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THE NORTH WEST GEOLOGIST
(Formerly THE AMATEUR GEOLOGIST)

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Editorial

It is with great sorrow that I begin my first Editorial with the sad news of Grahame Miller's recent death. This issue of *The North West Geologist* was to have been the last under Grahame's editorship which goes back to the 1988-89 session and which has seen the publication of the final three issues of *The Amateur Geologist* and the first four of *The North West Geologist*. Few will appreciate just how much effort Grahame put into our journal - apart from his undoubted editorial skills which assured us of an immaculate product, always issued on time, he was also unceasing in his quest for new ideas to improve the journal's image and in the much more difficult task of persuading reluctant members to contribute; and when all else failed by simply writing fresh copy himself. This issue still bears his hallmarks and includes his final paper - his definitive guide to the igneous rocks of Derbyshire. A full appreciation of Grahame's life in geology will appear in the next issue. I am sure that you would like to join the remainder of the Editorial team in sending our sincere condolences to Eileen and her family.

John R Nudds   Tom Metcalfe   N.C. Hunt
Spring 1994

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 2BX. 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....

Mini gold rush ?

The gold micronugget referred to in the last *North West Geologist* is not likely to start a mining boom in Derbyshire. But prospects elsewhere appear much more promising according to the last two BGS Annual Reports. Gold has been found in Shetland associated with the Unst ophiolites and the Dalradian rocks. It is widespread in stream sections of the South Hams district of Devon, and nearer home it has also been discovered in panned stream sediment concentrates at the northern edge of the Lake District. Here it is thought to have been transported by glacial action from mineralised Lower Palaeozoic source rocks in southern Scotland and the Lakes. But for something more substantial, of course, we have to go to North Wales or the Dalradian of the Scottish Highlands. In the latter the BGS Mineral Reconnaissance Programme has now identified four areas around Pitlochry and Glen Clova with "potential for economic gold mineralisation".

Birds versus rocks ?

In a recent *Geology Today* article Jerry Solwing described his unhappy experience in attempting to visit an exceptional fossil locality on Ramsey Island off St David's Head in Dyfed. The island came under the management of the Royal Society for the Protection of Birds in 1992 and this body actively discourages visitors, placing severe restrictions on their movement in the interests of the local seal and bird population.

This is not an isolated problem. One of our correspondents vividly recalls being stalked and harassed by wardens on a visit to Llandwm Island, one of the classic Anglesey localities for the study of the Mona Complex. Birds, seals and other forms of wild life certainly deserve a goodly measure of protection. But need it be at the expense of other sciences ? Our correspondent says that he also remembers visiting a locality in Shetland and studying the schists within 50 metres of at least 25 seals who displayed a monumental indifference to the human intruders ! At the local level, in for example the new RIGS groups, such clashes of interest can usually be settled amicably. But in such cases as Ramsey and Llandwm it is surely up to the Earth Science sections of English Nature and similar bodies to negotiate with the natural historians on our behalf.

Tidying up geological papers

"Long strings of references break up the flow of narrative text, and often seem to be used to create an illusion of serious scholarship, rather than providing evidence to support the case being argued". So writes Peter Francis in the *Preface* to his splendid book, *Volcanoes - a planetary perspective*, published by Clarendon Press last year. And so he has drastically reduced the number of references in his text with most listed at the end of each chapter.

This radical approach will appeal to every author (and editor) who has wrestled with the tortuous complexities of official referencing (which occupy upwards of 30 lines of print in the *Instructions for Authors* for at least one highly respected geological society). And while we are about it, why do so many earth science papers have to start with a lengthy and pious account of "Previous Research" ? Too often it is of purely historical interest, soon to be discarded, and designed to display the author's industrious reading of the literature. Put the vital parts of it in an Appendix, heavily prune the references and so save at least 20% of the space required !

Home and away

The annual migration of geological buffs will definitely take place again in 1994, between March and October. Outside Britain the Mediterranean does best this year. Cyprus is on offer in April from both the Manchester Extramural Department and Nottingham's Department of Adult Education. Cloister Study Tours of Durham promise Crete (late March/early April), Sheffield's Division of Continuing Adult Education choose the Languedoc in May/June, while the extensive volcanics of Sicily and the Aeolian Islands will be explored by Peter Cattermole's Journeys of Special Scientific Interest outfit in September/October.

The New World is represented by two ambitious field trips - a JSSI astronomical/geological tour of Arizona in May, and a Geologists' Association/Birkbeck College expedition to Alaska in August/September. JSSI, jointly with Sheffield, venture out to La Palma in the Canaries in April, the G.A. also has on its list Northern France in April and Northern Spain in August, and other contrasted expeditions are to Iceland (Sheffield in July) and Indonesia (JSSI, also July).

If you prefer to stay within the British Isles Scotland as usual offers a good choice including Mull (Liverpool Centre for Continuing Education in April/ May, and Hull Department of Adult Education in May/June), Harris (Bristol Department for Continuing Education in June/July), Islay & Jura (Nationwide Geology Club in May/June) and Ardnamurchan (Sheffield in June). Birkbeck College has North Wales on offer in April, and Bristol cross the Irish Sea to Wexford in May. In addition there is a wide variety of shorter courses available, including Cornwall (Nottingham), the Lizard (Bristol), the Isle of Wight (Sheffield), and the Forest of Dean and Ravenstonedale (both Liverpool).

GRAHAME MILLER

Grahame Miller died on 8 May 1994, aged 79. A Memorial Service will be held at St Ann's Church, Manchester, on Monday 4 July 1994 at 2.30pm. All members of the MGA are invited to attend.

Did you know...?

Did you know that the youngest known British graptolite was found in the Namurian (E_{2a}), 13 kilometres south of Consett in Co. Durham ? This record of *Pseudodictyonema heyi* sp. nov. is only postdated in global terms by a specimen from the Permian of China.

This fact comes from a detailed survey of the rare Carboniferous dendroid graptolites of Britain and Ireland by Chapman, Rickards and Grayson in the *Proceedings of the Yorkshire Geological Society*, **49** (1993). Much of the paper describes discoveries made on the northern flanks of Pendle Hill in the past 30 years.

The BGS in retreat

Elsewhere in this issue is a reference to the news that the Geological Survey is intent on closing its Aberystwyth Office - the only one in Wales. The Newcastle satellite is also going (and presumably Exeter too) which will leave only Keyworth and Edinburgh as BGS headquarters. This withdrawal in England and Wales to the Keyworth command bunker is a sad development - as we learnt from the closure of the Leeds Office, such centralisation inevitably leads to the impoverishment of the local geological communities. Societies, universities and museums all suffer from the loss of direct and personal contact with the Survey.

(G.D. Miller)

EARLY DAYS, SOME RECOLLECTIONS AND A PROPOSAL

by Iain A. Williamson

On October 15th, 1838, at the York Hotel in King Street, Manchester, a group of Lancastrians founded the Manchester Geological Society (Wood 1987). This was one of the earliest British geological societies only being preceded by the London (1807), Cornish (1814) and Yorkshire (1837). Since the Geological Survey was only founded in 1835 and the increasing momentum of the Industrial Revolution demanded ever increasing supplies of coal, it is not surprising that the early papers presented to the Society were heavily orientated towards the correlation and delineation of the Lancashire Coal Measures.

Significantly many of the early members were coal owners, geologists and mining engineers. Thus the first President was Lord Francis Egerton (Bridgewater Collieries) and other early ones included Sir Oswald Mosley (Bradford Colliery, Manchester), the Earl of Crawford (Wigan Collieries), Sir James Kay-Shuttleworth (Padiham Collieries), E.W. Binney (geologist, lawyer and petitioner regarding the underground employment of woman and children), Sir William Boyd-Dawkins (the first Professor of Geology at Manchester University) and Joseph Dickinson (Mines Inspector in Lancashire from 1850 to 1892).

Early members included the palaeontologists Captain Brown and Francis Looney; the former curated the Society's museum, which together with that of the Manchester Natural History Society was later to form the nucleus of the geological collection of the Manchester Museum. A library was maintained from commencement and it was with great pleasure that the writer saw this being transferred to to the Wigan Mining College in the 1960's. Whilst some of this library, including a major collection of geological maps, is still at the College, many of the periodical runs were transferred to Salford's excellent Mining Museum at Buile Hill [and thence to the Geology Department of the Manchester Museum - Editor]. Elias Hall was a member who prepared and published the first geological map of Lancashire in 1831 (his grave can be seen at Castleton, Derbyshire), as was Crispin Dugdale of Rossendale whose General Section of the Lower Coal Measures and Millstone Grit is still relevant today. Even the great "scientific law makers", John Dalton and James Joule, were members. The Society's *Transactions* from 1841 to 1918 contain a wealth of important geological detail.

In 1859 the first field trips were run when members visited Leigh, Whaley Bridge and Buxton. The first such field meeting to be fully reported was in 1860 when the Society's then President, Sir James Kay-Shuttleworth, a pioneer of the State education system as well as a coal owner, led the members around the Lower Coal Measure outcrops in the Burnley-Padiham area. This meeting was also attended by Edward Hull of the Geological Survey who had just commenced the mapping of the Lancashire Coalfield - the first time that mapping on the old scale of six inches to one mile was practised. The first such maps to be published were Sheet Nos 107 (Huyton/Prescot/Whiston) and 108 (St Helens). By 1869 the last of the sheets, that of Burnley (No 64), completed the coalfield survey.

By 1903 the Society had become primarily concerned with mining so that its title was changed to that of The Manchester Geological and Mining Society, and in 1904 it became federated to the Institution of Mining Engineers. Although some geological papers were still being given, in 1924, during the Presidency of Professor O.T. Jones (of Manchester University's Department of Geology), the Manchester Geological Association was formed as an entirely autonomous body (Jackson 1950).

Founder members included O.T. Jones, J.W. Jackson (Manchester Museum), R.C. Chalmers (Wigan Mining College), C. Fletcher (Atherton Collieries), G. Andrews, N.T. Williams and R.D. Sherlock. Amongst them also were R.C.B Jones and L.R. Tonks, of the Geological Survey, at that time commencing the resurvey of Hull's maps and, incidentally, in the days when the former used the Darwen-Bolton tram to reach his field areas (Wilson 1985). I must add the names of A. Bray, later to become H.M.I. for geological education, who had just mapped the Cowling area for his M.Sc., previous to being the only Honours student in his year at Manchester (Bray 1993, pp 7-8), and also those of E.W.J. Moore and J. Lomax. The latter ran a palaeontological laboratory at Bolton and prepared some incredibly perfect thin sections of coal in assisting Marie Stopes in her pioneer studies of coal petrology and palaeontology. At that time women were eschewed underground and I remember an old Burnley colliery manager telling me that in those days when Marie Stopes went collecting down Bank Hall Colliery she was only allowed to do so after dressing as a man ! Although she first identified vitrain, clarain, durain and fusain as the major banded constituents of coal, she subsequently attained far greater international acclaim for her vigorous popularisation of the birth control movement (Rose 1992).

Geology seems to attract "characters" to its ranks, and the Association is no exception. In this respect R.M. Chalmers was notable. Until 1957 he was Head of the Mining and Geology Department at Wigan. When I was first appointed there in 1958 stories of his rather autocratic personality were rife. Whilst his geological work consisted of a useful book on the geological map and a paper on *Gastrioceras*, he was principally a mining engineer. He was awarded the Military Cross during the First World War and ran his department to the last in the manner of an army unit - to the extent of reprimanding his staff when they appeared with dirty shoes prior to giving their lectures !

E.W.J. Moore taught chemistry at Haslingden Grammar School and in his spare time published much on the goniatite faunas of the Lancashire Namurian. During the International Geological Congress of 1948 and whilst he was leading a party, an American was heard to exclaim, "Gee, if this chap is an amateur what must the professionals be like".

In the late 1940's the Geological Survey was particularly active in the area when the various members worked from their Manchester office at Old Trafford - most apt if you were interested in both geology and cricket. F.M. Trotter, who lost an eye on Vimy Ridge in 1918, and wore a black eye patch in a piratical style, was engaged in his seminal work on the origin of rank in coal. All the Survey's officers were busy in assisting the National Coal Board in the correlation of the many deep prospecting boreholes and the underground sections exposed during the "horizon mining boom". Thus a series of important papers were published on the Lancashire coalfield including that by Don Magraw and Mike Calver (1960) on the underground sections between Bradford and Moston Collieries in Manchester.

Vernon Dean was another member who was active at that time and was particularly concerned with the discovery of various glacial overflow channels in north-east Lancashire. He came from Accrington and suffered from very bad eyesight. Consequently he was unable to see the features in the field clearly and therefore spent much of his time examining O.S. maps with a large reading glass. When he noticed a probable channel he sent a friend to photograph the feature, examined the photographs and, if satisfied, published. In 1948 a keen young geologist, who had just followed Dr Jackson to the Museum, was appointed to the Council and so a great personal friend, Michael Eagar, became known to many.

X I joined the Association in 1952 and particularly enjoyed the field trips and general camaraderie at that time. The Clitheroe and Nelson Sheet (No 68) had been mapped by then although it was not published until 1960. Consequently we were all excited to learn the latest survey views from Poole, Whiteman and Earp as to their interpretation of the classic "reef knolls" of that area. One field trip which was most memorable was led by Ron Firman to

Shap in 1955. During the afternoon, which for Shap was unusually warm and sunny, we followed the beck upstream beyond the unconformity at Shap Wells. The few who were keeping up with Ron were more than rewarded for their efforts for when rounding a bend we discovered a most delectable brunette spread out upon the bank and ensuring that she had an even tan all over ! By the time the laggards appeared a modicum of decorum had been attained - surely the finest exposure of the day and a future incentive to keep up with the leader and not slow the party down. Times are different now, so that our younger members are possibly more used to seeing such sights.

It is furthermore perhaps apposite that such recollections cease at this stage before one is accused of libel. However, it is appropriate to conclude with mention of a dinner which was held at the Packhorse Hotel, Bolton on October 15th, 1993. Following the final field meeting of the Manchester Geological and Mining Society held at Padiham in September (Williamson 1993), this illustrious society was wound up and ceased to exist after the Bolton dinner - exactly 155 years to the day after its formation. The number of active mining engineers in the society was not sufficient to sustain the main function of a learned society. Would it not therefore be appropriate if the original Manchester Geological Society, and after all our parent, be continued under the aegis of our own society ? Perhaps we might consider a reversal back to being a Society rather than an Association.

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A PLAIN PERSON'S GUIDE TO THE IGNEOUS ROCKS OF DERBYSHIRE

by Grahame Miller

INTRODUCTION

For several million people living north of the Trent Derbyshire's igneous rocks are easily the most accessible for study. Rarely spectacular, they nevertheless provide an excellent introduction to igneous phenomena, requiring no feats of mountaineering or scrambles along slippery shore exposures. Of the extrusive rocks, lavas, tuffs and hyaloclastites are present in a substantial area of the county from Castleton south-east to Hopton, with outliers at Tissington in the west and Ashover in the east (figure 1). In age they range from early Asbian to late Brigantian, over a period of some 20 million years (table 1).

There are at least eleven lava members (several with associated tuffs) and seven or so separate tuff units. The former attain 100 metres in thickness, the latter are between 2 and 95 metres thick. In addition there are many clay wayboards - thin horizons of clay minerals which are interpreted as altered air fall tuff deposits. These extrusive rocks can be grouped around six igneous centres: Tunstead (NW), Longstone (NE), Alport (Centre), Tissington (SW), Bonsall (S) and Ashover (SE). These centres contained no major volcanoes, only a series of unconnected and short-lived fissures and tuff cones (Aitkenhead, Chisholm & Stevenson 1985). Many of these can be related to a major basement NW-SE fault. Part of the volcanic activity was sub-aerial as indicated by flows with oxidised tops, and by palaeokarst surfaces above or below the lavas, tuffs and clay wayboards. Submarine activity is also demonstrated by the rare pillow lavas, the phreatomagmatic tuff deposits and occasional limestone intercalations (Ineson & Walters 1983).

These lavas are much altered olivine basalts with olivine (altered to serpentine or chlorite), plagioclase feldspar (altered to albite or calcite) and augite (altered to chlorite or calcite). Amygdaloidal and vesicular types predominate with infillings of chlorite, calcite or chalcedony. The basalts plot geochemically in the "within plate" field, with both tholeiitic and alkaline types represented. As to their origins, it is thought that a fertile mantle generated pockets of magma which reached the surface along fractures in an attenuated crust (MacDonald *et al.* 1984).

Among the intrusive rocks only two certain dykes have been identified,

Westphalian	Carlton Hill intrusion. Peak Forest and Tideswell Dale Sills. Potluck and Mount Pleasant Sills?			Bonsall and Duffield Sills?
Namurian	Waterswallows Sill			Ible Sill
Brigantian	Tunstead Centre	Longstone Centre	Alport Centre	Bonsall Centre
	Hope Cement BH lava and tuffs Monkadale Vents Upper Miller's Dale Lava Brookbottom Tuff	Litton Tuff Cressbrook Dale Lava	Conksbury Bridge Lava Lathkill Lodge Lava Cracknowl Vent? Shacklow Wood Lava Lees Bottom Lava	Upper Matlock Lava Hopton, Ember Lane, Bonsall Moor vents? Lower Matlock Lava Shothouse Spring Tuff (Ashover Volcanics) Winster Moor Lava
Asbian	Dove Holes Tuff Lower Miller's Dale Lava/ Pindale Tuff Ravensdale Tuff			(Tissington Volcanics)
Holkerian				Prospect Quarry Tuff Mound

Table 1. Stratigraphy.

but there are at least nine substantial sills in the area. In age they appear to be younger than the lavas and tuffs, viz. late Namurian to late Westphalian. The actively-quarried Waterswallows Sill is some 80 metres thick and the rest range from 25 to 65 metres. The great majority are tholeiitic olivine dolerites, commonly with spheroidal weathering, occasional columnar jointing and rare vesicles. Exceptions are the Calton Hill basanite intrusion (with analcime) and the Duffield Sills (picrite, analcime gabbros and dolerites).

RECOMMENDED LOCALITIES

Agglomerates

1. Hopton (SK 25815355).

The best example and most easily accessible, on the east side of the minor road from Ryder Point to Hopton village. Somewhat overgrown, but over 30m still visible along the bank. (See Arnold-Bemrose 1907; Frost & Smart 1979.)

2. Calton Hill SSSI, NW sector (SK 11607140).

For permission to visit this SSSI apply to the County Planning Officer, Derbyshire County Council offices, Matlock, Derbyshire. Access is on foot from road junction at SK 112709; follow bridleway east, then footpath north to the pool at the centre of the quarry. The talus-strewn slope on the north-western side has scattered blocks of agglomerate and tuff. (For detailed description see Miller 1988.)

3. Waterswallows Quarry (SK 084748).

The western portion is a large working quarry, but past Tarmac Ltd managements have occasionally allowed visits by interested geologists. Agglomerate horizons have been visible from time to time on the south side of the bottom level. (For detailed description see Miller 1986.)

Amygdales

Amygdaloidal basalts with vesicle fillings of calcite, chlorite, chalcedony (and rare hematite) are common. Good localities are:

1. Cave Dale, Castleton (SK 14898219).

Crossed by public footpath. 7.6m of Lower Miller's Dale Lava exposed.

2. Upper Cressbrook Dale (SK 17287521).

Within a National Nature Reserve, but just to east of public footpath. 3m of Cressbrook Dale Lava exposed.

3. Staden Low (SK 07157225).

Access by bridleway from Staden hamlet. 3.96m of Lower Miller's Dale Lava in hillside to east of water tank.

4. Masson Hill (SK 28995899).

Access by footpath from Heights of Abraham cable car top platform, or track from Salters Lane. Crags west of track show some 3m of Upper Matlock Lava.

5. Wormhill (SK 123740).

Cutting in the Peak Forest - Miller's Dale road (minor, but surprisingly busy). c2m of Lower Miller's Dale Lava exposed. East side rather overgrown, but west side less so. Zeolites reported by Wilkinson (1967). Hematite blebs more common.

Big feldspar basalts

Can still be found in scattered exposures by the roadside at SK 13627547, north of Monksdale House on the road to Wheston. Similar basalts were seen by Arnold-Bemrose (*ibid.*) near Rugshall, Matlock Bath, but extensions to Ball Eye Quarry appear to have destroyed the exposure.

Boles (red or otherwise)

The green to orange clays on top of some lavas have been interpreted as examples of contemporaneous bole formation (Walkden 1972), indicating periods of subaerial weathering. Some possible localities are:

1. West side of the A515 road south of Buxton at SK 06407229.

2.59m of vesicular Lower Miller's Dale Lava under 3.35m pale green clay. Somewhat overgrown.

2. Chee Dale (SK 13007337).

By the footpath along the River Wye. 3.51m of Lower Miller's Dale lava with irregular pyritous clay top under 9.14m limestone.

Columnar jointing

Best seen in the intrusive rocks at, for example:

1. Calton Hill SSSI, NW sector (SK 11607140).

The basanite forming the east end of the pool area and intruding cliffs north and south of the pool.

2. Waterswallows Quarry (SK 085749).

East side of the sump in the older and disused east portion of the dolerite quarry (see Stevenson & Gaunt 1971, pl. 21b). Better examples of both horizontal and vertical columns were revealed from time to time in both portions of the quarry, but these have now been destroyed by the workings.

Clay wayboards

Not uncommon, but most spectacular in the large limestone quarries. Greyish-green when fresh, yellow-brown when weathered. Classified as potassium bentonites (illite-smectite, some kaolinite). Occasionally contain pyrite, sometimes cover potholed surfaces, can be up to 1.25m thick. Examples:

1. Hillhead Quarry, Harpur Hill, Buxton (SK 07436924-SK 06716996).

Disused. At least 10 wayboards up to 0.66m thick.

2. Hartington Station Quarry (SK 15176125).

Disused. At least 13 wayboards up to 0.3m thick. Some on potholed surfaces.

3. Bee Low Quarry, Dove Holes (SK 09227915).

Disused. Three wayboards up to 0.45m thick.

4. Ivonbrook Grange Quarry (SK 23295830).

Working quarry. Four wayboards, top two on potholed surface. Up to 0.61m thick. (See Walkden 1972; Aitkenhead, Chisholm & Stevenson 1985.)

Contacts of lava flows

<u>Lower contacts</u>

1. Calton Hill SSSI SE sector (SK 121721).

Here the Upper Miller's Dale Lava rests on a tuff covering the limestone pavement. Note that this part of the SSSI is within a disused waste disposal site and can only be reached through a gate (usually chained) at the end of a small road from the A6.

2. Station Quarry, Miller's Dale (SK 13297347).

The north-eastern part of this large disused quarry shows limestones surmounted by the weathered Upper Miller's Dale Lava. But ropes and pitons are recommended for those trying to reach the actual contact from below or above !

<u>Upper contacts</u>

1. Ravenstor, Millers Dale (SK 15697298).

Well-known section just off the Miller's Dale to Litton road. Here a greenish-grey clay top to the Lower Miller's Dale Lava has been eroded to form a small cave. The overlying limestone (usually festooned with rock climbers) has an irregular base with lava intraclasts.

2. Black Rock Corner (SK 17946975).

Though visible from the A6 road the substantial cliff here is on Duchy of Devonshire land. It displays some 17m of the Shacklow Wood Lava separated by pyritous clay pockets from 17.6m of limestone.

3. Chee Dale (SK 13007337).

See above.

Dykes

Both known examples are on land owned by Buxton Lime Industries, Tunstead Quarry. That at SK 10057506 is now obscured. The other, at Buxton Bridge (SK 09747565), is in a narrow cutting which has now been walled off from the Buxton Bridge to Wormhill road. Access to it might be possible, with the permission of Buxton Lime Industries, through a locked gate by the roadside. (See Cope 1933.)

Flow fronts

Old Miller's Dale railway line near Litton Mill (SK 15697298).

On the south side of the cutting some 5.18m of the Lower Miller's Dale Lava (top 1.52m poorly exposed) are seen with crude flow banding which dips eastwards at 40°. This has generally been interpreted as a flow front. Another was seen by Cope some years ago in a temporary section not far away near Taddington.

Hyaloclastites

These are rare. Some have been identified in boreholes, but the only visible examples are:

1. The Speedwell "cone", Castleton (SK 14298254). A few scattered exposures in a low ridge near the Speedwell Cavern-Goosehill Hall path have been reinterpreted as hyaloclastites deposits by Cheshire & Bell (1977).

2. Ashbourne-Buxton old railway cutting (SK 18125243).

Easily accessible from the Tissington Trail car park, but now sadly overgrown. Within a Derbyshire Wildlife Trust Nature Reserve. Arnold-Bemrose (1899) described a substantial section in "coarse tuffs", and these have now been identified as hyaloclastites of the Tissington Volcanic Formation (Chisholm, Charsley & Aitkenhead 1988). The agile and persistent might still find occasional exposures when winter has cleared parts of the east side of the long cutting.

3. Woodeaves Farm (SK 18995115).

On private farm land. Scattered exposures of the hyaloclastites are visible in the banks of two streams NE of the farm.

Lava flows

Mainly vesicular outcrops

1. Lathkill Lodge (SK 20416617).

Within a SSSI (Biological), 3.8m of the Lathkill Lodge Lava are exposed alongside (and just above) the public footpath from Lathkill Lodge to Conksbury Bridge.

2. Great Shacklow Wood (SK 18226967).

Above the public footpath near the old sawmill, c4m of the Shacklow Wood Lava are exposed.

3. Long Lane South, Miller's Dale (SK 13417299).

On private land. Access through (wired) gate from Long Lane, a few metres from its junction with the B6409 road. 13m of Upper Miller's Dale Lava exposed in disused quarry.

(See also Staden Low, Masson Hill, Cressbrook Dale, Chee Dale, Cave Dale, and Wormhill above.)

Vesicular and non-vesicular outcrops

1. Long Lane North (SK 13417312).

Private land. Access through (wired) gate from Long Lane. 13.72m massive lava on 1.52m vesicular Upper Miller's Dale Lava in disused quarry.

2. Gratton Dale (SK 20806080).

Within a SSSI (Biological). By public bridleway from Dale Farm, 2m of Lower Matlock Lava ?in two flow units gently dipping NE.

3. Conksbury Bridge (SK 20986600 & SK 21106585).

Within a SSSI (Biological), 3.8m of massive lava exposed in recess by footpath to Conksbury Bridge and 1.5m of vesicular lava exposed on hillside a little further south. Conksbury Bridge Lava.

4. Grange Barn (SK 22455873).

Small disused eastern quarry on south side of the (busy) Pikehall-Grange Mill road. 1.22m of vesicular lava exposed on 3.05m of massive Lower Matlock Lava.

5. Old ICI Basalt Quarry (SK 099760).

Private land. Access off the Peak Dale-Wormhill road or the Buxton Bridge-Wormhill road. c6m of Lower Miller's Dale Lava exposed. Traces of a thin tuff and tuffaceous limestone were formerly seen at the top of the section.

6. Bonsall Wood Old Basalt Quarry (SK 28255744).

Private Land. Jug of Lead Inn car park and quarry in wood behind it.

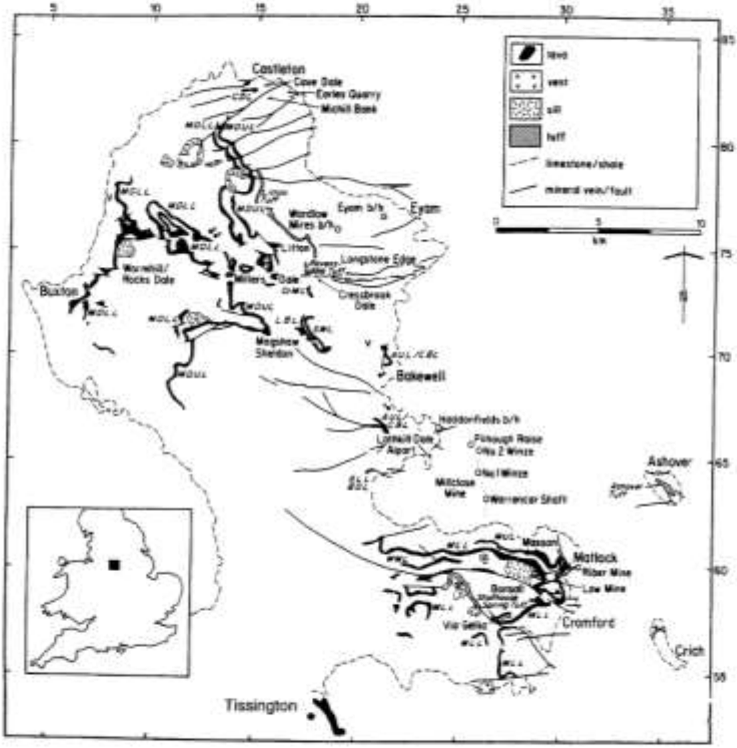

Figure 1. Distribution of the igneous horizons. (After Ineson & Walters 1983, with minor additions. Reproduced by permission of the east Midlands Geological Society.)

(Access by steps.) c9m Lower Matlock Lava under 2.4m tuff.

(See also Black Rock Corner above. The substantial massive base of the exposure is sufficiently coarse grained to be described as "doleritic" and was indeed interpreted by Arnold-Bemrose (*ibid.*) and others as an intrusive sill (Miller 1980).

Non-vesicular outcrops

1. Bole Hill (SK 10597543).

Small exposure by the side of the Peak Dale-Wormhill road. Coarse grained Upper Miller's Dale Lava.

2. Tunstead South East. (SK 11307465).

Recumbent slab just west of field wall and adjacent to public bridleway. c2m coarse grained and fresh Lower Miller's Dale Lava.

3. Blackwell Dale (SK 12907223).

3.3m exposure of Lower Miller's Dale Lava on private land just west of B6409 road from Blackwell to Miller's Dale. Mainly non-vesicular and coarse grained.

Marmorisation

Marmorisation of limestones by dolerite or basalt is rare in Derbyshire. Exposures in Waterswallows Quarry, Ible Dolerite Quarry and those close to the two known dykes have now disappeared. Still surviving are:

1. Tideswell Dale (SK 15397410).

Above the very busy (and dangerous) B6409 road on the west side of the Dale. At least 0.45m of limestone marmorised by the Tideswell Dale Sill.

2. Dam Side, Peak Forest (SK 11617880). Limestone crags north of Mill Cottage show 3.5m marmorised by the Peak Forest Sill and a further 1m partly so. (See Stevenson & Gaunt 1971, pl. 21a.)

Pillow lavas

Only found in four boreholes; none visible at surface.

Scoria

The nearest approach to a genuine scoria is perhaps in the basalts exposed at SK 180533, on the small eastern hillock close to Shaw's Farm, Tissington. (Private track from Tissington.) These basalts are believed to form part of the Tissington Volcanic Formation. Calcitised with very large vesicles and oxidised to a dark reddish-brown. See particularly the large upstanding block on the crest of the hillock.

Sills

The best exposed are:

1. Tideswell Dale (SK 15507385).

The large disused quarry on the east side of the Dale shows 25m of dolerite. Arnold-Bemrose (1899a) mapped textural variations in the face, but these are now very difficult to detect. Fibrous chlorite veining is a feature of the quarry face. Vesicles are found at both the top and bottom of the exposure, which according to the Geological Survey represents part of the sill, but according to Arnold-Bemrose (*ibid.*) and others represents the Lower Miller's Dale Lava. The red columnar clay described in all the accounts is now below ground and should not be disturbed !

2. Damside, Peak Forest (SK 11617880).

Scattered exposures of the Peak Forest Sill are best seen west, north and east of Mill Cottage (unfortunately disfigured by coring).

3. Waterswallows Quarry (SK 084748). Large working quarry. Sill at least 80m thick. Medium grained dolerite predominates, but there are also coarse grained lenses with large phenocrysts, and fine grained dolerites (with fresh olivine) in the lowest level. (See Miller 1986 for detailed description.)

Spheroidal weathering

Not uncommon - see Tideswell Dale quarry; Damside, Peak Forest (south-east of Mill Cottage); Black Rock Corner; Pig O'Lead Inn car park. Other examples at:

1. Grange Mill (SK 24425783).

Small disused quarry on the east side of the Grange Mill-Winster road.

2. Knot Low, Miller's Dale (SK 13397355).

This has a good section in the Upper Miller's Dale Lava with both vesicular and non-vesicular horizons. But it is now within the Monks Dale SSSI (Biological), defended by formidable fences and very difficult of access.

Tuffs

The exposures are disappointing and can be divided into two groups:

<u>Tuffs associated with lava flows</u>

1. Brook Bottom Tuff (SK 14447702).

Private land. Accessible through gate on west side of the road from Tideswell to Wallcliff. Two exposures in the hillside of banded calcareous tuff (up to 3m) ? within the Upper Miller's Dale Lava which is visible higher up the hillside.

2. Tideswell Dale Sewage Works (SK 15357450).

Private land. Access through gate just south of the Sewage Works on west side of the road to Tideswell, then oblique path up the hillside to top corner of the enclosure. Scattered exposures under a limestone escarpment. Recorded by Arnold-Bemrose (1899a), but not by the Geological Survey in recent mapping. ? Associated with the Lower Miller's Dale Lava. Recent badger tunnelling has unearthed finer grained tuff further south and below lava exposures.

3. Tearsall Farm (SK 26285989).

Private land. Access from bridleway past Tearsall Farm. 1.4m of bedded tuff exposed dipping east on the north side of the track to disused quarry, and 1.5m of blocky tuff exposed to the right of the track and a wire fence. Tuff just above the Upper Matlock Lava which can be seen in the bridleway beyond the gate.

4. Calton Hill SSSI SE sector (SK 121721).

There are good exposures of tuff in the bottom level, resting on the limestone pavement and below the Upper Miller's Dale Lava.

(See also the west workings of Waterswallows Quarry, Calton Hill SSSI NW and the top of the Bonsall Wood basalt.)

<u>Larger tuffs independent of lava flows</u>

1. Ravensdale Cottages (SK 17247393).

Access from the footpath running from the cottages to the top of Cressbrook Dale. Just within the Cressbrook Dale Nature Reserve fence, but a stile is promised ! 2.44m of tuff is exposed on the somewhat overgrown east bank of the dry streambed.

2. Hockley Kiln cutting, Ashover (SK 352625).

A recess just north of the Ashover-Stretton road displays nearly 6m of the purple-brown Ashover Tuff. (See Kelman 1980.)

3. Litton (SK 16797519).

The best exposure of the Litton Tuff was walled up in the Tideswell Trading Estate some years ago ! A small section is visible just north of the Litton-Wardlow Mires road on private land. Apply at the farm on the other side of the road for permission to go through the gate and examine the exposure.

4. Grangemill (SK 244578).

The Shothouse Spring Tuff is now poorly exposed, but one of its presumed vent sources survives in a small disused quarry just east of the Grangemill-Winster road. Some 5.5m of unbedded coarse tuff with spheroidal weathering can be seen here.

5. Holderness Quarry, Dove Holes (SK 08507840).

The type locality of the Dove Holes Tuff can still be seen (as in Stevenson & Gaunt 1971, pl.3b) from the floor of this disused quarry. But access to it is prevented by the flooded floor and a near vertical slope. A small exposure has been found in a subsidiary quarry to the south-west (about SK 081782) close to a public footpath and at the foot of the (dangerously overhanging) limestone face.

Tuffaceous limestones

These are uncommon. Although badly overgrown, the best locality is the disused Crakelow Quarry (SK 17565326), just to the west of the Tissington Trail and reached by an ill-defined path from the derelict Crakelow Farm. Here in a 14.8m limestone section there are several thin beds of tuffaceous limestone and a bed of tuff.

An alternative is a small disused quarry at Knowle End, Smalldale (SK 09777700) at the base of a 10.8m section.

Ultramafics

Only represented by the spinel-bearing lherzolite and harzburgite nodules to be found in the Calton Hill basanite intrusion. A diligent search of the basanite tongues and lenses in both the north-west and south-east sectors of the SSSI can still locate these distinctive olive-green nodules.

Vents

These are poorly exposed. Hopton Road, Calton Hill, Waterswallows and Grangemill are mentioned above. Smaller examples have been found in Monksdale (SK 12637558); Ember Lane, Bonsall (SK 28165827); Pounder Lane, Bonsall (SK 28025905); and Cracknowl Wood, Ashford-in-the-Water (SK 20856976) on private land. (See Miller 1983).

Zeolites

Not common, but have been reported from Cave Dale, Wormhill, the Lathkill Lodge Lava, and the Potluck and Duffield sills. The Calton Hill basanite has amygdales with analcime fillings.

PESSIMISTIC DISCLAIMERS

Geological exposures in Derbyshire have been disappearing at an alarming rate thanks to waste infill, landscaping, natural erosion and jungle-like vegetation. The author cannot therefore guarantee that all those in the Guide will still exist. Nor can he help with the formidable task of tracking down the owners of the land upon which some localities are sited. Ask at the nearest farm, but be prepared to find that the owner in question lives many miles away.

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NEW EXPOSURES IN THE PRECAMBRIAN STRETTON SHALE FORMATION, CHURCH STRETTON, SHROPSHIRE

by J.B. Moseley

SUMMARY

Three sections* within and adjacent to the Church Stretton Fault System have revealed intense faulting and deformation of the Stretton Shale Formation. The faulting parallels that of the strike-slip dominated Church Stretton Fault System. The main phases of Stretton Shale deformation may be post-Middle Cambrian. At least one period of faulting post-dates dolerites that intrude the Longmyndian Supergroup. Evidence is presented for thrusting west of the Church Stretton Fault System.

INTRODUCTION

The Stretton Shale Formation consists of shales with some mudstones, and is the lowest stratigraphic unit of the isoclinally folded Precambrian Longmyndian Supergroup. The shales and mudstones are part of the turbidite facies in a prograding turbidite to alluvial floodplain sequence (Pauley 1986, 1990). The Longmyndian inlier may be part of a terrane slice within the Welsh Borderland Fault System (Woodcock & Gibbons 1988). Stretton Shales crop out within and immediately west of the Church Stretton Fault System (fig.1), and are anticlinally folded (Greig *et al.* 1968). There is considerable structural and stratigraphic evidence to show that this strike-slip dominated fault system has been periodically reactivated (Greig *et al.* 1968, Earp & Hains 1971, Woodcock & Pauley 1989, Pauley 1990, Cocks 1989, Woodcock 1988, Toghill 1990, Toghill & Chell 1984, Richie *et al.* 1992).

Cunnery Road Section (SO 45099353).

A temporary exposure displaying Stretton Shales and a dolerite was created during the development of a building site for a private house.

Rock types and stratigraphic units

Stretton Shale Formation

At least 17m of grey shales have been exposed. These are finely

*These sections are on private land and permission should be obtained from the owners.

FIG.1 GEOLOGICAL SKETCH-MAP OF THE CHURCH STRETTON AREA

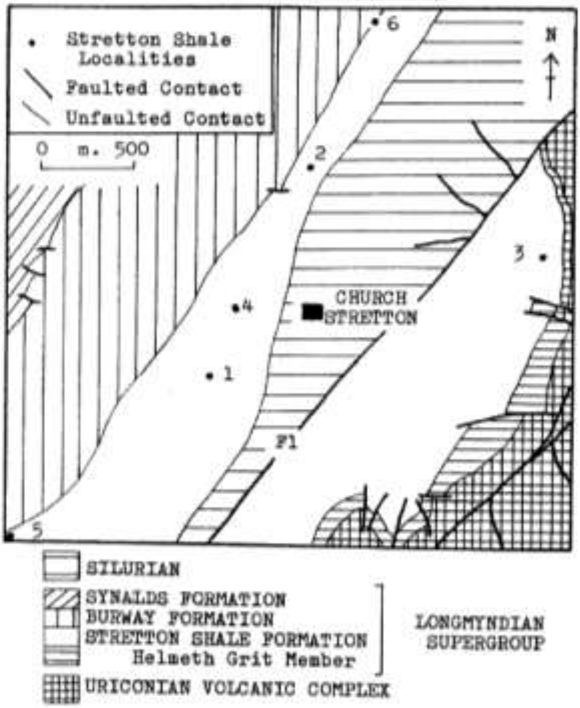
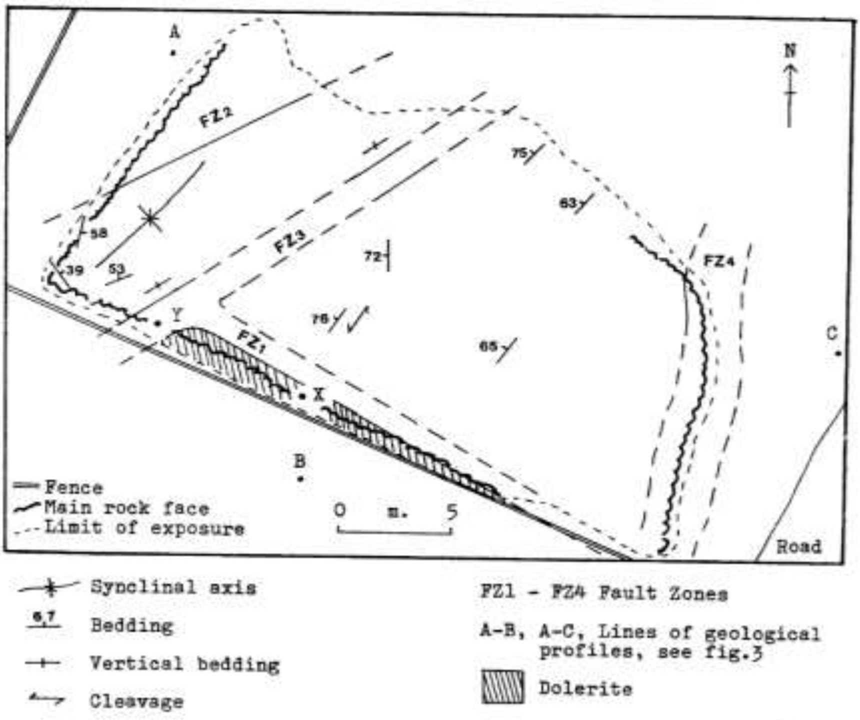


FIG.2 GEOLOGICAL SKETCH-MAP OF THE CUNNERY ROAD SITE



laminated with individual laminae 1-5mm thick. Chlorite development sometimes imparts a very dark green, or blue-green colour to the shales. The very fine clay mineral layers that probably originally settled from suspension, and are now chloritised, give rise to extremely smooth bedding surfaces.

Dolerite

The exposed dolerite occurs within a fault zone (figs 2, 5) and is consequently weathered, fractured and brecciated. A fresh zone of grey dolerite surrounded by clay and weathered brown dolerite occurs at point X (fig. 2). This dolerite may be continuous with a dolerite dyke 15m to the south-west (Geological Survey of Great Britain, Church Stretton, Sheet SO 49).

<u>Structure</u> (figs 2-5)

Bedding/Stratification

The shales are folded into a syncline, are locally kinked (see below) and steeply inclined in a west to north-westerly direction. This is in keeping with minor folding patterns and the location of the Stretton Shales on the eastern limb of Longmyndian isocline.

Slaty Cleavage

Slaty cleavage strikes parallel to, but is more steeply inclined than the bedding. In places it is only weakly developed and is sometimes refracted by subtle changes in the primary laminations of the shales.

Faulting

The south face of the exposure is a vertical fault zone (FZ1, fig.2) striking 057°-124° and developed at the contact of a dolerite with Stretton Shales (fig. 5). Thin lenses of dolerites (0-20cm wide) within the fault zone originated as veins or narrow dykes similar to that developed at the unfaulted margin of a dolerite in the Ordovician Shelve Inlier (SO 32759739).

Two vertical faults, striking 064° (FZ2) and 055° (FZ3) are almost parallel to and may be part of the Church Stretton Fault System. This site is only 540m northwest of the F1 component of the Church Stretton Fault System. FZ3 may be continuous with the 057° strand of FZ1. It was not possible to determine the displacements and sense of movement on these faults.

At road level there is an extremely shattered and disturbed zone (FZ4). This consists largely of randomly orientated, fragmented blocks of shale and some detached horizontal angular folds that close southwards. This zone is above the steeply tilted, but markedly less deformed shales that are exposed at lower levels on Cunnery Road (SO 45099361). The highly shattered zone becomes less disturbed upwards passing into steeply tilted shales with only discrete kinks and small scale folds. This zone seems to have a low, approximately westerly, dip and may be a thrust. The junction with FZ1 is not exposed.

FIG.3 GEOLOGICAL PROFILES FOR THE CUNNERY ROAD SITE

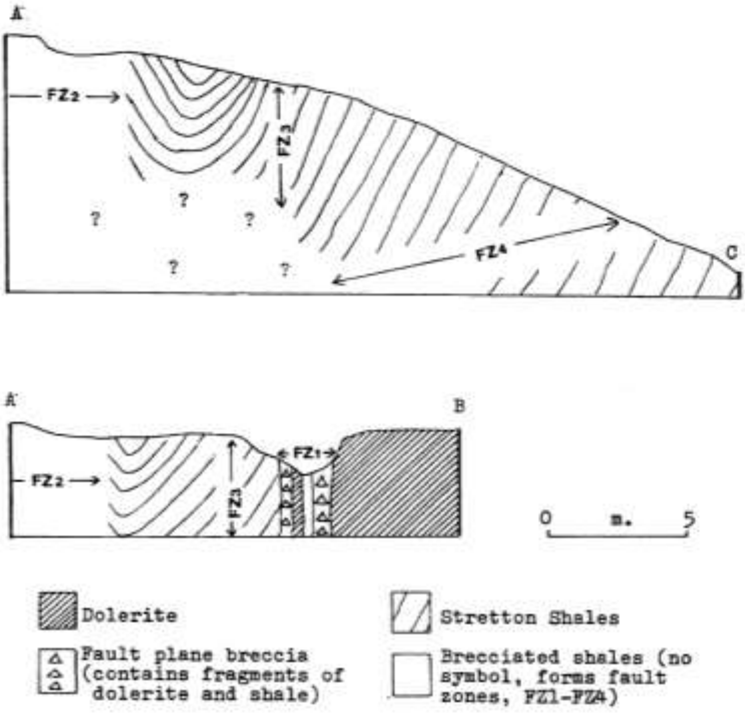
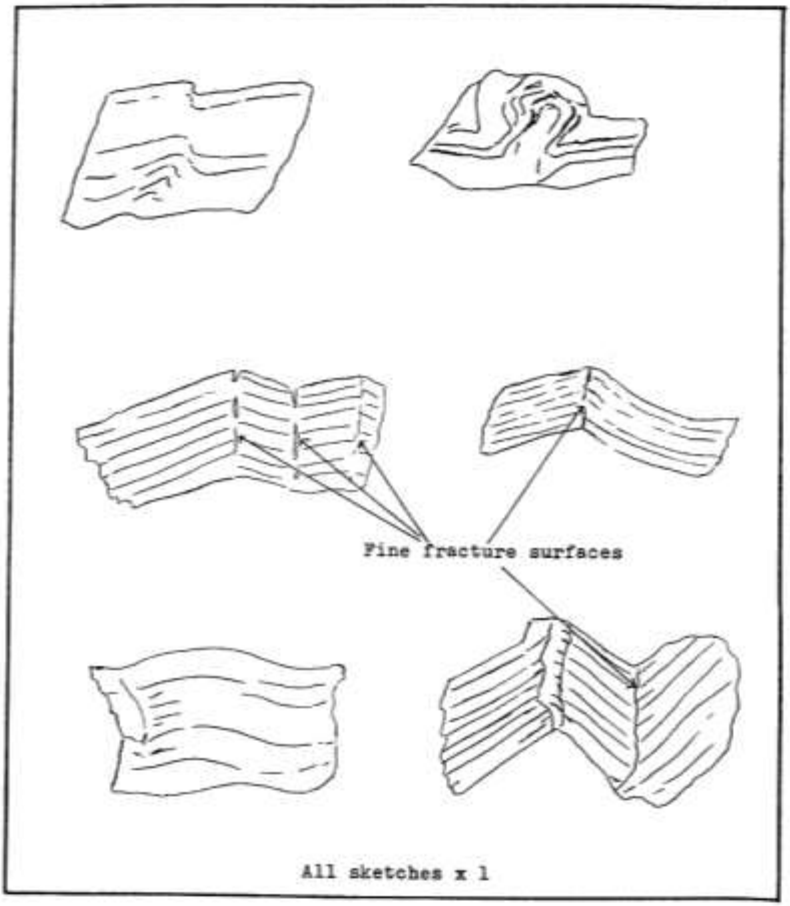


FIG.4 SKETCHES OF FOLD STRUCTURES AND KINK-BANDS DEVELOPED AT THE GUNNERY ROAD SITE



Folding

The Longmyndian Supergroup is believed to be folded into an isoclinal syncline (James 1956, Greig *et al.* 1968, Pauley 1986, 1990) so that the Stretton Shales usually dip steeply to the west and north-west, forming part of the eastern limb of the fold. Here the shales are folded into an asymmetric close syncline (interlimb angle 36°) with an axial trend of 050°, and plunging 35°/050°. The core zone of the fold is bounded by FZ2 and FZ3. This syncline is another of the minor or parasitic folds (Pauley 1990, Moseley 1992) which parallel the major isoclinal axis and locally corrugate the Stretton Shale Formation.

Small scale gentle and open minor folds evolve into tighter angular folds, and these into kink-bands by fracturing parallel to axial planes. Some fractures have developed small-scale fault breccia. Applying the models proposed by Ramsay (1967, p. 440-2, 449) for chevron folds and kink-bands, estimates were made for total finite shear strain and shortening (table 1).

The thinly bedded nature of the shales produces low t/l values, a situation which allows a significant take up of compressive strains (Ramsay 1967) and expectedly low values for e and γ. This suggests a weak component of shortening sub-parallel to the Longmyndian isoclinal axis.

It is uncertain how these kink-bands and very minor folds relate to regional and local tectonic events. Ramsay (1967) suggests that kink-bands evolve late on during an orogenic phase. A post-Longmyndian folding age for the kink-bands is therefore very likely. Kink-bands caught up in FZ4 indicates at least one fault phase post-dating these structures.

Church Stretton Mineral Water Offices, Shrewsbury Road, All Stretton (SO 45549465).

A vertical west-east face, exposing Stretton Shales was made accessible by the building development for new offices.

Rock types and stratigraphic unit

Stretton Shale Formation

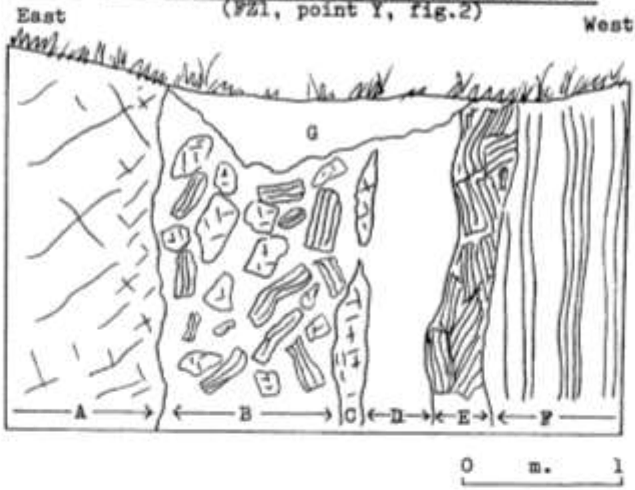
An estimated 12.54m of very finely laminated grey shales are exposed. At several horizons are excellent examples of dark grey, calcareous, unlaminated nodular lenses sometimes showing cone-in-cone structure. Similar structures have been reported from other localities (Greig *et al.* 1968, Whittard *et al.* 1953).

Structure

Bedding/Stratification

The shales dip at 45°/270° on the east side of the section, become slightly

FIG.5 SKETCH OF DOLERITE-STRETTON SHALE FAULT
(FZ1, point Y, fig.2)



A Fractured, weathered dolerite.

B Fault breccia, containing fragments of dolerite and shales.

C Dolerite vein.

D Fault gouge.

E Brecciated shales.

F Vertical shales.

G Soil and weathered fault plane material.

TABLE 1

α	t/1	1 + e	γ
71	0.10	0.39	3.1
65	0.15	0.48	2.2
53	0.12	0.61	1.4
53	0.24	0.65	1.4
10	0.09	0.98	0.1
10	0.27	0.99	0.01
19	0.13	0.96	0.3
16	0.15	0.97	0.2

α Inclination of fold limb

t Thickness of layers

l Length of fold limb (hinge to hinge)

1 + e Finite shortening

γ Total finite shear strain

steeper westwards and are vertical at the base of the exposure.

Faulting

The shales are cut by a network of minor faults. There has been slip on some bedding surfaces, some faults strike parallel to, but are steeper than the bedding, and there are horizontal fractures, including a minor thrust plane.

New House Farm, Church Stretton (SO 46889439).

A landscaping operation to develop a small lake produced a 70 metre long section.

Rock types and stratigraphic unit

Stretton Shale Formation

The series of parallel faults described below makes it difficult to estimate accurately the total thickness of shales and mudstone. The following sequence is exposed:

Brown shales with thin mudstones..................14.77m
Blue-grey, well-laminated shales...................1.97m
Blue-grey shales, brecciated.......................3.94m
Grey shales..13.79m
Shales, brecciated...................................3.94m
Shales, intensely faulted..........................9.85m
Olive-green mudstones with limonitic specks.......0.74m
Dark grey laminated shales.........................1.70m

This sequence is 80m above the base of the Stretton Shales and their contact with the Helmeth Grit. Sandy horizons that are developed elsewhere near the base of the Stretton Shales are not present at this locality. Thin clay horizons near the top of the sequence do not display the gritty character of fault-gouge and may be bentonites, or decomposed dust tuff horizons.

Structure

Bedding/Stratification

The shales and mudstones are steeply inclined to the west, striking parallel to their adjacent inferred contact with the Helmeth Grit (figs 1, 6).

Faulting

The shales and mudstones are cut by a series of parallel vertical faults and brecciated zones striking 355° (fig. 6). This trend is approximately parallel to some of the faults that cut the Uriconian Volcanic Complex of Caer Caradoc Hill and the Cambrian rocks of the Colmey area. The overturning of some shales, 71° to 81°/070° is thought to be due to the rotation of a fault slice rather than a tight synclinal-anticlinal structure.

Folding

A small monoclinal fold is developed next to a small fault, possibly the result of fault plane drag.

DISCUSSION

The new exposures of Stretton Shales reflect the structural complexity that might be expected of a thinly layered sequence, tightly folded and caught up in a major fault system.

The fault patterns at Cunnery Road and New House Farm show some similarity to, and may be part of, strike-slip duplexes which are characteristic of the Welsh Borderland Fault System (Woodcock & Fischer 1986, Woodcock & Gibbons 1988). Faults exposed in the section near New House Farm form a small scale imbricate pattern (fig. 6) that may be part of an extensional or contractional duplex. The change in strike of the shale-dolerite fault (FZ1) at Cunnery Road is typical of duplexes.

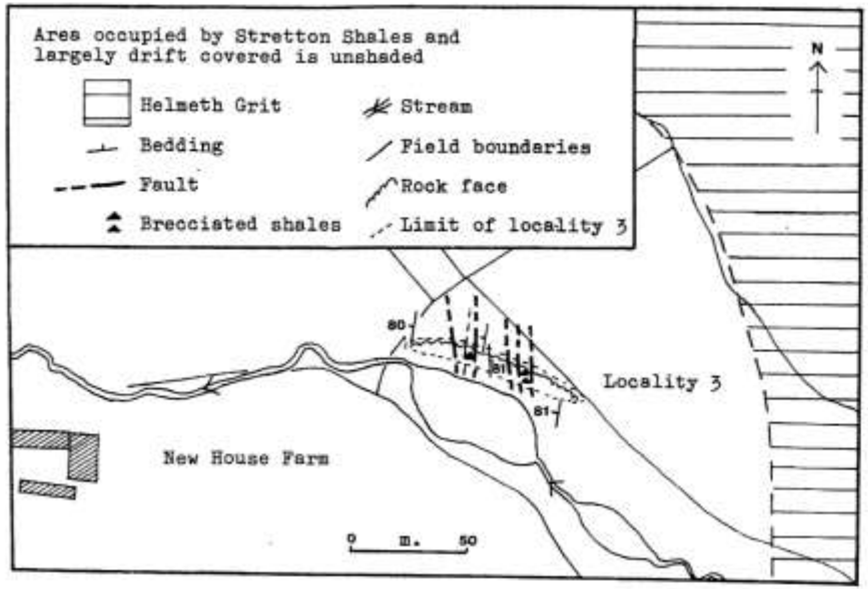
The low angle disturbed zone at Cunnery Road interpreted here as a thrust, is similar to the crushing, brecciation and thrusting developed in Uriconian Volcanics on Caer Caradoc Hill (Greig *et al.* 1968, p. 271). Thrusting may have played a more significant role in the evolution of the Church Stretton Fault System than previously appreciated.

In places the Stretton Shales display quite intense faulting and folding which contrasts with less deformed zones. As well as the localities described above various folds are exposed in the Burway Road cutting (SO 45209394, locality 4, fig. 1, Moseley 1992), and at the entrance to Ashes Hollow (SO 43949262, locality 5, fig. 1) the shales are kinked and overturned. In contrast, at Buxton Rock Quarry, All Stretton (SO 45959549, locality 6, fig. 1) the vertical shales are undeformed.

Although the Upper Cambrian *Orusia* shales of the Comley inlier are locally contorted (Greig *et al.* 1968, p. 99), Palaeozoic shale sequences within and adjacent to the Church Stretton Fault System are not usually as severly deformed as the Stretton Shales. Locally the oldest Palaeozoic shales are the Middle Cambrian Hill House Shales. This suggests that some phase or phases of Stretton Shale deformation predate and/or are contemporaneous with the intra-Cambrian earth movements represented by the Lower Cambrian-Middle Cambrian unconformity (e.g. Comley Quarry SO 48469648). This supports the suggestion (Woodcock & Gibbons 1988) that the Welsh Borderland Fault System originated during the late Precambrian to early Cambrian transcurrent movements.

Evidence from the Cunnery Road section shows some faulting post-dating dolerites intruded after main Longmyndian tilting and folding.

FIG.6 SKETCH-MAP TO SHOW POSITION OF LOCALITY 3



The deformation of the thinly layered Stretton Shales reflects the response of this Formation to various phases of earth movements. It is suggested that the Stretton Shale Formation may be viewed as a structural marker horizon and more detailed analyses may further elucidate the complex tectonic evolution of this part of the Welsh Borderland.

ACKNOWLEDGEMENTS

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A NOTE ON THE SLATE QUARRIES OF EASDALE ISLAND, ARGYLLSHIRE

by Derek Brumhead

During a sailing holiday among the islands of western Scotland, an opportunity arose to put into the harbour of the small island of Easdale where there are the remains of an industrial community based on the quarrying of slate from extraordinary quarries excavated deep below the level of the adjacent sea. The slates are among the oldest rocks in the British Isles - late Precambrian sedimentary rocks (Dalradian) metamorphosed by later earth movements. The enormous pressures and heat concertinared the rocks into a series of folds which took the slate beds down many hundreds of feet below the present level of the sea. It followed that when intensive quarrying for slate took place it became necessary to work far below the level of the sea which was only a few yards away. Some quarries were over 100 feet deep, and one at Ellanbeich (Seil), on the mainland opposite, was worked to a depth of 260 feet. Barriers of slate and concrete were erected to keep out the sea, but inevitably quarrymen worked by standing or wading in sea water, especially when the sea was rough.

Easdale slate, which is fine-grained, blue-black or black in colour, occurs in thick slabs tilted at a steep angle, which can be clearly seen in the quarries today. The strike is N 30°E and the cleavage dips at 55°E/10°S. A distinctive feature of the slate is the marked wavy lineation on the cleavage planes due to strain-slip cleavage, most strongly developed where the beds turn over sharply on the crest or in the trough of a fold. This is where most of the waste occurred. As might be expected, the quarrymen developed a good working understanding of the nature of the folding and its relation to pitch, joints and cleavage, and used this knowledge for the economic working of the slate. They gave gaelic names for different parts of a fold. A universal feature of the slates is the many scattered tiny cubes of pyrite, many of which have rusted away leaving only brown stains or cube-shaped holes.

It is difficult to decide whether or not the industrial archaeology is more fascinating than the geology. Not only are they both inextricably related with regard to the way the slates have been quarried, but there is also the added interest of two sets of igneous dykes intruded into the slates, forming walls of rock where they have been left by the quarrymen taking the slate on either side. The newer set of dykes (of Tertiary age) trends NW-SE and forms part of the famous swarm of dykes which radiate from an igneous epicentre on the nearby island of Mull.

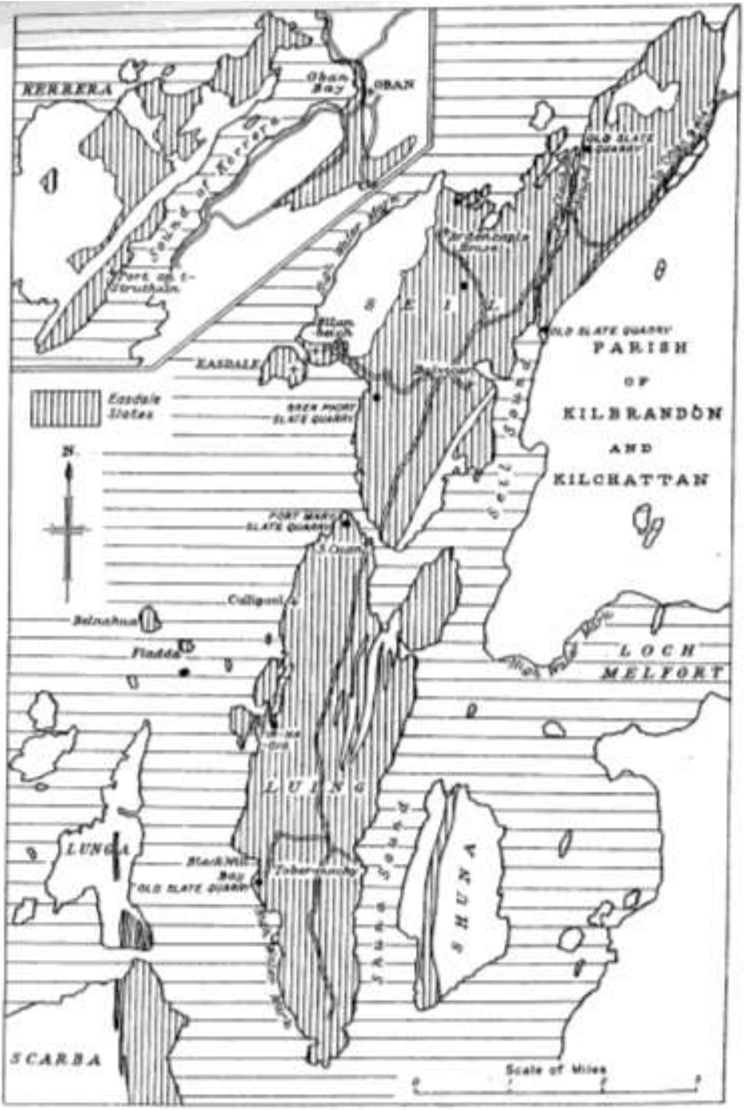

Figure 1. Map of Easdale Island slate belt with inset map of outcrops near Oban (Richey & Anderson 1944).

Figure 2. Map of Easdale Island in 1896 (drawn by Jean Adams, Easdale Island Folk Museum).

The first written record of slate quarrying is in the seventeenth century. In 1631 a castle at Appin was roofed with Easdale Slate. Slate was removed from shallow workings on the foreshore at low tide and an ingenious system of sluices removed water at low tide and delayed its ingress at high tide. In 1745, when Scotsmen elsewhere had other things on their minds, the Marble and Slate Company was formed, slates then being sold for 16s 8d per "thousand" of twelve hundred. By 1800 production had risen to 5 million slates per year, largely due to the introduction of pumping machinery, including a Newcomen engine and a windmill, which made it possible to quarry below sea level. Pumping gear was even acquired from wrecked ships. The company was dissolved in 1886 and the various quarries came into separate ownership. In 1881 a disastrous storm flooded all the quarries and although production eventually restarted it never reached the levels of previous years and the last slates were exported in 1911.

A series of railway lines was constructed on embankments built of slate waste and small steam locomotives were used to move slate to the jetties, from which small sailing and steam vessels were used to export the slates. When one sails into the harbour today with the help of an auxiliary engine, carefully negotiating the narrow channel and hidden rocks - with much awareness of wind and tide - the skill and courage of these sailors with their heavily laden boats can only arouse admiration.

There is also great interest in the housing which was built for the quarrymen and their families which today form very attractive groups. They are bungalows, originally of two rooms with a central lobby behind which was a closet. A roof space provided sleeping quarters for the children. Many have been refurbished to modern standards and are now sold for holiday homes for £50,000 and upwards. Those interested in industrial communities and their housing would find Easdale an interesting variation.

Perhaps one of the most surprising aspects today in such an isolated spot is an admirably designed and arranged museum of life and work on the island which was set up in 1980 by the island's owner at the time, Chris Nicholson. The curator, Jean Adams, who is a direct descendant of a quarrier's family, has collected and arranged the displays of artifacts, all of which are associated with the island. The displays are supported by historical documents photocopied from record office archives. The map of Easdale Island reproduced here (fig.2) was drawn by Jean Adams for the museum.

The island is accessible by the B844 off the A816 between Lochgilphead and Oban. A full day can easily be spent there.

ACKNOWLEDGEMENTS

Eric Robinson, Librarian of the Geologists' Association, kindly loaned me the first two references.

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Figure 3. Slate quarry on Easdale Island (Peach, Kynaston & Maup 1909).

THE MINERALS OF THE TERTIARY BASALTS OF THE ISLE OF SKYE

by David I. Green

INTRODUCTION

The Isle of Skye is the largest of the Inner Hebrides, with an area of nearly 700 square miles. It is separated from mainland Scotland by the Sound of Sleat, which narrows to 500m at Kyle of Lochalsh, where a controversial bridge is under construction. Skye's irregular landmass stretches about 50 miles from south to north and varies up to a maximum of about 25 miles from east to west. The climate is typically wet and mild, with long periods of gentle rain, even during the summer months. Statistically the best time for a visit is May; even then only half of the days are sunny, and this degenerates to a third in the peak season of July and August. The saying goes that "when you can see the Cuillins it is going to rain, and when you can't it already is".

The topography of Skye is varied, and to a large extent reflects the underlying geology of the island. Many of the pioneers of British geology worked here, and the early memoirs of the geological survey are classics of their kind. Skye also attracted the attention of many early mineralogists; pre-eminent amongst these was Matthew Forster Heddle (1828 - 1897) who seems to have explored every corner of the island. Heddle's book, *The Mineralogy of Scotland*, published posthumously in 1901, contains the most comprehensive account of the topographic mineralogy of the island.

GEOLOGY

In the south of the Skye, the Sleat (pronounced Slate) peninsula is a broad area of low undulating land oriented on a north east to south west axis. Its geology belongs almost entirely to the Precambrian, with many different rock types juxtaposed in an apparently random patchwork. This is the result of metamorphic alteration and complex thrusting deformation particularly during the Caledonian Orogeny. Topographically, Sleat has more affinities with the flow country in the far north of Scotland than with the rest of Skye.

Moving northward to Strath, we find Cambro-Ordovician limestones which conceal some of Scotland's most impressive caves. Although little known today, the Spar Cave, near Elgol, was on every Victorian gentleman's

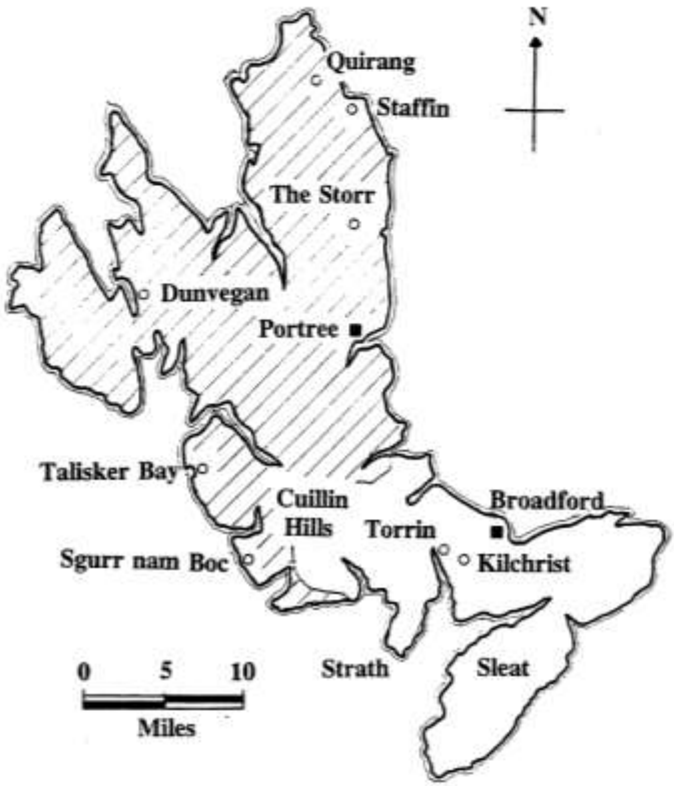

Figure 1. Location map. The hatched area is dominated by tertiary basalt. Productive zeolite localities include the Quirang, the Storr, Talisker Bay and Sgurr nam Boc.

tour of the Western Isles. Thermal metamorphism of the limestones has produced the famous Skye Marble, which is still quarried near Torrin. To the east of Torrin, the Beinn an Dubaich Granite furnishes a classic example of boron-fluorine skarn formation at its contact with the limestone. Small lenses rich in copper and iron sulphide minerals occur within the skarns and occasionally weather to produce colourful secondary species. Good exposures can be seen near the ruined Manse at Kilchrist. Generally however, the mineralization is unspectacular and does not provide fine museum specimens.

Central Skye is dominated by the Cuillin Hills. The western or Black Cuillins are carved from gabbro into knife-edged ridges which rise to more than 3000 feet. They provide some of the most challenging mountain walking in Britain. The Inaccessible Pinnacle, the only Munro which cannot be ascended without climbing, is in the centre of this range, and a full crossing of the Cuillin ridge is still regarded as a considerable mountaineering feat. The eastern or Red Cuillins offer a complete contrast; their rounded form is typical of the action of ice on the granite from which they are carved.

North of the Cuillin, the landscape changes once more. The northern half of Skye is dominated by Tertiary basalt. This forms areas of boggy plateau land punctuated by isolated flat-topped mountains and delineated in the west by spectacular sea cliffs. On the eatern side of the island a long scarp exposes Mesozoic sediments which underly the basalt. These are famous for their ammonite fauna. It is, however, the basalts which are of interest mineralogically, for concealed within ancient gas cavities (amygdales) is the suite of minerals for which Skye is famous.

MINERALOGY

The amygdales within basalt lava flows are mineralized by a well-defined suite of minerals worldwide. These include members of the zeolite group, which provide most of the species recorded, and a number of associated minerals, which on Skye include apophyllite group minerals and calcite.

The zeolites are a group of minerals with complex aluminosilicate frameworks in which water and ions of the alkali and alkaline earth metals are loosely bound. They have commercial uses in such diverse fields as water softening, catalysis, ion exchange and nuclear engineering. Zeolites occur naturally in a wide variety of geological environments, but it is as infillings in gas cavities in basalt that they are best known. The world's most spectacular specimens are found in quarries near Poona in India, where large cavities lined with stunning crystals are common. Although the Scottish specimens are not quite as spectacular, the basalts of Skye have produced specimens which are some of the best British examples of their species.

LOCALITIES

Heddle (1901) gives an extensive list of localities where zeolites occur, most of which can be located by patient examination of OS maps. They are all in the Tertiary basalts which make up the northern and western parts of the island. Many of the sites are well-away from roads, and often work is done on large boulders, so a lump hammer and chisel are usually required. The following sites are recommended on the basis of several weeks fieldwork over a number of years; they are sure to provide a good selection of the more common species.

Two of the best localities are The Storr [NG 500540] and The Quirang [NG 452692], which are at opposite ends of a long arcuate scarp which runs between Portree in the south and Flodigarry in the north. Zeolites can be found in the screes surrounding the crumbling basalt pinnacle of the Old Man of Storr and also in the large boulders below the Storr itself. With a little effort examples of almost all the common species can be collected. Specimens are similarly common at the Quirang. If a visit to the Quirang is intended, it is worthwhile visiting some of the small roadside quarries near Flodigarry [eg. NG 463711], where it is often possible to find good specimens. Indeed, as a general point it is worthwhile stopping at any recent road cutting or quarry in the northern part of the island, since blasting may have exposed unusual or interesting material.

On the west coast of Skye, Talisker Bay [NG 315301] is a mecca for mineral collectors. The boulders in the bay itself are no longer very productive, but a walk either northward or southward along the beach will certainly yield specimens. To the south in particular, orange calcite crystals can be found accompanying zeolites, notable as one of the very few colourful mineral associations on the island. Watch out for the tide here; the southern beach is cut off for several hours around high tide and there is no escape up the cliffs.

The cliffs of Sgurr nam Boc [NG 360209] situated on the inaccessible western coast between Loch Eynort and Loch Brittle have produced the finest British zeolites collected in recent times. This locality was described by Heddle (op. cit.). Access is difficult, the landward side being defended by crumbling basalt cliffs; indeed the only practical access is from the sea and this is only possible on very calm days. The locality was rediscovered in the 1980's through the efforts of the Sussex Minerals and Lapidary Society (Pearce & Pearce 1992), and such was the quality of the specimens, particularly stilbite and heulandite, it was chosen by the Royal Scottish Museum for a field trip in 1993.

IDENTIFICATION

The zeolites have traditionally been regarded as a difficult area for collectors and the mineralogist to make identifications at species level. Many collectors are content simply to label their specimen as zeolites. The reason is perhaps that almost all of the members of the group are white to colourless, leaving crystal morphology as the major clue to identity. Whilst it is true that some of the zeolites (and related species which occur in the vesicles) cannot be distinguished without recourse to complex analytical techniques, it is almost always possible to make a more specific identification than simply "zeolite". The following guide is not intended to be comprehensive; rather it covers all of those species likely to be encountered in good crystalline specimens on Skye. Two excellent texts for those interested in pursuing the zeolites further are Tschernich (1992) and Gottardi & Galli (1985).

Accession numbers quoted in the following pages, preceded by the abbreviation Manch, refer to specimens held within collections of The Manchester Museum, on which some of the descriptions are based.

Analcime

Analcime is one of the most common of the Skye zeolites. It can be found at many of the basalt outcrops throughout the Island. It occurs as transparent to opaque euhedral crystals which are easily identified by their characteristic trapezohedral habit (figure 2a). These can only be confused with the very similar wairakite, which is known only from a single obscure locality on the island (Oneta Wilson, pers. comm). Drusy aggregates lining the interior of amygdales are common; examination in sunlight under a hand-lens should reveal typical four-sided, specular reflections from the trapezohedron faces. Particularly fine specimens with crystals over 2 cm in length have recently been found near Flodigarry in the north of the island [Manch: N11914].

Apophyllite Group

The three members of the apophyllite group cannot be resolved without

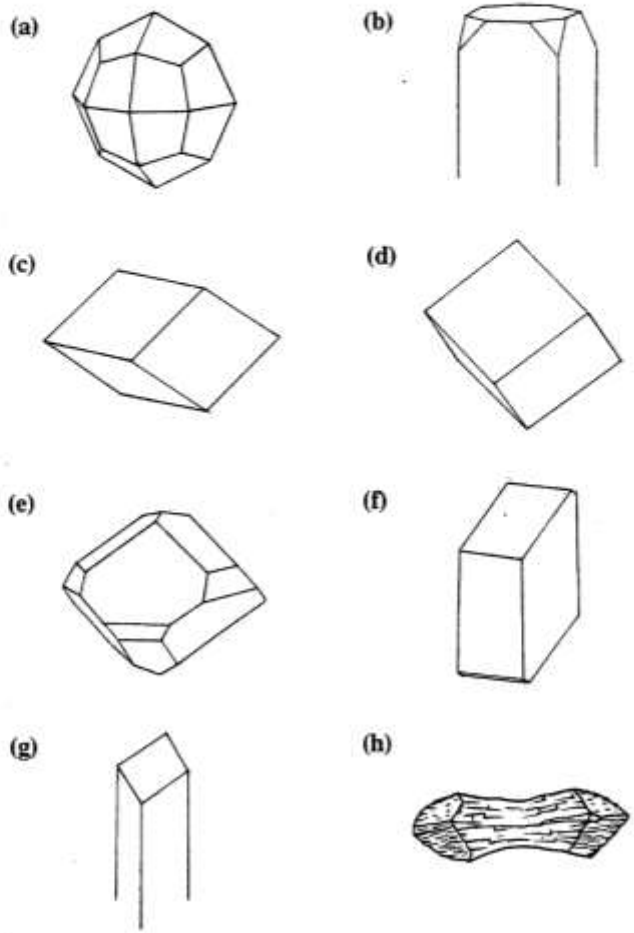

Figure 2. Some common crystal habits of the minerals of the tertiary basalts of Skye.

a) Analcime	b) Apophyllite	c) Calcite	d) Chabazite
e) Chabazite	f) Heulandite	g) Laumontite	h) Stilbite

recourse to analytical procedures. Their habit is, however, quite characteristic as beautiful, transparent, lustrous tetragonal crystals (figure 2b). The blocky crystal habit, high lustre, and striated prism faces are diagnostic features. Perhaps the easiest place to find specimens is amongst the fallen boulders below The Storr, where crystals up to about 10mm occur [Manch: N12001].

Calcite

Calcite is commonly found with zeolites, the most common crystal form on Skye being the simple rhombohedron (figure 2c), which can really only be confused with chabazite. Calcite is readily distinguished by its perfect rhombohedral cleavage. If this is not developed, or if the crystal form is unusual or distorted, a simple and reliable test is to drop a tiny fragment into dilute acid; only calcite will effervesce. Although most of the Skye calcites are colourless, the cliffs to the south of Talisker Bay occasionally produce beautiful orange crystal groups [Manch: N11977].

Chabazite

In its common pseudo-rhombohedral crystal form chabazite is relatively easy to identify; the crystals are usually small and clear and look almost cubic (figure 2d). Careful inspection, usually with a hand lens, will quickly reveal that the corners of the cube are in fact not quite at 90°. Chabazite also forms very complex twin crystals (figure 2e) which when intergrown into drusy crusts have no obvious characteristic habit. Specimens displaying large white opaque rhombohedral crystals were recently found on the north shore of Talisker Bay.

Heulandite

Heulandite is uncommon. It was reported by Heddle (1901) in crystals from both Talisker Bay and The Storr. By far the best recent specimens, and some of the best British heulandite, has come from fallen blocks below Sgurr nam Boc on the inaccessible western coast. These are hand specimens displaying white to salmon-pink crystals up to 2 cm on minor matrix. The crystals usually have slightly curved faces of the form of figure 2f.

Laumontite

This occurs as simple monoclinic crystals which if placed in a dry atmosphere dehydrate to form leonhardite. Specimens are typically white and friable, and crystals are often very tiny, requiring a microscope to resolve their characteristic habit (figure 2g). Although laumontite is widely distributed, good specimens are scarce and usually only found in freshly broken rock. A few good specimens were collected in 1993 from a roadcut near Drynoch [Manch: N11975].

Mesolite and other Fibrous Zeolites

Mesolite is frequently used by specimen mineralogists as a catch-all term to describe any fibrous zeolite. Although this practice has little to commend it, visual identification of the fibrous zeolites is not possible and there are no simple means of differentiating the members of this group which include natrolite, scolecite and a number of rare species.

Stilbite

Stilbite is relatively widespread, occurring in characteristic "bow-ties" (figure 2h) which cannot be confused with any other species except stellerite which appears to be rare on Skye. Good crystal groups can be found at The Storr [Manch: N11999]. A fine series of matrixless groups, wholly composed of interpenetrant translucent stilbite crystals, was recently found in a roadside quarry near Flodigarry [Manch: N11982]. Good specimens have also recently been found in a road cut at the head of Loch Greshornish [Manch N11427]. Probably the best stilbites ever collected in Britain were recently recovered from a house-sized boulder below Sgurr nam Boc (Mick Wood, pers. comm.). These are large museum specimens with beautiful, snow-white stilbite bow-ties up to nearly 10 cm in length.

Thomsonite

Distinct crystals are rare. Thomsonite usually occurs as spherical crystal aggregates which if examined closely will be seen to be composed of minute, thin, platey crystals. In this form thomsonite is common at The Storr and The Quirang [Manch N11995].

DISCUSSION

In addition to the minerals noted above, a number of rarer species may be encountered, including levyne, gmelinite, gyrolite, gonnardite, tobermorite and epistilbite. These are generally unspectacular and occur only in tiny crystals and it is for this reason that they have been omitted from this simplified guide. The Isle of Skye is well-suited to the dedicated amateur collector and mineralogist - less than half of the known zeolites are recorded from the basalt lava flows and miles of outcrop still await detailed inspection. If recent finds are any indication, the island will continue to give up its secrets for years to come.

ACKNOWLEDGEMENTS

Thanks to my girlfriend, Julie, who accompanied my last field trip to Skye and uncomplainingly wrapped the specimens I collected. Thanks also to Oneta Wilson and Mick Wood who suggested a number of productive sites to visit.

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THE BRITISH GEOLOGICAL SURVEY AT WORK

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

The Lancaster 1:50,000 geological map (BGS Sheet 59) has now been drawn up for publication in 1994. An accompanying explanatory memoir is in preparation, with publication again anticipated in 1994. The map will show new detail of the sub-drift bedrock geology in the west of the area and along the coastal belt between Heysham, Morecambe and Bolton-le-Sands. The memoir will contain much information on the Millstone Grit of the Bowland Fells with details given for many newly recorded fossiliferous marine band locations.

During the year the results were published of an urban geological mapping project for the City of Leeds jointly funded by BGS and the Department of the Environment (DoE). Work on an applied geological mapping project of the Wigan area for DoE continued throughout the year. Work started in September 1993 on a further contract with DoE to carry out applied geological mapping of the City of Bradford Metropolitan District Council area. BGS will be extending this programme in order to produce a revised geological map of Bradford (BGS Sheet 69).

A 1:50,000 geological map for Stoke-on-Trent (BGS Sheet 123) has been published, and that for Coventry (BGS Sheet 169) is in a late stage of production; memoirs to accompany these maps are in preparation. Work on the compilation of maps for Nottingham (BGS Sheet 126) and Birmingham (BGS Sheet 168) is in progress. Field surveys are being conducted in the Wakefield (BGS Sheet 78), Wolverhampton (BGS Sheet 153) and Loughborough (BGS Sheet 141) areas.

Lake District and Cumbria (From the *BGS Annual Reports* 1991-92 and 1992-93)

In the Lake District Regional Survey mapping was completed on the Ambleside Sheet (38) and continued on the Keswick (29) and Cockermouth (23) sheets. The two reports and suite of nine thematic maps resulting from the BGS/DoE studies of the Great Broughton-Lamplugh area have been published.

In the central Lake District the mapping and associated studies have shown that the Borrowdale Volcanic Group can be divided into a dominantly andesite lower lava sequence, interpreted as a plateau-andesite field, and an upper volcaniclastic sequence including large-volume ignimbrites and volcaniclastic sedimentary rocks, interpreted as caldera-related and post-caldera deposits respectively. Within this framework, several eruptive cycles have been identified. Continuing investigations in the Sellafield area, funded by UK Nirex Ltd, have confirmed interpretations based on mapping in the Wasdale area that the earliest caldera complex developed in the west. The products of later caldera complexes accumulated in the Scafell-Langdale and Ulpha synclines; they were previously considered to have formed during an intra-Ordovician compressive event, but are now thought to have developed initially as sag basins associated with the caldera complexes.

Preservation of the 6-kilometres-thick sub-aerial sequence, the probable rapid accumulation of the pre-caldera plateau-andesites, the extensive volcanotectonic faulting, and some of the geochemical characteristics support the thesis that the Borrowdale Volcanic Group was emplaced within an extensional tectonic regime.

Understanding of the Borrowdale Volcanic Group magmatism was further advanced by investigations in the Sellafield area (funded by Nirex Ltd), where an early caldera system comprises at least 15 separate acid andesitic, dacitic and rhyolitic ignimbrite sheets in a drilled thickness of 1140 metres. Seismic-reflection profiles around Gosforth contain only weak reflectors from the Lower Palaeozoic basement. By contrast, east of the Lake District Boundary fault in Wasdale, strong discontinuous subhorizontal reflectors are present within the Eskdale-Ennerdale intrusions. A sharp western margin to the Lake District Batholith is indicated.

In the northern Lake District, mid-Ordovician volcanism was preceded by regional uplift, which was probably the cause of extensive slump folding in the Skiddaw Group. The Skiddaw Group structures contrast strongly with those formed during the same, Acadian, event in the younger rocks of the Lake District inlier. The contrasts are attributed to differing rheological responses to varying and perhaps diachronous stresses, and possibly also to the impedance of thrusting by the combined mass of the Borrowdale Volcanic Group and the Lake District Batholith.

The Cockermouth sheet occupies a critical position within the Carboniferous outcrop of northern England. Detailed studies of the Namurian sequence, the least-known part of the west Cumbrian Carboniferous succession, were begun with the drilling of the BGS Dearham Borehole. This has provided the first complete section through these rocks. The Namurian here is in a Yoredale facies, with well-developed rhythmic units including thin limestones in the lower part of the sequence. Palaeontological investigations of the Dearham core indicate that only beds of early Namurian age are present; it appears that there is a major non-sequence beneath the Westphalian.

During 1992-93 two significant contributions to the biostratigraphical correlation and dating of the Skiddaw Group in the Lake District and the correlative Manx Group of the Isle of Man have been made. Palynological investigations of the Skiddaw Group have resulted in the formulation of ten biostratigraphical units in the late Tremadoc-Arenig sequence of the northern fells, including five named acritarch zones and five subzones. The acritarch zonation complements the graptolite zonation, providing a refined biostratigraphical time-scale for these rocks to aid mapping and structural interpretation. Locally, acritarchs are the most diverse and abundant fossils in the Skiddaw Group, and at certain levels the acritarch zonation is finer than that of graptolites. Graptolites have long been used to date and correlate rocks of the Skiddaw Group, but work on the acritarch floras is more recent, having proceeded mainly under the auspices of the Lake District regional survey.

Ironically, biostratigraphical work on the Manx Group has focused in recent years on the acritarch assemblages obtained there, because of the perceived scarcity of graptolites. But during a visit to the island in April 1992, Geological Survey palaeontologists recorded a new graptolite locality on the east coast, and were able to confirm the probable source of material already in museum collections [including specimens in The Manchester Museum -Editor]. The new finds, reported in *New Scientist* in December 1992, indicate that part of the Manx succession is of Arenig age, and support the acritarch evidence in suggesting that a re-examination of the stratigraphy and structure of the Lower Palaeozoic rocks of the island is overdue.

Wales (Dr Dick Waters)

The second phase of the Central Wales Rapid Mapping Project was initiated this year with a start made on the Builth Wells 1:50,000 Sheet (196). The mapping has concentrated on the Builth Ordovician Inlier, the basinal, late Ordovician and Llandovery sequences in the core and flanks of the Tywi Anticline and the Llandovery shelf sequence of the Garth Inlier. This year has seen the publication of the solid and drift editions of the Rhayader 1:50,000 Sheet (179), whilst the adjoining Llanilar (178) and Aberaeron (177) sheets are respectively in press and in preparation. The joint memoir describing the geology of the Rhayader and Llanilar sheet areas is in press.

In the Welsh Borders, the Montgomery 1:50,000 Sheet (165) has been published with both a solid and drift edition; the memoir is still in preparation.

In North Wales, the Aberdaron and Bardsey Island 1:50,000 Sheet (133), mapped by Cardiff University under contract to NERC, as part of the BGS/Academic Mapping Committee Programme, has been published. The accompanying memoir is in press. A single, solid with drift edition of the Corwen 1:50,000 Sheet (120) was published this year as part of the provisional series. Maps currently in press include Snowdon (119) and Cadir Idris (149) 1:50,000 Sheets; the memoirs for both sheets are also in press.

In north-east Wales the 1:50,000 Flint Sheet (108) map and memoir are both in preparation, whilst a provisional edition of the Wrexham 1:50,000 Sheet (121) is in press.

Of note this year is the appearance of *Geological Excursions in Powys, Central Wales*, published by the University of Wales Press and edited by Nigel Woodcock and Michael Bassett. Many of the excurions described in the guide are based on the results of the recent BGS mapping programme in the area.

The 1:20,000 bilingual map of Wales has once again been delayed in press for financial reasons, but should be published in 1994.

Finally, I have to report sadly that the Directorate of BGS have decided on financial and operational grounds to close the Regional Office for Wales, in Aberystwyth on 1st September 1994. The geological staff are to be transferred to Keyworth and all further mapping in Wales will be carried out from there. Opposition to the closure plans has been volubly voiced by public bodies, including County and District Councils and the geological community in Wales. Whether a reprieve is possible is uncertain at the time of writing.

A reorganisation within the Thematic Mapping and Onshore Surveys Division, effective from 4th January 1994, also means that Wales will become part of a new Central England and Wales Group managed from Keyworth by Mr Tim Charsley as Regional Geologist. Dr Gallois, the previous Regional Geologist, is to head a new Eastern and Southern England Group.

Enquiries about the purchase of books and maps, or details of the various aspects of BGS work in Wales, should be addressed to the Officer in Charge (Dr R.A. Waters), Regional Office for Wales, Bryn Eithyn Hall, Llanfarian, Aberystwyth, Dyfed SY23 4BY; Tel No 0970 611038; Fax No 0970 624822.

Publications (G.D. Miller)

In addition to the steady flow of maps, memoirs and specialist reports, the BGS also publishes a house magazine, *Earthwise*, twice a year, and at £2.50 a copy it is excellent value. Issue number 3 (September 1993) was mainly devoted to the role of the Survey in providing the scientific foundations for the hydrocarbon industry. Superbly illustrated, the magazine includes for example, sections on coal bed methane, oil possibilities around the Falklands, microfossils, tephrachronology, the Rockall Trough and earthquake hazards. There is even a fascinating reference to the evidence for a tsunami that struck the coasts of Scotland some 7,000 years ago.

The (unobtrusive) argument of this issue is pretty clear - the BGS is vitally important for the well being of a major UK industry. The same message emerges in a wider context too from the Survey's *Annual Reports* for 1991/92 and 1992/93 which were published during the year. Even the most blinkered Treasury mandarin would surely be forced to conclude that the BGS represents value for money after reading such sections of the reports as those on radioactive waste disposal, mineral reconnaissance, hazardous waste disposal and ground water pollution. And there are many more general notes on for example, the Cheshire Basin study, the Upper Carboniferous sediments of the Stoke-on-Trent area and recent UK earthquakes.

CONSERVATION CORNER

There have been no spectacular changes in the activities of the Joint Nature Conservation Committee and English Nature - quiet consolidation after the turmoil of recent years has been the watchword. The JNCC's main work appears to have been the publication of further GCR volumes, and those on *The British Tertiary Volcanic Province* and *Igneous rocks of south west England* are amongst recent issues. At prices from £65 up to £95 they are beyond the reach of all but the wealthiest specialist libraries - which is a pity.

English Nature has continued to give quiet support for geological conservation in many different areas, winning some battles and losing others. One example is Parys Mountain in Anglesey which must be well known to most members of the Manchester and Liverpool geological organisations. The copper deposits here form the only example of a Kuroko-type ore deposit in the United Kingdom, and English Nature has successfully negotiated the creation of five SSSI's in the Great Opencast and another at Morfa Ddu.

English Nature's many publications include the twice-yearly *English Heritage* magazine (formerly *Earth Science Conservation*). It continues to give advice and practical help to the RIGS movement - for example, modest support grants and half the cost of the RIGS Support Officer post. There are now over 50 RIGS groups and reports of the activities of north west bodies are given below:

Derbyshire RIGS (Leslie Noe)

Since the last edition of *The North West Geologist*, much has happened in the Derbyshire and Peak District National Park RIGS project. Nearly 1000 new records have been added to our database of geological sites, work on a further 100 RIGS sites is well underway, and in September Leslie Noe was appointed as the new Project Co-ordinator, taking over from Pauline Jones. Work on the project continues apace, but nominations for further potential RIGS sites are required, as are volunteers, to carry out field visits to sites under consideration. Within the next six months it is hoped to complete the database of all geological sites in the county and in the Peak District National Park, produce an educational register, and designate any remaining sites as RIGS - so don't let your favourite geological or geomorphological site be missed ! (For information please contact Mr Leslie Noe, RIGS Project Co-ordinator, University of Derby, Kedleston Road, Derby, DE22 1GB.)

Staffordshire RIGS (Keith Harrison)

Keith Harrison and John Reynolds have had a meeting with Jill Smethurst at Cheshire Wildlife Trust. No further progress has been made at Gannister Quarry. The G.A. Curry Fund were apprehensive about the safety of the site. There were still legal problems among the site owners. Colin Exley reminded the Committee that Professor Cope had done much work in the area.

The Astbury Mere Visitor Centre is open. The G.A. Curry Fund has agreed to fund a geological display board and future ideas include a geological trail on Congleton Edge.

Keith Harrison and Don Steward met with Mr Poole, Lord Stafford's Land Agent, concerning the filling of the quarry in the dyke at Highlows Farm, Swynnerton. He was unwilling to re-expose the dyke because of the problems of fly-tipping. He would be willing to uncover the site for a few days, but the cost would be prohibitive. David Thompson reported that he had included the site in his field trip for the British Association and was maintaining contact with Lord Stafford. Spring and autumn meetings were held at Brownend Quarry.

Cheshire RIGS and ROCKWATCH (Jill Smethurst)

It has been a very busy year on the geological front, and thanks are due to all those committee members, field leaders, recorders and volunteers for their help and support. As well as listing the most important sites as RIGS, we are building up "Resource Folders" to include photographs and additional information. This will be particularly useful for educational and interpretation work, for which we are receiving many more queries. Contributions are most welcome.

RIGS members have been involved with organising and leading ROCKWATCH events, some of which attracted more adult than junior participants; all have been great fun. None of us will forget the hectic and hilarious ROCKWATCH activity session at Grebe House, with Julie Molyneux's rear-end sticking out of an old mine adit at Bickerton (after which we all had a go !), or the children at Llangollen wanting to test *every* piece of limestone for fizz as well as fossils.

We have raised the profile of geology, not least at national events such as The British Association for the Advancement of Science and the national WATCH Education Conference, with displays, talks, field excursions and activity sessions. Other groups are asking our advice, which is a sure measure of success!

It has been suggested that we set up an adult field study group. Those interested in this and anyone willing to help with field trips, activity sessons, recording or administration of either RIGS or ROCKWATCH should contact Jill Smethurst at the Cheshire Wildlife Trust.

Lancashire (Christine Arkwright)

A Lancashire RIGS scheme was established in September 1991 with a central committee drawn from English Nature (EN), the Lancashire County Council (LCC) departments of Education, Planning and Museums, local consultants and amateur geologists. The group was based initially at Clitheroe Museum, the Lancashire centre of the National Scheme for Geological Site Documentation (NSGSD), with Steve Thompson, the Keeper of Geology, acting as co-ordinator.

We were fortunate to have immediate access to the NSGSD collection of detailed site records housed at Clitheroe and over 100 of these sites were selected and re-surveyed briefly to establish present condition and RIGS suitability. In early 1993 about 100 sites were submitted to EN for RIGS recognition and funding, and to LCC for designation as Heritage Sites within the county structure plan.

In June 1993 Steve Thompson moved to Scunthorpe Museum and handed over co-ordination to John Jewitt of Lancashire Wildlife Trust (LWT) which is now the "umbrella" organisation for Lancashire RIGS.

Unfortunately, although the submitted site records were suitable for EN recognition, many were not adequate to resist certain planning applications. Therefore the original 100 sites (plus a few more) are being re-documented and some re-surveyed to produce a site record more suitable for planning protection and with regard to RIGS site selection guidelines.

Local experts have assumed responsibility for their own areas and selection meetings are being held on a regular basis. It is now hoped that about 100 sites, representing the range of stratigraphy and structures present in the county, will be ready for re-submission as LCC Heritage Sites early in 1994. The actual surveying is being done by a variety of professional geologists, such as consultants, planners and teachers, and amateur members of the Lancashire Geologists' Association and the Open University Geological Society.

All energies at present are being directed at obtaining this planning protection for RIGS, but the subsequent use and maintenance of sites and the raising of public awareness of geology are also being addressed. There are proposals to publish a book of Lancashire RIGS trail guides and provide on-site information boards and leaflets for about 30 suitable sites. Also it is hoped that a proposed "adopt-a-rock" scheme, if accepted by site owners, schools, societies etc., will help to ensure their continued involvement once the RIGS are established.

Anyone wishing to help with the Lancashire RIGS scheme should contact Christine Arkwright (0772 39022; evenings) or John Jewitt (0772 324129; daytime).

Greater Manchester RIGS (Simon Riley)

The initiative to establish the long overdue Greater Manchester RIGS scheme, discussed in recent issues of *The North West Geologist*, has been taken up by the Geology Department of The Manchester Museum. Preliminary work started in August and with the help of MGA volunteers is beginning to take shape. County and district boundaries have been agreed with adjoining RIGS groups and, with the assistance of Lancashire, Cheshire and Mersyside, our list of criteria for the selection of sites is now complete.

The Manchester Museum already holds over 600 site records, compiled as part of the National Scheme for Geological Site Documentation (NSGSD) and, as with Lancashire (above), these records will provide the basis of a desk study to identify potential RIGS sites. In the coming months we will concentrate on identifying possible sites from this database (and other sources) prior to embarking on a site survey. Manchester RIGS would welcome any additional information on existing sites or potential RIGS sites and any offers of help with field work in the near future. Those interested should contact Simon Riley, The Manchester Museum, The University of Manchetser, Oxford Road, Manchester M13 9PL.

MUSEUMS ROUNDUP

Clitheroe Castle Museum succumbs to the pull of the "D" word !

Clitheroe Castle Museum is at present a hive of activity with the imminent arrival of some Mesozoic vertebrate material. The pull of probably some of the most talked about Triassic, Jurassic and Cretaceous animals has finally reached the ramparts of Clitheroe Castle and is in the process of launching a final assault, hopefully followed by a vanguard of the public. The display material comes from all corners of the globe, from Britain, France, Russia, China, USA and Canada, and includes a nest of six sauropod eggs, skulls of *Velociraptor* (cast), *Allosaurus* (cast) and *Protoceratops*. There are many other exhibits which are certainly as impressive as the skulls, including the maxilla and claw of *Tarbosaurus* and a section of hadrosaur skin with ribs pushing through. The exhibition will hopefully entice the younger visitor to the museum and in turn lead them into other parts of the gallery dealing with Ribble Valley geology and palaeontology.

The use of the "D" word has certainly received some exasperated gasps of "Oh not that again" and "Look at them jumping on the Spielberg bandwagon" etc. The attention that *Jurassic Park* received last summer was certainly justified, although the *Dilophosaurus* frills and chewing sauropods, along with other interpretations, should possibly not have been left to artistic licence ! The fact is that the film has increased public awareness about long extinct animals which are thankfully sometimes displayed in museums providing an invaluable magnet to visitors which cannot be ignored.

Clitheroe Castle Museum does not only review the local geology and palaeontology, but also has an extensive local history exhibition. The local and social history of Clitheroe provides an insight into how, since the 11th century, the market town developed through the Middle Ages and industrial revolution to the present day. The museum itself resides in the historic 17th century Castle House built for the Steward of the Lord of the Honor. The museum is comparatively new having been originally set up in 1945 in the old borough treasurer's office in Clitheroe, but it was not until 1981 that the museum finally came to rest in its present location. Many years of phased work on the exhibition areas have provided the residents of Clitheroe and tourists coming to the town with a museum which is certainly worth a visit.

The exhibition, which is under construction at the present, is planned for opening in mid-May, which will coincide with the *Progressive Palaeontology* meeting at the University of Manchester, and which is scheduled to visit Clitheroe Museum on its second day. This exhibition of "Mesozoic Material" could not have been put on without the invaluable assistance and advance of material from the Royal Ulster Museum in Belfast where Dr Andrew Jeram has patiently worked through the loan of exhibition material. The absence of the obligatory "D" word has, I hope, provided solace for those who abhor the recent broadside which this area has delivered over the past year. However, I will be surprised if *Jurassic Park 2* does not provide a similar rush of attention !

(Phillip L. Manning)

MGA FIELD TRIP TO APPLEBY-IN-WESTMORELAND (31st JULY 1993)

Leader: Eric Skipsey

INTRODUCTION

The field trip consisted of a traverse across the Eden Valley from west to east in the vicinity of Appleby. The traverse started at the base of the succession with Lower Carboniferous beds lying immediately below the Permian unconformity. This was overlain by Permian breccias composed of clasts of Lower Carboniferous limestones and sandstones transported by flash floods from high lands to the south and west.

In Permian times Britain was moving north from the equator and was roughly at the latitude of the present-day Sahara. During those times the Lake District was a mountainous area while the Pennines would have been a relatively flat rocky desert. Between the two there was a half-graben along the eastern side of the present-day Vale of Eden, downthrowing to the west, and forming a small isolated basin. The climate was very hot and dry, and hot easterly winds predominated. Erosion in the east thus provided a sediment supply which deposited in the half-graben. The Permian rocks therefore contain reworked Carboniferous material. The stratigraphy of the area is as follows:

Unit	Palaeoclimate & geography	Correlative
St.Bees Sandstone	Return to arid conditions. Dune fields.	Helsby Sandstone
Eden Shales	More humid climate in which playa lakes formed and evaporites (gypsum) developed.	Manchester Marls
Penrith Sandstone	Very arid. Sand dunes developed.	Collyhurst Sandstone

Hoff

The village of Hoff lies to the south-west of Appleby on the B6260. A footpath leaves the B6260 just north of the village at Hoff Beck in a south-east direction. Walk several hundred yards along this to some cliffs at 678174 to the first outcrop. Hoff Quarry is on the other side of the road at 676180.

The first cliff near to Hoff Beck is about 10 metres in height and shows Upper Visean sandstones overlain by limestones. The sandstone forms a massive unit, about 3 metres in height with iron staining and greyish-green reduction bands parallel to bedding. These were laid quickly in shallow water. The limestones are bedded, about 0.3-0.6metres thick, and were laid under water, but with periodic emergence. Rocks such as these provided a source of sediment in Permian times.

The iron staining probably originates from the Permian sandstones overlying the Carboniferous rocks, but remarkably the staining only affects the sandstones and not the limestones. There is a difference in the depth to which rocks are iron stained on either side of the Pennines. To the east staining is about 3 metres below the Permian, but to the west the staining can be up to 500 metres (e.g. near Stoke) where groundwater has penetrated faults with large throws.

Walking northwards from this outcrop, first up the cliff face then down the dip slope of the Carboniferous to the next scarp, the next outcrop consisted of Brockram. This was formed as a flood deposit when material from the south was carried along in wadis then deposited in fans consisting of thin beds of angular limestone clasts in an iron stained matrix. They occur in fining-upward sequences which are up to 0.6metres thick, with cobbles at the base fining to silt at the top.

Continuing to the other side of the road, Hoff Quarry (an SSSI) has a Brockram cliff about 12 metres high. The quarry was used to provide blocks for building purposes; the rock is much less coarse than at the previous outcrop.

Appleby

Proceed to Appleby and after passing through the centre of the town turn right onto the B6542. After half a mile turn right at a church. Bongate Quarry is on the bank of the River Eden directly opposite Appleby Castle, at 687198.

The quarry is in a valley cut by the River Eden through the Penrith Sandstone. The face is about twelve metres high and gives a cross section through barchan dunes. The dune cross bedding is particularly well seen here due to the flatness of the quarry face. Aeolian deposits tend to consist of sand grain sized particles as a minimum because the finer particles tend to be blown away. The red colouration is due a coating of hematite caused by evaporation of iron-bearing groundwater.

A little further north where the cliff meets the river, large mud clasts (up to 20cms across) can be seen in the outcrop. These must have been water-lain, desiccated, then swept along by water to be deposited here in a temporary fluviatile phase.

Coupland

Continue south-east along the B6542. Before this joins the A66 veer off the slip road on the minor road parallel to the A66 and turn left after a fifth of a mile. From this road at 714192 walk ESE along George Gill, a glacial channel, to cliffs at either side of the channel at 718188.

The cliffs in George Gill are formed from aeolian deposits and have survived because the rock has been cemented by quartz-bearing fluids from the extensive locally occurring faults. Examining the flatter beds above the bounding surfaces more closely, they are seen to consist of coarse grit. They are interdune areas, i.e. following one dune, but preceding another, and are the winnowed remains left after long periods of erosion. These dunes would have been about 20 metres high. The original dip of the face of the barchan was about 30°, which is the approximate limit of stability of sand on a slope.

This sandstone forms the gas reservoirs of the North Sea. Rounded silica grains with a thin coating of hematite overgrown by silica is a characteristic of the Penrith Sandstone.

Hilton Village

Take the road through Brackenber to Hilton. Turn left, then right and stop at the end of the village overlooking a stream (Hilton Beck) at 735208.

The village is built on the St Bees Sandstone and almost on the line of the Outer Pennine Fault. Further to the east there is another fault. Between the two is the Cross Fell Inlier of Lower Palaeozoic rocks. Beyond the second fault are Lower Carboniferous limestones succeeded on the horizon by Upper Carboniferous sandstones and shales.

Hilton Beck

Return through the village. Take the Appleby road running to the north of Hilton Beck. At 721207 walk across a footbridge over the Beck. The outcrops lie along the Beck in the Appleby direction.

The outcrop is in the Eden Shales consisting here of fine sand to silt grade material with dark organic beds known as the Hilton Plant Beds. These have been dated by pollen as basal Upper Permian and so correspond to the onset of marine conditions in the Durham area. The beds are analogous to an oasis in a present-day desert. Plant fossils have been obtained from these beds, and they are quite similar to earlier Carboniferous forms. One of the new plants discovered here is named *Hiltonia*.

Walking west along the river we go down sequence to outcrops of Penrith Sandstone, but these are flat-bedded. Continuing along the river another outcrop shows flat-bedded sandstones with thin beds of Brockram. Some of these contain clasts of dolomitised limestone and basalt which were probably derived from the Whin Sill to the east.

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(Jim Spencer)

MGA FIELD TRIP TO THE FLUVIOGLACIAL DEPOSITS OF THE WREXHAM AREA (26th JUNE 1993)

Leader: Hilary Davies

INTRODUCTION

The so called Wrexham Delta Terrace is an arcuate feature curving round Wrexham to the east and north. It consists of sands, gravels and tills and in places is up to 30 metres high. Three rivers meander through the area - the Dee, the Alyn and the Clywedog. The River Alyn cuts through the terrace and into bedrock.

Over the years a number of theories have been presented to account for its formation. It was originally thought to be a water-lain delta, deposited in the inlet of a lake by meltwater from the Welsh ice. Some proposed that the lake formed because the meltwater was funelled by the Alyn Gorge and constrained by the Irish Sea ice creating a barrier to the east. However, a delta this size would have had to be associated with a large lake, evidence for which has never been found. Later it was proposed that the feature formed as a fan sub-aerially. More recently it has been argued that the feature is a composite product of many sedimentary processes including deltaic and fan characteristics within it.

Borras Airfield Quarry

This quarry in the disused World War II airfield at Borras is owned by McAlpines who work it for sand and gravel. The entrance is on the A534 road at 369518.

The quarry contains sands and gravels and the balance of one to the other varies across it. In trying to deduce the source of the sediment the recognition of various indicators is important. Thus the presence of coal, ground down to sand grain size particles, is indicative of Welsh ice since the Irish Sea ice did not pass over coal-bearing terrain. Similarly the presence of Lake District volcanics would prove an Irish Sea ice source. However, erratics alone are not diagnostic because many could be reworked from previous glaciations. If the feature formed as one large fan the sediments should dip downwards radially around the fan, but if it consists of a number of smaller fans the dip should be more variable.

Locality 1.1

In the toe of the fan there is more sand than gravel, with some clay dispersed within it. Deposits with both Welsh and Irish Sea affinity occur here. Deposits of one have been reworked in the advance of the other. Although interpretation is difficult, because much has been quarried away, it would seem that the coal-bearing sands are associated with the last advance. When the dips are plotted on a rose diagram the evidence tends to support the idea of several small fans.

At this locality we saw what was probably a channel cut through sands containing ground coal. The channel was filled with gravels. The gravel contained rounded pebbles, some of which consisted of igneous material. Because the base of the channel was sharply defined the sand may have been frozen at the time the stream cut through it.

Locality 1.2

This locality is in the south-east corner of the quarry which is marginal to the feature. It consists largely of sand. However, gravels occur lower in the sequence so this may not have been the original margin, but may have been trimmed by an ice sheet. Large cross beds occur in the sands in the quarry faces here.

Locality 1.3

Locality 1.3 showed clay rich sands and gravels mixed together. A discussion was held on the use of the word "till" to describe such deposits. For this to be a true till it has to be proved that it was deposited directly by ice. There are kettleholes locally within the deposit so there must have been ice nearby. But because of its partially disaggregated nature the term "flow till" might be more appropriate. Flow tills form when glacial material is deposited with the assistance of melt water as the glacier decays. However, some workers suggest that it is better to describe such deposits as a diamict as this merely indicates the constituents and does not imply a mode of formation.

Gresford

From Borras Quarry turn left on the A534, then left again in a quarter of a mile onto the Marford road. After a mile and a half turn left (366540), then in a short distance left again. A footpath leaves the road to the left at 354535.

The area is undulating and is covered by channels and hollows. The footpath follows one such channel from which the hollows can be seen. The suggestion is that this is a kettled surface formed when embedded blocks of ice melted near the edge of an ice sheet. Many of the local people blame Gresford Colliery subsidence for this undulating landscape, something which cannot be entirely discounted.

As the kettleholes weather over a period of time they form rounded hollows. The hollows may be waterlogged or well-drained depending on whether they are underlain by clay or by sand and gravel. Those which are waterlogged possess distinct plant and insect communities and for this reason have been designated as SSSI's. (We viewed one of the well-drained hollows to the lefthand side of the footpath just before a stile.)

Marford

Return to the junction at 366540 and rejoin the Marford road. This road runs along the edge of the terrace which falls sharply away to the east. Join the old A483 through Marford, then turn left to park near the railway bridge at 357563. Marford Sand Pit lies between the railway and the town.

This old quarry was a desolate area until 1979 when the local council landscaped it to create a wildlife park. Climbing up the steep face of the former quarry gives a view across the Alyn Gorge to cliffs of glacial material on the other side at Singret. Here we examined flow tills, derived from glacial outwash, consisting of about 30% clay, 20% silt, 30% sand and 20% gravel. The area between this cliff and the Alyn has been quarried for sand and gravel.

Singret

Continue north from Marford on the old A483 to Rossett. Turn left on the B5102, then fork left off this at Mount Alyn. The entrance to this private quarry is at 344563.

This locality is a partially reclaimed sand and gravel quarry also partially used for tipping. Its cliffs were those seen across the Alyn from the previous locality. In its high faces thick tills can be seen and they provide evidence of the so called Llay readvance which occurred towards the end of the last glacial. There are also thick gravels which correspond to the melting of the preceding ice sheet. Again evidence can be found to support both a deltaic or a fan environment, suggesting that the feature is a composite. Unfortunately, nowadays the quarry faces are quite unstable and dangerous so close examination is not possible.

Gwersyllt Park

Proceed southwards to Gwersyllt to the park on the B5425. The entrance to the park is at 327535, and the esker runs east-west from the left hand side of the entrance.

At this locality, which is a public park, we saw the remains of the Gwersyllt esker. Although much of this has been removed, its line can be made out with the remaining edge disappearing steeply into a wood. This must have been formed sub-glacially and is therefore the best indicator of the presence of ice in the area when the Wrexham Delta Terrace was forming.

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(Jim Spencer)

MGA FIELD TRIP TO CHUNAL, NEAR GLOSSOP (16th MAY 1993)

Leader: Paul Selden

INTRODUCTION

This excursion consisted of a six mile circular walk starting in Glossop and taking in Chunal, Plainsteads, Cown Edge, Coombes and Charlestown en route. It offered panoramic views of the western flanks of the Pennine Anticline and related structures, more recent landslip features, and showed the influence of the underlying geology on local history.

The Namurian rocks in the area dip to the west and are part of a large anticlinal structure in the Pennines. Streams in the area flow along the strike of the west-dipping beds, or down dip, resulting in a lattice-like drainage pattern. Where streams flowing down dip have cut through the durable gritstones, a narrow gorge has been formed giving rise to fast flowing water. It is for this reason that mills were originally sited here giving rise to the town of Glossop.

Glossop to Gnat Hole

Start at Norfolk Square in Glossop town centre (SK 035941). The route goes eastwards along the High Street before turning south at SK 040942. Take a series of footpaths and unmetalled tracks over the hill to descend to Gnat Hole at SK 037925.

The leader pointed out that an idea of the underlying geology of an area can often be obtained by looking at the stones used in local buildings. Around Norfolk Square many of these are built of coarse sandstones quarried locally. As the railways developed it became possible to bring a variety of building stones from further afield, so newer buildings have been built from more exotic stone. When first quarried stone is "green" and needs to be seasoned to allow the water in it to filter out. The water extracts salts with it which are left towards the surface of the stone, helping to seal it.

Walking east along High Street East the party observed the forecourt of the *Howard Arms* which has been cobbled with stone sets. These are always laid with the bedding vertical to prevent spalling. Just a few yards further along the road a row of old cottages have been built using stone extracted from a small quarry behind in the Kinderscout Grit. They are tiled with thin stone slabs. The quarry has now been built over. Crossing over the road, cross bedding can be seen in the gate columns of a large house owned by Volcrepe.

Turning south off the High Street, river terraces can be seen in Glossop Brook. During the last glaciation an ice sheet covered the Lancashire Plain and pushed eastwards to this area. At this time the sea-level would have dropped causing streams and rivers to cut downwards leaving the old flood plains as terraces.

Ascending the hill to the south there are views of Whitfield down the dip slope to the west. This is in the lower leaf of the Kinderscout Grit. The field walls here are made of thin slabs of coarse sandstones. From here descend to Gnat Hole.

Gnat Hole to Plainsteads

Walk west along a minor road to join the A624. Continue south along the A624 to Chunal then turn off on a farm track at SK 034913 which descends to Long Clough before climbing to Plainsteads.

At Gnat Hole there is a small stream in a curved valley, which looks like a glacial overflow channel. Some glacial erratics occur in the bed of the stream. The suggestion is that there was a glacial lake on the Shale Grits to the east and overflow from this cut the channel. All of the earlier pre-glacial drainage would have been north-south. In the valley outcrops of the coarse, massive Kinderscout Grit dip west about 10° and represent a delta system of river-lain fluvial channels.

The A624 is on the dip slope of the upper leaf of the Kinderscout Grit. Turning off along the farm track fragments of "Glossop Obsidian" can be seen on the surface. These are man-made glasses, probably from local kilns.

A steep scarp slope is seen to the west which is caused by another grit, the Hollingworth Head Rock, although only shales can be seen. Four marine bands occur within the shale. Above the Hollingworth Head Rock there is another shale, then the Chatsworth Grit forming another scarp. The Chatsworth Grit is unusual in that current bedding indicates that it was derived from the south. The Hollingworth Head Rock does not persist laterally and probably represents a channel.

Plainsteads to Cown Edge

From Plainsteads turn right onto Monk's Road, walk several hundred yards then turn left at SK 023913 for Cown Edge.

On a clear day (!) Kinderscout can be seen to the east from here. The Kinderscout Grit on Kinderscout can be seen to be flat-lying, but at the localities above it was seen to be dipping west. This demonstrates the large scale anticline of the southern Pennines. The view to the south shows that the west-dipping strata change to an easterly dip - forming the Goyt Syncline - before dipping to the west again - the Todd Brook Anticline.

The rocks here are Namurian, not far below the lowermost Westphalian, and are transitional into typical Westphalian facies. Thus thin coal seams occur and remains of old pits can be seen in the immediate area where the Simmondly seam has been worked.

At the summit of Cown Edge small, disused quarries occur in the Rough Rock. Large carbonate concretions can be found at the base of the beds and these are thought to be derived from the calcite from bivalve shells. They can be up to one metre across.

Cown Edge to Charlestown

Continue over the hill to the steep face of Coombes. Turn north-east along the path to rejoin Monk's Road. Walk south-east along the road for several hundred yards then descend Whitely Nab to Charlestown.

At Coombes there is a view across the Lancashire Plain over Hattersley and Audenshaw. There is a large landslip caused by the weight of the Rough Rock on the shales beneath, possibly lubricated by ground water from a nearby fault with rotated blocks. Boulder clay within this indicates a post-glacial date and pollen analysis gives a probable date of about 5,000 BP.

FURTHER READING

SELDEN, P.A. (1991). Itinerary IV. *In* Eagar, R.M.C. & Broadhurst, F.M. *Geology of the Manchester area*. Geologists' Association Guide No. 7.

(Jim Spencer)

MGA FIELD TRIP TO SOUTH CUMBRIA (18th APRIL 1993)

Leader: Tony Adams

INTRODUCTION

The purpose of the trip was to look at Carboniferous limestones and younger sediments in the area of Kents Bank and Humphrey Head. The area was first described by Garwood before World War I, and later by Rose & Dunham as part of their work on the hematite deposits of South Cumbria. The Carboniferous Limestone sedimentology has been studied in detail by Tony Adams and research students, Richard Vaughan, Andrew Horbury and Abdel Aziz. More recently the BGS has renewed interest, but there is still no BGS sheet of the area.

A sequence of Carboniferous rocks overlies the Silurian unconformably. The succession dips gently in a generally eastward direction. A system of approximately north-south faults runs through the area causing the succession to repeat. One of these occurs on the western side of Humphrey Head giving rise to a steep cliff face.

Guides Farm

From Kents bank station turn right and walk uphill until the road curves left. Turn right onto a footpath, descending some steps. Continue parallel to the railway, onto a lane, until a level crossing is reached on the right. Cross the railway with care and walk in the opposite direction (SW) along the shore until some limestone rocks are reached (401763). The locality is on the opposite side of the railway to Guides Farm, so called beacuse the Morecambe Bay guide lives there.

The rocks here are in the Upper Urswick Limestone which consists of cycles of limestone and volcanic ash. The surface below the volcanic ash is karstic. One of the features here is the spotted limestone (or pseudo-breccia). These light grey limestones possess darker grey patches which are generally thought to be caused by bioturbation.

During Carboniferous times the area was shallow marine and in a warm climate, rather like the Bahamas today. At times it was exposed sub-aerially, thus allowing the development of karst and the growth of vegetation. During this phase calcretes developed, caused by the high evaporation in the warm climate - rain water flowed through the ground dissolving carbonate, which was then deposited where the water evaporated at the surface.

Small faults run approximately north-south. One of these, examined by the party, was marked by calcite veining and hematite stains. Approximately at right angles to the line of this fault calcite-filled *en echelon* tension gashes could be seen. The limestone here contains only a few macrofossils (c. 1%), but there may be as much as 30% microfauna. There are some large corals, brachiopods and gastropods which probably lived on these sediments, but are generally not found in life position.

On one surface there are circular mounds with holes within up to 0.75m in diametre. Their calcrete rims had radial markings, and the insides are lined with laminae. These are interpreted as tree roots. The holes represent the position of the root and the radial marks are the rootlets. When the tree died, carbonate rich water penetrated around the root forming the laminae. The centre rotted away and was in-filled by mud which has weathered out.

Rougholme Point

Take the B5277 westwards out of Kents Bank through Allithwaite and turn left into a lane (382762). Continue along lane and over the railway. Turn left at junction to Humphrey Head. Cars may be parked at 390740. Walk westward on the seaward side of the coastal defences to rocks at 387741.

This is the only exposure of the Permo-Triassic Brockram in south Cumbria, although it is known from boreholes elsewhere. Drilling by the BGS here proved a 270m thickness of Brockram underlain by Namurian.

The leader has examined the clasts in the Brockram conglomerate from the borehole; those near the surface are limestone, but those deeper down are basalt. This suggests that the limestones were covered by volcanics, and the Brockram records the weathering of this. They were probably locally derived because the clasts are sub-angular. There are also intra-formational clasts of Permo-Triassic material. The basalts are late Dinantian (Brigantian) age, and although there are none of this age exposed in the area now, they do occur on the Isle of Man.

Many of the carbonate clasts have hollow centres. A possible explanation is that they have been dolomitised by percolating groundwaters proceeding from the outside, but ceasing before the whole clasts was replaced. Subsequent groundwaters have preferentially dissolved the calcite cores, calcite being more soluble than dolomite. The magnesium ions necessary for the dolomitisation probably came from hypersaline fluids derived from beds laid down in an arm of the Zechstein Sea.

Humphrey Head

Retrace steps to 390740, then continue south-south-east along the foot of the cliff at Humphrey Head. Care needs to be taken with the tides at this exposure.

Walking along the foot of the cliff it can be seen that the easterly dipping beds of the Urswick Limestone have been dragged steeply downwards to the west by a fault bringing the Brockram beds down as seen at Rougholme Point. There are in fact several faults. To the west of the cliff the younger Gleaston Formation, as proved by fossils, can be seen.

A good example of a hummocky palaeokarstic surface covered by clay can be seen in this section. Other contacts are not bedding planes, but pressure solution surfaces. These occur within massive limestones. The solubility of limestone increases with pressure so that at points where pressure was particularly intense the limestone has dissolved. Because any impurities in the original rock are less soluble they are left behind along the pressure solution surface - called a stylolite. This process can only occur when there is still porosity in the rock, so that fluids can remove the dissolved material.

FURTHER READING

ADAMS, A.E., HORBURY, A.D. & ABDEL AZIZ, A.A. (1990). Controls on Dinantian sedimentation in south Cumbria and surrounding areas of northwest England. *Proceedings of the Geologists' Association*, **101**, 19-30.

ADAMS, A.E. & HORBURY, A.D. (1989). Tree roots on a Dinantian palaeokarst. *Proceedings of the Yorkshire Geological Society*, **47**, 345-348.

ADAMS, A.E. & WADSWORTH, W.J. (1993). The Humphrey Head borehole: evidence for Carboniferous vulcanicity and Permian dolomitization in the southern Lake District. *Geological Journal*, **28**, 159-170.

ROSE, W.C.C. & DUNHAM, K.C. (1977). Geology and hematite deposits of south Cumbria. *Economic Memoirs of the Geological Survey of Great Britian.*

(Jim Spencer)

JOINT MGA/OUGS FIELD TRIP TO ECTON HILL MINE
(28th JUNE 1993)

Leaders: Geoff Cox, Alistair Fleming, Jill Smethurst

INTRODUCTION

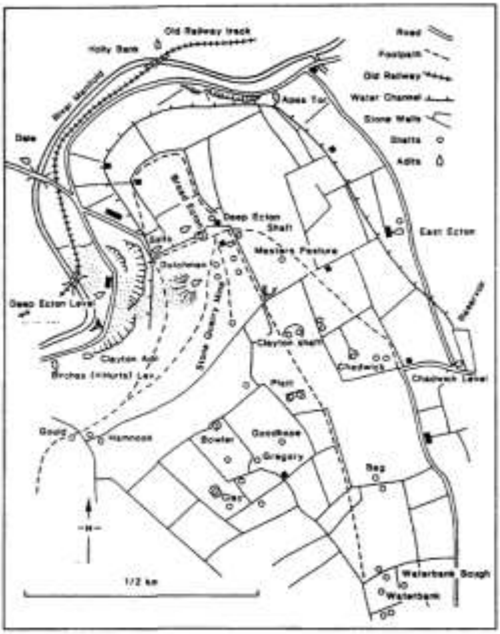
The South Pennine Ore Field has been famous since Roman times for production of lead and zinc and more recently for fluorite and barite. Copper deposits are limited to a few locations on the western edge, the principal one being Ecton. The copper and lead deposits there have been worked over three centuries with mining being at its peak in the 17th century when Ecton was one of the largest copper mines in Europe. However, mining ceased there in 1889.

Ecton lies in the SW corner of the Peak District National Park and Geoff Cox owns the mine with its buildings and some of the surrounding land from which he runs a study centre promoting links between schools and the mining industry. The centre is used at weekends by hundreds of A-level chemistry and geology students led by volunteer teachers.

The Educational Centre very kindly organised a similar study day for a party of MGA and Open University Geological Society (OUGS) members which started with an open air talk by Geoff Cox on the running of the centre together with the mining history and geology of Ecton. The party then split into two, half going into the mine, while the rest of us had an al fresco chemistry session with Alistair Fleming. Small samples of minerals were tested in solution to prove the existence of various elements such as copper and iron. This was fun, but then we had to work out the equations ! The two parties then swapped helmets and lamps for acids and things and the second group went into the mine. It was actually a horizontal adit (named Salt's Level after the original excavators), so the walking was fairly easy and the cool inside the mine was a bissful contrast to the heat outside.

Mineralisation here occurs as veins, both cross-cutting and parallel to the limestone bedding, but also as large, irregular, vertical cavity filled deposits called pipes. Salt's Level was cut in 1804 to gain access to Ecton Pipe from new dressing floors situated 40 metres above the river level. It proved a nice little earner for the Salt brothers who were able to buy a farm each from the proceeds of excavating the 70 metre tunnel.

The leader explained much of interest about the geological structure and mining history as we progressed deeper into the mine. For example, we saw



Old Railway track
Holly Bank
Road
Footpath
Old Railway
Water Channel
Stone Walls
Shafts
Adits
Apes Tor
Dale
Deep Ecton
Shaft
East Ecton
Salts
Dutchman
Masters Pasture
Deep Ecton Level
Clayton shaft
Clayton Adit
Birches (=Hurts) Lev.
Chadwick
Chadwick Level
Platt
Gould
Hannoos
Bowler
Goodhope
Gregory
Bag
N
1/2 km
Waterbank Bough
Waterbank

marks left by drill steels which had been held by a younger member of the Salt family, the steels being driven in by alternate blows of his father and uncle guided by lights of the last spark - candles were expensive !

Eventually we reached Ecton Pipe which had been worked so clean by the miners that a slight solution staining is the only evidence of minerals left today. (The steel measuring tapes hanging free in the pipe were being used by mining survey students who were carrying out a field exercise in lower levels of the mine.) We were led down further passages, the dimensions of which varied according to the machinery available at the time of excavation, and emerged about an hour later in time for a delicious al fresco lunch provided by the Centre.

The art of jiggling and buddling was then explained by Jill Smethurst. The Great Egg Race had nothing on the team effort which resulted in the immediate separation of different mineral grains using some guttering fitted with wooden slats, plastic containers, many willing hands, plus water and gravity, of course.

Jill Smethurst then took us on a field walk up the hill past a small stone building, the former explosives store. Ecton was the site of the earliest recorded use of explosives in British mining. Walking alongside drystone walls we saw many examples of the different facies represented in the Lower Carboniferous limestones of the area. The Milldale Limestone ranges from light and sparry with abundant crinoid fragments, to fine grained and black, interbedded with thin calcareous shales. Ecton Limestone lies unconformably on the Milldale and ranges from grey biosparite to calcareous mudstone. At last we reached the tops of the Ecton and Clayton pipes with their associated spoil heaps which on close inspection revealed many minerals and fossils.

The area is noted for its high degree of folding, attributable to the Variscan Orogeny. In fact the whole of the hill is a large anticlinorium which plunges 10° to the NNW. Marvellous examples of this folding were seen by the roadside at Apes Fold. Unfortunately, there wasn't time to sketch in the missing section on the handouts - perhaps another visit ? We finished the day by examining the cemented screes formed as a result of solifluxion in the late Pleistocene.

It had been a thoroughly interesting and enjoyable day to be highly recommended and was a credit to the voluntary efforts of all at the Ecton Hill Centre.

ACKNOWLEDGEMENTS

Grateful thanks are due to the Geologists' Association for permission to use Fig. 19 from Braithwaite, R.S.W. (1991).

FURTHER READING

BRAITHWAITE, R.S.W. (1991). Itinerary XV. *In* Eagar, R.M.C. & Broadhurst, F.M. *Geology of the Manchester area.* Geologists' Association Guide No. 7.

(Christine Arkwright)

BOOK REVIEW

The Isle of Man. Trevor D. Ford. Geologists' Association Guide No. 46, 1993. £8.50.

This is a most welcome addition to the GA series. For too long the Isle of Man has been unjustifiably neglected by geological enthusists. Just as Arran is a microcosm of the Scottish Highlands and Islands, so the Isle of Man represents Cumbria in miniature and is ideal for long weekend field trips. It is true that descriptions of the geology are not plentiful; after Lamplugh's massive 1903 Memoir there was little until Simpson's papers in the 1960's. But Trevor Ford has changed all that by new research work, by the field excursions he has led and now by this Guide.

Because of the paucity of other recent material the outline of the Island's geological history is longer than is customary - some 52 pages in all. Then there are eight excellent itineraries beginning with the Ordovician Manx Slate Group and continuing through the Caledonian granites, the mines and mineralisation, the ?Devonian Peel Sandstones, the Carboniferous Limestone (and Scarlett Volcanics) to the Tertiary dykes and finally the extensive Quaternary deposits of the north coast. Then follow three pages of references. These are very full although they might perhaps have included the great Geikie's description of the Scarlett Volcanics which he published in 1897 in the second volume of *The ancient volcanoes of Great Britain*. Although pre-pillow lavas and pre-hyaloclastites, Geike's account of the traverse he conducted with Lamplugh makes instructive and entertaining reading.

The Guide contains many helpful line drawings and in addition 37 black and white photographs. The latter are unusual for the GA series and are not entirely successful compared with the splendid colours of the front and back covers. There is no Contents page; on figure 3 the outcrops of the Barrule Slates and the Caledonian granites appear indistinguishable; and the reference to Cooper & Molyneux (1990) on page 9 is not included in the References. But these are trivialities - buy this excellent Guide and get yourself to Manxland next summer !

(G.D. Miller)

PROCEEDINGS OF THE LIVERPOOL GEOLOGICAL SOCIETY

1992/93 SESSION

1992

Sep. 27	*Loggerheads* by Chris Paul.
Oct. 6	The Presidential Address by Dr Rodney Wright - *Up and down in the Alps - a geo-traverse*. Hon. Treasurer's and Hon. Secretary's reports.
Oct. 27	*The NERC North Sea Project* by Martin Preston.
Nov. 10	*Mechanisms and consequences of triple junction subduction in the southern Andes* by Steve Flint, Dave Prior & Peter Styles.
Nov. 17	Practical Session at Liverpool John Moores University on *Fossils and environment* with Joe Crossley and Clare Milsom.
Dec. 1	*The geology of natural disasters* by Ros Todhunter.
Dec. 8	*The geology of German wine* by Geoff Tresise.

1993

Jan. 19	*Late Precambrian glaciation of the Arctic North Atlantic region* by Mike Hambrey.
Jan. 23	Practical Session at The Liverpool Museum on *The Jason Project*.
Feb. 9	The Distinguished Member's Address by Professor Robin Bathurst - *Deep burial of limestones and the rewriting of history*.
Feb. 19	The Society Dinner at Jenny's Seafood Restaurant.
Feb. 23	*A walk across the mid-Atlantic ridge* by Peter Regan.
Mar. 3	*The Jason Project* at The Maritime Museum.
Mar. 9	Joint meeting with the N.W. Regional Group of The Geological Society - *The geomorphology of Holocene hillslope gullying on the*

Howgill Fells, Cumbria by *Adrian Harvey.

Mar. 13/14 The Welshpool area with Richard Cave.

Mar. 16 *Ordovician extinctions - cosmic calamity or climatic change?* by Pat Brenchley. Election of Officers and Council.

May 9 The Triassic rocks of the Wirral with David Thompson.

Jun. 19 The copper and lead mines of Ecton Hill with the Ecton Education Centre.

Sep. 25 Hilbre Island with Chris Bower, Jill Smethurst & Hazel Clark.

Officers and Members of Council for the Session 1992/3

President - R.C. Wright MA, DPhil
Ex-President - Prof. A.L. Harris BSc, PhD, MIGeol, FGS
Vice-President - Mrs H. Davies MA
Hon. Secretary - J.D. Crossley BSc, CertEd, MIGeol, FGS
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Hon. Treasurer - G.W. Rowland MIMBM
Hon. Asst. Treasurer - L.J. Baxter BA
Hon. Editor (Geol. Journal) - P.J. Brenchley MA, PhD
Hon. Editors (N.W. Geologist) - N.C. Hunt BEd; T. Metcalfe BA
Hon. Librarian - Mrs L. Rimmer ARIC
Hon. Excursion Secretary - Miss H.E. Clark MSc, AMIGeol
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Mrs D. Bowcock
N.M. Harrison
A. Clarke
Mrs M.E. Williams BSc, CertEd
Miss L. White
Miss B.D. Jones
C. Rigby
R. Shacklady
Miss N. Ion

Membership

On 30th September 1993 there were 196 Ordinary Members, 43 Student Members, 6 Honorary Members and 3 Life Members, making a total of 248 members.

The Liverpool Geological Society Prizes for General Excellence in The University of Liverpool and The Liverpool John Moores University Honours Degree Finals were awarded as follows:

University of Liverpool;
- Geology - Wayne Bailey
- Physical Geology & Geomorphology - Karen Madawee
- Geophysics - Katherine Silva

John Moores University;
- Earth Sciences - Simon Smith

(J.D. Crossley - Hon. Sec.)

PROCEEDINGS OF THE MANCHESTER GEOLOGICAL ASSOCIATION 1992/93 SESSION

1992

Apr. 29	*Conversazione* at The Manchester Museum with a tour of the new Earth Sciences Collection Centre.
May 10	Knolls, limestones and cement: the Clitheroe reef knolls, Salthill trail and tour of cement works with Peter del Strother and Adam Czarnecki.
Jun. 6	Tideswell Dale and Millers Dale: Dinantian limestones and igneous rocks with Derek Brumhead.
Jun. 20	Annual Dinner at Hulme Hall, University of Manchester. Guest of Honour: I.A. Williamson.
Jun. 28	Ecton copper mine, above and below surface with Geoff Cox, Alistair Fleming, Jill Smethurst. (Joint meeting with OUGS.)
Jul. 25	Rocks and fossils of a Snowdonia circuit with Fred Broadhurst.
Aug. 22	Cheesden area north of Rochdale. Namurian sequences with Paul Wignall.
Sep. 6	Triassic sandstones of Alderley Edge and mineralisation with Tony Browne and Phil Ingham.
Sep.16	*Mineralisation on the margins of the Lake District* by Brian Young.
Oct. 3	Geology of Rooley Moor with John Stopforth.
Oct. 7	The advertised speaker, Dr Mottershead, was unable to speak owing to sudden family illness. At short notice John Nudds spoke on *Corals of Ravenstonedale*, David Green on *Minerals* and Paul Selden on *A geological tour of Australia*.
Nov. 11	*The behaviour of some of the earliest animals from the Precambrian and Cambrian* by Dr P. Crimes.

Dec. 9 *Soft tissue preservation in bivalves* by Dr M.A. Whyte.

1993

Jan. 13 *Continental flood basalts in the Karoo of southern Africa* by Dr W.J. Wadsworth.

Feb. 10 Annual General Meeting and Presidential Address by Dr Paul Selden - *Some geological highlights from around the world.*

Mar. 10 *The life and work of Alfred Wegener* by Roy Clarkson.

Officers and Members of Council for the Session 1992/3

President - P.A. Selden BSc, PhD, FGS
Vice-Presidents - D.C. Arnott MBA, PhD; J.R. Nudds BSc, PhD, FGS, CGeol
Hon. Secretary - D.D. Brumhead MA, MEd
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Hon. Librarian - M. Elsworth
Hon. Excursion Secretary - Norma Rothwell BA
Hon. Auditor - E. Foster MA
Council - G.C. Allen MSc
R. Clarkson
G.M. Henderson
W.A. Kennett BSc
J.A. McCurdy MEng
J. Spencer BSc
J. Stopforth MEd
B. Whitehead BSc
President of the University of Manchester Geological Society (Ex Officio)

(Derek Brumhead - Hon. Sec.)