears and developed new displays to liven up the dreary image which our subject often portrays.

Pride of place, certainly in terms of the "total experience", and incorporating light, sound and even smell, goes to the **National Museum of Wales** in Cardiff with the brand new *Evolution of Wales* exhibition opened in October 1993. Not so much a gallery, more a science centre, this exhibition incorporates the very latest in multimedia presentation and allows the visitor to sit on glowing lava while a volcano erupts before him (or her !), or to be enchanted in the small planetarium as tiny stars appear twinkling on the walls, carpets and very seats on which he sits. Computer imagery encapsulates the whole of geological time into a minute and shows tectonic plates rushing around the globe, while robotic dinosaurs roar from Jurassic plains. In another scene, from the Ice Age, a huge woolly mammoth towers above the visitor with braying wolves threatening to pounce from their rocky perch. Real specimens are also displayed although the multimedia distractions tend to divert one from reading the tiny labels.

On a much smaller scale, but no less acclaimed, is the *Time Trail* exhibition recently opened at **Dudley Museum** in November 1992. Here, geological history is narrated as a story with layers of rock strata gradually unfolding and turning like the pages of a book. A series of detailed dioramas is juxtaposed with fossil-rich rock faces emphasising the link between past and present, while ingenious modelling and the use of high-quality reproduction fossils, has enabled real specimens inside the cases to continue "through the glass" onto the walls of the gallery where they provide a truly "hands-on" display for the visitor.

For those traditionalists amongst us who like to see rather more in the way of real specimens, is the equally new and equally enthralling *Earth...Life* exhibition, just opened at the **Hunterian Museum** in Glasgow. Here, a range of innovative specimen-based displays includes meteorites, rocks and minerals, trilobites, dinosaur remains (don't miss the superb clutch of eggs with preserved embryonic remains), early hominids and some exquisitely preserved Scottish fossils, all exhibited in refreshingly modern cases that somehow seem quite at home in the early 19th century Main Hall.

By the end of the century Scotland will have another gem in the new museum being built alongside the Royal Museum of Scotland in Edinburgh. Scheduled to open in 1998, the geological gallery will show the variety and change of the Scottish landscape shaped by volcanoes, tropical lagoons and glaciers. Where it will differ from anything currently available will be in the use of touch screen computers to provide additional information on the collections. A key feature of the new museum will be a specially developed educational resource called MOSAICS (Museum of Scotland Advanced Information Computer Systems). With this highly innovative system the user will see how objects were made and used; damaged objects restored to pristine condition; additional views of objects - inside, back or base; related objects outside the Scottish collections; and people and places associated with these national treasures.

While this is still some years off, perhaps the nearest to this presently available is *The Natural History Centre* at **Liverpool Museum**. Opened in

1987 the centre offers the ultimate in interactive displays: specimens are available for examination either by direct handling or through the use of microscopes or specially modified video-cameras. A micro-computer linked to the collections database provides additional information on the mineral collection. Video-cameras also provide the theme at the **Buxton Micrarium** where again specially designed microscopes allow the public to explore the hidden world of microscopy in geological, zoological and botanical specimens. This small, family-run enterprise is well worth a visit and is the only one of its kind in the world.

Finally mention must be given to **The Natural History Museum** in Kensington which has had its fair share of criticism in recent years for the demolition of its much loved and traditional displays. While many of the new displays are rather devoid of specimens and sometimes rely too much on the push-button mentality, I really can recommend the *Dinosaur Gallery*, where many of the museum's very best skeletons and real fossils are perfectly complimented by just the right amount of robotics, models and reconstructions. The latter are used to interpret the former and not as an end in themselves and this strategy should satisfy even the purists amongst us.

And what of the future ? There is undoubtedly much more on the horizon in terms of interactive and multimedia display of earth science exhibits. Since November I have attended two conferences on this subject, at the University of Lancaster and at the National Museum of Wales, where exciting new ventures were described. Some of these were at museums in the traditional sense, but the trend seems to be towards including more geology and earth sciences at the large science centres such as **Techniquest** in Cardiff and **Satrosphere** in Aberdeen. This is true, at least, for the hi-tec end of the market where computers are clearly playing an increasing part, but other new initiatives are being shown by various outdoor centres, such as **The National Stone Centre** at Matlock and **Killhope Mining Museum** in Weardale, where very low-tec interactives, such as the gloriously messy occupation of gem panning, take us back down to earth. And that, after all, is what geology is really all about !

(John R. Nudds)

MGA FIELD TRIP TO THE MARPLE AREA (17th OCTOBER 1993)

Leader: Hugh Johnson

INTRODUCTION

At the beginning of the excursion the leader gave a short resume of the glacial history of the Marple region. He recalled that much of North West England was covered by ice sheets on several occasions during the Pleistocene Epoch, but noted that there is little evidence for any of these transgressions except for that of the last great ice sheet development which took place some 15 to 25,000 yrs ago (15-25 ka). The extension of this last ice sheet into the Manchester region effectively destroyed almost all the evidence of any earlier ice movements, but at Chelford organic deposits dating from a glacial inter-stadial prior to the last major glacial stadial have been exposed. Beneath the organic beds, which are dated by thermoluminescence to c. 90-100 ka, there are sand deposits which are found elsewhere in East Cheshire. At Arclid, a mammoth tooth was recovered from these beds and this has been dated to c.120ka. There is thus a sequence of deposits extending from the Late Ipswichian Inter-Glacial through to the Late Devensian Glacial Stadia. Beneath these sands an older till has been seen at Chelford, but its age is as yet unknown.

During the Devensian/Dimlington Glacial Stadial the ice sheet deposited a series of glacial sediments, mostly thick tills, that now mantle most of the Lancashire and Cheshire Plains and extend into the adjacent hills of the Pennines and Welsh Borderland. Erratics found within these till sheets indicate that the ice sheet glacier sources were in the western Scottish Highlands, Islands and the Southern Uplands, the Lake District and possibly the northern approaches to the Irish Sea basin. Outlet glacier streams moved southwards from these source areas and while, most of the ice flow passed into the southern Irish Sea region, a substantial body was deflected towards west Lancashire and Cheshire. From here the ice streams moved southwards through the Cheshire Gap to the vicinity of Worcester and to the North-West Midlands west of Birmingham. The maximum phase of the ice sheet transgression probably occurred about 20,000 yrs BP (20ka) and at that time the area around Manchester was deeply buried by ice possibly more than 300m thick. Various attempts have been made to estimate the thickness of the ice cover, but because the ice sheet was generally unstable at this time, its outer areas would have been thinning rapidly and the ice streams within it spread forward very quickly. Local thicknesses would therefore be governed by the pore-water pressures found in the bedrock over which the ice was moving, and the nature of the ice flowage, within the local area, which in turn was dependent upon distance from still stable ice source regions.

It is important to note that there was no substantial ice field developed within the South Pennines and any ice reaching the West Pennine hill margin came from the northern sources already mentioned. A very small glacier was possibly formed at Seal Edge, on the east flank of Kinder Scout, but most of the central parts of north Derbyshire although snow covered, remained substantially ice free at this time. The most southerly ice source was located in the Upper Ribble area but its outlet glaciers were diverted eastwards into West Yorkshire and were unable to extend westwards to Preston as they were blocked by glacier streams from the Lake District.

THE LOCAL GLACIAL SEDIMENTS

Some 130-140 years ago, E. Hull and his associates in the Geological Survey, identified Pleistocene sand members interbedded with "clays with boulders" (viz. Upper and Lower Boulder clays) in the Pennine valleys of the rivers draining towards Manchester. They believed that this tripartite succession characterised the glacial deposits of much of northern England and it was interpreted as evidence of two major glacial ice sheet advances separated by a series of outwash materials formed during a retreat stage. This tripartite division has been mapped in these valleys on several occasions, but it is now recognised as being an over simplification of the true depositional succession and that the interpretation is no longer tenable even though it was accepted for nearly one hundred years. Rather than the slow advance and retreat of the ice as originally envisaged (by earlier workers) it is now believed that there was a rapid advance of the ice sheet with its subsequent rapid disintegration during a period of climatic warming. The wasting of the ice sheet would have left large areas of stagnating ice melting in situ in this area.

From their observations of modern glaciers and their deposits, Boulton and many other glacial geologists now interpret such sedimentary sequences as reflecting conditions typical of a downwasting ice sheet. They interpret the Lower Boulder Clay as a lodgement till formed beneath a glacier, whilst the Middle Sand sediments are associated with melt stream activity taking place within, or at the front of the ice margin; the Upper Boulder-Clays are derived for the most part from supraglacial materials originally deposited along the ice front or upon the ice margin itself and subsequently affected by slumping or other mass movement processes (flow tills). Such a model of glacial deposition is an appropriate one for areas at the ice margin where the ice became stagnant or only slow moving. It is therefore applicable to many locations at the Pennine margin and to Marple in particular. Further to the west, on the Cheshire Plain, these sediments have been collectively identified by Worsley as representing a particular stratigraphical unit within the Late Pleistocene which he called the Stockport Formation.

In the Marple area, the local relief of the Pennine hills strongly influenced depositional conditions at the edge of the ice sheet. Within the local valleys lodgement tills were formed upon the floors of the valleys in locations where the ice lobes extending from the west were at their thickest, but with the later melting and downwastage of the ice sheet much meltwater activity occurred and these basal tills became overlain with a sequences of fluvio-glacial and flow till sediments, the latter often extending as a veneer onto the higher slopes of the local hills.

Marple Bridge

From Brabyns Brow car park (964894) turn right down hill and cross the River Goyt at Marple Bridge, turning right to the first stop at Town Street (965894).

In the centre of Marple Bridge the River Goyt is located within a gorge segment of its valley. On the western flank of the gorge Carboniferous (Westphalian) sandstones and shales are exposed, but on the eastern side most of the upper slope is formed of till and other glacial materials with only the lower slope eroded in bedrock. A temporary section here exposed the basal glacial deposits of weathered red-brown and unweathered blue-grey till overlying Coal Measures sandstone and shales. The leader explained that the eastern flank of the gorge was eroded in an infill sequence of glacial deposits which blocked the former valley of the Goyt which is sited to the east of the present gorge.

This recognition of this river diversion and reasons for its occurrence were first explained by Rice (1959) who noted six other similar gorges in the valley at New Mills, Hague Bar, Strawberry Hill, Marple, Offerton and Stockport. Johnson has also recorded similar features in the Etherow valley south of Broadbottom, and several other diversions are known from locations in other Pennine valleys that are tributary to the Mersey and were invaded by ice spreading from lowland areas to the west. Johnson has suggested that this partial derangement of the drainage occurred when these valleys were first blocked with a glacial infill and that the gorges were eroded by meltstreams. These cutting through the tills and other glacial sediments at the ice margin or beneath the ice, became superimposed onto the underlying bedrock. He has argued that the gorges, which are located on the sides of the former valleys and are some 25m deep, were eroded at c.15ka when meltwater discharges were at their highest and once the rivers were incised into bedrock their courses became fixed. Following the erosion phase some valley aggradation took place with river gravels and alluvia being deposited on the floor of the gorge. These have been dissected into terrace features which can be traced through the gorges.

When visiting the temporary exposure, the nature of the valley glacial infill was discussed. Generally its sedimentary character is very variable and ranges from "varves" or glacial rhythmites exposed beneath and passing upwards into basal till at Broadbottom, to thick beds of well-graded sand beds of glacial-fluvial origin and exposed in sections found in tributary gulleys of the Goyt and Etherow. Such deposits are usually capped by, or interbedded with, tills whose character changes according to its origin and position within the stagnating ice sheet margin.

Brabyns Park

Cross back over the bridge. On the other side of the road enter Brabyns Park and follow a path leading to the Sports Pavilion.

O.T. Jones (1924) described four terraces (the Mersey High Terrace, two intermediate ones, and a flood plain terrace) as occurring in the Mersey valley between Stockport and Stretford. Simpson and Rice also mapped these terrace features upstream from Stockport, but did not agree as to the number to be found there. Johnson extended their work and mapped the terrace suites within the Etherow, Dane and Bollin valleys and also mapped the Mersey valley terraces downstream to Warrington. He concluded that the Mersey High Terrace could be identified throughout the lowland areas of the river system but that there was less reliable evidence for the "pairing" of the later terraces remnants within the valleys and that these relics have been preserved by a number of variable conditions such as the effect of hydrological, climatic and sea-level changes through time and variations within the stream channel, including the effects of engineering improvements undertaken in historical times and some climatic and sea level fluctuations in the Post-Glacial period.

At Flixton Johnson (1969) found peat beds which had formed *in situ* during the aggradation phase of the Mersey High Terrace and these Dr Franks was able to date palynologically to a period of c.10-8 ka. It would appear that there had been an aggradational phase within the valley which may have begun as soon as the meltwater volumes began to decrease and was probably intensified during the Loch Lomond Scottish Glacial stadia. This aggradational phase was associated with an accelerated bed-load (gravel/sand) alluviation that was linked with a readjustment of meander belt geometry, channel form and the surface slope of the flood plain. Rapid sedimentation led to rapid shifts in the channel form and to possible braiding. As stream sinuosity increased within the parts of the valley not constrained by the gorges, the older alluvium at the valley edge became undercut and the width of the floodplain increased. This aggradational phase must have continued for some time following the formation of the peats at Flixton, but a decrease in turbulence and bed load led to a second phase of readjustment with deepening of the channel and the temporary entrenching of the meander belt within the floodplain. This erosion of the lower levels of the valley with also associated with terrace development which took place whenever the river regime controls permitted. In the Dane valley, new work, by Harvey and Hooke, has shown that much of the downcutting there has taken place between 4,725 BC to 975 AD and was followed by a subsequent phase of valley floor aggradation. This phase too has been interrupted as a result of human interference with the river channel from 1,800 AD onwards.

In Brabyns Park the pattern of terrace development was explored and shift of the river to its course described. Because downstream the channel is now confined within bedrock, the meander shifts in Brabyns Park have become distorted in shape and several cut-offs have taken place during downcutting. On the far side of the river bend below Cote Green (965902) the river cliff consists of shale and sandstone at the base which is overlain with part of the glacial infill that blocked the pre-glacial Goyt valley abandoned when the Town Street Marple Bridge gorge section was eroded.

Ludworth Intakes

From Marple Bridge drive north east on the A626 towards Glossop and after 2km turn right into Sandy Lane (979906) and follow this to a viewpoint at Ludworth Intakes (995913)

The excursion route between Ludworth Intakes and New Mills allowed the party to see some of the landforms of the higher hillslopes around Marple. At the Intakes the view to the northwest includes one of the best glacial meltwater channels in the country. It can be described as a col channel as it cuts across a minor divide at its lowest point. It is a steep-sided valley, sinuous in form and 8-9m deep. Unlike a normal valley there is no spring head and the channel was apparently eroded when the Devensian ice sheet covered the local relief. At this time, meltwater under hydrostatic pressure, may have flowed across the col eroding the initial channel and the erosion continued until such time as the ice surface melted to level lower than that of the col.

Charlesworth Landslip

Continue a short distance before turning right into Gun Lane (966910). A short distance along the road stop at a farm road junction (968909) and walk a short distance down the farm track to obtain a view of the landslip on Cown Edge to the northeast.

A large scar on Cown Edge marks the location of a large-scale landslide. Previously described as a rotational landslide, it is in fact a rotational slide in which there has been also some translational movement along an inclined failure surface which for much of its length is aligned along a bedding plane which lies above, but close to the Simmondley Coal seam. Although the upper part of the slide is broken into large coherent rock masses which have rotated relative to the original slope the toe areas of the slide flowed down the hill slope and onto the till mantle covering the lower parts of the local valley. This demonstrates that the slip movement took place at some time after the tills were emplaced. The till mantle had the effect of impeding groundwater flow and increasing pore-water pressures; this contributed to the ultimate slope failure.

A second datum point can be also established by examining peat deposits formed in depressions located on the surface of slump. The earliest pollen extracted from these peats and their sub-soils dates from 9-7ka and it has been shown that similar landslide hollows mapped in Longdendale also date from this time. It would therefore appear that most of the landslides occurred on South Pennine hillslopes some time after the last major glacial stadial, but are not a product of any one post-glacial climatic or hydrologlacial change which may have affected the hillslopes.

Mellor Moor

Continue along lane to the Moorfield Inn (002895). The next view point is on the minor lane at the side of the inn and may be reached by walking about 200m from the lane-road junction (000891).

The viewpoint is located close to the divide between land descending on the west to Marple Bridge, and on the east to New Mills. Much of the topography round here, consisting of benches and scarps, is determined by the lithology of the Carboniferous strata and their position within the Goyt Syncline and by past erosion conditions which bevelled the crests of the escarpments. Within the valleys the lower ground is covered by tills, but on the upper slopes there are only patches of till and mounds of sand and gravel. Immediately to the south of the inn, there is a large col channel whose floor slopes eastwards, and Johnson has suggested that the nearby mounds of fluvial-glacial material were once part of debris that blocked former melt-channels that drained beneath or at the margin of a former ice sheet. Similar mounds have been found elsewhere on the south-west Pennines on the higher hillslopes and some contain marine mollusc shells. Such fossils were originally eroded by meltstreams from the sea floor, but as they come from different faunal groupings it is assumed that they were frozen into the ice base as parts of sand/gravel concretions which were then transported to the ice margin.

Mellor Moor

Return to the junction and continue south along Shiloh Lane. At the next junction park on unmetalled road opposite (997882). Return to the junction and walk south west along the road below to the next stop (996880).

Here, a small valley is seen to cross the lane. On the downhill, western side of the road, the valley cross-section is trough-shaped and the valley form is sinuous: part of the valley floor was affected by coal mine subsidence. To the east, the valley head is shallow and incapable of providing a sufficient discharge to erode the valley section to the west of the road. A glacial origin for the features seems likely and it is possible that meltwater erosion would have occurred at the time when the ice sheet downwasted from off the higher hill summits. These hills would have remained snow-covered, but with ice remaining on the lower ground stream flow off the high ground would have been supplemented by meltwaters and channels eroded to allow the streams to enter the ice at the lower level.

New Mills

Proceed to New Mills then continue along the Goyt Valley on the B6101 to a viewpoint (990855).

As at Marple, the Devensian ice sheet covered the New Mills area with glacial sediments providing a thick infill within the Goyt valley, but decreasing in thickness on the upper slopes of the valley. According to Johnson, there is no evidence for the existence of a former "Lake Goyt" within the valley, but in favoured locations some drainage impedance with small ephemeral lakes forming at the ice margin was possible. At New Mills the rivers Sett and Goyt have both been diverted into gorges eroded in bedrock and the diversion was due to the presence of a former ice lobe that blocked the valley and left a substantial infill within it. With downcutting the rivers are now constrained, but upstream of each gorge meandering of the stream channel took place and this has enabled the river to remove much of the glacial infill. The remaining glacial infill has often been made unstable through river undercutting at the base of the slopes and one such landslip is seen on the valley-side opposite.

Marple Aquaduct

Return to Marple. A small road off the A626 (at [illegible]) follows the canal to the aquaduct (955901). Car parking close to the aquaduct is limited.

From the Aquaduct there is a good view down the river gorge which, like those seen at Marple Bridge and New Mills, was initiated during downwasting of the ice sheet. The original valley now plugged with a glacial sediment infill is located to the north of the gorge and at Romiley is aligned parallel to it. River terrace remnants have been mapped within the gorge and the same levels appear both upstream and downstream of it.

Marple Hall

Return to main road (A626) and turn right through Marple. About 2km to the west of the town turn right down Hill Top Drive leading to Marple Hall School. Stop at end of the cul-de-sac at [illegible].

This locality is on the site of the former Marple Hall which was demolished in 1959. A short distance from the Hall foundations there is a steep, high, curving cliff section eroded in bedrock. This marks the outer edge of an abandoned valley meander whose core is formed by the Turncliff Woods seen opposite. The valley floor of this meander core has been examined using seismic and palynological methods and it appears that the cut-off took place some time between 5 and 10 ka.

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(R. Hugh Johnson)

MGA FIELD TRIP TO CAER CARADOC, CHURCH STRETTON (5th JUNE 1994)

Leader: Susan Beale

INTRODUCTION

This was an excellent field trip in the Church Stretton area, despite rain throughout the walk. Sue Beale led a group of 22 people to 11 localities showing volcanics, sediments and many fossils. All localities, except the first, were on public footpaths, and all had scree for collecting specimens, if it was felt to be necessary.

The rocks examined were Uriconian volcanics (Pre-Cambrian, 650-600 million years old), Stretton Shales (Pre-Cambrian, 590-575m.y.), Wrekin Quartzite (basal Cambrian) and rocks from the Upper Ordovician. There was very little chance of appreciating any structure, due to isolated exposures and much faulting. Sometimes it was difficult to assign a rock outcrop to a particular formation !

Locality 1: Stretton Shale (Grid Ref SO 4680 9437)

This vertical face, some 50m long and up to 3m high, shows laminated green grey shale. Bedding varies from vertical to almost horizontal due to faulting, and flexures and shear bands were well displayed. The regional dip is steeply to the west or northwest. Near the centre of the face is a channel, 6m wide by 2m deep, filled with till. With its basal Helmeth Grit, the Stretton Shale Formation is the oldest formation of the 8,000m of Pre-Cambrian (Longmyndian) sediments in this area. Since it shows a general coarsening upwards, it may be a distal turbidite. Walking eastwards along the track (i.e. down the succession) one passes over the Helmeth Grit onto the Ragleth Tuffs.

Locality 2: Uriconian dolerite (Grid Ref SO 472 943)

This natural exposure of dolerite is some 20m above the track and measured approximately 5m by 3m. It is a dark green-grey intrusion (probably a sill) in the Ragleth Tuffs, the uppermost of the 1,300m of Pre-Cambrian Uriconian volcanics beneath the Stretton Shales. Some crystalline hand specimens can be found, with the crystals being oligoclase feldspar and augite (the latter commonly altered to chlorite); while quartz can be present interstitially or in amygdales.

The track to the next locality follows a branch of the Church Stretton Fault, which brings the Ragleth Tuff and the other underlying volcanics on the western side of the fault against the upper part of the Longmyndian sediments on the east, thus cutting out most of the Longmyndian.

Locality 3: Wrekin Quartzite (Grid Ref SO 476 948)

This is on the right-hand side of a new access to the path up Caer Caradoc. It is a low exposure, measuring about 7m x 1m, and shows the hard, light grey "clean" quartz-arenite, with occasional current bedding. Being east of the fault, the dip is to the northeast. The quartzite is interpreted as being a beach sand, marking the basal Cambrian transgression of the sea in this area. It is up to 50m thick and rests unconformably on both Longmyndian sediments and Uriconian volcanics. It has a conglomerate at its base. Trace fossils, in the form of worm borings, have been found on the Ercall, north of this area.

Immediately to the east, across the stream, the low rounded hills are of Ordovician Hoar Edge Grit and Harnage Shales, while the higher Hope Bowdler Hill beyond is back into Pre-Cambrian rhyolites, andesites and tuffs.

Walking on up the track towards the summit of Caer Caradoc, loose pebbles of dark grey, vesicular basalt and of pink amygdaloidal rhyolite can be found.

Locality 4: Uriconian Rhyolite (Grid Ref SO 476 795)

This craggy location near the summit shows the pink Caer Caradoc rhyolites, "with marked flow banding and a steep dip to the southwest". There are also amygdaloidal and brecciated varieties, although at this location the angular, broken appearance of the rock face was due to natural weathering. There were, however, obvious fault planes, with slickensides. The rhyolites are composed of albite and orthoclase feldspars in a matrix containing chlorite, quartz and scattered hematite. The amygdales are of quartz and chlorite.

Moving westwards across the summit there is much to see overlooking the Church Stretton Valley and the Long Mynd. The fault-guided Church Stretton valley is obvious, with the plateau of the Long Mynd beyond. In the foreground the main fault line follows the foot of Caer Caradoc, with its westerly downthrow bringing in Silurian (Wenlock, Ludlow and Llandovery) rocks to form the valley floor, covered by glacial deposits. Wenlock Limestone crops out in the wood. The Long Mynd plateau is formed by the pile of Longmyndian sediments dipping steeply west.

During the glaciations, ice did not get onto the Long Mynd, and so was funnelled through the valley. Immediately opposite is a valley called "The Batch", with a side valley, Cwmdale, to the southwest. Cwmdale has been described as a glacial meltwater channel draining The Batch while its exit was blocked by ice.

The marked ridge to the northeast is "The Lawley", formed by andesites and tuffs of the Uriconian volcanics. West of the fault at the base of The Lawley, the glacial till is underlain, not by Silurian rocks, but by Carboniferous Coal Measures. Moving on, the excursion route descends the steep north ridge of Caer Caradoc, to pick up a path to the east, with a stile over the fence.

Locality 5: Boulder Collection (Grid Ref SO 4806 9570)

This locality is not an exposure, but a heap of boulders, mainly of local rocks. The more notable ones show pebbles (Hoar Edge Grit, Upper Ordovician) or trace fossils. There is also Wrekin Quartzite and vesicular basalt. The green and orange boulder is a mystery !

Continuing along the path, notice the isolated peak of Robin's Tump to the northeast. Here, Middle Cambrian strata unconformably overlie Lower Cambrian. before reaching the next locality we pass over one of the main fault branches, which separates Caer Caradoc (Uriconian volcanics) from the younger sediments in the valley immediately to the east.

Locality 6: Wrekin Quartzite (Grid Ref SO 4815 9525)

This is a ground-level exposure, approximately 3m by 2m overall. It is a grey sandstone, weathering to light brown. It is probably Wrekin Quartzite, with an east-west strike and almost vertical dip. (The geological map also has Hoar Edge Grit in this vicinity, which is described as "brown sandstones".) It is separated from Locality 3 by the unconformable cover of Ordovician sediments, and is closer to the more extensive area of complexly faulted quartzite along the eastern side of Little Caradoc, to the north.

Locality 7: Hoar Edge Grit (Grid Ref 4828 9513)

This exposure, 2m long by 1m high, on the left-hand side of the track, is of low quality, but shows brown sandstone of variable grainsize. Fossils are reasonably easy to find: mainly brachiopod moulds, probably *Dinorthis* and *Salopia*, but also occasional crinoid fragments and bryozoans.

The Hoar Edge Grit is of Upper Ordovician (Caradoc) age and is up to 120m thick in this area. The sequence is mainly coarse sandstone with a basal conglomerate, although there are limestones and shales locally. They lie unconformably on older strata (the gap is approximately 30 million years), being part of a continuing transgression, from the northwest, across the arid landscape of the Midland Platform. At this time Britain was at latitude 30° south (equivalent to South Africa today) and land plants had not yet evolved.

The route then carries on up to the road where one turns eastwards to the small exposures.

Locality 8: Chatwall Sandstone (Grid Ref SO 4869 9512)

This is an old roadside quarry, some 15m long and 2m high. It shows a well-jointed, purple, silty, fine sandstone (thought to be unfossiliferous prior to our visit). It contains brachiopods (particularly *Sowerbyella*) and gastropods, and a one trilobite pygidium was found (possibly *Broeggerolithus*, a trinucleid).

The Chatwall Sandstone is also of Caradoc age, but is younger than the Hoar Edge Grit. Despite an intervening fault, the route has been moving up through the succession which dips at 65° to the southeast. From this point the route continues down the road until just prior to Willstone Farm when it turns hard right to traverse the hillside field.

Locality 9: Chatwall Sandstone/*alternata* Limestone

This exposure on the right-hand side of the path measures some 30m by 4m high. It is packed with brachiopod bands. Between the Chatwell Sandstone and the younger Cheney Longville Flags is the 20m thick *alternata* Limestone, made up of repeated 20-30cm thick, lenticular, shelly limestones interbedded with flags and shales. The limestones contain numerous *Heterorthis alternata*, along with other brachiopods, such as *Sowerbyella*, and some trilobites. The route then carries on up the steep hillside opposite to the next locality, beyond the field wall on the right.

Locality 10: Chatwall Sandstone/Cheney Longville Flags (Grid Ref SO 4851 9459)

This locality was mostly obscured, not by the usual soil or grass, but by a corrugated sheet roof blown off the adjacent barn ! However, it is still possible to appreciate the change in lithology from the Chatwall Sandstone on the western (right) side to the overlying softer Cheney Longville Flags on the left. The Flags are some 180m of interbedded, greenish-grey flags, shales and siltstones, with occasional thin, fine-grained sandstones and shelly limestones. Brachiopods and trilobites tend to be fairly common; indeed a trilobite cephalon was found at this locality.

The route continues along a level walk, with boggy patches, along the northern flank of Willstone Hill and the Battle Stones (Uriconian rhyolite, as on the summit of Caer Caradoc). This path is the approximate line of the Sharpstones Thrust, separating the high ground to the south, formed by the west-northwest trending Pre-Cambrian volcanics, from the northeast trending Ordovician sequence to the north.

The final locality is to the west, across marshy ground and across a stream, with the exposure in the slope above the stream.

Locality 11: Ordovician sandstone (Grid Ref SO 4767 9439)

This is a small exposure, 2m by 1m, of dark brown, silty, fine sandstone, placed in the Ordovician by the brachiopods found in the stream bed below. They are rare in the exposure itself, although trace fossils can be found. From this point one walks downstream to re-join the outward route, and back into Church Stretton.

MAPS

Topographic: 1:25,000 Pathfinder 910, SO 49/59
Geological: 1:25,000 Church Stretton Special Sheet.

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(Iain Fletcher)

JOINT MGA/NEGS FIELD TRIP TO WENSLEYDALE
(31st JULY 1994)

Leader: John Nudds

INTRODUCTION

This joint trip with the North Eastern Geological Society was to the suitably "neutral" county of Yorkshire, juxtaposed between the Counties Palatine of Durham and Lancashire, not only the rival homes of NEGS and MGA, but also the former and present abodes of the leader ! Once local dialects had been unscrambled, the party got along admirably with only minor squabbles !

The leader began by explaining the historical and world-wide importance of Wensleydale (formerly "Uredale") as being the type-area of the "Yoredale" facies as first described by John Phillips in 1836. The object of the trip was to relate the unique scenery of Wensleydale to the development of this facies and the following localities were visited:

National Park Centre, Aysgarth Falls Car Park (Grid Ref SE 012887)

The party viewed the interesting model of the dale in the National Park Centre which demonstrates the glacial geology. The Wensleydale glacier, moving eastwards, accumulated large amounts of drift and boulder clay. This mound, a terminal moraine, remains today across the valley, its western edge at Mill Falls (just upstream from Aysgarth) and its eastern edge at Bishopdale Beck. As the climate warmed, the glacier stopped and the melting ice formed a lake extending westwards up the valley and held in by this moraine. Eventually the melt water spilled over the terminal moraine carving a gorge through the limestone at Aysgarth. The party noted the steep slope of the River Ure at this point (which falls 50m in 2 kilometres), compared to gentle slope of the tributary Bishopdale Beck (which falls only 10m in 2 kilometres), due to presence of the Great Scar Limestone on the valley floor which slows down the cutting action of the river. Bishopdale is cut in much less durable ground.

Aysgarth Lower Falls (Grid Ref SE 018888)

Here, the valley floors expose the Great Scar Limestone, a massive limestone at the top of the Asbian Stage. The upper beds of the limestone are interlaced with clay. As the river flows over it the clay is washed out by eddies so that the leading edge of the limestone becomes unsupported and collapses forming a staircase waterfall. The party noted the potholes formed in the limestone by swirling pebbles and also noted the common chert nodules. Fauna collected included fasciculate lithostrotionid corals (*Siphonodendron irregulare*, *S.pauciradiale*, *S. junceum*), ceriold lithostrotionids (*Lithostrotion decipiens*), *Diphyphyllum furcatum* and the sclerosponge *Chaetetes*.

Hardraw Force (Grid Ref SD 869916)

Above the Great Scar Limestone is the Wensleydale Group (of Brigantian age), a cyclic sequence formerly known as the "Yoredale Series". (This name is now used only to describe this particular facies and has no stratigraphical significance.) At Hardraw Force a typical cyclothem was seen, with the Gayle Shales passing upwards into the Gayle Sandstone into the Hardraw Scar Limestone. The 100' waterfall (the highest single drop waterfall in England) was formed by Fossdale Beck flowing over the hard limestone and sandstone beds onto the softer shales beneath, which were quickly eroded.

Arn Gill, Askrigg (Grid Ref SD 953923)

Here, another typical cyclothem shows the Simonstone Shale and Sandstone passing upwards into Middle Limestone. A coral band at the base of the Middle Limestone suggests calm, shallow-water deposition and the fauna includes *L. decipiens*, *D. furcatum* and the rare, astraeoid coral, *Orionastraea*.

Haw Bank, Woodhall (Grid Ref SD 987897)

In the 19th century lead mining made the Yorkshire Dales a major industrial centre. The mines around Woodhall (the Wet Grooves Mines) were probably the site of greatest activity in the dale in the 17th century. At this locality a level can be seen entering the base of Haw Bank and large spoil tips are present at its entrance yielding calcite, fluorite, quartz, barite, sphalerite and rare galena. The disused shafts of this mine can be seen above Haw Bank (Simonstone Limestone) and below Ivy Scar (Undersett Limestone).

(John Nudds)

LITHO-STRATIGRAPHY	CHRONO-STRATIGRAPHY	
Main Limestone	NAMURIAN	UPPER CARB.
Underset Limestone	BRIGANTIAN (= "Yoredale Series")	LOWER CARB.
Three-Yard Limestone		
Five-Yard Limestone		
Middle Limestone		
Simonstone Limestone		
Hardraw Limestone		
Gayle Limestone		
Hawes Limestone		
Great Scar Limestone	ASBIAN	

Figure 1. Table showing stratigraphical succession of Wensleydale cyclothems (left), chrono-stratigraphical stage names (middle) and position within the Carboniferous (right).

ROCK TYPE	ENVIRONMENT
COAL	MARSH VEGETATION
SEAT-EARTH	MARSH SOIL
SANDSTONE	CHANNEL-FILL
UNFOSSILIFEROUS SILTSTONE	DELTA FRONT
FOSSILIFEROUS SHALES	PRO-DELTA
LIMESTONE	SHALLOW OPEN SEA

Figure 2. Table showing succession of rock types in an idealised cyclothem and their equivalent environments of deposition.

MGA TRIP TO THE SKIDDAW GRANITE (24th SEPTEMBER 1994)

Leader: Norma Rothwell

INTRODUCTION

The general geological form of the Lake District is that of a glacially eroded asymmetric anticline, with an axis trending NE/SW (i.e. compatible with the tectonics of the Caledonian orogeny). The core of the anticline consists of much deformed Lower Palaeozoic rocks (Skiddaw Slates, volcanic tuffs and andesites) surrounded by near horizontal Upper Palaeozoic strata (Carboniferous limestones and Permian sandstones). Recent glaciation has removed much of the recent cover and exposed the underlying older rocks.

The Skiddaw Granite of the English Lake District is seen at the surface in three small outcrops set in a classically concentric aureole of contact metamorphism of Skiddaw Slates. The extent of the metamorphic aureole suggests that the three outcrops form part of a large single granite mass present at shallow depth in the form of a flat-topped, steep-sided cupola, with a depth variously estimated from 6km to 9km, which is connected at depth to the Lake District batholith.

The magma from which the Skiddaw Granite evolved was most probably of sub-crustal origin and related to a southerly dipping subduction zone at the closure of the former Iapetus ocean.

For the greater part of its extent, close to or at the surface, the granite intrudes the Skiddaw Slate Group, although it abuts the Carrock Fell Complex at its northern margin.

The consensus of the age of the Skiddaw Granite is 395±8MA, i.e. of very early Devonian age.

Trace element trends are compatible with those of calc-alkaline intrusions with low Rb, enhanced Zr, Sr, Ba and average Nb and Y.

Four phases of the granite are identified - grey, white, microgranites and aplites, all of which are altered to a greater or lesser degree. Even the 'freshest' samples contain biotite altered to chlorite or chlorite plus muscovite, and plagioclase altered to sericite.

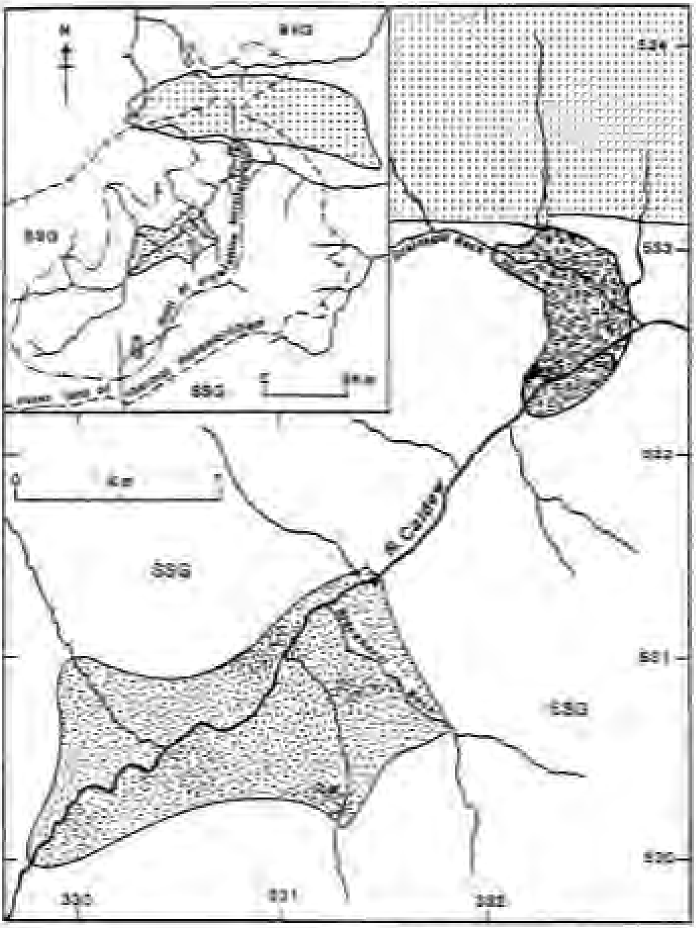
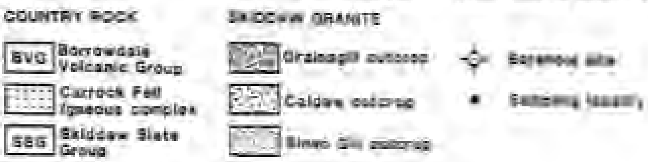


Figure 1. After Webb & Brown 1984.



The granite seen at the surface is located in the more evolved and altered roof zone of the intrusion and may not be representative of the whole body at depth.

At the surface the microgranites of the River Caldew section make up approximately 25% of the rocks seen at outcrop, but are absent at depth. This, and their configuration *in situ*, seems to indicate that they have been emplaced as late stage fractionation pulses in the roof zone.

Post intrusion alteration has been significant and varies within and between the outcrops.

Alteration of the granite by metasomatic and hydrothermal processes has occurred at variously estimated dates, beginning with one associated with the cooling of the granite (392±4MA), greisenisation (385±4MaA) and further episodes in the Carboniferous and through to the Jurassic.

Alteration products of the granite involve:-

a) the breakdown of the granite into its component minerals with the decomposition of feldspar

b) the sericitisation of feldspars and chloritisation of biotite

c) greisenisation of the Grainsgill outcrop to a mixture of quartz and muscovite.

The rocks at depth show alteration, even to greisen, below the zone of surface weathering which shows that the alteration is not restricted to the surface rocks, nor is the greisen uniquely associated with the Carrock Fell complex. However the surface rocks do show a decrease of alteration with distance from Grainsgill. The mineral veins show a close association with wall rock alteration which suggests that the fracture systems in the granite acted as channels for mineralising fluids.

Within each of the outcrops there is variation, but the variation from one outcrop to another is greater and progressive from south to north. In general there is a decrease of mafic minerals with increase of felsic minerals from Sinen Gill northwards across the River Caldew outcrop to the greisen of Grainsgill Beck. Biotite/chlorite diminishes, at times to nothing, as muscovite increases. Sericite also increases northwards as feldspars decrease and there is a corresponding, but lesser, increase in quartz.

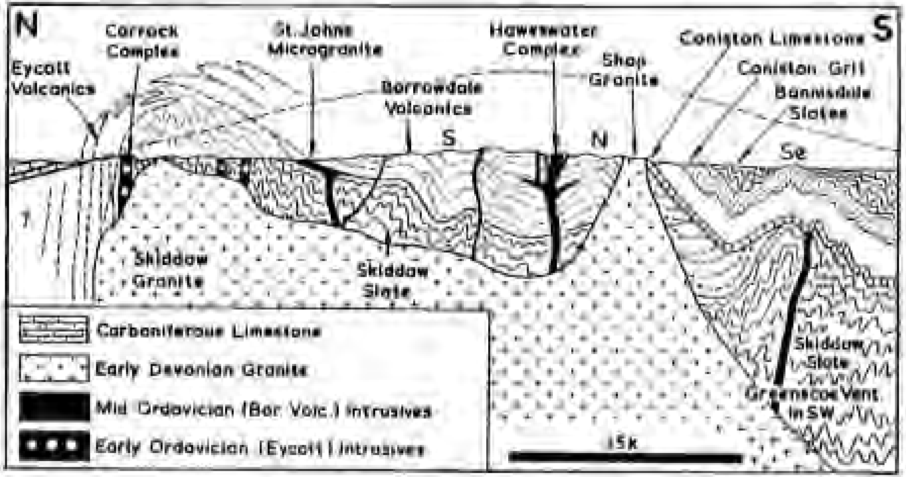


Figure 2. After Moseley 1978.

Diagrammatic profile across the Lake District showing the early Devonian granite batholith intruded into Skiddaw Slates, Borrowdale Volcanics and post-volcanic sediments.

Major element variations from the outcrops show a decrease of Ti, Fe, Mg, Ca, Al and P and increase of Si and K with fractionation. The degree of fractionation has no obvious delineation with the exception that the least evolved rock types are not found in the Grainsgill Beck outcrop, but are well represented in Sinen Gill. The most evolved, the microgranites, are concentrated in the River Caldew outcrop, with some also present in Grainsgill Beck, but none have been found in Sinen Gill. From the cumulative evidence there is a pattern of lesser evolution of the granite from the north to the south and with increasing depth. However the geochemical information, even from unweathered little altered samples, may not be representative of the bulk of the intrusion. Surface sampling is entirely in the roof zone where many of the late-stage fractionation products are likely to be preferentially emplaced.

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(Norma Rothwell)

MGA FIELD TRIP TO THE SEFTON COAST (16th OCTOBER 1994)

Leaders: Silvia Gonzalez & Gordon Roberts

INTRODUCTION

An integrated study of the Sefton Coast is being carried out by a research group from the Earth Sciences Department of John Moores University, Liverpool, of which the leaders are both members. The oldest rocks in the area are Triassic, and these are covered by glacial tills, the Shirdley Hill Sands, and Holocene sands, silts and peat. The Holocene sequence is complete for the last 10,000 years. After melting of the ice, sea-level rose by 25m and silts were deposited during this transgression. However, during a relative fall in sea-level, peats were formed and three such transgressive cycles are recorded. The changing sandbanks in the Mersey estuary may have complicated these cycles. Dating of the peats found at Leasowe on the Wirral show that they were not formed at the same time, so there may not have been simultaneous transgressions.

The Shirdley Hill Sands were thought to be Late Glacial aeolian cover sands derived from the till, but recent analysis has shown that there are several different facies of reworking during the mid-Holocene represented in the sands. Near Hightown the sand is probably derived from an estuarine beach, while to the north the structures are more aeolian. Greswell's Hillhouse Coastline is now thought to be caused by the passage of the ice, scouring the rock and leaving a hollow in which marsh developed during the Holocene, rather than a relic coastline.

Hightown

From the Liverpool-Southport road (A565) turn off for Hightown. Cross over the railway bridge at Hightown Station and continue south from the roundabout through a housing estate for about half a kilometre. Turn right to park at Blundellsands Sailing Club (297 029).

On the foreshore at Hightown, between the estuary of the Alt and the town, two metres of marine silts are overlain by peat and forest beds. At the top of the silt, Phragmites and Alder roots can be seen protruding. These are covered by a forest bed in which the abundant rotted remains of trees, such as Oak, Silver Birch and Alder, occur, as well as ferns, such as Royal Fern. The trees occur both as fallen logs, up to 5m long, and as roots *in situ*. The evidence points to marine silts becoming exposed as sea-level fell, then the area becoming colonised first by pioneer species, then by forest.

About 100-200m further along, the silts are well-exposed on the banks of the Alt (although Wellingtons are essential to approach them). The silt is very well sorted and is thinly layered. Again, roots can be seen protruding from the surface of the silt. An attempt is being made to establish the rate of deposition of the silt by matching magnetic data from the silt (declination, inclination and intensity) against a standard curve produced from lake sediments containing datable organic material (Turner & Thompson 1981).

The forest beds continued south along the coast, but have now been covered over by buildings as, for example, at Blundellsands.

Formby Point

Return to the A565 and proceed northwards. Turn left on the B5424 for Formby. After a kilometre turn left for Formby Point. Continue along this road for about 2.5km to the Lifeboat car-park (274 066).

About 4,500 years BP the landscape at Formby Point was slightly different; a tidal island was situated a kilometre out into Liverpool Bay, and to the east of it was an intertidal lagoon into which ran several freshwater streams. The present-day sand dunes had not formed at that time, and the area was covered by a forest. Various animals of the forest came to the lagoon to drink, and left tracks in the mud on its banks. By 3,500 BP, continuing rise of sea-level overwhelmed the sand barrier. Extensive sand dunes have accumulated today.

The first locality was a forest bed at the foot of the dunes. This does not contain any ferns, and was probably a smaller forest than that at Hightown. Continuing several hundreds of metres directly out to sea from this, a bed of consolidated mud running parallel to the shore was encountered, containing auroch and red deer prints. The auroch prints are about 20-30cm long, while the red deer prints are about 15cm long and consist of two half-moons. Further along the foreshore, walking northwards, there are bird prints about 3cm long and 0.5cm wide, and speckles of charcoal.

Further along the coast the face of the dunes has been cut away by the sea to reveal a dark brown deposit. This is not a natural deposit, but the remains of an old tobacco dump, formed when de-nicotinised tobacco waste was dumped in an old slack (a hollow in the dunes, containing a shallow lake) about

25 years ago. In places beneath this, a peat base can be seen containing small water snails, and about 5-10cm below a line of shells indicates a storm deposit.

Continuing along the foreshore the party examined prints of Roe Deer (about 5cm long) and thin elliptical hollows (2-4cm long), caused by the washing out of *Scrobicularia* shells.

These beds are slowly being eroded by the sea, so that prints visible are constantly changing. Although none were seen on this visit, human prints have been seen, first recorded by Gordon Roberts. These ancient footprints should not be confused with modern ones; firstly the beds are only partly consolidated so that a bare-footed modern bather would only make a slight impression on the surface, whereas the ancient human walking across a mud would have left deep imprints. Secondly, modern footprints, deformed by shoes, differ from habitually unshod footprints which have long, straight, splayed-out toes. Finally, modern humans leave two tracks formed by their left and right feet, while those of earlier man tend to form one line of alternating left and right footprints.

FURTHER READING

TOOLEY, M. (1978). *Sea level changes in north west England during the Flandrian Stage.* Clarendon Press, Oxford.

TURNER, G.H & THOMPSON, R. (1981). Lake sediment record of the geomagnetic secular variation in Britain during Holocene times. *Geophysical Journal of the Royal Astrological Society*, **65**, 703-725.

HUDDART, D. (1992). Coastal environmental changes and morphostratigraphy in southwest Lancashire, England. *Proceedings of the Geologists' Association*, **103**, 217-236.

PYE, K. & NEAL, A. (1994). Coastal dune erosion at Formby Point, north Merseyside, England: causes and mechanisms. *Marine Geology*, **119**, 39-56.

(Jim Spencer)

BOOK REVIEWS

Fossil fishes of Fenton and Longton: The John Ward Collection. Don Steward. 1994. City Museums and Art Gallery, Stoke-on-Trent. ISBN 0 905080 69 6. A5 paperback £1.95.

The first part of the booklet gives a biographical summary of the amateur geologist John Ward (1837-1906). Although he lived all his life in the Potteries area his prolific work earned him an international reputation and the Geological Society of London's Lyell Award for "long services to the geology of his district". From his teenage years he developed a systematic approach to collecting fossils, marking each fossil with the precise rock from which it was collected. Thus he made an important contribution to the understanding of Carboniferous Coal Measures fossils and recognised their significance and value in determining the relative position of economically viable seams of coal and ironstone. The specimens, mainly of fish remains, but also plant and invertebrate material, increased the store of information available for the reconstruction of the area some 300 million years ago and there is hardly a museum in Europe which does not have some contribution from Ward. He also left behind a legacy of published articles, many describing contemporary finds in working quarries and mines in the North Staffordshire Coalfield.

The second part of the booklet gives a comprehensive guide to the species index as well as their stratigraphical and geographical distribution. There is also a complete publications list. These make the booklet a valuable reference for anybody working on fossil fishes of the Carboniferous Coal Measures.

(Hazel Clark)

Geologists' Association Guide No. 52: ICELAND. Bamlett, M. and Potter, J.F. 1994. £8.50.

As a regular visitor to Iceland I looked forward to reading this new guide with eager anticipation. Regrettably I was very disappointed on several counts. The excellent, glossy colour photographs on the cover in no way prepare the reader for what lies inside ! The first copy I received had ten blank pages which did not to persuade me that my £8.50 had been well spent !

The Editor's note on the inside cover states, "Any information that would update and improve a revised edition of this guide would be welcomed by the Association". A future revision might consider some of the following points.

Errors vary from those of simple formatting such as the unnecessary blank line near the bottom of page 2 resulting in a single line of text carried over to the top of page 3, to fundamental omissions in the general outline of the geology.

Although different petrologies are referred to in the itineraries there is no overall petrology map of Iceland such as I have included here as Figure 1 (after Jakobsson 1980). Accompanying this ought to be an explanation for the origin of the different petrologies and their relationship to the different volcanic landforms. For example, the olivine tholeiites are thought to originate from partial melts of the upper mantle which then pass through the crust with little or no time in a magma chamber to fractionate out the olivines. Therefore those lava types are hot and of a low viscosity and produce shield volcanoes such as Skjaldbreidur. The geochemistry of the transitional and alkali rocks suggests that the increasing alkali content is due to a lesser amount of partial melting at a greater depth than the conditions producing the tholeiitic rocks.

Figures 1 and 2 of Bamlett and Potter are of poor quality and the text is "breaking down", presumably due to the resolution of the computing devices used in the production process. In other of their figures (e.g. 3 & 9), again the limitation of the resolution is evident with diagonal lines displaying a "stepped" appearance. Figure 2 has also distorted the shape of Iceland, shortening it in a N-S direction and extending it in a E-W direction and it gives the main geological divisions of Iceland without explaining the interesting basis for them. The main basis for the stratigraphic division is magnetic reversals plus a further refinement of climatic change as shown here in Table 1. In Figure 9 itineraries 13 and 14 are the wrong way round.

Iceland Stratigraphy

Stratigraphic Group	Basis of Division
Post Glacial	Last 9,000 to 13,000 years
Upper Pleistocene	Back to 0.7Ma Corresponds to the present Brunhes normal geomagnetic epoch
Plio Pleistocene	3.1 - 0.7Ma Includes the Matuyama epoch and the Gauss epoch upwards of the Mammoth event. Onset of glaciation resulted in drastic change to environmental conditions - subglacial volcanism producing hyaloclastites and pillow lavas
Tertiary	16.0 - 3.1Ma Tholeiitic flood basalts

Table 1.

There is some reference to the *en echelon* relationship of faults in the peninsula between Thingvellir and Keflavik, but without placing them within an overall context it has little meaning. Figure 2a herein shows a map of the volcanic systems in Iceland displaying the *en echelon* offset to the east in the south west and *en echelon* offset to the west in the north east, due to the eastwards displacement of the ridge. Within each of the volcanic systems this *en echelon* offset is evident in the surface fissure swarms, particularly at Thingvellir (Itinerary 12). This displacement to the east probably took place about 6-7 Ma. Prior to this the ridge was active through the Skagaheidi Peninsula, as shown on Figure 2b. Brief reference is made to the Skagaheidi Peninsula on page 4 as being younger than Tertiary, but there is no explanation why ! A guide written for geologists ought to include a better interpretation of the Mid-Atlantic Ridge spreading axis than is shown in their Figure 1. Figure 2b herein shows a more sophisticated interpretation and is actually taken from a publication "written for tourists interested in natural science" (Gudmundsson and Kjartansson 1984). Other interpretations (such as Saemundsson 1980, p.12, fig. 6) are available.

Although the guide states that it "...does not include all the sites of geological interest in Iceland, but instead it provides a representative selection of such sites for the interested visitor", there is a feeling that the content reflects the places the authors have visited rather than being an objective representation of what is there ! Oraefi, in particular, has many geological attractions worthy of mention including:

1. The Kota debris fan resulting from the 1727 eruption (not 1717 as stated on page 27 !) where jokulhlaup deposits can be seen in section where the present day river has incised producing a series of terraces (Thompson & Jones 1986).

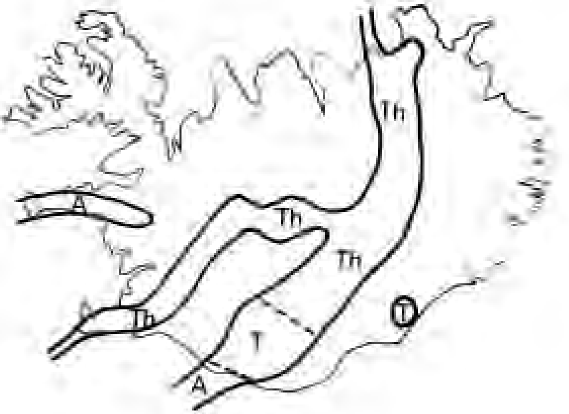
2. The Middle Pleistocene fossil bearing glacial lake sediments at Svinafell.

3. The historic significance of Svinafellsjokull in glaciology, being the locality where the first measurements of ice movement were made by Otto Torell in 1857.

Figure 15 of Hamlett and Potter of the Skaftafell area is seriously in error. It shows Svartifoss on the Morsa in Morsardalur, some 3km from its actual location on Skaftafellsheidi.

The glossary definition of a diamictite is misleading: "A lithified flow of mud and rock fragments originally set in motion by heavy rain which accompanied a volcanic eruption". A diamictite does not have to be caused by heavy rain or an eruption ! A better definition might be: "Poorly sorted

Figure 1. Simplified map of Iceland showing petrology within the Neo-volcanic zone.



A - Alkalic zone
T - Transitional zone
Th - Tholeiitic zone

accumulation containing rock fragments of all sizes in a silt/clay matrix".

The guide is particularly useful for areas not visited previously and I have found four locations to add to the itinerary for my next trip. However, its shortcomings become apparent in familiar areas !

In the absence of anything better I suggest you buy it and visit the geologists' paradise at the first opportunity. The guide is best used in conjunction with other publications such as those cited here and with reference to the 1:500,000 Geological Map of Iceland (Johannesson and Saemundsson 1989).

REFERENCES

GUDMUNDSSON, A.T. & KJARTANSSON, H. (1984). *Guide to the geology of Iceland.* Bokaugafan Orn og Orlygur hf. Reykjavik.

JAKOBSSON, S.P. (1980). Outline of the petrology of Iceland. *Jokull* **29**, 57-73.

JOHANNESSON, H. & SAEMUNDSSON, K. (1989). *Geological map of Iceland. 1:500,000 bedrock geology.* Icelandic Museum of Natural History and Iceland Geodetic Survey. Reykjavik.

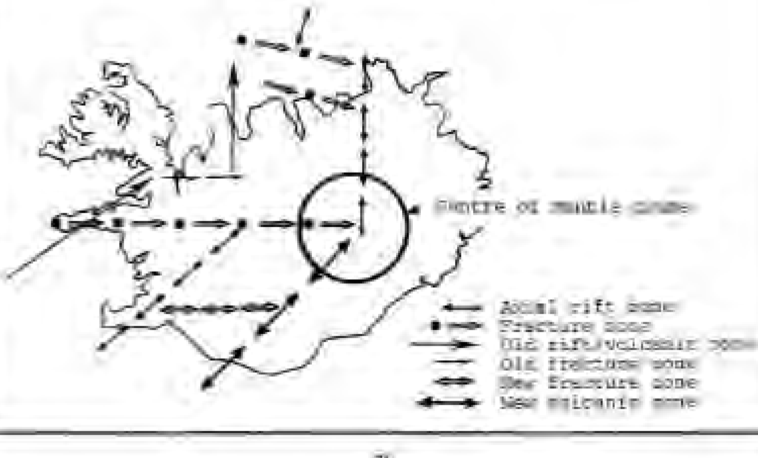
SAEMUNDSSON, K. (1980). Outline of the geology of Iceland. *Jokull* **29**, 7 - 28.

THOMPSON, A. & JONES, A. (1986). Rates and causes of proglacial river terrace formation in southeast Iceland: an application of lichenometric dating techniques. *Boreas* **15**, 231 - 246.

(Chris Hunt)

Figure 2: a) Volcanic systems in Iceland.
Note the en echelon offset to the east in the SW and offset to the west in the NE.

b) Interpretation of fissures and volcanic sytistems.
After Gudmundsson A.T. and Kjartansson H. 1984



PROCEEDINGS OF THE LIVERPOOL GEOLOGICAL SOCIETY

1993/94 SESSION

1993

Oct. 5 The Presidential Address by Hilary Davies - *The geology of Chile*. Hon. Treasurer's and Hon. Secretary's reports.

Oct. 19 *Geomorphology and highway engineering* by Alan Thompson.

Nov. 2 The Distinguished Visitor's Address by Professor John Crowell - *Glaciations through geological time*.

Nov. 14 Field trip to examine Holocene sedimentary environments and sea-level changes, south west Lancashire led by David Huddart.

Nov. 23 *A crinoid conundrum* by Clare Milson.

Nov. 27 Practical Session at Liverpool John Moores University (Joint meeting with The Wirral Mineral and Lapidary Society).

Dec. 7 *The geology of Spanish and Portuguese wine* by Geoff Tresise.

1994

Jan. 18 *Presentation of The Liverpool Geological Society's Silver Medal to John K. Shanklin* followed by The Distinguished Member's Address by John Shanklin - *Geopolitics in Europe !* (Joint meeting with The North West Group of The Geological Society).

Jan. 25 Practical Session at Liverpool John Moores University on *Introductory practical geophysics* with William Taylor & Graham Sherwood.

Feb. 8 *Permafrost and mining in sub-arctic Canada* by Frank Nicholson.

Feb. 12 The Herdman Society Symposium on *Environmental change*.

Feb. 18 The Society Dinner at Jenny's Seafood Restaurant.

Mar. 1 *Granites* by Dave Bryon.

Mar. 13 Field trip to Castleton and Edale led by Joe Crossley

Mar. 22 *The structural evolution of the Himalayas* by Steve Reddy.

May 14/15 Field trip to the Lake District led by Tony Adams & Mike Hambrey.

Jun. 25 Field trip to the Wrexham Delta Terrace led by Hilary Davies

Jul. 19 Field trip in Liverpool led by Joe Crossley

Sep. 25 Field trip to Ingleton led by Clare Milson & Hazel Clark

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R. Bell
Ms R. Fleming

PROCEEDINGS OF THE MANCHESTER GEOLOGICAL ASSOCIATION 1993/94 SESSION

1993

Apr. 28 *Conversazione* at The Manchester Museum.

Apr. 18 Field trip to South Cumbria led by Dr Tony Adams.

May 16 Field trip to Chunal and Charlesworth near Glossop led by Dr Paul Selden.

Jun. 19 Annual Dinner at Hulme Hall, University of Manchester. Guest of Honour: I.A. Williamson.

Jun. 26 Field trip to study the fluvio-glacial problems of the Wrexham area led by Dr Hilary Davies.

Jun. 28 Field trip to Ecton Hill Mine led by Geoff Cox, Alistair Fleming and Jill Smethurst.

Jul. 31 Field trip to study the Penrith sandstones in the Vale of Eden led by Eric Skipsey.

Aug. 21 Field trip to study the geology, mills and bridges of the Torrs, New Mills led by Derek Brumhead.

Aug. 29 Field trip to Mam Tor led by Professor Charles Curtis.

Sep. 12 Field trip to study Triassic sediments and Eocene dykes in North Staffordshire led by Dr David Thompson.

Sep. 15 *The mineral resources of the Coalbrookdale Coalfield, Shropshire* by Dr Ivor Brown. (Joint meeting with the Manchester Region Industrial Archaeology Society.)

Oct. 13 *Landforms of the Peak District* by Roger Dalton. (Joint meeting with the Manchester branch of the Geographical Association.)

Oct. 17 Field trip to study the Late Quaternary and Holocene in the Marple area led by Dr R.H.Johnson.

Nov. 10 *Catastrophic sedimentation at volcanoes* by Dr Mike Branney.

Dec. 8 *After the gold rush: recent discoveries of gold in the Scottish Highlands* by Dr Richard Pattrick.

1994

Jan. 12 *The 3D geometry and growth of faults: evidence from western USA to Lancashire* by Dr John Walsh.

Feb. 16 Annual General Meeting and Presidential Address by Norma Rothwell - *The "Norman" conquest of Skiddaw*.

Mar. 9 *"Old mussels" provide new dates and surprises - from Arizona to Norway* by Michael Eagar.

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