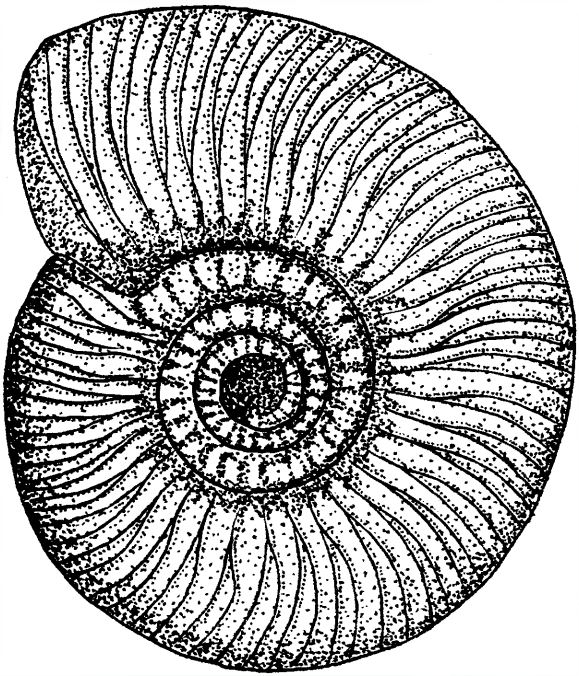
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CONTENTS

EDITOR'S NOTES **145**

ORIGINAL ARTICLES **146**

Multum ex parvo: graptolites from Threlkeld Quarry and their implications. Dr A. W. A. Rushton. 146

The fossils collected during John Bolton's marathon search at Rosside. Dr A. W. A. Rushton and Dr P. Shepherd. 154

On identifying frontal positions of Lake District valley glaciers. Dr R. P. K. Clark. 162

FIELDWORK REPORTS **177**

The Geology of the Northern Marginal Zone complex on the isle of Rum, Scotland. Edward Loffill 177

Late Devensian outwash environments in the Tyne Valley: Preliminary investigations. Lynda Yorke 179

Biological responses and environmental change across the Carboniferous boundary, Rejmyrefjellet, Templefjorden, Svarlbard. Tom Challands. 184

EXCURSION REPORTS 2004 **190**

Chalk Beck Quarries, East Curthwaite - David Powell 190

Sale Fell: minette intrusion and Skiddaw Group - David Livesey 192

The Coal Measures south of Whitehaven Harbour - David Kelly and John Brown 193

The submerged forest on Allonby beach – Fred Lawton 194

The Namurian rocks and mineralisation around Alston – Dr Charlotte Vye and Dr Stu Clarke 195

Force Crag Mine, Coledale - Penny Webb 199

The Borrowdale Volcanics of upper Wasdale and Illgill Head – Dr Alan Smith 207

The Howk, Caldbeck - Anne Freeland and Susan Beale 211

EXCURSIONS REPORTS 2005 **212**

The Borrowdale Volcanic Group at Water Crag, Wastwater - David Kelly 212

Fossil hunt at White Horse, Broad End, Skiddaw Massif - Dr Alan Smith 213

North Pennine Carboniferous at Hallbankgate and the Great Whin Sill quarry at Midgeholme - Judy Suddaby 229

Skiddaw Group geology - Dr Adrian Rushton 230

Raise Beck, Dunmail Raise - Dr Richard Johnson 231

Geology of the Kirkbeck Valley - Mervyn Dodd and Michael Forsdyke 233

Mineralisation in the Caldbeck Fells - Brian Young 236

Geology of the northern part of High Rigg – Dr Alan Smith 237

Other excursion held in 2005 238

LECTURE REPORTS 2004 – 2005 **239**

Remote sensing and fieldwork on active volcanoes - Professor Harry Pinkerton 239

The Burgess Shale fauna: new light on theories of evolution - Professor Simon Conway Morris 241

Other lectures held in 2004 - 5 242

LECTURE REPORTS 2005 – 2006 **243**

Windows on a geological profession – Dr Dennis Jackson 243

Iapetus: the other side – Dr Alan Smith 244

Other lectures held in 2005 - 6 245

REVIEW **246**

OBITUARY NOTICE **247**

GENERAL MEETINGS **249**

ANNUAL DINNERS **250**

THE SOCIETY SMALL AWARDS FOR STUDENTS **251**

LIST OF SOCIETY OFFICERS AND COUNCIL – 2005 and 2006 **252**

EDITOR'S NOTES

I would like to thank the following people who have contributed to the production of these Proceedings: the authors of the original articles; those who have submitted reports of Society activities, particularly Mervyn Dodd, Alan Smith and David Powell; Eric Skipsey for his help in proof reading; Mervyn Dodd for submitting a review; Ben Steel for help in the production of various figures. We are also grateful to Eric Robinson for his contribution.

The Proceedings is a biennial publication that caters for contributions on all aspects of geology and geomorphology of northern England. Contributions are welcome and should be submitted to the Editor. As well as full papers, the Society would be interested to receive shorter communications on the geology of Cumbria; these might include descriptions recording temporary exposures or other items of interest to the general readership of the Proceedings.

David Kelly

Editor

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MULTUM EX PARVO: GRAPTOLITES FROM THRELKELD QUARRY AND THEIR IMPLICATIONS

Adrian Rushton

Introduction

Graptolites are not particularly easy to find in the Skiddaw Group of the Lake District, but the present account shows that even a modest-seeming discovery can prove of importance in interpreting the geology. In 2004 Sheila Lawton showed me a graptolitic sample she had collected from rocks of the Skiddaw Group exposed in Threlkeld Quarry. It contains three tiny juvenile graptolites, which are none the less sufficient to show that the Threlkeld microgranite is intruded into strata at least as young as the *cucullus* graptolite zone, of late Arenig age. This suggests that the local outcrop is not part of the Buttermere Formation, as some maps indicate, but is in the lower part of the overlying Tarn Moor Formation.

Geological setting

The Threlkeld microgranite lies 6 km east of Keswick [around NY 328 243] and is intruded into the Skiddaw Group, a thin selvage of which is exposed on the eastern side of Threlkeld Quarry. The ground from Threlkeld village southwards and southeastwards across the Glenderamackin–Greta valley to Threlkeld Common is very largely covered by superficial deposits, making it difficult to assess the Skiddaw Group thereabouts. Exposures of bedrock are few and small. Additionally, the area is crossed by major faults and only a few fossils have been recorded. It is scarcely surprising that there has been difficulty in interpreting the solid geology in this neighbourhood (Figure 1).

In the review by Cooper *et al.* (1995, fig. 2), the Threlkeld microgranite is shown as intruded into mudstones of the Tarn Moor Formation, the highest division of the Skiddaw Group. However, on the Keswick 1:50 000 map (British Geological Survey 1999), the country rock, based on poor graptolitic evidence, is shown as Buttermere Formation, a thick olistostrome deposit that is considered to underlie the Tarn Moor Formation; and the same interpretation is given in the Memoir on the Skiddaw Group (Cooper *et al.* 2004, fig. 18, p. 39). Although when well exposed these two formations can be reliably distinguished, in small exposures the disruption characteristic of the Buttermere Formation may not be evident, and, similarly, the volcaniclastic and bentonite interbeds typical of the Tarn Moor Formation may not be visible.

The Buttermere Formation has been dated primarily by the ages of the fossils extracted from clasts within the olistostrome; emplacement of the olistrostrome must have been later than the youngest faunas and floras recorded

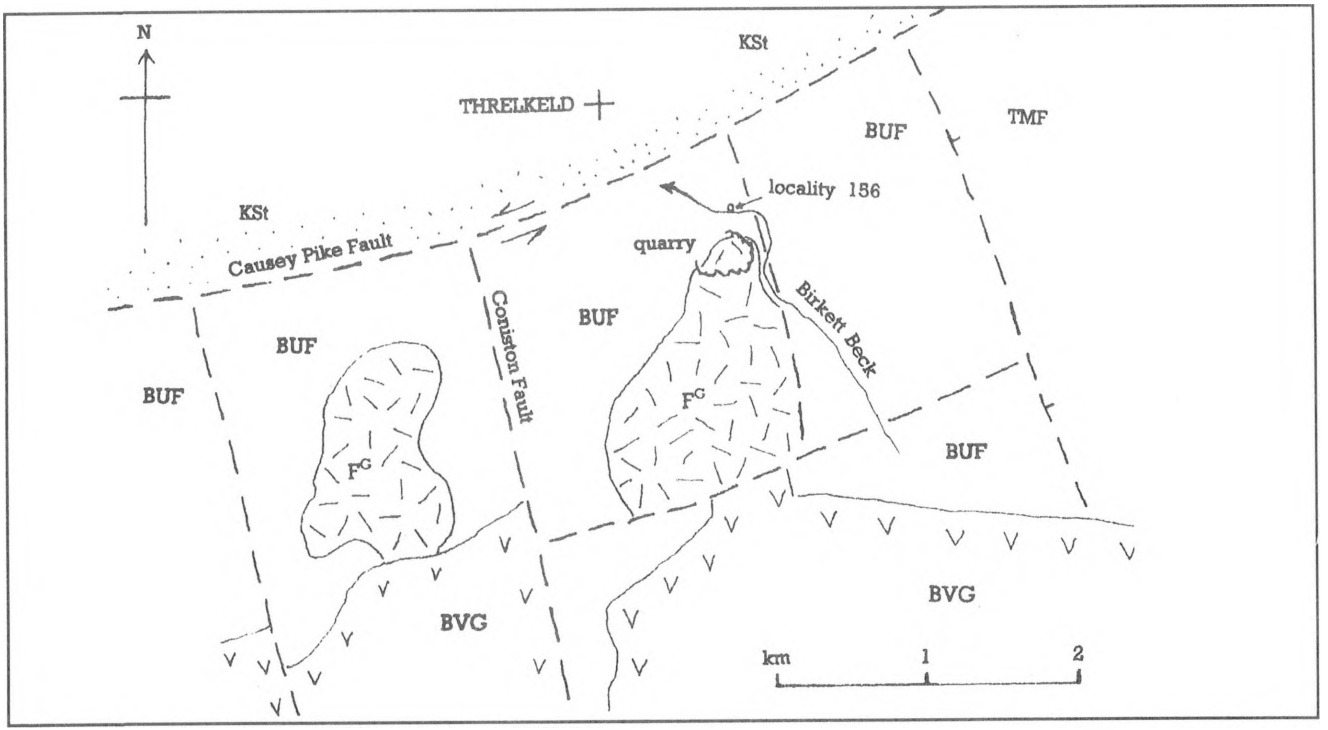


Figure 1 - Sketch of the geology in the area around Threlkeld Quarry, based on the British Geological Survey 1:50 000 map 29 (Keswick). Keswick itself lies about 2 km west of the area represented on the map. KSt = Kirkstile Formation (edged with dots). BUF = Buttermere Formation. TMF = Tarn Moor Formation. BVG = Borrowdale Volcanic Group (edged with vees). F^G = microgranite. It is suggested here that the area to the east of the Coniston Fault is more probably Tarn Moor Formation than Buttermere Formation.

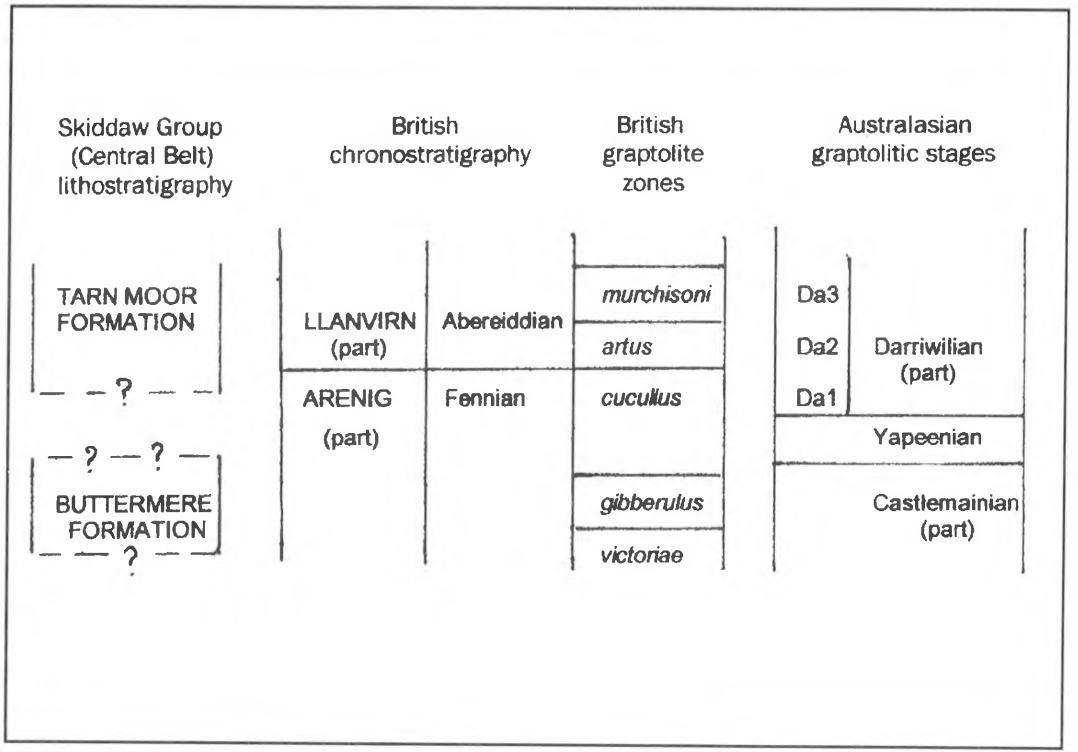


Table 1 - Approximate correlation of the Central Belt of the Skiddaw Group (i.e. south of the Causey Pike Fault) with the British graptolitic zones and the Australasian graptolitic succession.

from the constituent clasts. The youngest known acritarch assemblages are of the *hamata–rarirrugulata* Zone and a few graptolites suggest that some of the clasts are as young as the *gibberulus* graptolite zone [the one record that doubtfully suggests the *cucullus* graptolite zone (Cooper *et al.* 2004, p. 133, locality 154) is based on a single horizontal didymograptid whose identification is not certain]. The age of emplacement of the Buttermere Formation is inferred to be late in the Arenig, possibly near the boundary of the *gibberulus* and *cucullus* graptolite zones (Cooper *et al.* 2004, p. 53).

The Tarn Moor Formation is mainly referred to the *artus* and *murchisoni* graptolite zones of the Llanvirn, but the base of the formation appears to pass down into top of the *cucullus* graptolite zone and the uppermost part of the *hamata–rarirrugulata* acritarch zone, both of which are latest Arenig in age (Cooper *et al.* 2004, p. 55). See Table 1.

Fossils found in the neighbourhood of Threlkeld

Earlier collected specimens from the east side of Threlkeld Quarry include a *Tetragraptus* and a good specimen of *Pseudotrigonograptus ensiformis* (Hall). The range-chart in Cooper *et al.* 2004 (p. 9) shows that in the Skiddaw Group *P. ensiformis* ranges through the upper part of the Skiddaw Group to the top of the Arenig, and may just pass into the Llanvirn. The graptolites in the new sample that Mrs Lawton collected from Threlkeld Quarry [between grid reference NY 3297 2439 and 3289 2447] are discussed below. They are indicative of the *cucullus* Zone at the top of the Arenig and are younger than any known clasts from the Buttermere Formation.

The right bank of Birkett Beck, 200 m north of Threlkeld Quarry [NY 3280 2469], yielded a small collection of fragmentary graptolites, trilobites and *Caryocaris*. At first I assessed the zone there as *gibberulus*, but later favoured the *cucullus* Zone (with some reserve), based on the presence of the late Arenig trilobite *Cyclopyge grandis brevirachis* Fortey & Owens (1987), and suggested that the Tarn Moor Formation might be present (Cooper *et al.* 2004, p.133, locality 156).

Farther west, immediately below the Borrowdale Volcanic Group at Causeway Foot [NY 2907 2197], Molyneux (Cooper *et al.* 2004, p. 55) recorded an acritarch assemblage of the *hamata–rarirrugulata* Zone. This zone spans the *gibberulus* and *cucullus* graptolite zones.

The new material

Mrs Lawton's specimen is a flake of grey, slightly micaceous mudstone that shows no sign of thermal alteration or induration, even though it was collected close to the contact with the Threlkeld microgranite. It shows the juvenile stages of three graptolites, two of *Isograptus* and one resembling *Eoglyptograptus*?, together with further unidentifiable fragments.

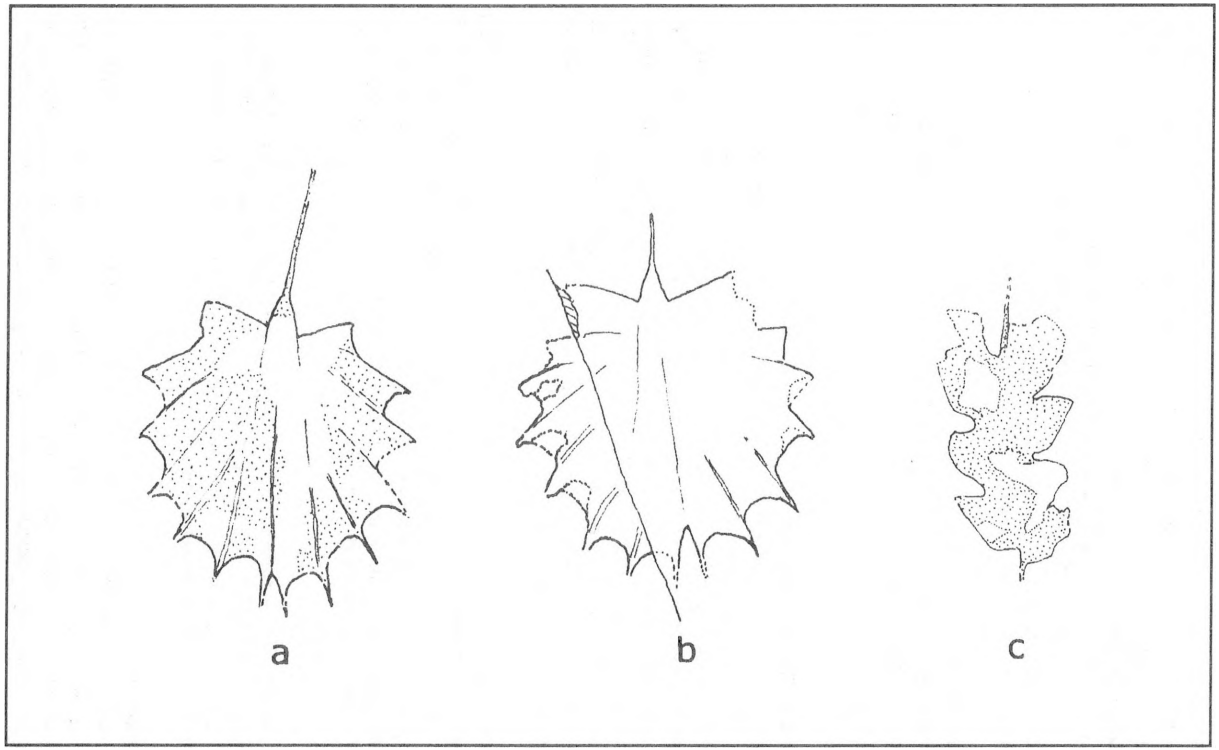


Figure 2 - Graptolites from Threlkeld Quarry now housed in the palaeontological collections of the Natural History Museum, London. **a**, **b**. *Isograptus caduceus*? cf. *nanus* (Ruedemann), specimen numbers NHM QQ.229(1), NHM QQ.229(2). **c**, *Eoglyptograptus*? sp. juv., no. NHM QQ.229(3). All are magnified x10.

Isograptus caduceus? cf. *nanus* (Ruedemann). Figure 2a, 2b.

The two specimens of *Isograptus* are much the same size and at a similar stage of development. They are strongly flattened and retain traces of the periderm (stippled in Fig. 2a), but the interthecal septa are not very distinct. Sicular length 3.0 mm, width of aperture 0.45 mm; supradorsal height about 0.3 mm, supradorsal width 0.25 mm. The notch between the sicula and theca 1_1 is about 0.4 mm deep and 0.25 mm wide. There appear to be ten (five pairs) of pendent thecae. The last-developed thecae, the sixth pair in the specimen in Fig. 2a and the seventh in Fig 2b, are only partly formed; the specimens are not fully grown, so the distal parts of the stipes, which in any case are very short in *I. caduceus*? *nanus*, are not developed. In size and general appearance, these resemble North American specimens of *I. caduceus*? *nanus* figured by Cooper (1971, figs 3g, 3h) and Churkin and Carter (1996, figs 27D-G, I, K). The Threlkeld specimens differ from the American examples because they have slightly narrower thecae, with thecal apertures 0.5 mm or less in width, whereas the American specimens have apertural widths of 0.6 mm or more. The Threlkeld specimens also have more pendent thecae, neither Cooper's nor Churkin and Carter's having more than three pairs. A specimen figured by Lenz and Jackson (1986, fig. 9E) has narrower thecae, of which seven or eight (3 or 4 pairs) are pendent, and is therefore more like the Threlkeld specimens in those features. The specimens figured by Tzaj (1974, pl. 11, figs 15-17, text-fig. 30) have more fully developed distal stipes; the siculae in his pl. 11, figs 15 and 17 have much greater supradorsal height than the specimens from Threlkeld, and although the specimen in text-fig. 30 is more similar, it appears to have wider thecal apertures. *Isograptus caduceus*? *nanus* is recorded from the *tentaculatus* graptolite zone near the base of the Darriwilian Stage (Da1-Da2) in North America, about equivalent to the boundary between the Arenig and Llanvirn series (see Table 1). Tzaj's (1974, p. 24) record is from beds equivalent to the lower Llanvirn.

Eoglyptograptus? sp. juv. Figure 2c

On the same piece of rock is an immature stage of a diplograptid showing four pairs of strongly alternate thecae of 'glyptograptid' form. The lowest parts of the earliest-formed thecae (thecae 1^1 and 1^2) are at distinctly different levels. There is a virgella but no other basal spine is seen.

This specimen is not preserved well enough to be identifiable, especially in the light of such detailed investigations as those of Mitchell (1987), but among early diplograptids the asymmetrical proximal end is reminiscent of *Eoglyptograptus*. This genus, exemplified by *E. dentatus* (Brongniart) as described by Bulman (1963), is one of the earliest diplograptids to appear. In the Skiddaw Group that species occurs in the *cucullus* graptolite zone (Cooper *et al.* 2004, pp. 10, 16), and it is widely reported in the lower part of the Llanvirn Series.

Discussion

The new specimens show that the Skiddaw Group mudstones at Threlkeld Quarry are at least as young as the *cucullus* graptolite zone and are younger than any definitely identified fossils from the Buttermere Formation. According to our present understanding, this makes it more probable that the mudstones intruded by the Threlkeld microgranite are the lower part of the Tarn Moor Formation, as indicated by Cooper *et al.* (1995), rather than the Buttermere Formation, as shown on the geological map of the Keswick district (British Geological Survey, 1999). However, in view of the uncertainty that remains concerning the age of emplacement of the Buttermere Formation and the fact that the base of the Tarn Moor Formation is as yet unproved (Cooper *et al.* 2004, p. 55), it remains a possibility that the mudstones of Threlkeld Quarry represent an olistolith that happens to be the youngest known constituent of the Buttermere Formation. A resolution of this uncertainty might follow from further examination of outcrops of the Skiddaw Group in the neighbourhood of Threlkeld Quarry and Birkett Beck, and especially from the discovery of additional fossils.

Acknowledgements

I thank Mrs Sheila Lawton for offering me her specimen for study and for presenting it to the Natural History Museum. I have benefited from discussion with my colleagues at the British Geological Survey, Dr A. H. Cooper and Dr S. G. Molyneux.

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Dr Adrian Rushton
[redacted]

FOSSILS COLLECTED DURING JOHN BOLTON'S MARATHON SEARCH AT ROSSIDE

Adrian Rushton and Paul Shepherd

John Bolton (1790-1873) was a self-taught geologist who, by decades of detailed observation and assiduous fossil collecting, contributed much to the knowledge of Furness. Kelly (2001) gave an account of Bolton's life and work, and alluded to a remarkable episode when, over a two-year period, the seventy-year-old Bolton spent two hundred days searching for fossils in the singularly unfossiliferous strata known to him as the "Coniston Flag", but now recognised as part of the much more recently defined Coniston Group (Kneller *et al.* 1994). The present note illustrates some fossil shells that he collected and comments on their present status.

Bolton gave an account of his exploit in his fascinating book "Geological Fragments" (1869, republished in 1978). He recounts his self-appointed task of levelling the road at Rosshead using a hammer and chisel to extract slabs which he then split up in search of fossils. Although Bolton is self-deprecating about his laborious task, which he described as "...foolhardiness..." and "...a great waste of valuable time which might have been spent to better purpose", he uses it to illustrate the value of patience and persistence on the part of fossil collectors in general; and reading between the lines it is evident he was rather proud of his achievement, and especially of the fossils of the shell *Cardiola interrupta* that he succeeded in finding. Bolton (1869, p. 144) records that he gave the Geological Survey of Great Britain (BGS) two or three good specimens of *Cardiola interrupta* which he said were "very superior" to some good examples of Bohemian specimens that Barrande had presented to the same institution, and that Rosshead was "the best place in Europe" for these fossils. Work published after Bolton's death, however, shows that his assessment of his material of *Cardiola*, though understandable, was too optimistic.

Bolton's fossil collections

Cleevely's compilation *World Palaeontological Collections* (1983) quotes that Bolton's fossil collection was reputed to be the largest from the Lake District, but reported that the whereabouts of most of it is now unknown. Records in the British Geological Survey, Keyworth, Nottingham, cite around 600 specimens, purchased from John Bolton in 1862 and from his widow, Mrs Ann Bolton, in 1873, the year of Bolton's death.

The collections, though not closely localised by present standards, have proved of use to palaeontologists and stratigraphers, and over the years several of his specimens have been described and figured.

The locality

Bolton's locality "Rosshead" is now known as Rosside, a village one mile north-west of Ulverston (national grid ref. SD 271 788). According to the BGS

map of the Ulverston district (1997, p. 53), the strata that Bolton worked in the main street were cleaved siltstones of the Moorhowe Formation, which is equivalent to a local unit, the 'Rosside Flags' of Dunham & Rose (1977, p. 21). Kneller *et al.* (1944) published a full review of the lithostratigraphy. The Ulverston Memoir (Johnson *et al.* 2001) gives the age as Ludlow, probably within the *scanicus* graptolite zone, but noted that no fossils had been recovered during their re-survey; Dunham & Rose (1977), however, did allude to Bolton's specimens of *Cardiola*. The specimens we have studied are in the BGS, numbered ZI 9215-9218, and are recorded as being from the collection purchased from Mrs Bolton in 1873; the specimens donated during Bolton's lifetime have not been separately identified.

Cardiola interrupta

Cardiola interrupta was originally described and figured by Sowerby in the *Silurian System* by Murchison (1839, p. 617, pl. 8, fig. 5, reproduced here as Figure 1). The surface sculpture of radiating grooves intersected by concentric grooves is distinctive, making the fossil easy to recognise, and the species has since been recorded from lower Ludlow strata in very many places in England and Wales.

Type-specimen: the specimen on the left of Sowerby's figure, BGS Geol. Soc. Coll. 6650, was stated by Blake (1902, p. 7) to be the "type specimen" (Smith 1989). It came from Garden House Quarry, Aymestrey. Later Kříž (1979, p. 63) formally designated the original of the right-hand figure, BGS GSM 51556 as lectotype; this specimen is from Water-break-its-neck, west of New Radnor. Kříž did not mention Blake's work, but added a note that Geol. Soc. Coll. 6650 lacked sufficient diagnostic features to allow it to be compared with other cardiolids. Nevertheless, we believe that Blake's designation of Geol. Soc. Coll. 6650 is technically valid.

The British specimens are often badly preserved and the details of their morphology is usually obscure, and British identifications have not, as a rule, taken into account the variety of cardiolid taxa that have been described abroad. In 1881 Barrande figured *C. interrupta* from Bohemia and added no fewer than 70 other species. Kříž (1979, pp. 121-130) reviewed all of those, and he suppressed several as synonyms, whilst transferring some others to different genera such as *Butovicella*. Kříž, who studied features often passed over in earlier work, such as the early growth-stages of the shells, considered that 24 of Barrande's species were valid and recognised 23 other species; these he distributed among 11 genera. Because the Bohemian specimens, which are commonly preserved in limestone, are well preserved, comparison of the Bohemian species with the type species of *Cardiola*, *C. interrupta*, is still inconclusive Kříž (1979, p. 64). What is needed to resolve this is suitable topotypic material to be collected from Garden House Quarry and studied using Kříž's methods; alternatively, if good material could be obtained from Water-break-its-neck, application could be made to the International Commission on

Zoological Nomencalature to set aside Blake's choice of type specimen and replace it with Kříž's preferred lectotype.

Bolton was justified in thinking that his specimens were of good quality compared with the flattened and fragmentary condition of many British specimens, but it is obvious that his are strongly deformed by tectonic pressure. We show here some figures retrodeformed using the method described by Rushton & Smith (1993) to give an idea of the original shape of the shell. It should be noted that the restoration may not have arrived at an exact representation of the original shape because there was insufficient information to establish either the original proportions of the shells or the exact direction of compression. However, the retrodeformation does suggest that the surface sculpture of Bolton's specimens is more like, in which the radial ribs are only slightly more closely spaced than the concentric grooves, than GSM 51556, in which the ribs are about five times more closely spaced than the concentric grooves. Compared with the Bohemian species, the sculpture is most like that of *Cardiola docens* Barrande (Kříž 1979, pl. 14); *C. docens* appears to be relatively taller than Geol. Soc. Coll. 6650 and our reconstruction, but the difference may be insignificant because we cannot be sure of the original proportions of our specimens.

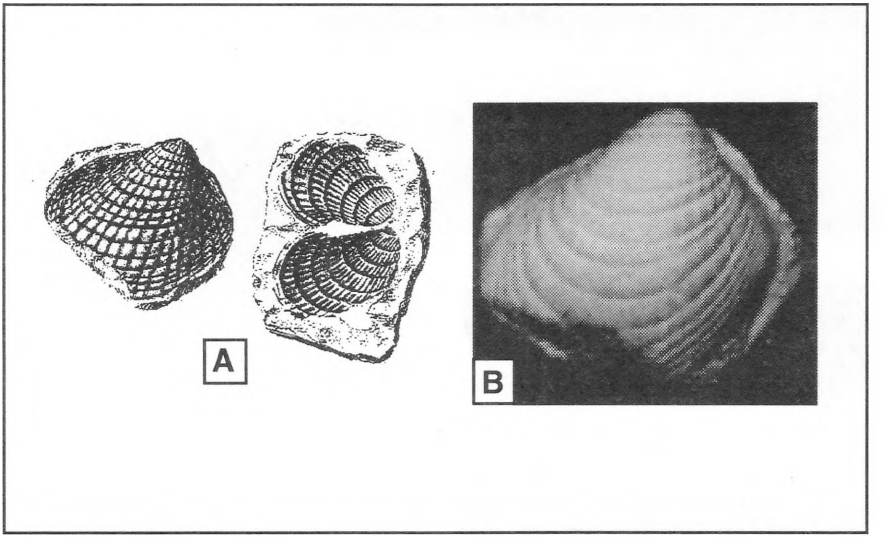


Figure 1 - A, Copy of the original figures of *Cardiola interrupta* J. de C. Sowerby (from Murchison 1839, pl.8, fig. 5), original size. B, cast of the type, Geol. Soc. Coll. 6650, from Aymestrey, x1½.

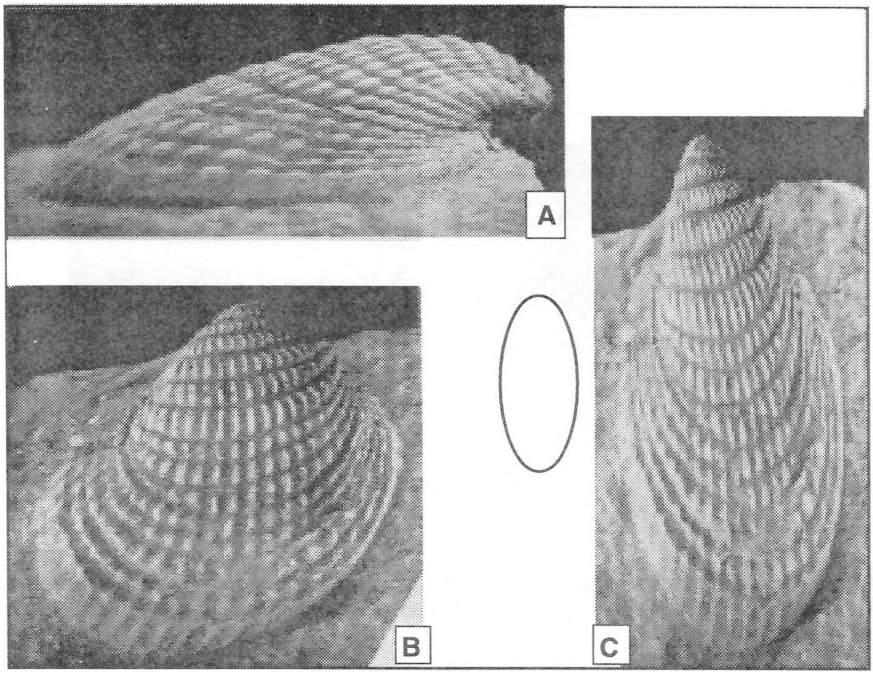


Figure 2 - BGS Figure 3. *Cardiola* from Bolton's collection. A, end view, and B, lateral view of specimen foreshortened by cleavage, with an approximation to the strain-ellipse in the plane of bedding, ZI 9415, x1½. C, the same retrodeformed so as to preserve the same area in the plane of bedding.

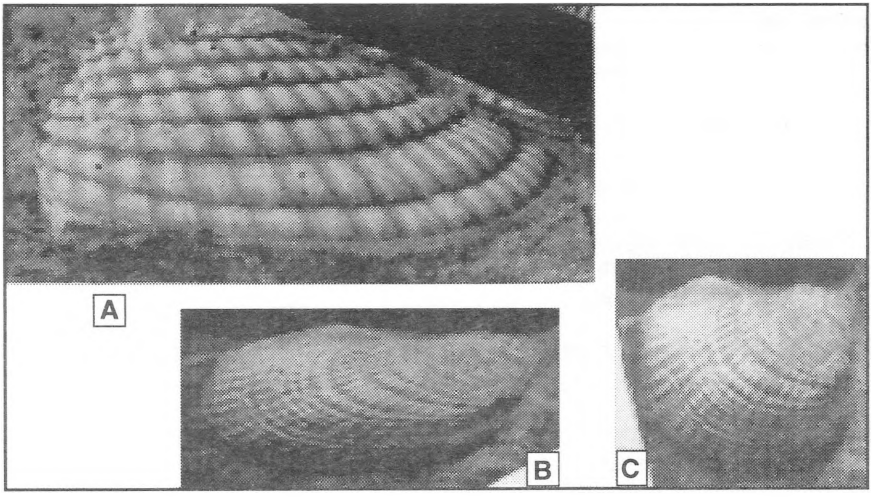


Figure 3 - A, cast of a fragment of a large specimen compressed by cleavage, ZI 9216, x1½. B, a small specimen, ZI 9218, x1½, and the same retrodeformed.

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Adrian Rushton (Research Associate) and Paul Shepherd
[redacted]

ON IDENTIFYING FRONTAL POSITIONS OF LAKE DISTRICT VALLEY GLACIERS

Richard Clark

Introduction

There is a "general lack of terminal moraines in the Lakeland valleys" wrote Thomas Hay (1944, 121). It is the case that not many such moraines have been described from the main dales within the upland. Hay believed he could explain their scarcity from circumstances at Rosthwaite in Borrowdale. Moraines there had been protected from river erosion by a rock bar best seen at The How, a large roche moutonnée which "lies between the Derwent and the Stonethwaite Beck and, since the last ice retreat has held these becks apart" (Hay, 1944, 120 – 1). Elsewhere in the Borrowdale area the valley sides were, he thought, too steep to hold moraine and the bottoms had been worked over by shifting streams so that any frontal moraines would have been eroded. From this, Hay assumed that there might well have been more frontal moraines and thus a stage of valley glaciation after loss of the latest widespread ice cover. He concluded that "the retreat of ice in these valleys may not have been quite so rapid and continuous as it has sometimes appeared" (Hay, 1944, 121). To the contrary, Pennington thought "the absence of frontal moraines from the floor (sic) of the main valleys - - agrees with the rapid decay *in situ* of the residual ice of the Main Glaciation" (Pennington 1978, 213 – 214). She regarded the ridge at Rosthwaite as controversial but did not say why.

As it happens, there is little evidence that The How had significantly inhibited erosion and there has been some recent erosion of moraine. Overall, the Rosthwaite moraine ridges stand rather high above the stream beds. They and adjacent glacial material may lie locally on high rockhead from which The How is a particularly prominent protrusion. A cross-valley rock bar here may have stabilised glacier fronts and facilitated deposition. As well, river regimes may have changed since the times when valley glaciers were in decline.

Recognising a process, river erosion, that could have eroded frontal moraine does not demonstrate that, in general, there had been moraines to be eroded. Nevertheless, the matter of end-moraines and valley glaciers is important, and increasingly so as the complexities of Late Pleistocene climate and ice-mass responses become more evident. The end-moraine question may be approached by way of Borrowdale but will be further explored with cases from another part of the Lake District.

Clifton Ward (1873, 1875) had identified moraines in many high Lake District daleheads including those of Borrowdale. He rather dismissed them with "Very little needs to be said about the moraines proper. Most of them belong to the latest set of valley glaciers and are confined to the higher parts of the district and the upper ends of large valleys" (Ward, 1873, 426). This episode of restricted glaciation has since been associated with the Late Pleistocene

Younger Dryas cold phase and, for Great Britain, termed the Loch Lomond Stadial (LLS): it is now dated to about 13 – 11.5 ka BP. Sissons, largely for Scotland (eg Sissons, 1967), but also for the Lake District (Sissons 1980), used the distribution of hummocky moraine as principal indicator of the extent of these late glaciers. He believed this topography of short ridges and mounds was formed during the dissipation of immobile glaciers at the end of the cold period. Many years earlier Hay (1934) had realised that the hummocky ground could be derived from sets of parallel, frequently concentric, ridges that marked successive ice margins. It is somewhat surprising that so many years were to pass before it was established that many hillocks were likely formed as frontal moraines, possibly marking still-stands or slight readvances, of shortening but still active glaciers (eg Benn, 1992). Despite this reinterpretation, the correspondence of hummocky moraine with LLS glacier sites still generally stands (Benn and Ballantyne 2004).

In his account of the LLS in the Lake District, Sissons (1980) recognized six LLS glacier sites in the Borrowdale catchment including one in each of the two main valleys above Rosthwaite. Sissons (1980) mapped the terminus of the Seathwaite glacier near Seathwaite Farm and that of a Langstrath glacier near Blackmoss Pot. Between each of these locations and Rosthwaite are groups of moraine ridges which turn towards or, as at Thorneythwaite, onto the valley floor and these probably mark temporary frontal positions of valley glaciers (Clark and Wilson 1994). Marr thought there was a moraine on a rock bar rather more than a kilometre down-valley from Rosthwaite, "the lowest moraine that can be traced definitely in Borrowdale" (Marr, 1916, 184).

In a recent consideration of late glaciation of this area, McDougall (2001) considered the Thorneythwaite and Rosthwaite moraines to mark outermost positions of LLS glaciers in the Seathwaite and Stonethwaite valleys respectively, thus beyond the areas of hummocky moraine. Sissons' (1980) interpretation is compatible with there having been a phase of more extensive valley glaciation before the LLS. McDougall's (2001) account permits the possibilities of (i) an earlier valley glacier that extended at least to the moraine described by Marr (1916), (ii) that LLS glaciers extended beyond the limits of any older valley glaciers, (iii) there was no earlier valley glaciation. Glacier lengths required by McDougall's account and their extent beyond hummocky moraine need further consideration: it has yet to be determined which, if any, of the versions is wholly supportable.

Drift accumulations elsewhere in the Lake District have been described as moraines marking limits of valley glaciers as by Gresswell (1952, 1962) for the lower southern parts of the area, and by Manley (1959) for, notably, valleys between Grasmere and Windermere. Some of these features are quite remote from recorded LLS sites and, if authenticated, would require there to have been quite long valley glaciers some reaching well beyond the upland. Latterly, Wilson (2004) considered the possibility that moraine ridges in Eskdale were formed by a valley glacier during the interval between major Late Devensian

glaciations and the Loch Lomond Stadial. The outermost moraines there would have required a glacier little less than 7 km long. The Borrowdale question thus becomes a broader one and Hay's "general lack of terminal moraines" may seem an exaggeration. But in the Ullswater area, which he most thoroughly studied and mapped, he identified no end moraines in lower parts of side valleys and in the main valley beyond his dalehead hummocky moraines and places Sissons (1980) was later to describe as LLS glacier sites. It is therefore pertinent to pursue this matter of valley glaciation by enquiring whether limits of valley glaciers might be identified by landforms and deposits other than moraine ridges wholly or partially crossing valley floors. Certain sites in the Ullswater area (Figure 1) suggest this might be the case.

Patterdale

This site (NY 398155, P on Fig 1, Figure 2A) extends for 1.6km north - south along the main valley floor south of Ullswater. On its south side the valley bottom, about 400m wide, is floored by alluvium including the northern, distal end of a fan built out from Deepdale (D, Figure 1) which joins the main valley from the west. Then, for about 800m, the areas of alluvium are discontinuous and narrow. In this part of the valley floor several rock bosses (R on Figure 2A) protrude through superficial materials and the river is or has been in contact with rock. The outcrops may mark a bar between rockhead basins in the valley, the northern of which extends to Ullswater. Several of the outcrops are flanked by mounds of bedded sand, gravel and cobbles (S).

West of the river, from Norran Bank Farm (N) north to the Youth Hostel (Y), sand and gravel masses are more extensive than on the east. Near the farm is a small but prominent flat-topped bench at the edge of the valley floor. From there almost to the hostel (about 250m) are two sinuous almost parallel ridges. Parts of their east sides are eroded by the river. Erosion has not destroyed the ridge forms. The material is dominantly sand with gravel and rounded pebbles. Observed structures are confined to faint discontinuous bedding planes. There are embayments in their flanks and at the north end of the northern ridge where it is in contact with a rock boss there is an enclosed hollow (KW) between it and the foot of the western hillside.

From about 100m south of Norran Bank Farm near the base of the hillside, the top of a small well-defined bench in superficial material slopes down north along the hillside and levels to be the site of the farmstead. Further north it is obscured by buildings and vegetation. Hereabouts it stands above the flat bench below the farmstead. No direct relationship between farmstead and valley floor benches has been established but their proximity suggests the former should be included as a member of this local landform assemblage.

The rest of the area from Norran Bank to the vicinity of the school (L) and Side Farm (F) is of low, gently undulating ground punctuated by rock bosses and with low areas at about alluvium level. These latter have little evidence of river erosion along their margins. Further north, much of the valley floor is taken by

well-defined alluvial terraces (T) that stand 2-3 metres above riverside alluvium. North of Side Farm there are two terrace levels.

The rock bosses are ice-abraded and ice plucked but that probably occurred before the events being considered. Similar ice-moulding occurs further down the valley. The significance of the rock outcrops is in the protection they have given to water-sorted deposits and as evidence for a cross-valley rock bar. Such a bar might serve to stablise the front of a declining glacier. The constructional forms of some sand-gravel masses suggest little or no erosion by ice has taken place during and since their formation. Some low till ridges aligned parallel with the valley near Goldrill Bridge (G) may be due to ice-moulding before the sands and gravels were deposited. Otherwise, there are no obvious constructional landforms at this site attributed to moving ice. Some erosion of sand-gravel deposits could have been by meltwater as well as, later, by the river.

The material of the undulating areas is assumed to have been formed by aggregation of subglacial, englacial, and supraglacial debris undisturbed by substantial channelled meltwater. The low parts (K), including enclosed depressions, may mark sites of low rockhead on the rock bar, locations of thicker ice. These places did not accumulate sand-gravel deposits and the margins of those near the beck are little affected by stream erosion. They may have retained ice masses late into the sequence of events including when the terraces were being constructed. These latter appear to have been built out from an ice margin largely by water flowing where the Goldrill Beck now runs. The Norran Bank Farm bench may have accumulated along the west margin of the ice but despite its proximity to other features no presently-available evidence shows it to be contemporary. It is not crucial to the overall interpretation.

The site shows a sharp transition from glacigenic landforms to fluvial deposition beyond ice cover. It is proposed that the accumulated evidence from the various features at Patterdale implies the occurrence there of a front of a former valley glacier. If a Patterdale glacier had been fed, as seems more likely, from the head of Deepdale, it would have been some 6 km long. The lesser possibility that it was fed in part or wholly from the main valley cannot be presently discounted.

Glenridding

Glenridding opens onto Ullswater from the west near the south end of the lake. Almost a kilometre upstream from the lake shore, at Rattlebeck (NY 380 169), Glenridding Beck has cut into a thick deposit of superficial material (G, Figure 1 and R, Figure 2B). The exposure there (X, Figure 2B) engaged Hay, on and off, for over a decade and in the last paper in which he wrote about it he concluded that "even if not right at the ice front it was not far from it", (Hay, 1944, 124). Hay saw four sedimentary units in the bluff, in all 10-12 metres thickness.

1. At stream level a "stony boulder clay almost horizontal but dipping slightly downstream";
2. foreset deltaic beds "dipping downstream at an angle of about 18^0";
3. the "lower part of an upper boulder clay";
4. "the top part of the upper boulder clay", (Hay, 1944, 124).

He regarded the two upper units as being ground moraine (basal till) derived from englacial debris. None of the transitions between units is sharp.

The significance Hay gave to the sequence was that, the deltaic sediments having been deposited beyond the ice, the upper units represented an ice readvance. Here the emphasis is on the likely proximity of an ice margin when the deltaic deposits were being laid down. The exposure is now almost wholly obscured. Previous examination had suggested to the writer that the upper units might include poorly-sorted deltaic topset beds and flow tills, material that when saturated crept or flowed from adjacent morainic or ice-surface slopes. The rather level top of the deposit (c. 180m OD) is some 3-4m above the once-obvious foreset beds. At the eastern, outer part of the exposure the bottom unit showed more bedding than is common in basal tills (boulder clays) and might include poorly-sorted bottomset beds. For brevity, the associated landform is termed 'the delta'.

The extent of the delta (D) and positions of the adjacent landforms are shown in Figure 2B. The river-eroded south front of the delta indicates that is once extended further in that direction. In the northeast it falls to a level surface of smaller extent. This is turn falls east to the lower slopes of the northern hillside and to an alluvial fan (F, Figure 2B) which extends east to Ullswater. The east slope of the delta, as seen at the Rattlebeck exposure, falls to river terraces (T, Figure 2B) and to the fan which is built of sand, gravel, rounded pebbles and cobbles up to 35cm long.

South of the beck and its fringe of alluvium are river terraces (T, Figure 2B), their surfaces below the top of the delta. To the east they are cut out where the beck has touched the southern hillside and in the west they start almost opposite the west, proximal, edge of the delta. The top of the higher southern terrace is above the terrace levels on the north side of the beck. South of the southern terraces and along the foot of the southern hillside thick glacial deposits form a bench with a steep fall north to the terraces. The rather level west end of the bench (B, Figure 2B) at Gillside Farm (G, Figure 2B) stands somewhat higher than the delta top and its steep northern side turns towards Glenridding Beck so constraining the terrace there.

North of the delta the hillside is till-covered rising to the steep scree and rock slopes of Glenridding Dodd. Immediately west of the delta the surface of glacial deposits rise above delta-top and bench altitudes with slopes facing up-valley as well as eastward down to the delta surface and towards the beck. The

'narrows' through which the beck passes coincide with western limits of delta and terraces.

Hay did not discuss evidence other than from the Rattlebeck exposure in concluding that the delta there was built up at an ice margin. The disposition of adjacent features also shows that there was transition to fluvial transport and deposition seemingly at the front of a glacier in the Glenridding valley.

Low Hartsop

This site (NY 410130, LH, Figure 2C), is south and east of Low Hartsop village in a valley tributary from the east to the main valley from the Kirkstone Pass north to Ullswater. It extends south-east – north-west for a little more than 400m mostly on the south side but on both sides of the beck at the south-east end. There it is 1.6km downvalley from the Hayeswater LLS site (H, Figure 1) and 800m from the Pasture Beck (PA, Figure 1) LLS site, both mapped by Sissons (1980). There is an area of made ground at the east end of the village: otherwise the site consists of these elements:

1. In the east, steep bluffs separating thicker hillfoot drift accumulations from valley floor. They turn, the southern one to greater degree, down valley towards the beck so constricting the valley floor.
2. Valley floor east of the constriction with narrow alluvial strip and glacial sediments between alluvium and bluffs. Here the stream flows over alternating rock and cobble reaches.
3. Steep rock bed where the stream passes through the constriction.
4. On the north side, east of the constriction, for about 130m along the lower valley side, a set of short drift ridges aligned downslope. Some drainage from the hillside passes between them but there is little indication that the ridges derive from dissection of the hillside drift. Rivulets on the hillside elsewhere have not produced similar forms: no comparable forms occur between this site and the LLS glacier sites. A pit, now degraded, on a flank of one ridge was worked for gravel and cobbles and showed much less fine matrix than in the diamicts of the lower hillside.
5. Ground rising above the south side bluff where it turns towards the valley centre. A short but marked drift ridge and an ice-abraded rock boss break the smooth surface of this area.
6. A terrace (T, Figure 2C) of water-worn gravel and cobbles on the south side of the site. Its east end is narrow at the north side of (5, above), and its surface is several metres above the beck in the constriction. It broadens westward and falls downvalley for about 300m to an abrupt end. Generally its surface is 4 – 5m above the stream bed. In parts it slopes also towards the southern hillside and it can be concluded it was not built from the hillside but downvalley from feature 5. It is not evident whether the abrupt western end of the terrace is due to subsequent erosion or whether deposition was inhibited in some way as by a residual ice mass. There is no evidence to indicate the effect of residual ice in diverting northwards water and debris that would have arrived from the east. At this

distal end the terrace is still 4 – 5m above the beck and is adjacent to the apex of a lower, younger alluvial fan which extends across the main valley floor to Brotherswater (B, Figure 1).

7. West of 3 the alternation of cobble and rock stream bed reaches resumes, the fall steeper than upstream of the constriction.

This site has similarities with both Glenridding and Patterdale localities. The assemblage may be explained by there having been a ice-front at the east end of the site. In particular, it is not easy to explain otherwise the characteristics of the terrace. No terrace fragments are found upstream. A valley glacier ending at this site would have been about 5km long if fed from Hayesdale, 3 km long if from only the Pasture Beck valley.

Hartsop Hall

Hay's unpublished field maps show discrete moraine ridges in Dovedale (DV, Figure 1), the outermost of them just south of Hartsop Hall (NY 398120, HH, Figure 1) near Brotherswater. Clark (1992) concurred but later came to regard a clear but discontinuous ridge ending about 110m further north (north of Hartsop Hall) as the outer limit. He attributed these ridges to a LLS glacier. Sissons (1980) did not include this site among the LLS glacier sites he identified.

At the foot of the steep hillside north of Hartsop Hall there is a large bench of diamict. The hillside is widely scree-clad with protrusions of bed rock and with patches of drift on the lower slopes. Little of the scree has spread onto the bench which at its southern end lies above and overlaps the outermost moraine ridge. In that vicinity its top stands some 20m or more above the northern end of the outermost ridge. This bench extends for about 300m north along the foot of the hillside, narrowing and falling in that direction. It is some 80-90m across at widest. It has a high steep front to the east and a narrow irregular top that slopes east and falls north. Rather poor exposures at the north end show a matrix-rich diamict.

There are oblique, south-west – north-east, ridges across higher parts of the bench, neither as large nor as well-defined as the Dovedale moraine ridges. The northern part of the bench top is crossed by gullies. There are mounds and short ridges, some oblique, but it is not clear that they are parts of formerly continuous ridges. Across the valley, for about 250m north from Sykeside (NY 403119: S, Figure 1) is a drift bench. It has been cleared for farming, much has been ploughed in the past, and it is not possible to determine whether once it had ridges. It corresponds in position on the east to the Hartsop Hall bench on the west.

The Hartsop Hall bench can with reasonable assurance be attributed to glacial processes. Whether the ridges on it may be interpreted as moraines formed along ice margins is less readily determined. Alignment and forms of the more prominent support that possibility: no more probable mode of formation at that site presents itself. Without the ridges there would be the question of how

the bench relates to the Dovedale moraine ridges in time and manner of formation. With the possibility that the ridges mark ice margins the question extends to whether the bench denotes the greater extent of Dovedale LLS glacier north from Hartsop Hall or pertains to an earlier somewhat longer valley glacier. It is to be noted that the bench and Dovedale moraine ridges are contiguous whereas distances between the other localities and their nearest LLS glacier sites identified by Sissons (1980) range from 4km to 800m.

Despite the uncertainties met in interpreting the Hartsop Hall site, drift benches of its sort are potentially relevant to the Lake District valley glacier question. They have been given little consideration: their distribution is unknown. It can only be advantageous that they receive more attention.

Discussion and Conclusion

The three first-considered sites are similar in that each has contiguous glacial and fluvial landforms and at each a terrace commences well above river level with no upstream lead-in. This shows transition over a very short distance from subglacial or englacial to proglacial fluvial debris transport. Valleyside glacial deposits downvalley from the sites are taken as pertaining to earlier ice covers and there are probably glacial deposits beneath the terraces and alluvial flats. The evidence from individual sites for locations of valley glacier fronts is substantial: collectively it is stronger. It is significant that at these near-by sites the evidence for ice fronts does not rely on cross-valley moraine ridges. There is, apparently, another way to identify front, if not necessarily outermost, positions of former valley glaciers. The contrasts between landforms at Borrowdale, and at other sites, and those at the Ullswater sites may reflect differences in thermal regimes and ice dynamics. Their significance requires further consideration as do the relative ages of the landforms sets.

The significance of the Hartsop Hall site is somewhat different. Either the Dovedale LLS glacier had been longer than previously thought and had built somewhat different landforms in its further reach or there had been an earlier and longer valley glacier with a rather different sort of activity. It may be the case that, as at Hartsop Hall, substantial drift benches have not been examined because their potential to hold relevant evidence had not been appreciated.

These sites within a 5 km span in the Ullswater valley are clearly pertinent to the broader question of valley glaciation in the Lake District between the loss of last widespread ice cover and the Loch Lomond Stadial. There is the matter of whether the incursions of glacier ice onto the coastlands of West Cumbria during the Late Devensian (Merritt and Auton, 2000) were accompanied by a general growth of valley glaciers in the Lake District. Implications of these events for landform development in Cumbria beyond those coastal lowlands were considered by Clark and Smith (1998). Assemblages such as those here described have been little reported from elsewhere in the Lake District. In the paper where Hay asserted the general lack of terminal moraines he also noted that the most prominent features along Stonethwaite Beck south from

Rosthwaite to the meeting of Greenup and Langstrath are two well-developed river terraces. Sissons (1980) placed the outer limits of Greenup and Langstrath hummocky moraine and so of LLS glaciers well above the meeting of the valleys. McDougal (2001) thought the LLS limit was at Rosthwaite further north, well beyond the hummocky moraines. It would be opportune to see if the terraces identified by Hay are like those in the Ullswater valley and similar in their proximal settings: they might help clarify this Borrowdale uncertainty. Even more appropriate would be systematic reconnaissance of Lake District valleys for assemblages of a sort with those in the Ullswater valley.

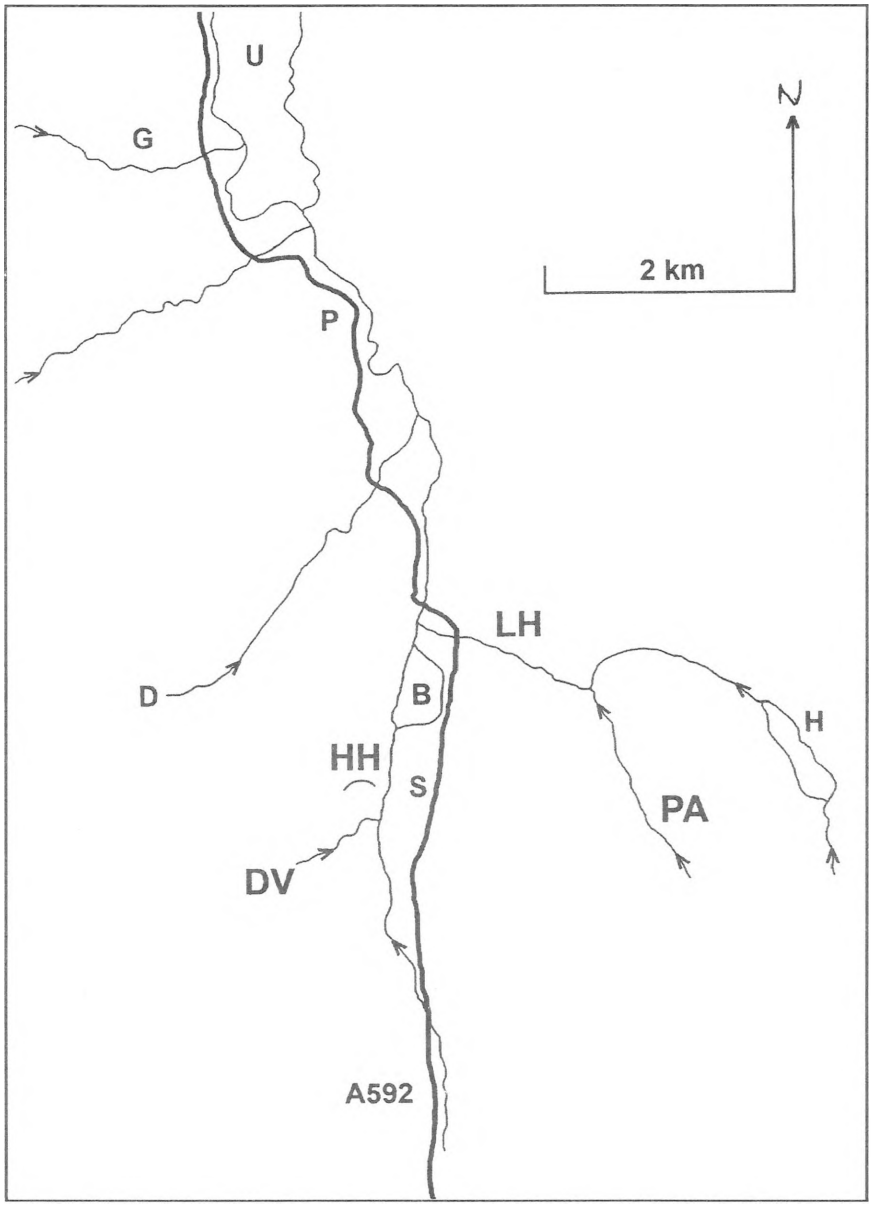


Figure 1 - Sketch map to show locations of places referred to in text, areas covered by Figure 2A, B, C, and the course of the A592 road.

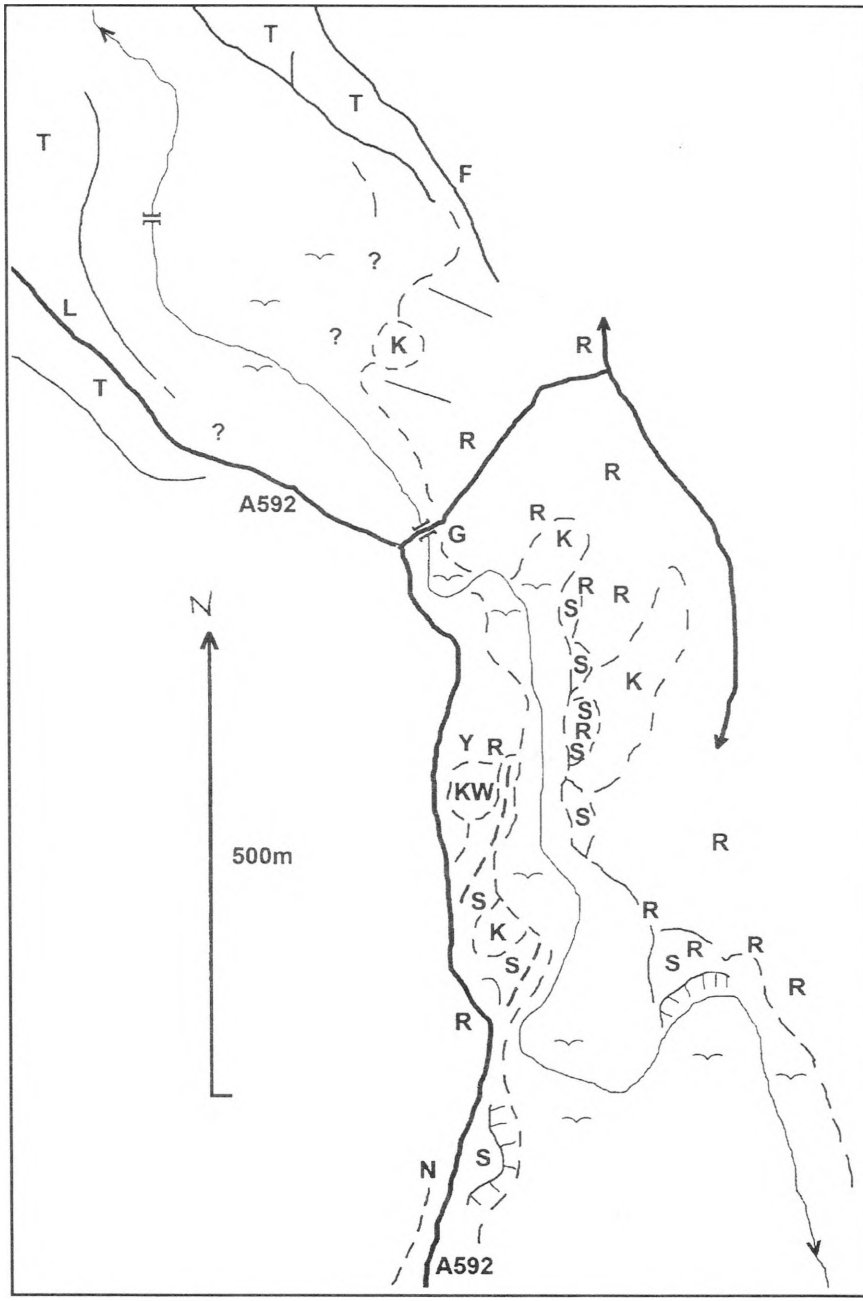


Figure 2A - Sketch map to show features at Patterdale.

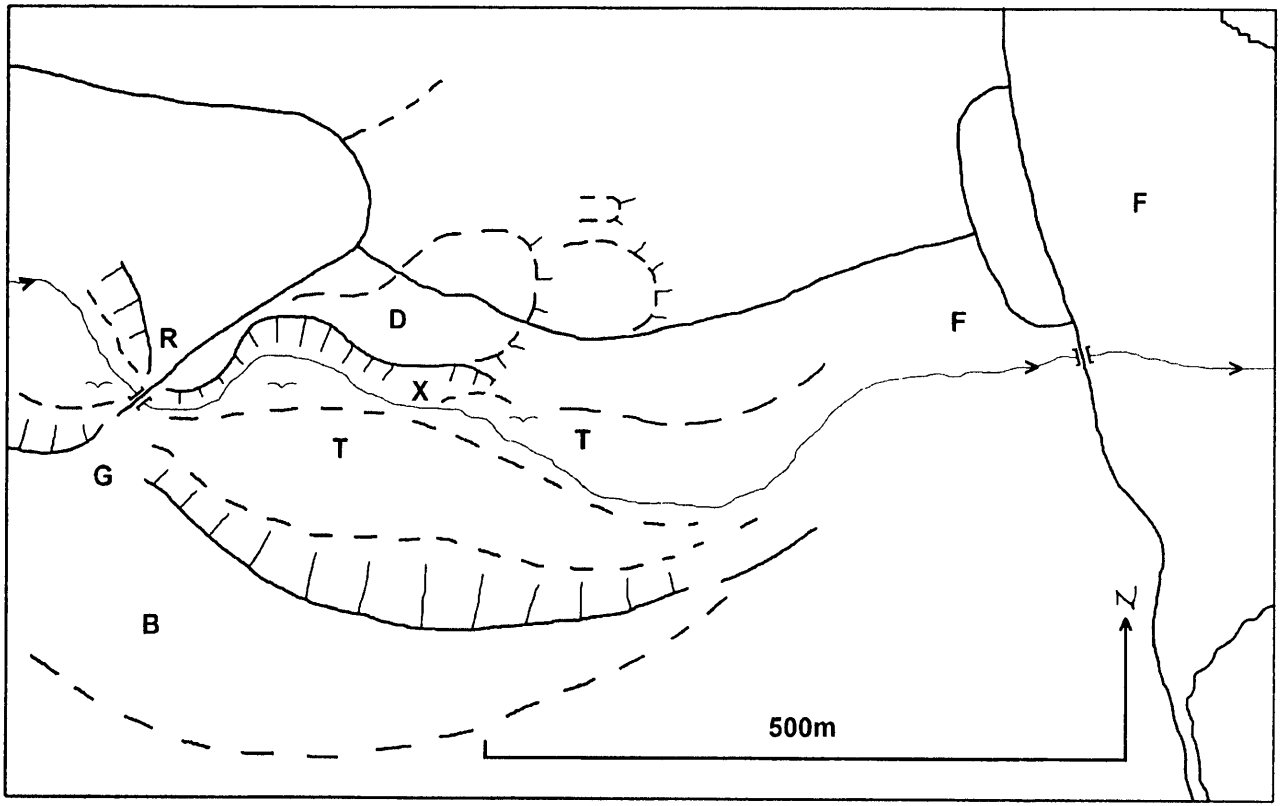


Figure 2B - Sketch map to show features at Glenridding.

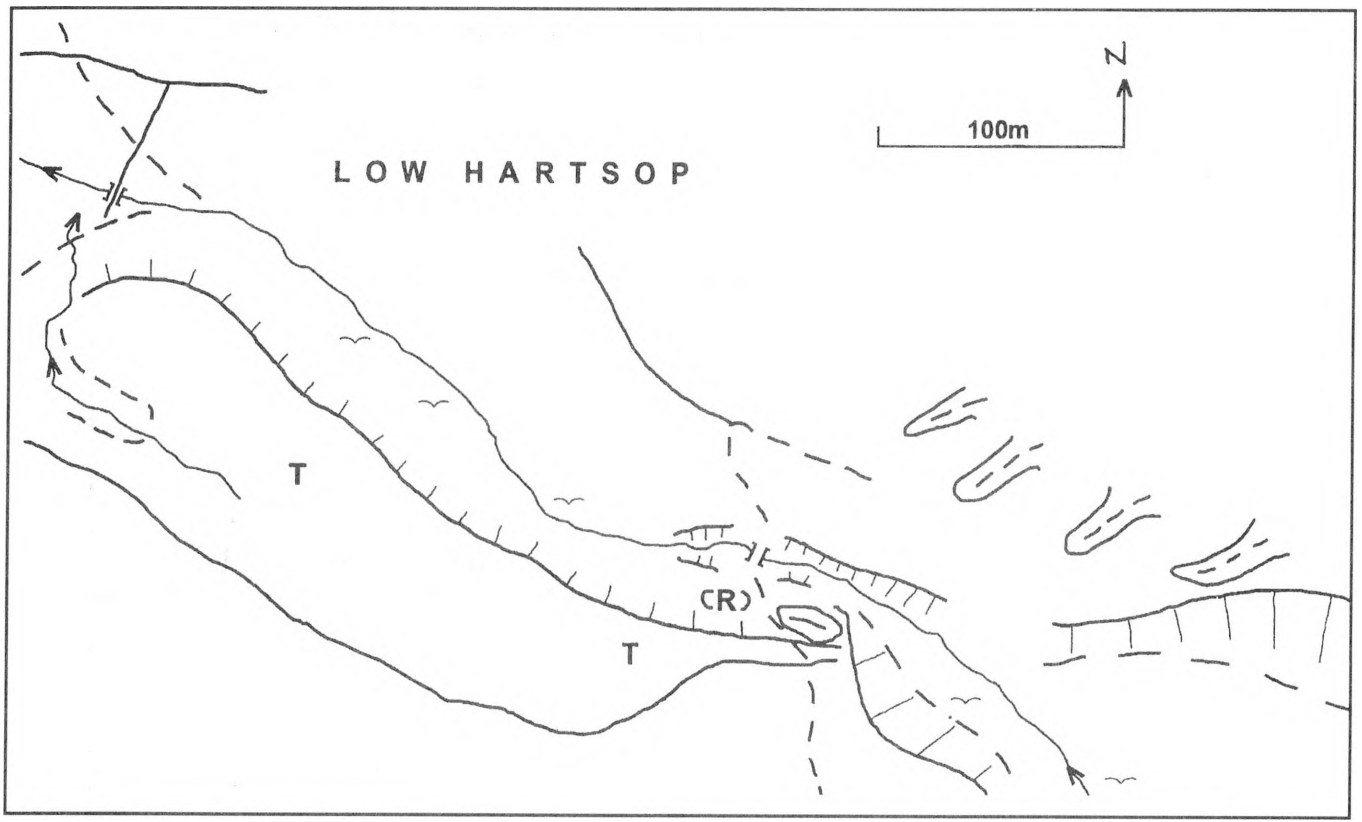


Figure 2C – Sketch map to show features at Low Hartsop.

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FIELDWORK REPORTS

THE GEOLOGY OF THE NORTHERN MARGINAL ZONE COMPLEX ON THE ISLE OF RUM, SCOTLAND

Edward Loffill

In early July 2004, Jaqueline Malarkey and I went to Rum for 6 weeks to map parts of the Northern Marginal zone as part of my final year Part II mapping project in Geological Sciences at the University of Cambridge.

The project was to map out the rock types associated with the volcanic episode on Rum ~ 55Ma in the northern marginal zone. The Northern Marginal Zone (NMZ) is the boundary zone between the famous layered peridotites seen in the Rum Cuillin and the country rock type of Torridonian sandstone seen on the North of the Island. The Rum Cuillin layered peridotites are known as the Eastern Layered Series (ELS) and represent the basement of a volcanic magma chamber associated with the igneous activity seen during the Tertiary period ~55 Ma.

The island has been widely studied for the past 125 years and was first mapped by Alfred Harker in the 1900's who created the first geological map for the island, it was then subsequently mapped throughout the 20th century most notably in recent years by Henry Emeleus (responsible for the most recent 1:20 000 geological map of the island commissioned by Scottish Natural Heritage), Colin Donaldson from the University of St Andrews and Valentin Troll of Trinity College Dublin.

The Rum volcano was formed as part of what is known as the British tertiary Igneous province. These volcanic centres are generally seen on the west coast of Scotland and are associated with the opening up of the Atlantic Ocean during this period. Related volcanic episodes can be seen on Arran, Mull, the Ardnamurchan peninsula, Skye and anywhere where you see numerous dykes present on this west coast.

What we were mapping was the zone of faulting surrounding the ELS. There were two major faults, one surrounding the ELS and another further out, like the rim of a bicycle wheel. These faults represent the collapsed caldera of the volcano and, as with most faulting associated with collapsed volcanoes, they trapped many of the extrusive and intrusive rocks associated with the volcanism.

In the fault zone we encountered many rock types. The most common rock types were huge faulted blocks of Torridonian Sandstone and intrusive breccias. In this area other rocks present included the regionally famous Lewisian Gneiss, rhyodacites whose origin is hugely debated and gabbro and peridotite intrusions. Identification of the Torridonian Sandstone in the NMZ was made difficult by the massive amount of thermal deformation that the rock had undergone.

Identification was often made by looking at the weathering of the outcrop (cross-stratification became apparent) as little could be gleaned from a fresh surface as the sandstone frequently resembled hornfels. Of interesting note however, was that the thermal metamorphism could be mapped by the bleaching of the surrounding Torridonian Sandstone.

The most interesting rocks we saw in the NMZ were undoubtedly the intrusive breccias such as the Corrie Dubh Breccia and the Am Mam Breccia. These are thought to be emplaced as a fluid but with huge clasts (metres in size) of gabbro and Torridonian Sandstone (see picture). Similar rocks can be seen in some Scottish volcanic provinces such as in the Glencoe volcanic centre but the Rum volcanic breccias are unique in exposure, size and scale.

The rhyodacites are controversial. They are markedly different from the basic composition of the ELS and the gabbros, as the rhyodacites are acidic and possibly represent fractions released from the metasomatised layer in the mantle as the plume head hit. Mineral alignment represents flows within the rhyodacite but argument still surrounds these rocks as to whether they represent intrusive or extrusive igneous rocks.

Throughout the area there were a huge number of dykes of basaltic composition, however some of the dykes were ultrabasic, composed of pyroxenite nodules.

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LATE DEVENSIAN OUTWASH ENVIRONMENTS IN THE TYNE VALLEY: PRELIMINARY INVESTIGATIONS

Lynda Yorke

Background and Rationale

In contrast with adjacent areas (e.g. Vale of York, Swale-Ure, Till-Tweed), little work has been undertaken on the pre-Holocene river valley landforms in this part of northern England. There has been little attempt to interpret the pattern and chronology of deglaciation in northeast England, with the exception of studies in the Cheviots (Clapperton, 1971; Douglas and Harrison, 1985) and on the Durham coast (Teasdale, unpublished), this constitutes a significant gap in our knowledge of post-glacial geomorphic and sedimentary response. The model for deglaciation in the Tyne Valley is by *in-situ* ice wastage (cf. Beaumont, 1968; Clark, 1970). However, it is unclear how the depositional landforms that crop out along the Tyne Valley developed because there have been no detailed sedimentological investigations. Consequently, the sediments and landforms are poorly understood, the spatial distribution of the landforms is poorly resolved and there is no chronological control for development of the sequences. It is anticipated that the identification and interpretation of these landforms in the Tyne Valley will develop and extend the regional history into the Late Devensian.

The Study Site

In the lower Tyne Valley, extending between Stocksfield and Blaydon at 25-73m OD, there is a complex of mounds on the south side of the River Tyne. Extensive quarrying has revealed a complex sequence of Quaternary sediments underlying these features. Crawcrook sand and gravel pit (NZ 412564), located 7 km west of Newcastle upon Tyne (Figure 1), is excavated into one of the mounds. Although much has already been quarried away, there is good exposure in a single face (*c.* 50 m in length).

Other than the Industrial Mineral Assessment Unit survey (Giles, 1981) and the British Geological Survey memoir (Mills and Holliday, 1998) detailed investigations have not been carried out on the deposits. However, Francis (1975) investigated the sediments exposed in a ridge excavated near Crawcrook, interpreting the feature as an esker with sediments accumulating sub-aerially in an ice-walled channel. He attributed the undulating topography to melting of ice buried beneath the sediments.

Results

A combination of geomorphological mapping and field walking of the site established that deeply entrenched meltwater channels extend up the valley side and dissect the mounds, and smaller run-off channels degrade the edges of the mounds. Data collected from exposure in the quarry, and sediment analysis (lithological and textural) has provided information on sediment architecture and the sequence underlying the landforms.

The dominance of horizontally laminated (Sl) fine sands, thick sets of fine-grained silts (Fl) and climbing ripples (Sr) in fining-upwards units at the base of the sequence, (Fig. 2) suggests quiet water deposition possibly under lacustrine conditions with migrating ripples representing large quantities of sediment deposited from suspension. The horizontally bedded (Sh) coarse and fine sands at the top of the sequence indicate an alternation between low and high energy flow regime sedimentation and suggests a switch to fluvial conditions. Small-scale scours and asymmetrical hollows (*sensu* Marren, 2001) cut into these sands are also evidence of localised increases in stream power and erosion.

The occurrence of the fining-upwards units indicates an initial low-energy depositional environment that was subsequently replaced by higher-energy fluvial conditions. The depositional model proposed is supraglacial sedimentation by lacustrine and fluvial aggradation above stagnant ice resulting in the deformation of sediments and the undulating (mound) topography that distinguishes the landforms from the lower river terraces above the River Tyne.

Significance

The sedimentological data presented here has begun to provide information on the processes involved in their formation. However, more detailed sedimentological and geomorphological assessment is required to understand the deglacial valley fill sediments, develop models of supra-, en- or sub-glacial sedimentation and elucidate the deglacial history in this part of northern England. At present work is still ongoing at this site and others along the Tyne Valley. Currently no absolute dating exists for the late Devensian sequences in the Tyne, and without a chronological framework a full consideration of the implications of geomorphic and sedimentary response is not possible. However, a funded programme for Optically Stimulated Luminescence dating of the sequences is now underway to derive absolute dates for the Crawcrook site and other sites along the Tyne Valley.

Acknowledgements

I would like to thank Dr. Andy Howard (Birmingham) and Dr. Ian Fuller (Massey) for useful discussions and invaluable assistance in the field. Field mapping was greatly improved under the guidance of Dr. Wish Mitchell (Durham). RMC Aggregates kindly gave permission to access the Quarry site and undertake work. This project forms part of a PhD research project that is funded by a Graduate Teaching Assistantship awarded by the University of Hull to L. Yorke. A small research grant from the Cumberland Geological Society towards fieldwork is gratefully acknowledged.

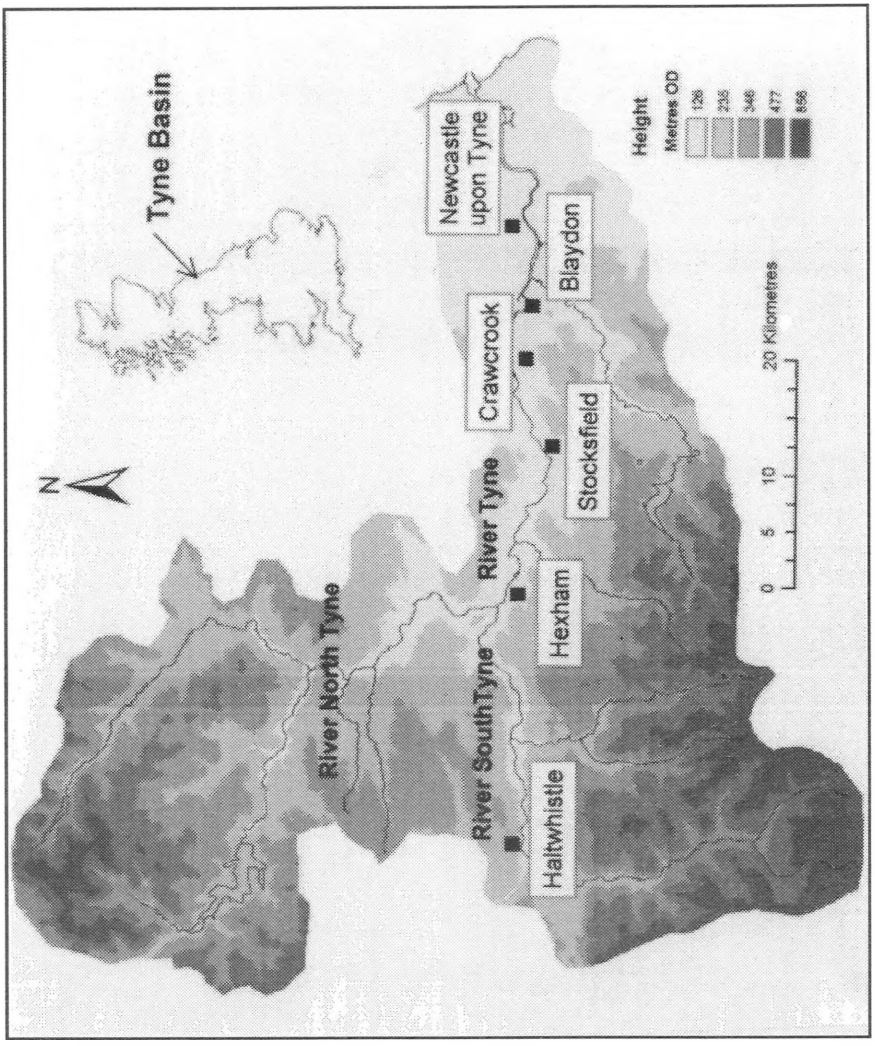


Figure 1 – Map of the Tyne Basin showing relief and locations mentioned in the text

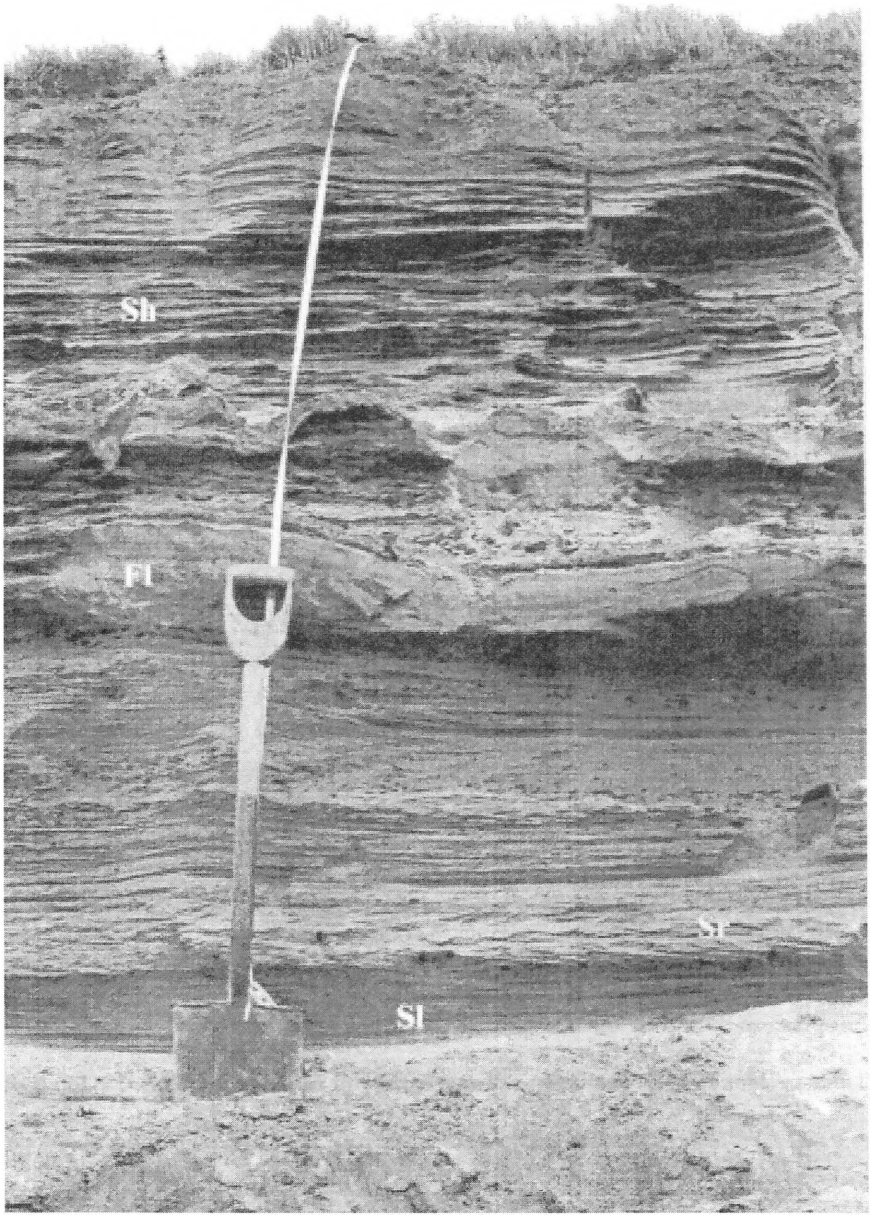


Figure 2 – Details of the facies exposed at Crawcook. Note the thinly bedded, horizontal nature of the sediments with occasional lags of coarser (coal grains) sediment and the small-scale ripple bedforms towards the base. Thick accumulations of silts are interspersed between these. Spade is 1m in height.

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Lynda Yorke
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BIOLOGICAL RESPONSES AND ENVIRONMENTAL CHANGE ACROSS THE CARBONIFEROUS BOUNDARY, REJMYREFJELLET, TEMPLEFJORDEN.

Tom Challands

The mountains immediately surrounding Tempelfjorden are composed of some of the most striking and conspicuous sedimentary rock sequences in Svalbard. On the rocks of Carboniferous and Permian age, Brian Harland, of the University of Cambridge and an extensive researcher into Svalbard's geology wrote "Few geologists have been to the archipelago without noticing fossils and making some observations of these rocks." (p. 310). Our original intention was to study macro faunal responses to Late Triassic marine regression, however we were not successful in reaching our intended locality, the nunatak Hallberget. We therefore turned out attention to the suitably prominent and accessible rocks of the northern slopes of Rejmyrefjellet (614m), which lie immediately due south of base camp, (Figure 1). Our intention at this location was similar, to study faunal and environmental change in rocks spanning the Carboniferous and Permian Periods, over 34 million years. Two simple hypotheses were proposed:

1. The light-dark banding so evident in the rocks surrounding Templefjorden indicate a change in the depositional environment of sediment and, as such, the fossil faunas in these rocks will also change and be representative of each changing environment.

2. Within a given rock horizon, the abundant brachiopods, though similar in superficial appearance, do in fact belong to more than one genus. By looking at variation and clustering of measurements of shell morphology of a random sample of these brachiopods, different genera may be distinguished.

Careful bed-by-bed measurement of the sedimentary rock types and the associated fossils along a transect on Rejmyrefjellet clearly revealed a change from a warm shallow marine environment to an even shallower open arid shoreline environment. Using principal component analysis (PCA), we found no basis to differentiate our sample population of productid brachiopods into more than one genus. All those observed are believed to be *Horridonia timanica* and confirm the proposal made by Gobbett (1961) that the Permian brachiopod *H. timanica* is an individual and distinct arctic form.

Geological Setting

Rejmyrefjellet is composed of rocks of the Carboniferous stage, the Pennsylvanian, and the earliest Permian stage, the Rotliegendes stage, 323-256Ma. The rock units in this area are grouped within a suite of rocks collectively termed the Gipsdalen Group. The lower slopes of

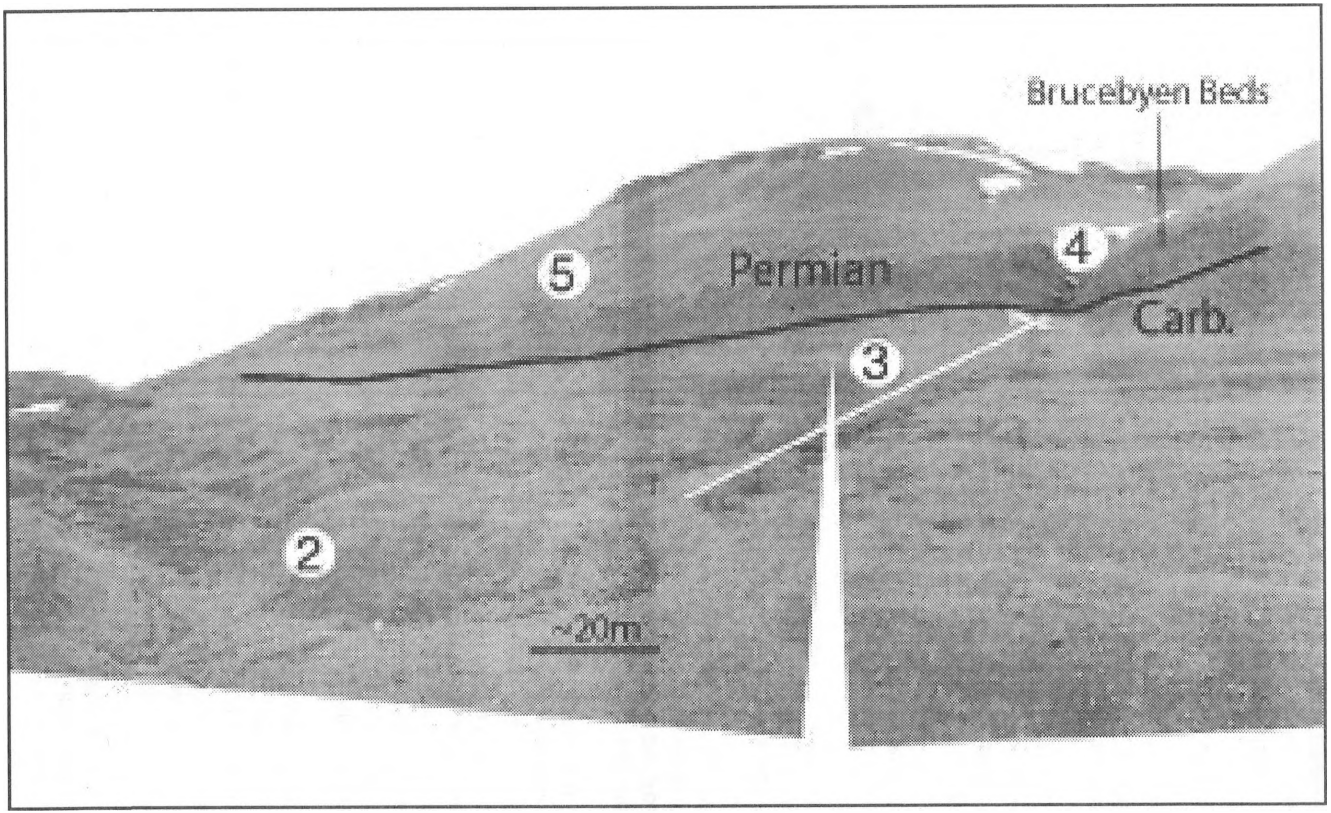


Figure 1 - Localities on the north of Rejmyrefjellet. Locality one is the site the photograph was taken from.

Rejmyrefjellet, up to an altitude of approximately 250m, consist of muddy limestones containing abundant fragments of skeletal material from invertebrate marine organisms (bioclastic debris) and are placed in the Wordiekammen Formation. Such limestones are characteristic of conditions of formation in warm shallow seas and, in this region, formed in a topographical depression during the Carboniferous and Permian, the East Spitsbergen Basin. The western edge of this basin, defined by the Billefjorden fault zone and including the region of this study, preserves the greatest accumulations of Carboniferous rocks in Svalbard, exceeding 1500m in thickness.

The Wordiekammen Formation changes characteristics laterally, being composed of coarser-grained limestones that pass into calcareous sandstones in the east. The upper 60-70m of the Wordiekammen Formation are characteristically different and warrant the assignation of a further subdivision, the Tyrrellfjellet Member. The base of this unit is defined by thick beds of dark, crumbly limestone, rich in organic matter and, most noticeably, containing abundant large shells (tests) of single-celled organisms called fusulinid foraminfers. These are known as the Brucebyen Beds. The Brucebyen Beds occur just a few metres above the boundary between the Carboniferous and Permian and are an important defining horizon throughout the region. During the Carboniferous-Permian transition, there was a short period of regional uplift creating a drop in relative sea level and the deposition of sediments that characteristically represent shallow warm seas close to a land mass. Such sediments include coarse conglomerates that formed around reef environments and may be represented in the Rejmyrefjellet section by coarser-grained bioclastic limestones.

In the upper parts of the Wordiekammen Formation, Miloslavskij *et al.* (1998) recognised 4-5m thick units of what they term wavy laminated limestone. It is possible that the microbially laminated mudstones immediately below and within the Brucebyen Beds, having a wavy appearance by virtue of the microbial mats, are these wavy laminated limestones. In any case, the presence of these delicate structures, and numerous rhynchonellid brachiopods in these rocks, indicate a quiescent shallow restricted lagoonal environment. The presence of gypsum bands in the Tyrellfjellet Member suggests that sea level was gradually falling during this time.

Sedimentary environment

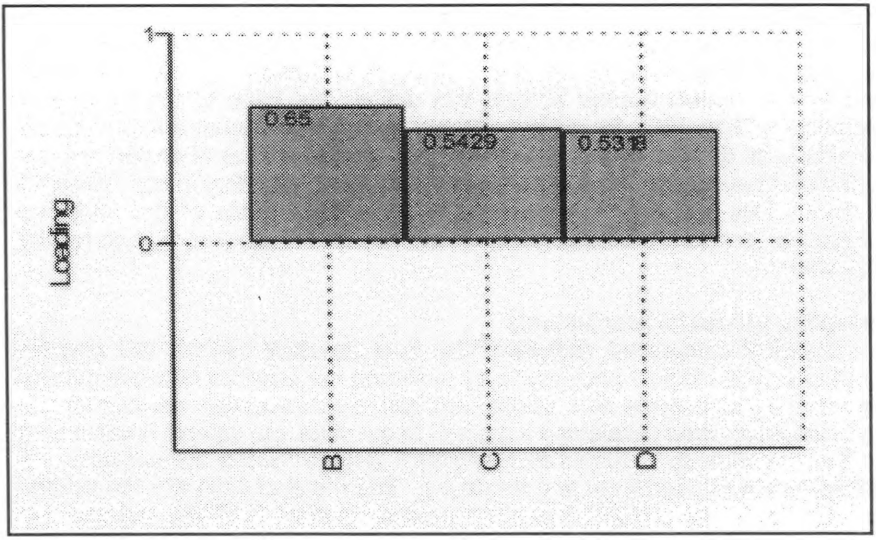
The sequence of rocks at localities 2 and 3 record an environment of deposition of limey muds, now hard and recrystallised, with fragmented shelly material dispersed throughout. This environment is dominated by solitary and colonial corals, echinoids and fragmented crinoids, with occasional partially complete productid brachiopods. Immediately above this, at locality 4, the sedimentary environment is characterised by thick, 4-5m units of lime mud bound by microbial mats with rhynchonellid brachiopods and benthic (fusulinid) foraminifers occupying isolated lenses between microbial mats. Microbial mats are indicative of calm, shallow warm water, the lack of shelly material testifying

to this. Between the microbial mat horizons, distinctive crumbly units occur, up to 5m thick. They are dark-coloured, rich in organic matter and contain hugely abundant fusulinid foraminifers. These beds are known as the Brucebyen Beds and form a distinct marker horizon that defines the base of the Tyrellfjellet Member. They also lie a few metres above the Carboniferous-Permian boundary, as defined by the appearance and disappearance of certain species of foraminifers, and so allow us to crudely define this boundary in our measured section. This boundary is concurrent with the appearance of the limestone containing abundant microbial mats, which, may be the defining horizon for the boundary.

Sampling productid brachiopods

Principal component analysis (PCA) is a statistical method that may be used to identify distinct populations by analysing the variance between several different measurements on a sample and also which variables account for the most variance when considered together. In our case, our sample is composed of 100 brachiopods collected from locality 5 (Figure 1) and our variables are simply length (*a*), width (*b*) and height (*c*). The result of PCA are two values, 'principal component 1' (PC1) and 'principal component 2' (PC2), that describe the variance of the variables in the sample. Principal component 'loadings' may then be calculated to investigate how much each variable contributes to each principal component value. The loadings can simply be illustrated as bar charts from which we may begin to interpret how each variable contributes to variance between the three variables. By observing that one variable has a high loading for a principal component, we may infer that that variable has a high variance and may be the distinguishing measurement for characterising a distinct population. To confirm this, principal component 'values' are calculated for each sample specimen for PC1 and PC2 and plotted on a scatter chart. If two or more distinct clusters are apparent, we may assume we have two different populations, the difference between the two populations being accounted for the variable with the heavy principal component loading.

For our sample population of productid brachiopods, PC1 accounts for 83.5% variance and PC2 accounts for 11.8% of the total variance in the data set. A scatter plot of principal component values does not reveal more than one distinct population (Figure 2). The principal component loading for PC1 suggests that the variance is equally distributed throughout the three variables, length (*b*), maximum pedicle valve width (*c*) and pedicle valve height (*d*) (Figure 1), and so our selection of brachiopods display a continuum of size as may be expected from a normal distribution; there is only one genus of productid brachiopod in our sample that, following the description of Gobbett (1961), most closely resembles *Horridonia timanica*. The variance observed may be attributed to intra-specific variation.



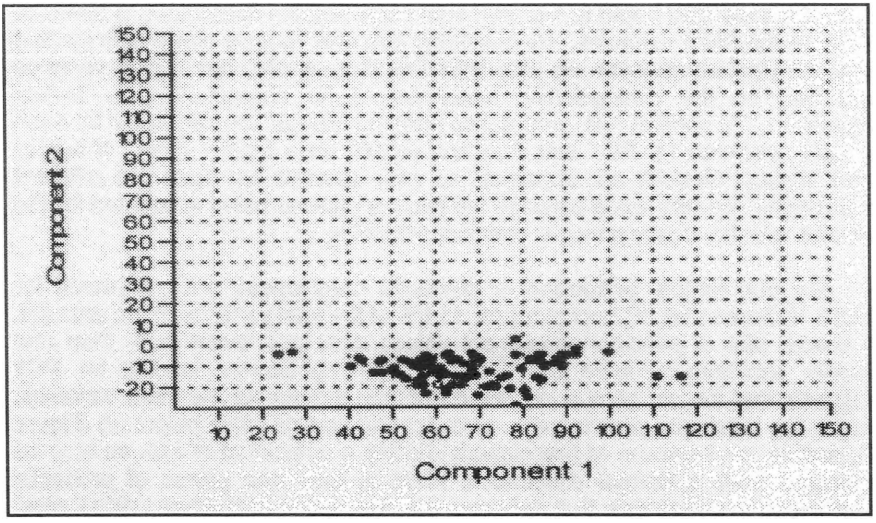


Figure 2 - a) One isolated cluster of PC values suggests a single brachiopod population. b) Equal loading of variables for PC1 also suggests that the variation in length, width and height of brachial valves is similar as may be expected from a normally distributed population.

Conclusion

The northern slopes of Rejmyrefjellet, Tempelfjorden record a change from a warm shallow marine environment to an even shallower open arid shoreline environment. This transition is associated with a change in the dominant fauna from a shallow water shelly association with productid brachiopods to one dominated by microbial mats, benthic fusulinid foraminifers and rhynchonellid brachiopods. The Brucebyen Beds, a significant marker horizon in the lower Permian, are recognised and the approximate position of the Carboniferous-Permian boundary is recognised from change in gross faunal associations and lithological changes.

Using principal component analysis (PCA) we found no basis to differentiate our sample population of productid brachiopods into more than one genus. All those observed are believed to be *Horridonia timanica* and confirm the proposal made by Gobbett (1961) that the Permian brachiopod *H. timanica* is an individual and distinct arctic form.

Note

Foraminifers ('forams') are single celled, chambered organisms that secrete a shell, or 'test' of calcium carbonate. As a group of organisms, they exhibit great morphological diversity, are abundant in many marine rocks, globally widespread and, by virtue of rapid speciation, are extremely useful for dating rocks. They are found in rocks from the Cambrian Period up to the present day. Fusulinid forams are just one group and are characterised by their lozenge shape and large size.

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EXCURSION REPORTS 2004

CHALK BECK QUARRIES, EAST CURTHWAITE

Leader: David Powell (Cumberland Geological Society)

Wednesday April 28th 2004

A large party met at the bridge on the minor road in East Curthwaite (NY 338486). The excursion was planned with the assistance of Mervyn Dodd who was unable to attend. The large party followed the west (left) bank of Chalk Beck upstream (south) from the road along a track through the gorge in the northern exposure in the St Bees Sandstone. The valley eventually widens out in the Eden Shales. The walk took the party diagonally across the dip and down the north-westerly dipping succession to older rocks. See Figure 1.

The St Bees Sandsone (Triassic) in this northern area has been quarried down dip west of Chalk Beck until the mid-20th Century. It is quite different from West Cumbrian exposures. The dull red sandstone beds are much thicker (up to 5m in places), more uniform without much lateral variation; bedding and joints are regular; there is very little of the green sandstone; shale beds are almost all ½ metre thick or les; rip-up clasts are not extensive. Small scale cross bedding is very clear in some of the many large abandoned quarries. White and grey sandstones, highly sought after in the early 20th Century were worked near the base of the St Bees Sandstone. Tom Smith's Leap is a remnant of these, reached by a short scramble on the right bank.

The Eden Shales (Permian) lower in the succession, here are equally red but dominantly shale and siltstone with subordinate ½ metre beds of white/grey sandstone. There is an interesting group of small faults, dipping southwest with minimal throws but some mineralization. The basal breccia outcrops beyond the first difficult gorge.

The Hensingham Grit Formation was not reached on this excursion. It has white coarse poorly sorted sandstones similar to West Cumbria, besides much thin purple shales. Limkilns suggest there is (no longer exposed) good quality limestone.

The southern exposure of the St Bees Sandstone, not seen on this visit, has the Green Quarries. These worked the much thinner sandstones (with thicker shale beds) for "green and red slates" in the 18th Century according to Hutchinson's History of Cumberland.

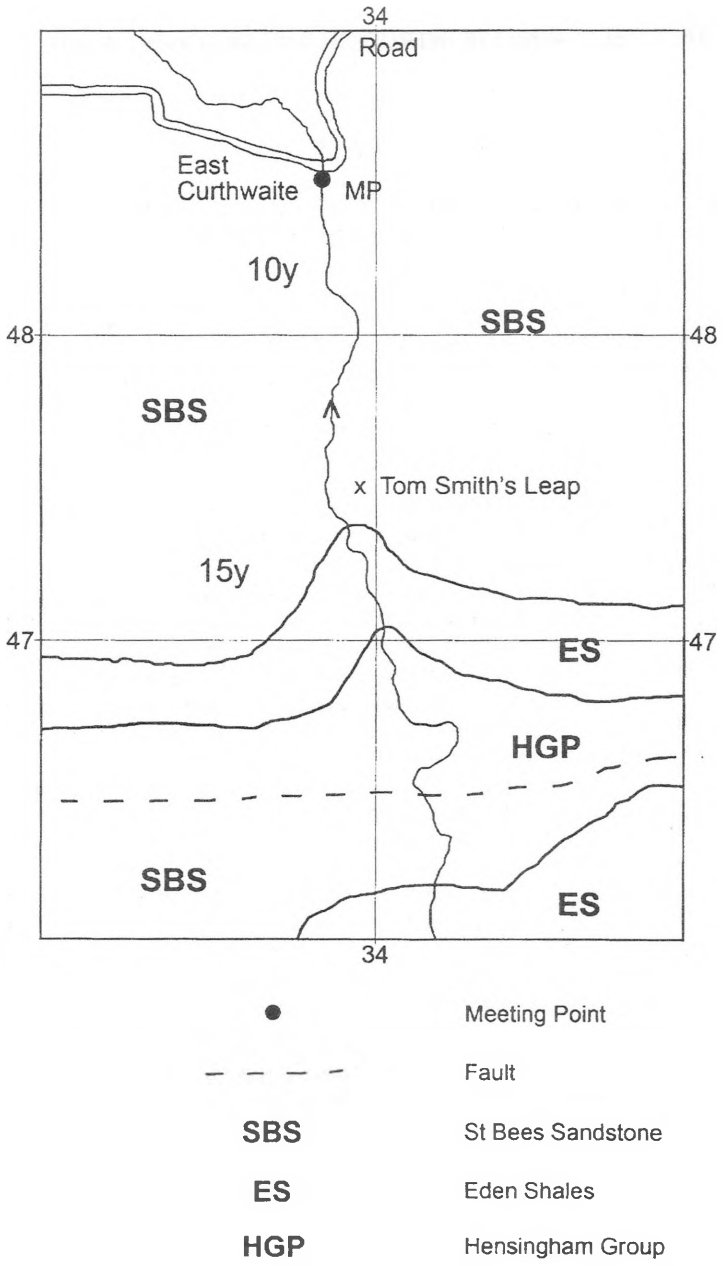


Figure 1 – Sketch map of the geology of the Chalk Beck area.

SALE FELL: MINETTE INTRUSION AND SKIDDAW GROUP

Leader: David Livesey (Cumberland Geological Society)

Wednesday May 5th 2004

A party of members met on an extremely wet spring evening just east of St Margaret's church, at the start of the footpath to the fell (NY 192302).

About a dozen members gathered below the northern slopes of Sale Fell (NY 192303) to examine structures in the Skiddaw Slates of the area. The leader explained that Sale Fell was an anticlinal fold with a west north-west – east south-east axis. Rocks of the Loweswater Formation make up the bulk of the fell with younger Kirkstone Formation rocks on either side. The exposures to be examined lay in the Loweswater Formation which is of Lower Ordovician age (Arenig).

The first exposure (NY 193302) was clearly visible from the road and easily reached. Detailed structures observed here were more complex than expected on a plunging limb of a simple anticline. Complicated folding showed dips that varied from near horizontal to 60 degrees south-east and many discontinuities were present. The leader explained that the Loweswater Formation consisted of sandstones of varying grain size together with mudstones and siltstones. These were derived from deposits laid down in deep water on the continental shelf of an ancient land mass. Such deposits would be liable to slumping down gradients with folding and possible overturning, before being consolidated. At this first locality the extreme and sometimes discontinuous changes in dip within short distances vertically and horizontally were thought to be evidence of synsedimentary structures formed before any tectonic folding. Later folding of the Caledonian orogeny formed the Sale Fell anticline.

The party circled round with little difficulty to further exposures of Loweswater sediments some 100 metres west of the summit cairn (NY 193297). A prominent quartz vein lying parallel to the anticline axis was noted on the way. At the second exposure the sediments showed examples of small scale (5 to 10 cm) upright folding overlain with comparatively undisturbed horizontal laminated layers, additional evidence for structural distortion before lithification. Further eastwards a large feature that took the form of a smooth wall was identified as a near vertical bedding plane striking west south-west – east north-east. Dip at ground level was 50 degrees south-east and steepened to almost 90 degrees at a height of 3 metres. This impressive wave-like feature was surmounted by near horizontal beds. The party was not able to decide whether the steep bedding plane was overturned or not. The BGS Sheet 29 (Keswick) map, 1999 edition, shows overturning at this locality.

Before leaving this last locality a small group of massive, rounded rocks, some 50 metres north-east, was visited. This was an exposure of the Sale Fell

minette, a dyke of calc-alkaline lamprophyre, possible associated with the Shap Granite and intruded into the Skiddaw Group in early Devonian times. The minette is a hard and compact rock with greenish grains in a red-brown matrix.

The party regained the road as light was fading where the President thanked the leader for an interesting excursion.

THE COAL MEASURES SOUTH OF WHITEHAVEN HARBOUR

Leaders: David Kelly & John Brown (Cumberland Geological Society)

Wednesday May 19th 2004

The party met at Whitehaven south beach car park (NX 967183) where it was explained that the aims of the visit were to view parts of a Coal Measures cyclothem exposed in the cliffs immediately south of the car park, to look at aspects of the mining history of the area and to examine the reasons for the slope stability problems currently affecting attempts to redevelop the cliff top area.

The lower cliff section lies in the upper Coal Measures and is of Westphalian C age. It is in the part of the succession which includes the Brassy and Unnamed E seams. The first unit examined was a sandstone which is exposed in cliff sections beside the path immediately south of the car park. Here the sandstone is about 7m thick but it thins southwards along the coastal cliff (not seen on this visit). The sandstone is light grey to buff coloured and fairly fine grained. The sandstone comprises several separate beds. A prominent feature is the strong cross bedding in the top metre of the unit. This is clearly seen in dip and strike sections and dips consistently to the south south-east. The sandstone is overlain by a seat earth and a thin coal which are no longer exposed. It has been interpreted as a crevasse splay deposit formed by a levee breaking allowing sediment and water to flow into the inter-channel area. A minor fault tending roughly east-west is seen in the corner of the quarry.

The party then clambered down the difficult collapsed slope to the shore. Amongst the collapsed boulders, part of the succession was exposed in the cliff. The lowest bed is a dark grey mudstone with prominent rootlets; this has been interpreted as a seat earth. This passes upwards into 10cm or so of black mudstone with carbonaceous laminations and then into a bright coal seam about half a metre thick. This could be the Brassy Seam. Above this is a sandstone with an erosional base and above this a second sandstone – that seen by the path at the first locality. Many of the fallen blocks of sandstone contain large ironstone nodules.

Leaving the shore the party then made its way up Sea Brow, passing the remains of Wellington Pit. At the top of the cliff the purpleish beds of the Whitehaven Sandstone were visible. The relationship between the Whitehaven Sandstone and the Coal Measures has long been a topic of debate. It has, in the past, been attributed to secondary deep oxidation of the already deposited Coal Measures due to the lowering of the water table and the onset of the arid conditions of the Permian. Evidence for this was claimed to be an irregular base and thickness variation of the Whitehaven Sandstone. However the 1997 Geology of the west Cumbria district memoir, following Kendal (1896) and Eastwood (1931), describes it as a separate lithological unit with an erosional base. The Whitehaven Sandstone Formation is described as being 300m thick with a 100m thick Whitehaven Sandstone Member at the top.

The cliff top area has been cleared of much evidence of former mining activity. Its potential re-development is hampered by the risk of slope failures. The cause of the slope failures could be partly due to the lithological characteristics of alternating permeable and impermeable layers, structural characteristics of gentle dip towards the coast and strong joints and faults tending roughly north-south parallel to the cliff and also to former mining activity. A recent drilling programme has attempted to determine the extent of this problem.

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THE SUBMERGED FOREST ON ALLONBY BEACH

Leader: Fred Lawton (CGS)

Wednesday June 2nd 2004

A large group of members and visitors met at Allonby with the aim of walking the beach to ascertain whether any exposures of the submerged forest still exist and are visible at low tide. The excursion had been advertised on local radio and in the press and it was clear there was great interest from the public on these features.

The Society had last visited the beach in June 1985 when good exposures were present. The leader produced a wood fragment from the last excursion and there was much discussion as to its identification.

An area north-west of the Allonby (around NY 078442) was searched but proved unproductive. There were a few poor exposures of peat beneath the surface beach sand but no clear evidence of wood or tree remains.

A site further north directly out from the board walk at Beckfoot (NY 083483) revealed some excellent tree stump remains rooted in the beach muds. Additionally there were fragments of tree branches and trunks still intact in the beach material which is clearly a boulder clay deposit. Most of the tree remains are said to be oaks but the group did not have the means of identification.

There was a general explanation given on the origin of these features based on the previous research literature. Many questions from the visitors suggested interest in this topic. It was a useful excursion to publicise the Society and the topic of geology.

THE NAMURIAN ROCKS AND MINERALISATION AROUND ALSTON

Leaders: Charlotte Vye & Stu Clarke (BGS Edinburgh)

Saturday June 5th 2004

This excursion was to the edge of the Alston Block, a pre-Carboniferous structural high underpinned by the Weardale Granite. Sedimentation in the Dinantian was very much thicker in the surrounding basins like the Stainmore and Northumberland Troughs than on the Alston Block. Namurian sediments were much more clastic, heavy minerals suggesting provenance from the north-east.

Charlotte Vye and Stu Clarke of the BGS led the group of 15 or so members to the West Allen valley in the morning and to the Nent valley between Nenthead and Blagill in the afternoon. These two leaders, enthusiastic, young officers of the BGS, had a lively, witty, humorous but authoritative approach. They were working on the remapping of the area east of Alston and showed us some of the Yoredale sequences and mineralisation of the district.

The north north-east trending extensional faults with small throws which are of Namurian age control the mineralisation. As shown in a diagram in Bulman "The Geology of Alston Moor", p26, the faults in hard beds are high angle and open, thus carrying the minerals. In soft rocks the faults are at lower angles and the mineral veins are pinched out. When mineralisation occurred, the Weardale Granite was coolish, about 100^{0}C. Locally the main minerals are are zinc minerals, barites and baryto-calcite, lead minerals being of less importance.

The morning excursion began near Carrshield (NY 803703) and followed the River West Allen upstream south to Coalcleugh (NY 802452). We started by looking at the gated Scraithhole Low Level with its fine masonry. This was a very extensive working in the Great Limestone (thus very close to the Dinantian-Namurian boundary) and the rocks above. Immediately across the river were the abandoned Barney Crag Mine Shop and the Barney Crag Level. This level was first cut in 1760 into the shales between sandstone posts to reach the Coalcleugh East Vein.

Under the bridge over the West Allen River, the sandy, unfossiliferous Iron Post limestone is poorly exposed in the stream bed. This is an important marker band in mine shafts. The small, abandoned Barney Crag limestone quarry west of the river exposes the full thickness of the Great Limestone locally. The sketch section (Figure 1) summarises the sequence there.

The more or less horizontal rocks young upstream towards the Firestone Sill and the Little Limestone. The river has a stepped profile, reflecting differences in rock hardness with its valley narrowing markedly near the small waterfalls. About 100m upstream from the quarry, the beds show desiccation cracks and many sponges (as yet unidentified) were seen.

The West Allen crosses a small graben about 100m wide, which has little expression in the landscape, other than not very obvious changes in the vegetation apparent in aerial photos picking out the fault lines. The graben lies between 2 cross veins, the parallel noth-west – south-east trending Coalcleugh East/West Allen Great XV and Coalcleugh West XV faults. Younger rocks near the Firestone Sill are exposed, probably the Little Limestone with a shale band immediately below, in the graben just south of the Coalcleugh East/West Allen Great XV fault. These contain large (½ - 1m across) exposures of sponges.

Between the graben and Coalcleugh are several small waterfalls, more large sponge "colonies" and a small coal adit near a shale. The sandstone beds are important stratigraphically but of limited lateral extent and are named differently in neighbouring mines. One could be the White Sill.

The Coalcleugh area had abandoned mines with rapidly eroding tips of friable shale and sandstone west of Sunnyside (NY 801452). North of Sunnyside, a horizontal, resistant, heavily fossiliferous sandstone (probably the Pattinson Sill) had "created" a 5m high waterfall, very much at the edge of the valley. Upstream were the well-vegetated remains of flat (or flattened) tips, part of the Low Coalcleugh Vein complex of lead/zinc mines which extended towards Nenthead. Immediately south of Sunnyside, large tips contain quite good fluorpsar samples besides the usual vein material with a little galena and sphalerite. A waterfall 200m west of Sunnyside is though to be caused by the Firestone Sill, a good marker band. This is a heavily cross bedded sandstone, coarse, resdistant with distinctive brown/red iron oxide flecking.

Shortage of time made the afternoon visit to the south facing slopes of the Nent Valley all too brief. We followed a track from near West Cocklakes (NY 753470) to a viewpoint overlooking the Blagill Valley at NY 743475. This side of the valley had a stepped profile in the Namurian rocks with structural benches, attributed to glacial plucking. The rounded north facing slopes opposite are till.

Immediately below the track was a broad bench in the almost horizontal Great Limestone with shake holes, a collapse feature due to solution of the underlying limestone. A little lower down are small limestone quarries and a limekiln, all long abandoned. Nearer the river and lower again is another structural bench, developed either on a lower limestone (Four Fathom?) or a sandstone sill. Above the track are a series of small coal drifts, the coal seam splitting into 2 westwards. These mark the top of a cyclothem in the rock succession below the Little Limestone. In one of the tips of characteristically dark shale and sandstone fragments one of the party found a good specimen of *Calamites/Sigillaria*. The Little Limestone is pinched out by a fault and seems to thin out westwards.

One final stopping place was where our track crossed Fista's Rake. This was a very productive mineral vein long worked with many small tips near the track. This stop gave a panorama across the Blagill valley to the hamlet of the same name and the upper workings of the Blagill Mine, which in large part worked Fista's Rake.

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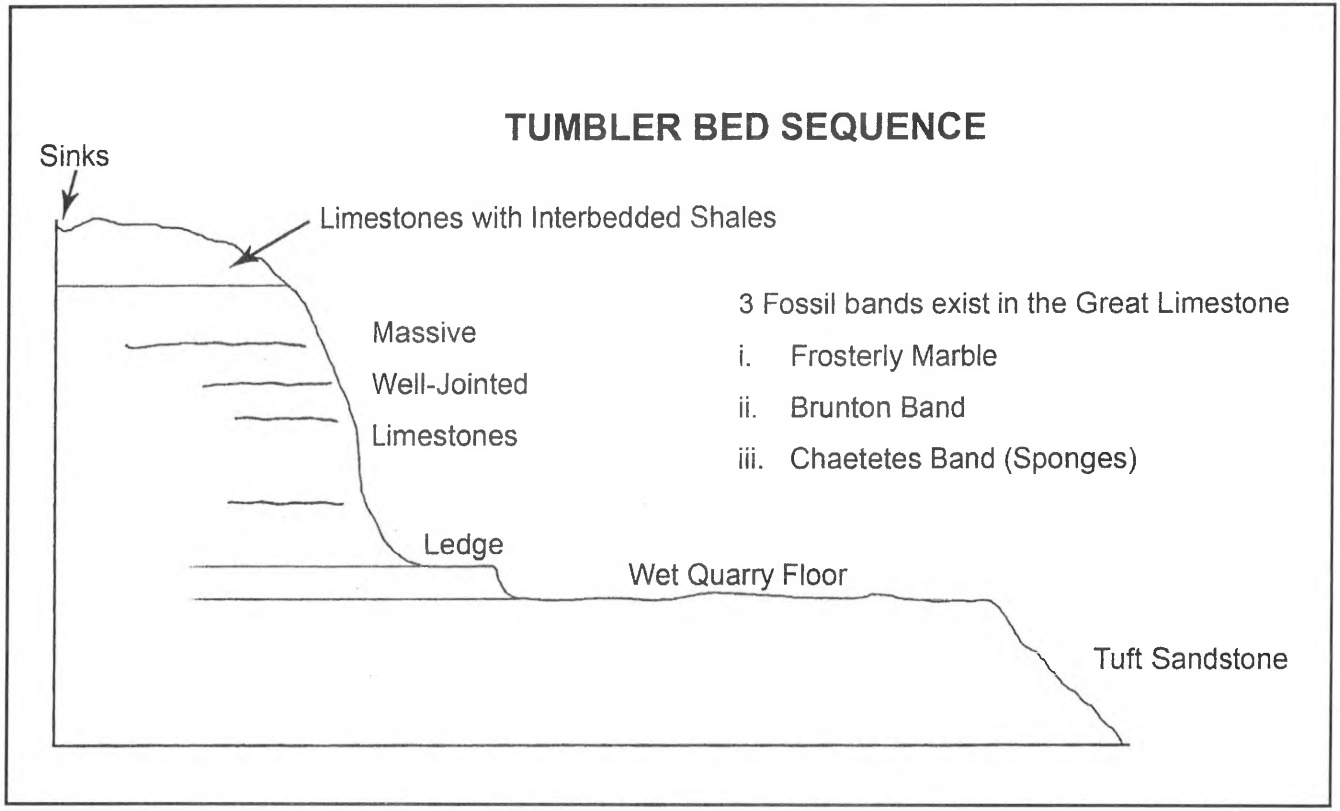


Figure 1 – The succession at Barney Crag Quarry – complete Great Limestone Succession.

FORCE CRAG MINE, COLEDALE

Leader: Penny Webb (National Trust)
Organized by Alan Smith
Wednesday June 23rd 2004

This excursion started from the National Trust Headquarters at Bowe Barn on the Borrowdale Road. We were transported to the head of the Coledale valley by minibus where the mine is situated, 2½ miles south-west from Braithwaite village.

This excursion was to see the surface of the mine and to visit the interior of the mill and the process of how the minerals were extracted from the mined material. The mine has a very chequered history and in its time has produced barytes, lead and zinc. Other minerals have been found in smaller quantities: silver, pyrites, cerussite, stolzite, fluorspar and manganese have all been produced at the mine. The mill itself has been built using the natural slope of the hill to utilize gravity to assist in the process of moving the mined material about through the different processes. It was amazing to see how much machinery there was in such a confined space. The mill has been at its present location at a height of 300m since 1908. Over the years the mill has been rebuilt and the machinery replaced and renovated. The mine closed in 1992, the last working metal mine in the Lake District. The mill, which remains today, dates from its last owners, the Coledale Mining Company. The last products from the mine were zinc and barytes.

The geology and the mine.

The whole area is within the outcrop of the Skiddaw Group (Kirkstile Formation). Structurally this is a complex area, dips are broadly to the south-east, but there are some complex folded areas on the northern flank of Coledale. The mineralised vein exploited at the mine runs almost east across the valley. The steep end of the valley exposes rocks within the Crummock Water aureole. A genetic relationship between the Lake District batholith and mineralisation is still advocated. At Force Crag there is evidence for vertical zonation of the mineralisation: abundant baryte with some manganese oxides and relatively scarce lead-zinc sulphides give way downwards to more sulphide-rich, lead-zinc mineralisation with very little baryte. The main vein rock varies between about 1 and 1.6 metres, but is up to 3 metres in places. Generally the country rock is sound and hard, as a result many of the workings particularly in the lower levels require little support.

Two levels of mining exist, the Low and High Level Workings, represented by a series of horizontal adits on the fellside leading to large open stopes (areas where the minerals have been removed). Additionally, surviving evidence of mining operations includes tips, dressing floors, settling ponds and mine processes buildings.

The processing mill

The mined material was first dumped on to a "grizzly". This is a large sized grid made out of Bull Head rails that are made at Workington for the permanent way for our railways. Any lumps that would not pass through this were broken up by hand to allow them to pass through the nine-inch square of the grizzly.

Beneath the grizzly is a hopper that fed material onto a short apron conveyor that delivered it onto a belt conveyor. This conveyor then delivered the material to the 21-inch jaw crusher inside the mill. The jaw crusher was the start of the process to reduce the size of the material and to sort the ore from the country rock. A conveyor then took it to a single deck screen where the coarser material was returned to the crusher. The remainder went to the coarse ore hopper. Under the hopper was a screwfeeder that fed onto a conveyor that then went on to a double deck screen that fed into the coarse 4-department jig.

This is where the initial separation took place by using the different specific gravities of the different minerals in the ore. This was done by agitation in water. The heaviest minerals – cadmium and galena – would drop first, followed by pyrite and manganese finally the zinc and barytes. From the coarse jig a conveyor transferred the ore to the fine ore hopper across a screen and into the fine 4 – department jig. The light country rock that remained was sent to the waste tip. A bucket conveyor now transported the concentrated ore to a surge hopper whose purpose was to ensure that there was a continuous flow to the ball mill. The ball mill now crushed the concentrated zinc and barytes to a powder by rotating a cast iron cylinder that inside had 4-5 inch steel balls. From the ball mill, the slurry passed into a rake classifier that returned any particles that were too coarse for the next flotation process back to the ball mill. A slurry pump now pumped the material in to the flotation tanks.

The flotation tanks are where the zinc and barytes were separated. The finely crushed powder from the ball mill and the other processes reduced the particles down to about 7 microns, this allowed mechanical separation. This was now a complicated flotation process that separates the barytes from the zinc. For this to happen the specific gravity mix was calculated in the flotation tank and when this was right, hydrophobic xanthates were added to repel water off the zinc particles. A mix of 'collector' oils and air bubbles floated the zinc mineral particles to the surface and the bubbles were creamed off over the edge with rotating paddles into a sloping gutter taking the zinc with them. The same process was carried out on another set of flotation tanks that are oiled and geared for the barytes. Finally the separated ores were put through a rotating disc filters that removed the water and on to the final packing and dispatch.

The National Trust

The Society thanks the National Trust for the visit and all the work that has been done on the preservation of this site for the future. This is a most important site of the mining history of the Lake District and we wish them well for the future.

References

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Acknowledgment

The Society thanks Mike Davies-Shiel for the flow chart of the process and the technical information text on the flotation process.

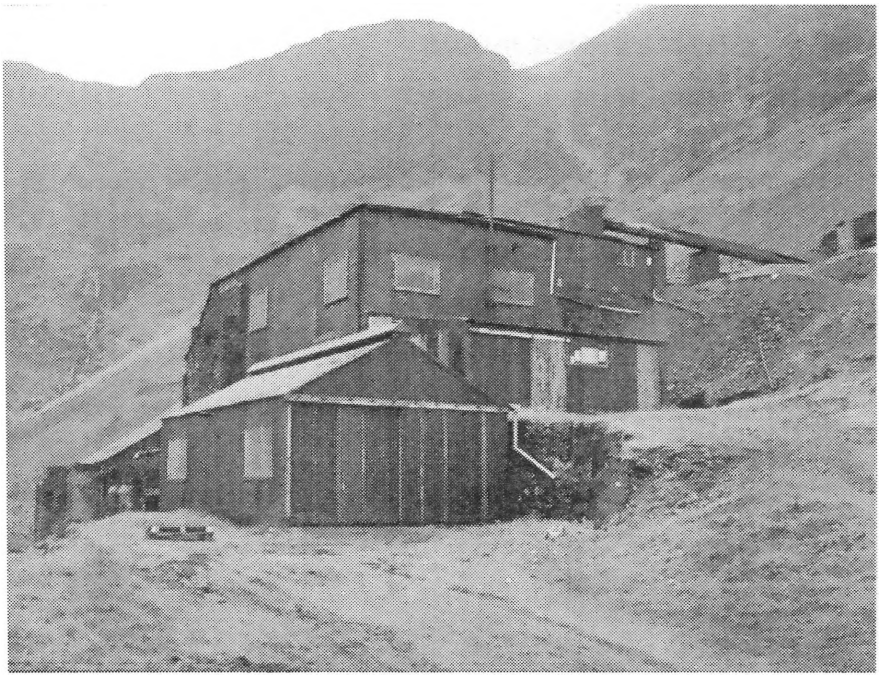


Figure 1 – The process mill at Force Crag Mine



Figure 2 – Adit No.1 Force Crag Mine

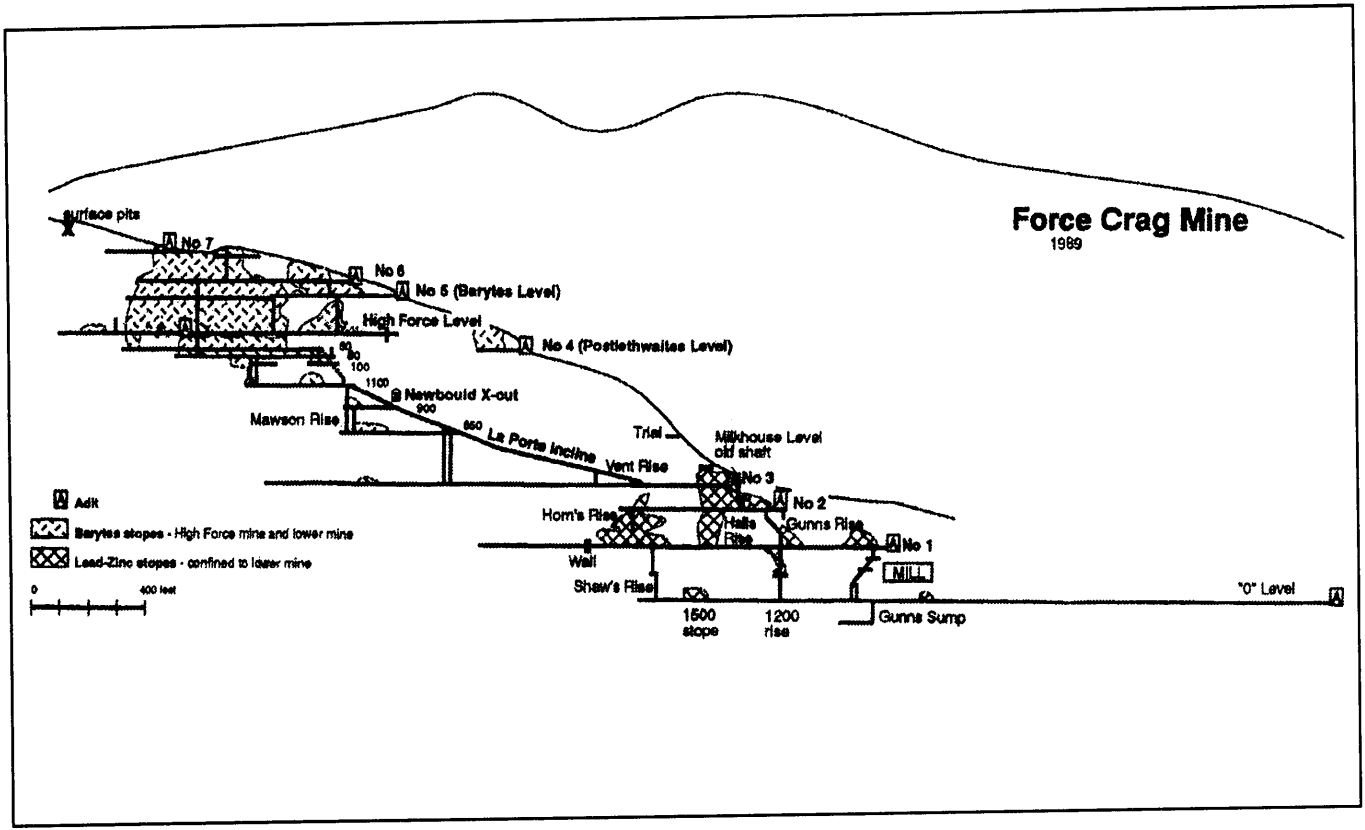


Figure 3 - Diagram of Force Crag Mine, by R. A. Smith

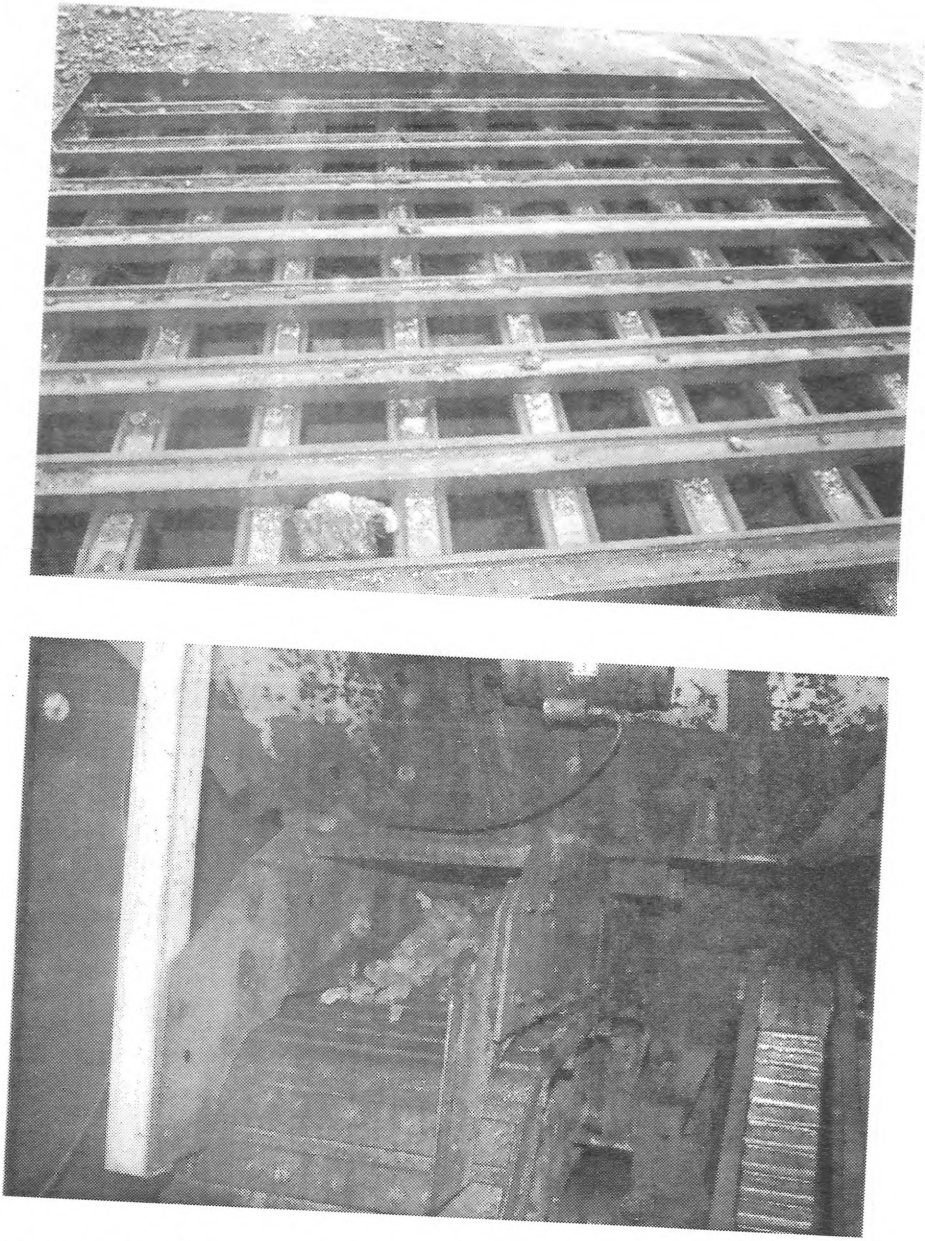


Figure 4 – The Grizzly (top) and the Apron Conveyor (bottom)

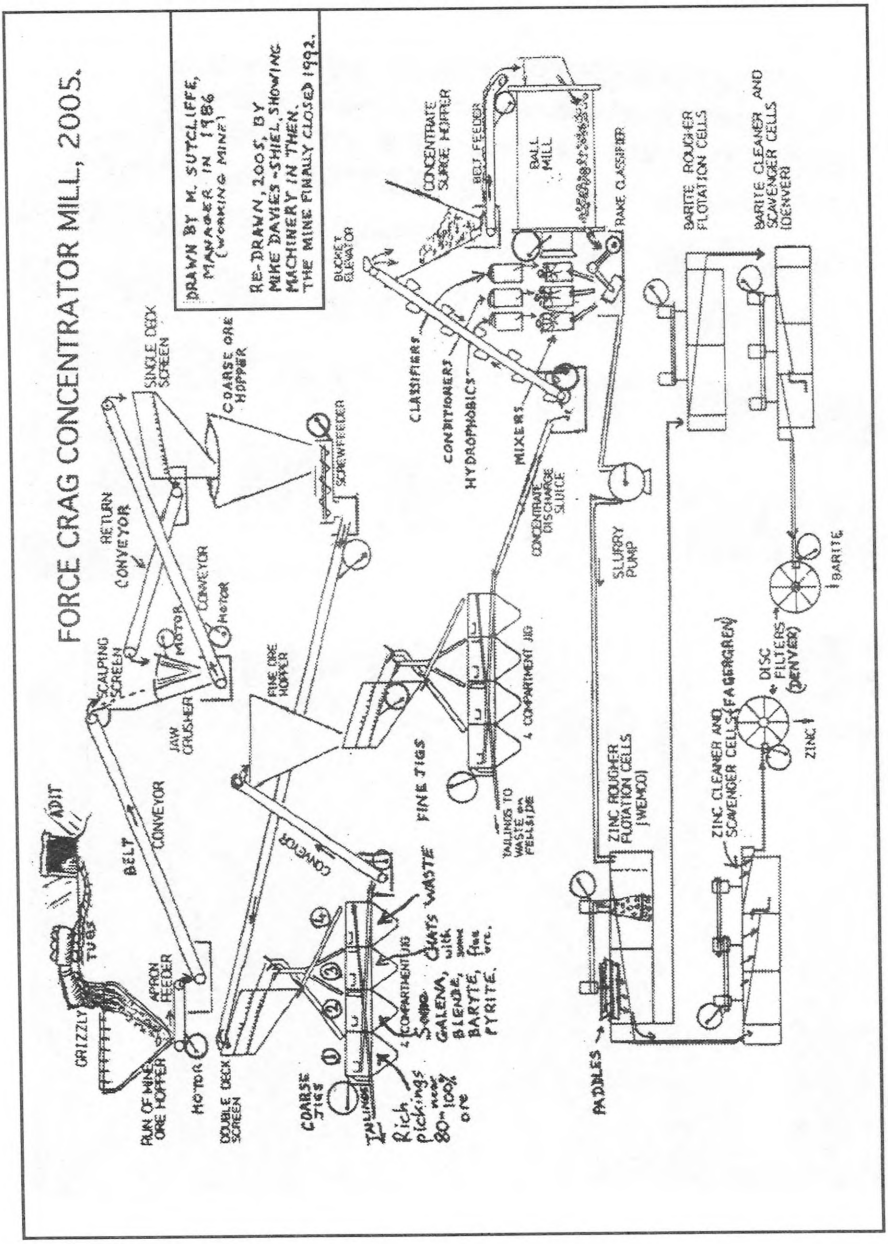


Figure 5 – Force Crag Concentrator Mill 2005

THE BORROWDALE VOLCANICS OF UPPER WASDALE AND ILLGILL HEAD

Leader: Alan Smith (CGS)

Saturday July 3rd 2004

A group of around 20 members enjoyed a fairly strenuous excursion from Wasdale Head to the summit of Illgill Head and back via the Burnmoor Tarn corpse road. Misty conditions in the summit area made the location of outcrops at times rather tricky.

The excursion was aimed primarily at the graben structure of Illgill Head which contains an upper BVG succession faulted into the Birker Fell Formation (lower BVG), which underlie most of the upper Wasdale area. The general structural features of the area were also illustrated and their relationships to the landscape discussed. The glacial and paraglacial landform features were also explained.

The lower part of the ascent from the Wasdale Head campsite car park towards Illgill Head traverses Birker Fell Andesites (BFA). Good exposures exist in the pathside crags. Typically these rocks are dark massive andesites, often porphyritic and sometimes brecciated. These sequences lie in thick sheets over the Upper Wasdale area and represent the earliest andesite flows of the BVG.

The path closely follows a prominent quartz-felspar granite porphyry dyke which runs for a considerable distance from upper Wasdale striking in a southerly direction to Illgill Head and beyond where it intrudes the Eskdale Granite. There is an exposure of the dyke which members examined in Lingmell Gill (NY 186074), but better sections along the path close to the ruined buildings at NY 183064 where the dyke forms a topographic feature and the contacts with the BFA can be examined, prompting much interest. The dyke is usually between 5 and 20m thick in this section but it is wider further north. It has now been dated and is of similar age to the Shap Granite.

The eastern (unnamed fault) that delimits the edge of the Illgill Head graben is marked by a distinct change of slope. Sections in the Long Top Tuffs (LTT) were examined at NY 176057. These are ignimbrites, full of small lithic fragments and showing weak foliation and fiamme. It produces a fairly massive rock, poorly sorted with few bedding features. Whether it represents a single volcanic event or was fed by a more continuous flow of material collecting over a period of time is unclear. In total the LTT are over 300m thick supporting the idea they collected in a caldera. It is dacitic in composition and the way the fiamme weather 'in' was noted.

Further uphill the Crinkle Tuff exposure was seen. This is a dense black rock, only about 30m thick – a welded ignimbrite, notable parataxitic. Sections of the dyke were again located in the summit area of Illgill Head.

The summit of the fell is formed of the very distinctive Napes Needle Member – a coarse tuff, garnetiferous, well-bedded, with distinctive fiamme and a distinctive fretted weathered texture. The summit plateau is formed of the highly brecciated Yewbarrow Breccia.

On the south-west flank of the fell outcrops of the bedded tuff – accretionary lapilli bearing (shown dotted on the map) were seen. Discussion regarding their origin ensued.

The structural impact of the fault structures on Illgill Head and the major Greendale and Dore Head faults that cut across the Wastwater trough were illustrated from the summit viewpoints. Similarly the effects of the N-S Whillan Beck Fault on the depression of Burnmoor Tarn were explained. The leader also discussed the formation of the Wasdale screes and the way the slopes are controlled by the Iron Crag Fault and the eastern unnamed fault of the inlier. A paraglacial rock slope failure at NY 174057 was also explained (see recent paper in Proc.Geol.Assoc. vol. 116, 2005).

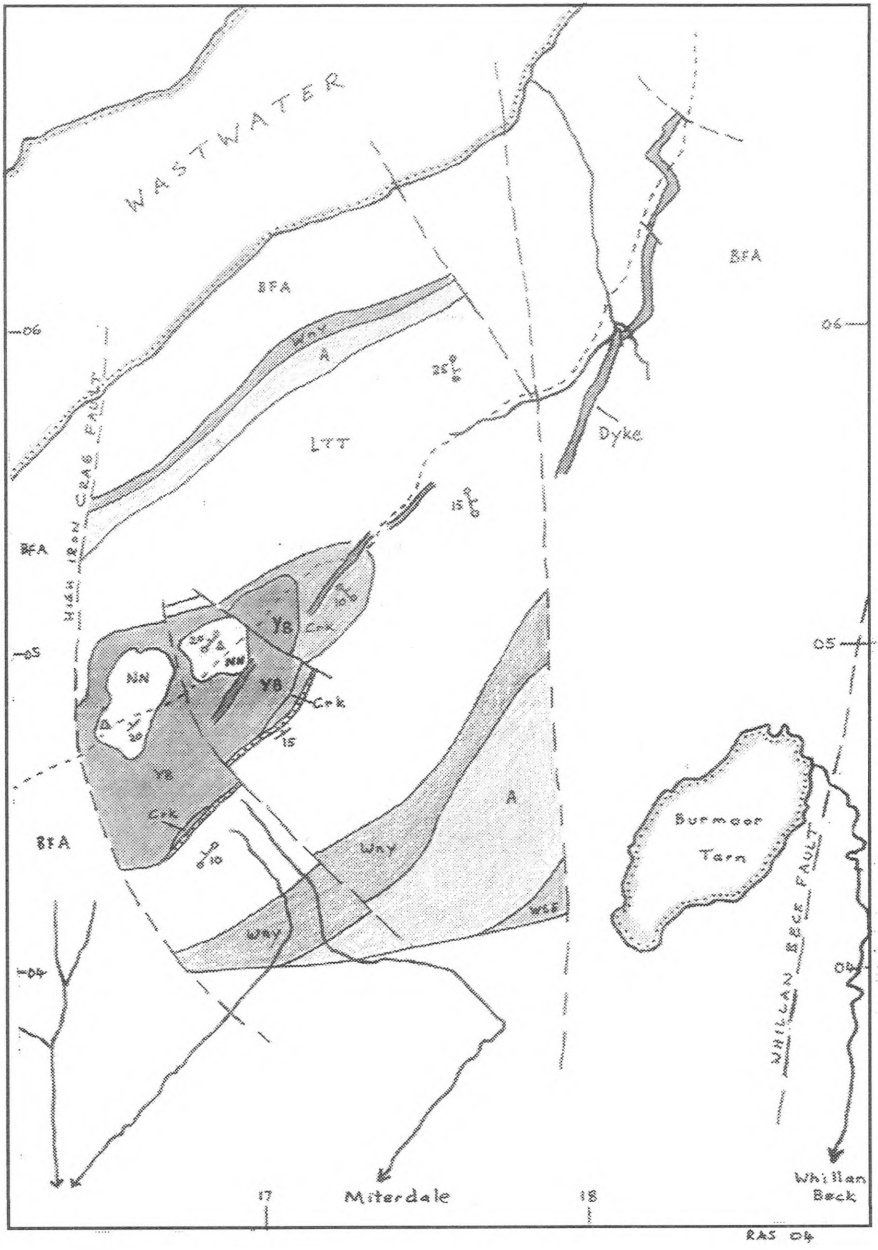


Figure 1 – Geological map of the area based on BGS 1:50,000 sheet 38 and data from Beddoe Stevens (personal communication) 1994. For key, see Figure 2.

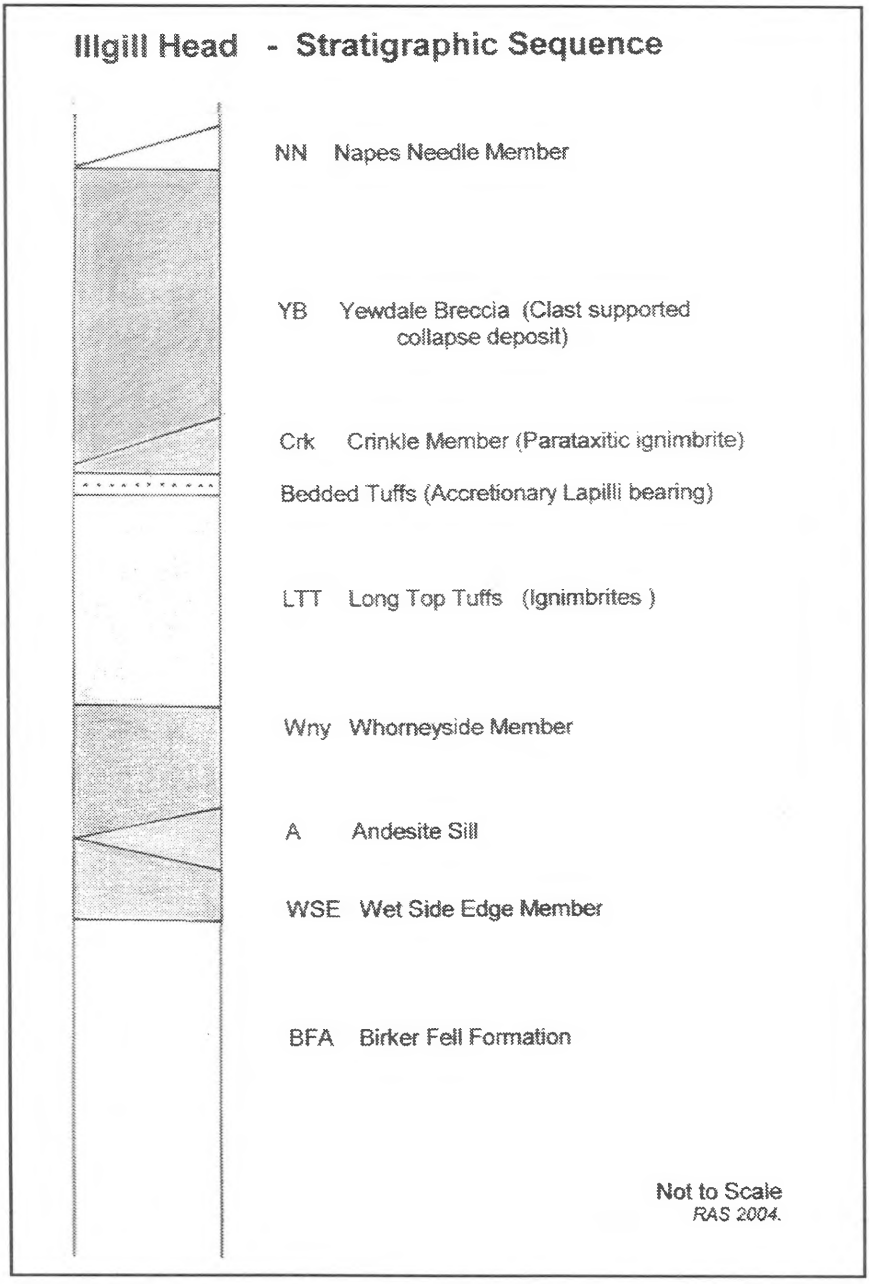


Figure 2 – The stratigraphic sequence at Illgill Head.

THE HOWK, CALDBECK

Leaders: Anne Freeland & Susan Beale (CGS)

Wednesday September 15th 2004

An extremely large group of members and friends met at the village car park, Caldbeck, (NY 323399). Here the leaders explained that Caldbeck is an ancient village set in a valley developed in the Lower Carboniferous rocks. A hundred years ago the population was some 1500 – twice that of today – based partly on the mining of lead and copper. The last mines to close were the Potts Gill and Sand Beds barytes mines in the 1960s. There are many limestone quarries in the vicinity but only one is still working. Many streams flowing from the south were used to power mills, especially Welpo Beck which lies between the limestone scarp and the Eycott lavas. The rocks of the area are Asbian in age and lie close to the base on the Carboniferous in north Cumbria. The rocks seen on the field trip are in the 5th and 6th Limestones.

The party followed the path upstream along the left bank of the beck, seeing progressively younger rocks. At the first gate a damp area may indicate the position of the outcrop of the 6th Shale. The party paused at The Howk bobbin mill where there was much debate about the origin of the red sandstone seen in the buildings. Poor light prevented making any definite conclusions. The 6th Limestone is exposed in river cliffs at The Howk. Thurlow's "homogenous layers", lacking in sedimentary structures, are said to indicate deposition below the wave base. Productids and corals were noted. The view to the south of the river showed the transition to nodular limestone, whereas on the north side there was some apparent lateral facies change.

Fairy Bridge is said to be a former natural arch and from the bridge a very large fallen block of nodular limestone was seen. Brachiopods are visible in the limestone in the stream bed. From this point the 5th Shale can be seen upstream. The prominent waterfall and stream bed potholes are in the 5th Limestone.

In badly deteriorating light the party made its way out of the gorge path into the fields beyond to view the well-developed river terraces. The origin of the gorge was discussed and rejuvenation, superimposed drainage and cavern collapse suggested as possible causes.

THE BORROWDALE VOLCANIC GROUP AT WATER CRAG, WASTWATER

Leader: David Kelly (CGS)

Wednesday May 4th 2005

A large party assembled by the lakeside road at Wastwater for the first excursion of 2005. The purpose of the visit was to examine the volcanic rocks at the Rigs site either side of the road at SD 155060. The rocks form part of the Birker Fell Formation, low in the Borrowdale Volcanic Group. The 1:50 000 Ambleside sheet shows andesite and sandstone at the locality. The party examined various natural exposures, all within 100m of the road. Interpretation of the rocks was difficult and, for some of the exposures, the party could not reach a concensus of opinion.

The highest, and probably youngest, exposure examined was in the prominent crag on the north side of the road. The rock forming the crag was a mid-grey lava with pale phenocryts, presumably of feldspar. The phencrysts weather to give a charachteristic pitted appearance. The rock had a distinctive pale weathering patina with some rusty brown traces. There were numerous small vertical joints.

Below the crag, still on the north side of the road, after a small area without exposure, is a particularly dramatic exposure where sediment is seen overlying a lava. The sediment is a strongly laminated silty mudstone. Apart from the laminations, no other sedimentary structures were identified. Dips are variable but very gentle. The boundary with the underlying lava is irregular and, at one point, displaced by a minor fault. The lava is dark-grey in colour, with prominent black phenocrysts which stand proud on weathered surfaces.

Tracing the exposures of the sediment and the underlying lava on the south side of the road proved problematic, although both rocks are clearly present. It was noted that, further north-east, the lava became more blocky and had areas of sediment included within it. It was suggested that this could represent the blocky end of the lava flow or, alternatively mass movement deposit.

There is also some evidence that there may be a second sediment deposit beneath the distinctive lava. Still further south of the road there is another lava, more similar in its characteristics to the one at the highest part of the sequence.

FOSSIL HUNT AT WHITE HORSE, BROAD END, SKIDDAW MASSIF

Leader: Dr Alan Smith (CGS)

Wednesday June 1st 2005

A group of members carried out this fossil hunt in preparation for the visit of Dr Adrian Rushton the following week. Our search was not especially fruitful but, with more time, it is likely that we would have been more successful. On his later visit, Dr Rushton identified for members the graptolites they had collected at this site in the Kirkfell Formation. This site, on the northwest side of the Skiddaw massif, is in the *gibberulus* zone of Arenigian rocks immediately below the *cucullus* zone. Species found included *Tetragraptus amii* and at least two other *Tetragraptus* species, Didymograptids including *?D. extensus linearis*, a pentad form of *Dichograptid* with only five stipes, and the trace fossil *Palaeochorda min.*

This is a significant site and any fossils found should have their localities recorded precisely and sent for expert identification. The following account is Dr Rushton's guidance to us.

"About 140 species of graptolite have been recorded from the slaty beds of the Skiddaw Group, though many of them are known only from very few specimens. The attached pages illustrate some of the types you are most likely to find, together with pictures of one or two rarities to keep your eyes open for, as to find one of those would be a real coup. The big branching species are shown at natural size (x1), but many smaller species are shown at x4 or x5 to draw attention to specific features that can only readily be seen with a magnifying glass or microscope.

In practice, nearly all Skiddaw graptolites are collected from scree. Although splitting the mudstones at outcrop is worthy in spirit, it rarely proves successful (the graptolites being so much 'diluted' by the huge amounts of sediment in which they are buried), whereas Nature has split the slabs and laid them out – all we have to do is to look. I usually try to work up-slope, and do not generally turn the blocks over unless there is a lot of lichen on them.

Finding the first graptolite at a site can be an important moment. You then see the typical preservation, which might be a shiny black specimen with periderm, a pale chloritic replacement or a rust stain where a specimen is preserved in iron pyrites (or has left a weathered impression) – and then know better what to look out for.

To identify a graptolite it is almost always important to see the earliest-formed part of the colony. In the big spreading species you can then see the pattern of branching; in the simpler two-stiped forms, the way the early parts branch off from the sicula (initial bud) and then curve and become wider are of significance; and in the diplograptids (double-sided species) you can see if the

colony starts blunt or pointed, and how little spines at the proximal end are arranged. BUT if you find a fragment, don't reject it – or not until you have found more complete specimens of the same thing.

The most varied of the fossils found in the Skiddaw Group may be the graptolites, but probably the fossil most commonly found is the shrimp-like crustacean Caryocaris wrightii. Usually one only finds the carapace, an elongated plate (the head-shield), around 3 cm long, that looks a bit like a small pea-pod. Occasionally the tail-piece is found; it consists of three pointed plates, either occurring singly or as a fan.

Figures 1 - 14 show fossils that may be found at Barf, White Horse, around Scawgill, Outerside, and Trusmadoor."

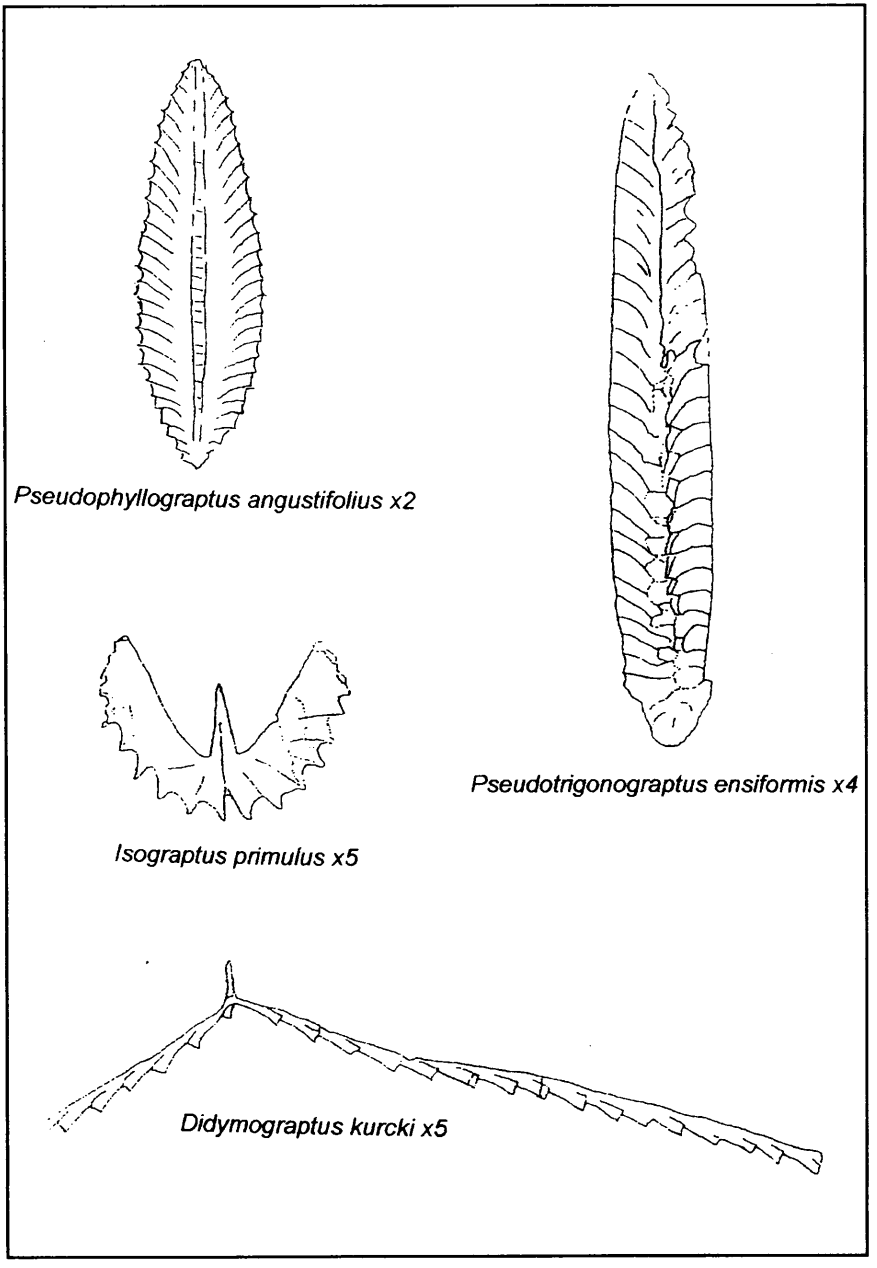


Figure 1 – Fossils which may be found at Barf

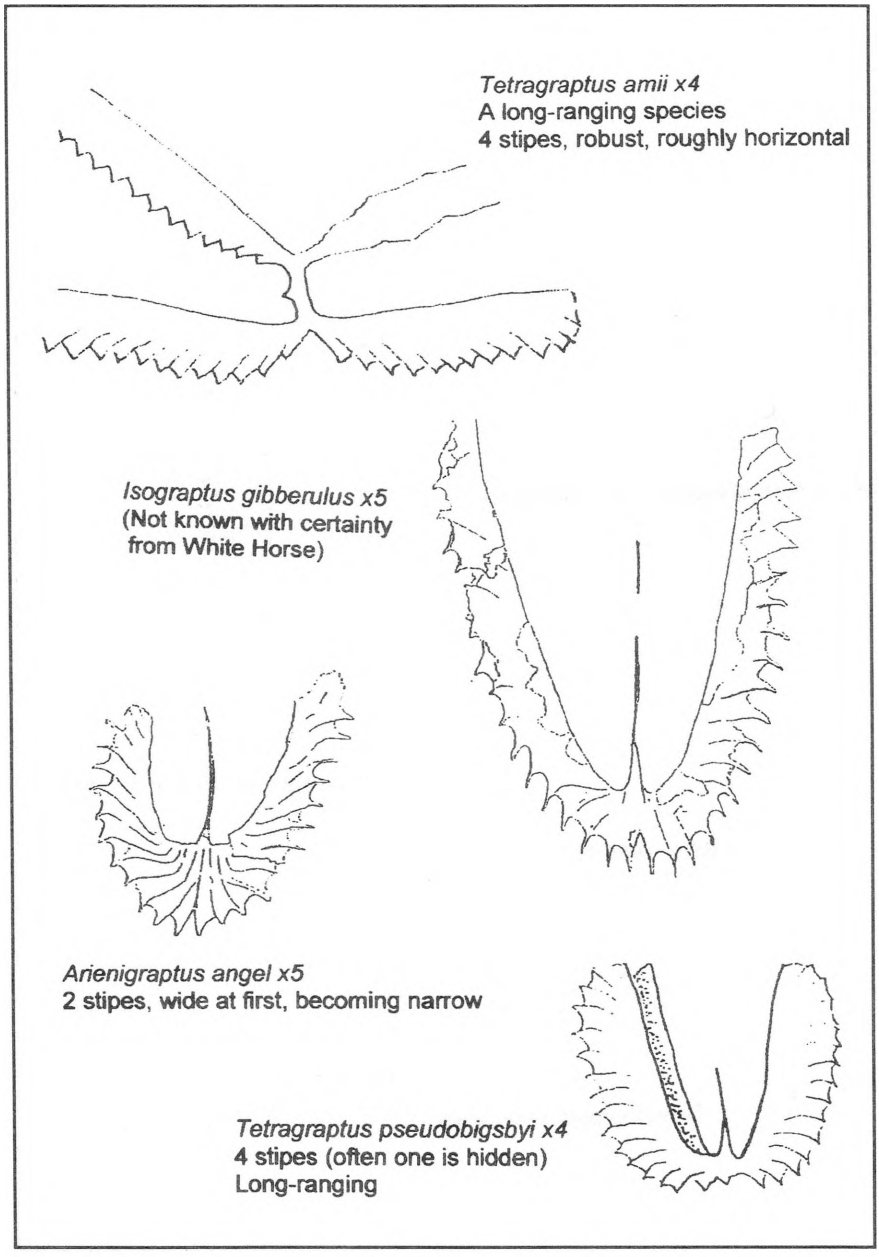
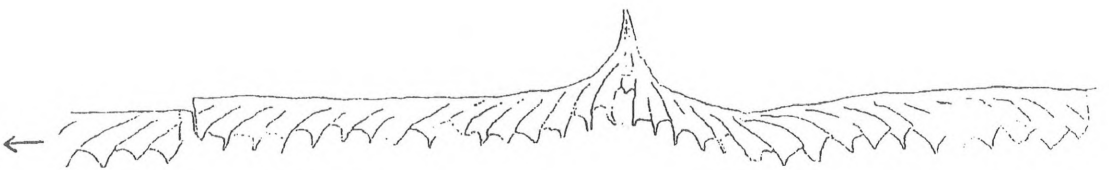


Figure 2 – Fossils which may be found at White Horse



Didymograptus nitidus x4
Long, stipes bend down a bit, widen steadily
Long-ranging



Didymograptus goldschmidti x4
Long, parallel-sided
First thecae hang down alongside sicula

Figure 3 – Fossils which may be found at White Horse

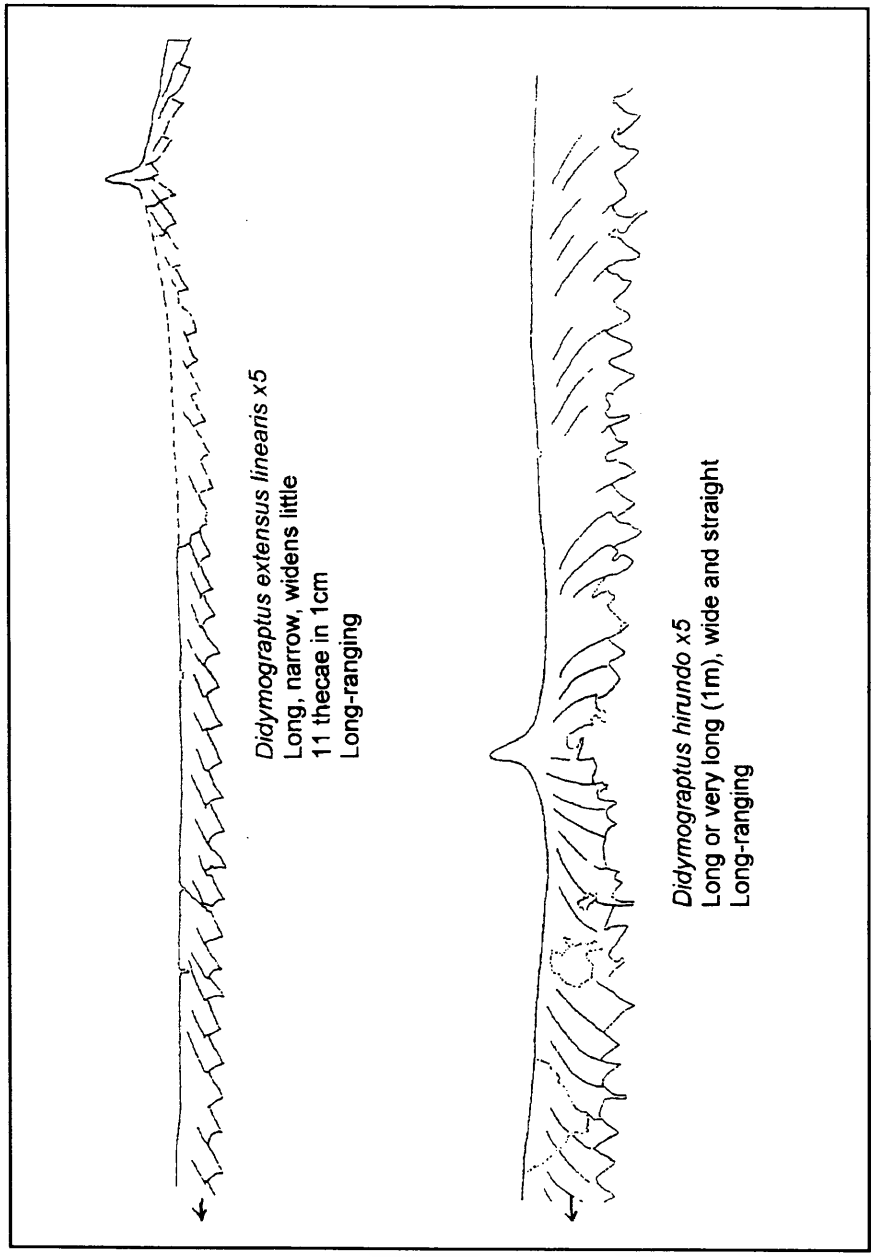


Figure 4 – Fossils which may be found at White Horse

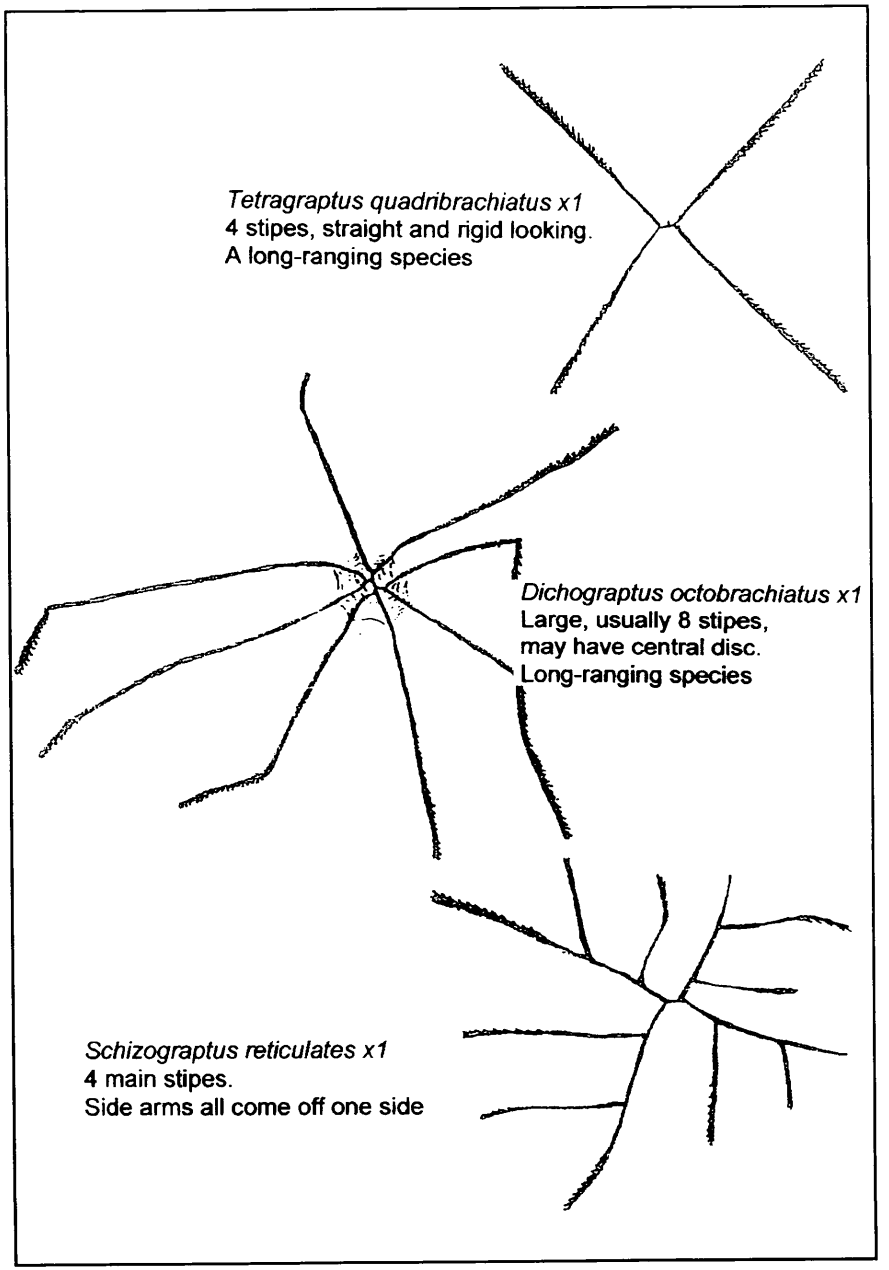


Figure 5 – Fossils which may be found at Scawgill (*Varicosus* Zone)

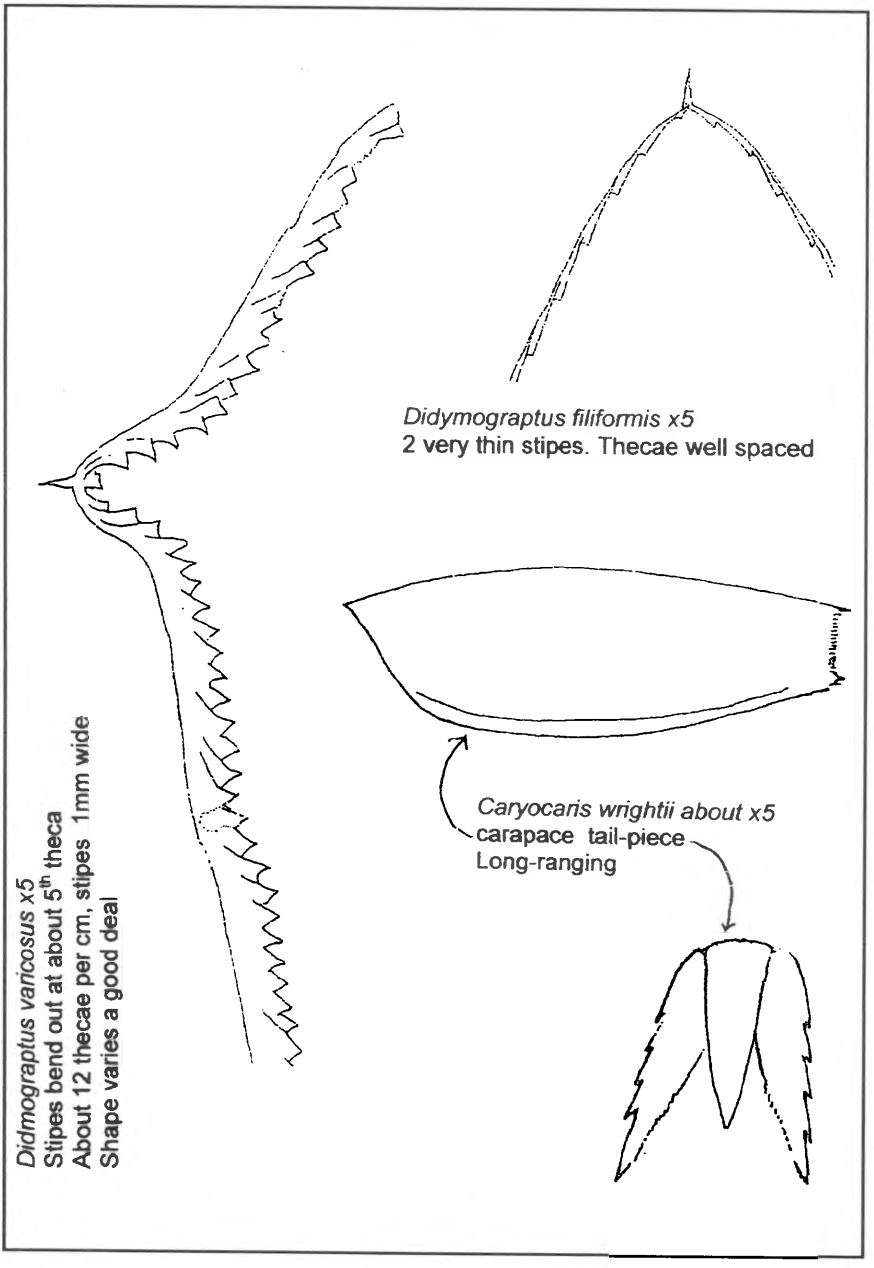
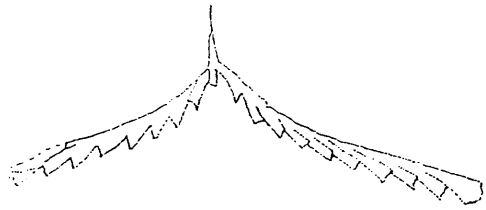
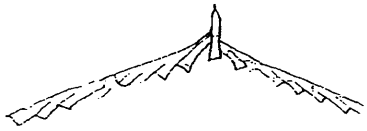


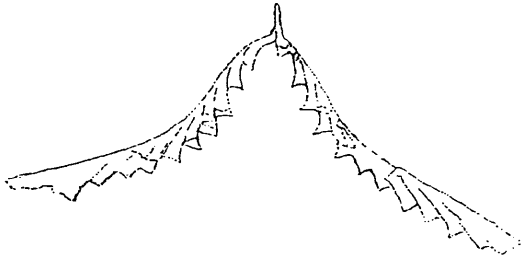
Figure 6 – Fossils which may be found at Scawgill (*Varicosus* Zone)



Didymograptus simulans x5
2 stipes, slightly curved outwards

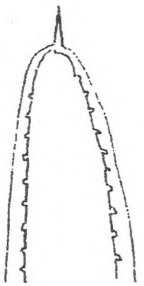


Didymograptus infrequens x5
Stipes straight, narrow; thecae densely set, 14 per cm



Didymograptus deflexus x5
Like D. varicosus, above, but stipes less than 1mm wide

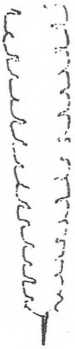
Figure 7 – Fossils which may be found at Scawgill (*Simulans* Zone)



Aulograptus cucullus x4
Small. Thecae are notches in stipe



Eoglyptograptus dentatus x4
Pointed end, sharp thecae



Undulograptus cumbrensis x4
Blunter end, blunt thecae



Cryptograptus hopkinsoni x4
Short spines, thecae clear

Figure 8 – Fossils which may be found at Outerside (*Cucullus* Zone)

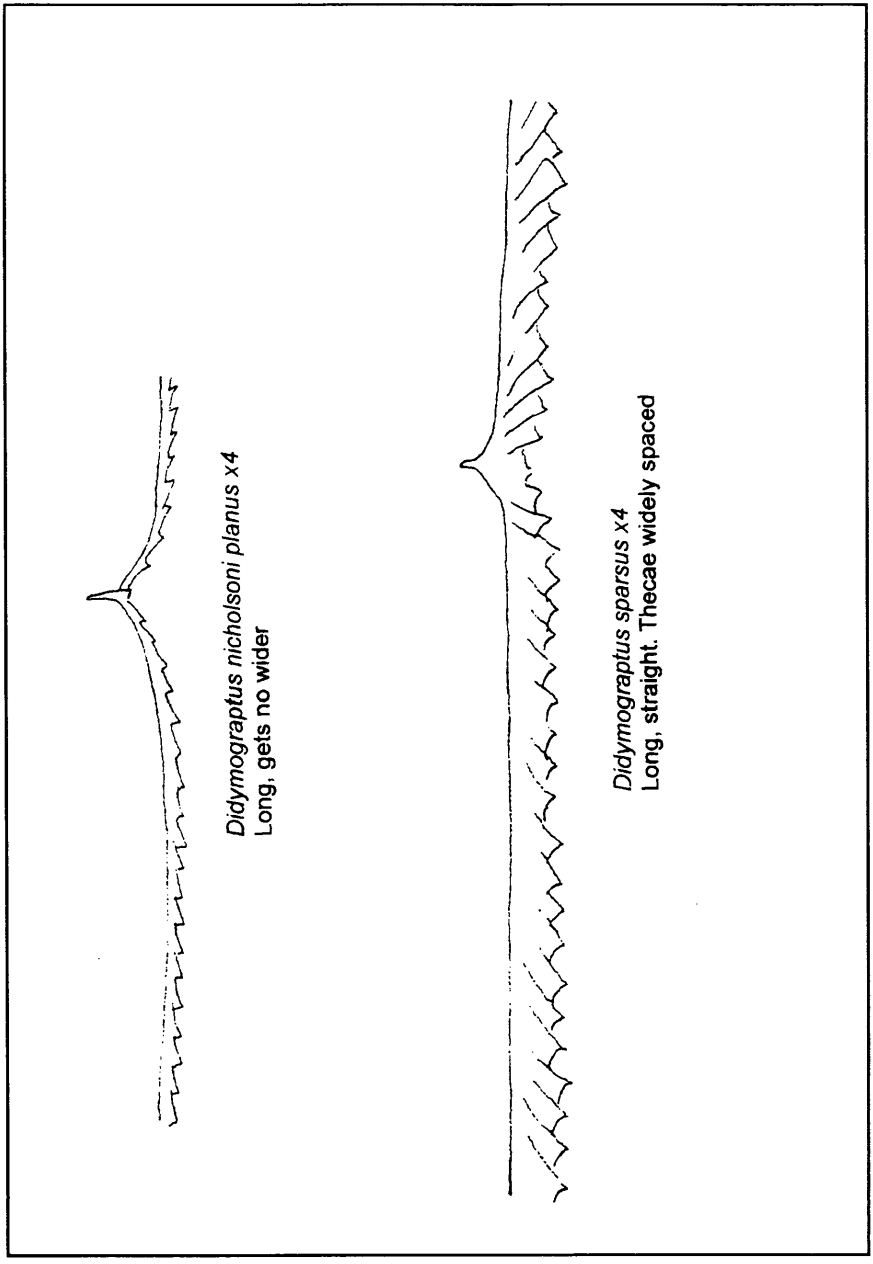
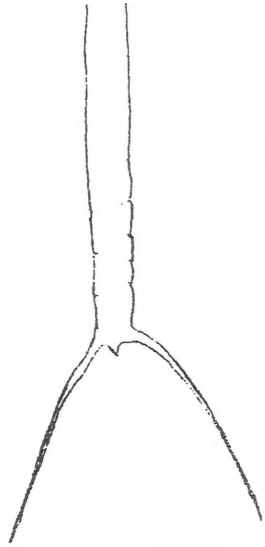
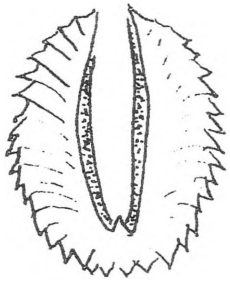


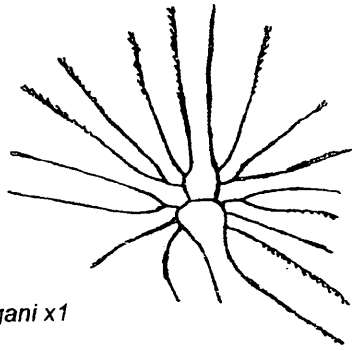
Figure 9 – Fossils which may be found at Outerside (*Cucullus* Zone)



Crytograptus antennarius x4
Long spines. Thecae obscure

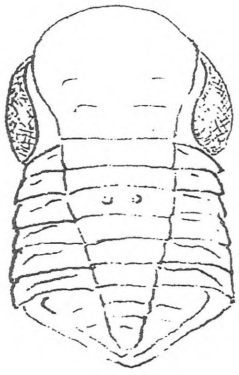


Tetragraptus bigsbyi x4
Stipes almost meet upwards
Long-ranging

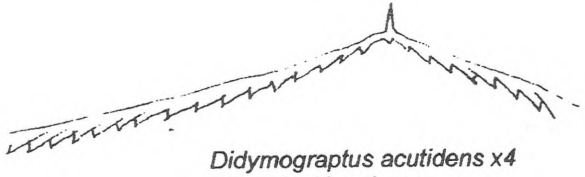


Loganograptus logani x1
About 16 stipes
Long-ranging species

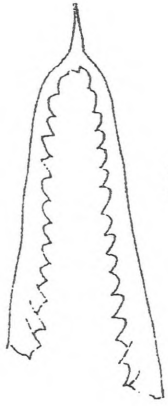
Figure 10 – Fossils which may be found at Outerside (*Cucullus* Zone)



Pricyclopyge binodosa x3
Long-ranging

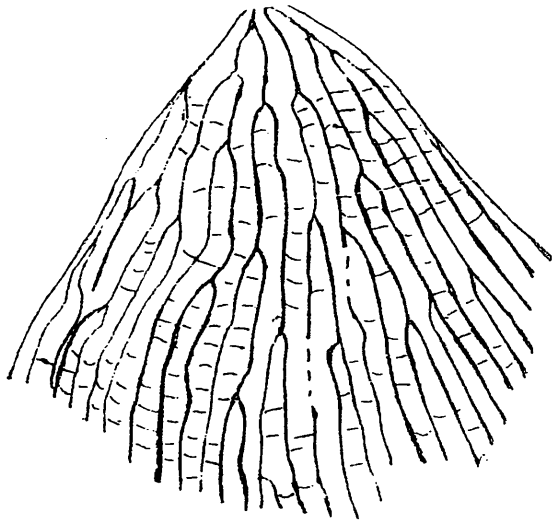


Didymograptus acutidens x4
Sharp looking thecae



Didymograptus spinulosus x4
Tuning fork shape. Thecae denticulate

Figure 11 – Fossils which may be found at Outerside (*Simulans* Zone)



Araneograptus murrayi
Large net-like species. A complete specimen would cover this page



Tetragraptus approximates
This distinctive H-shaped species has never been found in England. But if it is present, I expect it to be between murrayi: and protobalticus

Figure 12 – Fossils which may be found at Trusmadoor (*Murrayii* Zone)

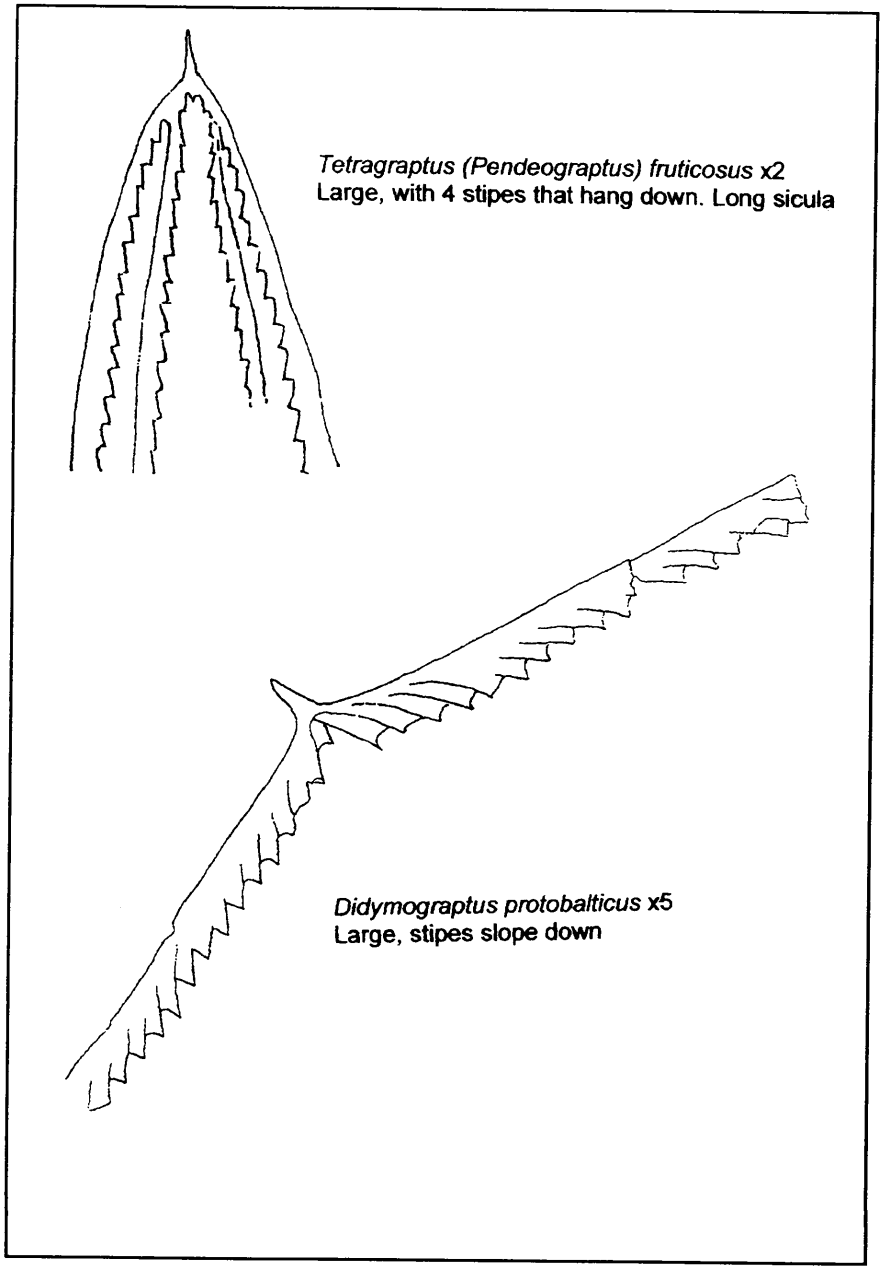


Figure 13 – Fossils which may be found at Trusmadoor (*Phyllograptoides* Zone)

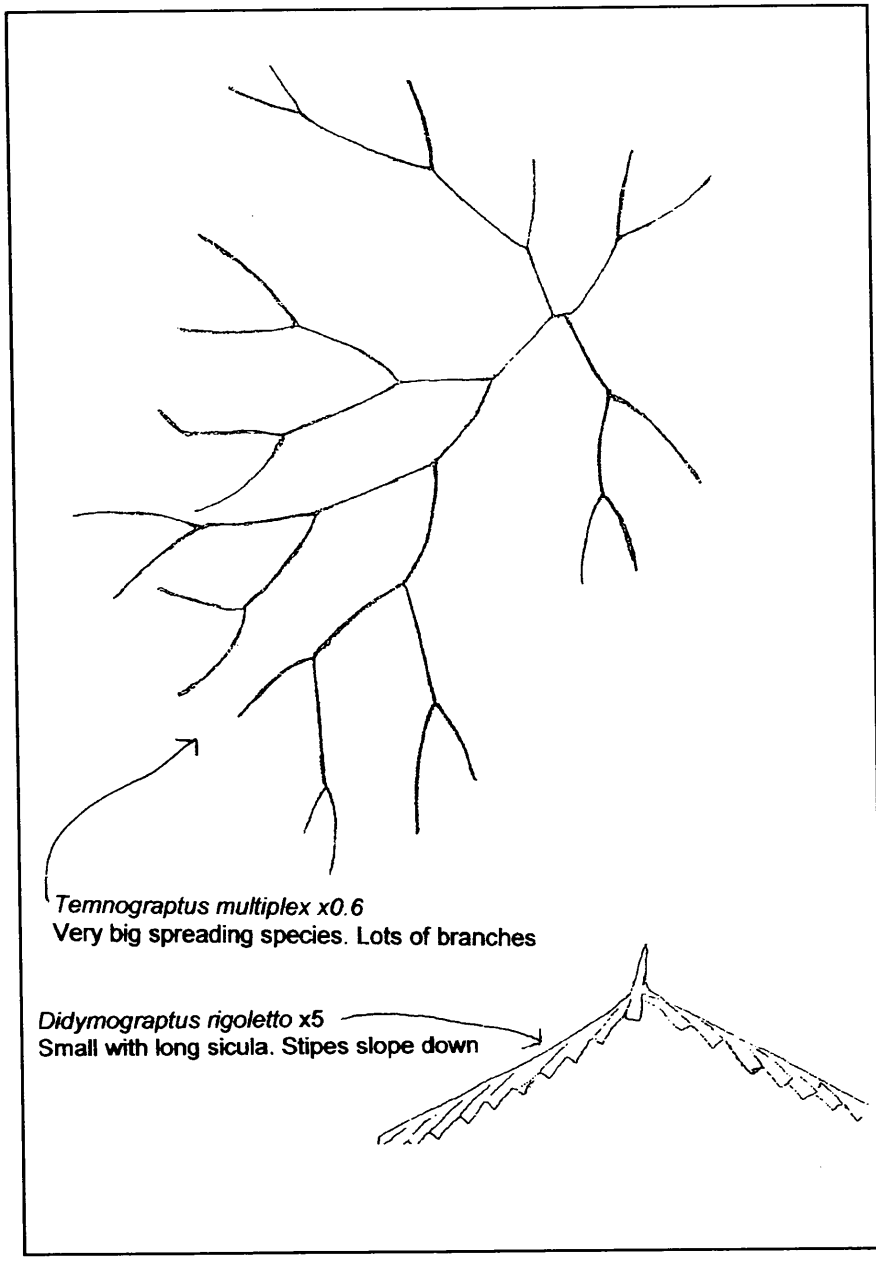


Figure 14 – Fossils which may be found at Trusmadoor (*Phyllograptoides* Zone)

NORTH PENNINES CARBONIFEROUS AT HALLBANKGATE AND THE GREAT WHIN SILL QUARRY AT MIDGEHOLME

Leader: Judy Suddaby (CGS)

Saturday 4th June 2005

A group of eleven assembled on a wet June morning at the entrance to Clowsgill Quarry (NY 588593). This was a new area of study for most of the group, who had approached from the west, crossing the Pennine fault system in the 6km between Brampton and the meeting point at Hallbankgate. It was explained that the Mid-Carboniferous strata in the quarry, although older than the Triassic at Brampton, have come to be at a higher altitude as a result of the Pennine faulting that occurred during the Hercynian Orogeny. Quaternary glacial drift covers the fault system, which is in reality a whole set of faults. In the quarry the effects of the disturbances were plain to see if not easy to interpret and much lively debate took place. The west side of the quarry has an exposure of tight isoclinal folding adjacent to a minor fault. In the south-west corner a fast flowing stream enters down a waterfall. It cuts through floor debris before disappearing down a swallow hole at the foot of the cliff. The limestone here is mapped as Great Limestone, (base of Namurian). Dark grey shale bands, fossiliferous and about ½ m thick are interbedded with the limestones. As elsewhere in Cumbria, it was found that the Great Limestone itself is unfossiliferous.

The heaps of quarry waste all over the quarry floor are now overgrown but the ruined remains of lime-kilns are still visible as are many overgrown wagon-ways. There has been no quarrying since the late1800s when its main purpose was to get lime to condition the land for agriculture and some was used for making mortar. The shale bands were used for crushing and making into bricks e.g. at the nearby Kirkhouse brickworks. Operations were quite economic at their height because coal was being drift- mined from Namurian seams in the adjacent valley in which Tindale Tarn lies and also further east at Midgeholme where the Coal Measures used to be a rich source of coal. Industrial archaeology is of great interest in this area because of the early-built railway lines joining all the mining and quarrying locations between Brampton and Alston and beyond.

Opinion was expressed that if the vertical exposures in Clowsgill quarry were cleared of vegetation they could qualify to be added to the list of Cumbrian RIGS.

The afternoon was spent exploring southwards along the valley of the Blackburn Beck. Our starting point was the disused railway line (NY 636587), on the Cumbria-Northumberland border. The beck originates near the summit of Cold Fell and cuts through surface peat and Namurian sandstones (with thin coal seams) on the North Pennine moors. After a fresh and exposed walk of

about half an hour the Great Whin Sill exposure at NY 626580 and at an altitude of 305m was reached. The disused quarry is on the eastern side of the valley cut by the Blackburn Beck. The vertical quarry face/exposure of the sill was estimated to be approximately 30m thick. Irregular columnar jointing is a very prominent feature. The quarry floor has numerous fallen blocks and piles of graded chippings, showing its use in the past as roadstone. The dolerite is topped only by drift and peat; the base of the sill was not visible in the quarry area. Attempts were made to find a lower contact zone in the adjacent valley. Unfortunately, the steepness of the heavily vegetated slopes meant that such activity was unsafe for the group and the day ended with another brisk walk back to the cars near Midgeholme.

SKIDDAW GROUP GEOLOGY

Leader: Dr Adrian Rushton (Natural History Museum)

Saturday 11th June/Sunday 12th June 2005

Members met Dr Rushton on the Saturday at the Spout-Force car park. Dr Rushton began by explaining it was easier to find fossils in the screes than in the bedrock. It was important that these screes were of local origin, the result of weathering of the overlying Skiddaw Group rocks and not transported into the area.

Our first sites were in Scawgill Quarry and the screes towards Spout Force. The rocks exposed were in the *varicosus* zone of the Loweswater Formation. The greywackes were medium to thick, evenly bedded, showing a wide range of soft sediment features, including large sole and flute structures, microripples, chattermarks, local crenulated cleavages and many burrows. There were many Bouma sequences, mainly B to D. Fossils were mainly found in the outlying screes, less carefully picked over than the main quarry. A small number of slabs around 25 cms long contained graptolites preserved as rusty stains of iron pyrites. *Tetragraptus quadribrachiatus*, a long-ranging species, with four, rigid stipes, was the most distinctive find. *Didymograptus* species including *varicosus* were also found, as was a Dichograptid.

The next site (NY179251), across Blaze Beck in small screes above the Hope Beck road, was rather lower in the Loweswater Formation succession but still in the *varicosus* zone. Preservation here was as pale chloritic replacements and fossils were easier to find. Good *Didymorgraptus varicosus* (previously seen at Scawgill), good specimens of the easily recognisable trace fossil *Palaeochorda min* (a burrow) and *Caryocaris wrightii*, a shrimp like creature,

(perhaps the most common macrofossil in Skiddaw Groups rocks) were found. *Tetragraptus bigsbyi* and *Dicranograptus octobrachiatus*? were also recovered.

The final site visited on Saturday was in small screes (NY214216) on the Northwest facing slopes of Outerside. These were in the Kirkstile Formation close to the top of the Skiddaw Group, near the junction of the Arenigian and Llanvirn rocks in the *cucullus* zone. Good specimens of *Caryocaris*, the easily recognisable *Cryptograptus hopkinsoni* and the zone fossil *Aulograptus cucullus* were found. The time available did not allow the party to do full justice to the locality.

Keen collectors accompanied Dr Rushton on the Sunday in deteriorating weather to the unique and internationally important site at Trusmadoor. This allows correllation of the fossils (*murrayii* Zone) present in Tremadoc rocks of the Bitter Beck and Watch Hill formations with those in foreign sites. An excellent, quite large fragment of the zone fossil *Araneograptus murrayii*, found by David Steele, was extracted from outcrop on Meal Fell. It represents an *in situ* record of a species previously collected from screes at Trusmadoor and was taken by Dr Rushton to the Natural History Museum for preparation and conservation.

Dr Rushton's infectious enthusiasm and lucid explanations how the species were identified were particularly appreciated. He was thanked for providing us with such fascinating, stimulating and enjoyable excursions over the two days. In his turn Dr Rushton thanked members for their assiduous collecting and for supplying useful specimens of graptolites for further study.

References

COOPER et al, 2004. *The Skiddaw Group of the English Lake District.* British Geological Survey, pp 11 – 22/

RAISE BECK, DUNMAIL RAISE

Leader: Dr Richard Johnson (University of Central Lancashire)

Wednesday 29th June 2005

A large group of members met at the summit of Dunmail Raise. Here the leader explained that the Thirlmere catchment, like many upland locations, has a history of flooding and landslides. These events can be hazardous in proximity to human land uses. For example, the A591 has been blocked by debris on numerous occasions: 2nd November 1898 (Dunmail Raise and north to Wythburn); 1st February 1995 (Dry Gill, Raise Beck); 17th February 1997 (40 tonnes from a landslide).

The purpose of the visit was to examine the effects of the 1995 flood event in Raise Beck. Raise Beck has an altitude range from 790m (on Dollywaggon Pike) to 240m (at Dunmail Raise). The catchment area is 1.27 km^2. The valley slope is steep at 0.206-0.235 m m^{-1}. There are 2 main first order streams with a 2^{nd} order confluence at 500m. In addition there are small left bank tributary streams. The stream flows in a V –shaped valley then divides at 300m OD at the apex of an alluvial fan. Prior to the flood event the stream flowed northwards to Thirlmere. However, it only became part of Thirlmere catchment sometime between 1913-1935 as a result of engineering works to increase the Thirlmere catchment area. (Thirlmere was impounded 1894). Prior to this flow was to the south towards Grasmere.

The party walked over the fan and into the narrow section of the valley where the leader explain his research of the area and the 1995 flood. A detailed study of the Raise Beck torrent was undertaken to better determine the controls on flooding in this upland catchment. The investigation had three main objectives:

1. To reconstruct the 1995 flood using a combination of geomorphological, sedimentological and archive evidence.

2. To examine the available field evidence to determine the long-term flood history of the site (thus providing a context for the 1995 flood event).

3. To evaluate the engineering works and management strategies used following the 1995 event.

Catchment ground conditions were wet prior to the 1995 flood. December rainfall totals were up to 184% of the long-term average. Coupled with frozen ground and snow cover, very high runoff rates were likely during the storm. The rainfall total was 163.5mm at the Nook (1 in 80 year event) with a maximum intensity of 17.5 mm in one hour. Rainfall totals and intensities may have been higher at higher altitudes.

Estimating the magnitude of hydrological events in upland catchments is difficult because such catchments are ungauged and detailed knowledge of the catchment characteristics and runoff generation methods are unknown. Flow characteristics need to be reconstructed using indirect techniques.

The primary impact of the flood was a channel avulsion at the fan apex. The flood breached the left bank of the north channel and flowed along the course of the southerly palaeochannel towards Grasmere. This event deposited significant amount of fresh debris adjacent to, and on the A591 road. In combination with the flood waters this closed the A591.

Aerial photos, pre and post flood, have been used to note other changes. These include a landslide which removed a length of path adjacent to Raise Beck, re-working of channel deposits which reduced the sinuosity.

Documentary and field evidence demonstrate that Raise Beck has suffered high magnitude flood events prior to 1995. One major source of evidence are lichens, where the age of certain lichens is deduced from the diameter. This allows boulder deposition to be dated and different flood units to be identified. The validity of these flood unit dates has been checked against historical rainfall records which provide general support to the results.

Recent engineering work was described, including the reconstruction of stream banks with local boulders (riprap); re-establishment of the footpath lost to the landslide and diversion of the stream north to Thirlmere, with a minor culvert at the fan apex to maintain a minor flow in the southerly channel towards Grasmere. It was noted that natural cross sections are generally larger than engineered cross sections. The latter could not cope with a 1995 magnitude flood. This could lead to failure of the riprap and further disruption to the A591. These may be particularly significant given possible increases in winter rainfall in the future.

Reference

JOHNSON, R. M. AND WARBURTON, J. (2002). Flooding and geomorphic impacts in a mountain torrent: Raise Beck, Central Lake District, England. *Earth Processes and Landforms,* 27, pp945 969.

GEOLOGY OF THE KIRKBECK VALLEY

Leaders: Mervyn Dodd and Michael Forsdyke (CGS)

Wednesday 6th July 2005

This part of the Kirkbeck Valley is where the stream runs in its 'normal' direction to the south-west, between the meltwater channels where it flows in a southerly direction in the Nannycatch and Stockbridge-Haile gorges. The bedrock is the Buttermere Formation of the Skiddaw Group, with 3 or 4 south-west – north-east trending dykes of Ordovician age, identified by BGS as felsites and microdiorite. Landforms reflect the glaciation of the area.

Site 1 was at the foot of the approach track. The rocks here are thinly bedded and parallel laminated shales and greywackes, very variable, both laterally and vertically. Dips here are fairly gentle, whether normal or overturned bedding the new BGS 1:50 000 map does not specify. There appears to be a well-marked channel 5-10m wide near the top of the (quarried) section. An

upright antiform (upfold or slump fold) a little further up the track was not as convincing as the synfold alongside.

Site 2 was where the party entered Nannycatch Gorge. On the north bank the party first passed steeply dipping (direction uncertain), thinly bedded, rather fragile, Buttermere Formation rocks. Raven Crag, between the Kirk Beck and the unnamed tributary following a meltwater channel from the north, is quite different. Its rocks are blocky, with angular faces and strong vertical divisions in its small crags and are quite fine grained with abundant small quartz crystals. This south-west – north-east trending dyke tapers out and is difficult to trace beyond the tributary stream and the old lead mine trial. Interesting sedimentary details and a small slump fold/ tectonic fold occur just beyond the stile.

Site 3 was on the valley side above and south of Uldale Farm. From above it looks wrongly like a solitary drumlin. At ground level it is flat topped and more or less attached to the valley side. The limited outcrops contain granite (?Ennerdale) and volcanic rocks (BVG?) which do not outcrop in the valley. These are not completely angular, showing some rounding. So is it dominantly a glacial or fluviglacial feature? What landform is it? Alan Smith suggested it was a slump feature – the material coming from the slope above.

Site 3 was a good viewpoint for other features which time prevented the party visiting. The valley floor here is much wider and the sides are almost straight. Downstream on the north bank are 2 alluvial fans, the nearer one being clearly seen in profile. Outcrops visible on a forestry road in a clear felled section are mainly of steeply dipping Buttermere Formation rocks, more robust than those at Site 1. At least one other dyke seems to occur, being much more massive than the Skiddaw Groups rocks around.

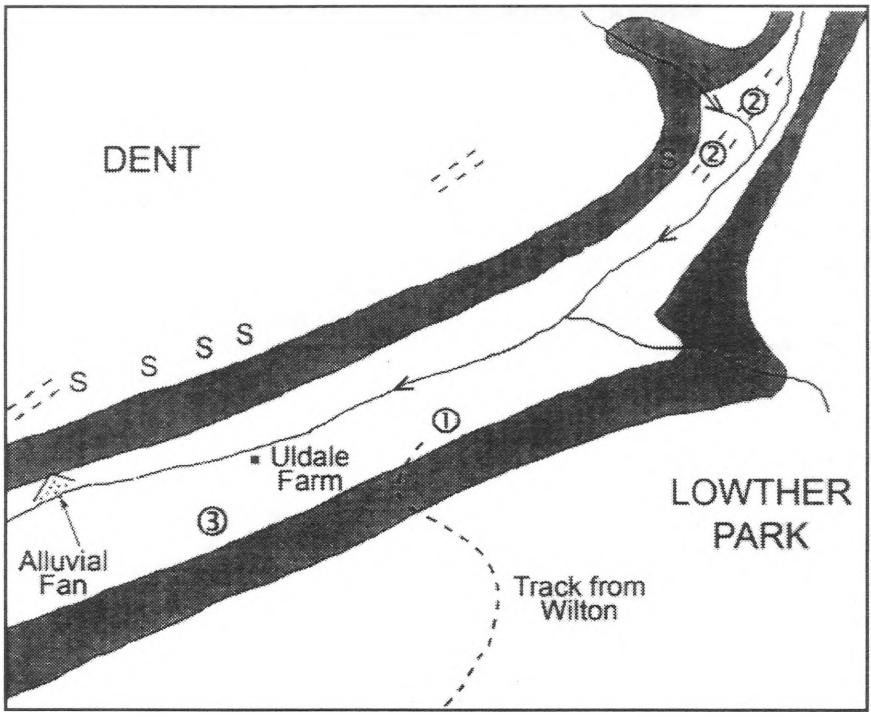


Figure 1 – Sketch map of the area visited.

MINERALISATION IN THE CALDBECK FELLS

Leader: Brian Young (BGS Edinburgh)

Sunday 31st July 2005

A large group of members met south of Caldbeck where the leader described the main rock groups in the area. The Eycott Volcanic Group is distinct from the Borrowdale Volcanic Group in mineralogy and chemistry. The thickness is similar but the Eycott outcrop is smaller due to the steep dip and greater degree of burial. There are few Eycott Group exposures on the Caldbeck Fells where the domed hills are largely drift covered. Beyond the Carboniferous scarp to the north, the rocks dip away to the Solway Basin and the Northumberland Trough forming scarp and dip topography. The unconformable boundary between the Eycott Group and the Carboniferous rocks is often faulted (the Maryport – Gilcrux – Stublick fault system) and this is relevant to the mineralisation in the area.

Faulting began in pre-Carboniferous times. The Lake District buoyant block is underpinned by granite, whereas the Solway Basin/Northumberland subsided. The result of this is that south of the fault, around Caldbeck, the Carboniferous is much thinner than it is north of the fault. At Westnewton near Aspatria a borehole recorded the Dinantian over 1½km thick. Mining began in Elizabethan times but was never on a very large scale.

The party then proceeded via the Dale Beck Valley to the Roughten Gill Mine. The route provided views of Swinburn Gill and Red Gill where there are lines of mining scars where collapses along old working show the veins following faults. The spoil heaps of the Brae Fell Mine were seen. This was a treatment plant for a barites mine. Lead, zinc, copper as well as silver, cadminium and arsenic minerals have been found. Despite the great variety of minerals, little is known about the actual deposits. Details of early collection from the spoil heaps was not recorded. Common place minerals are significant, e.g. quartz provides evidence from fluid inclusions. Some of the Eycott Group rocks were seen, largely much-altered andesites. Much of the mapping of the Eycott Group in the area is undivided.

At the Brae Fell Mine, hand-dressed spoil was seen. A gulley going up the hillside from the spoil is a source of secondary lead minerals. The gulley provoked a discussion on the doubtfulness of the use of hushes in prospecting. Specimens from the mine are found in the British Museum: linarite, hemimorphite, sphalerite and galena, covalite and goethite. The leader cautioned the party on the unreliability of field identification without the use of X-ray diffraction. The permit system for collecting on the Caldbeck Fells was also discussed.

At the head of Dale Beck, north-east – south-west trending veins cross the face of Iron Crag, though the Eycott Group but also through the ilmenite and apatite gabbros of the Carrock Fell intrusion. Quartz veins were seen in the gill. Lunch was taken at the Roughton Gill lead mines where yellow mountain saxifrage indicates the presence of calcium. At the head of the gill an Elizabethan coffin level was seen with magnetite debris from the Carrock Gabbro. The rock here is highly altered.

The party climbed the steep slope to higher Roughton Gill across various gabbros and lavas and observed a vein with a trial level. Metasomatism has altered the wall rock to produce a clay-rich rock which was difficult to support in the mines. This also means that veins are seen as trenches in the landscape. The highest workings were seen in a vein in the foot of a river cliff on the left bank. The river follows the line of the vein – the Roughton Gill South Vein. The vein is steeply inclined and has a complex structure. The Eycott Group occurs to the south and the Carrock Complex to the north with a small outcrop of microgranite. There is abundant pyromorphite and quartz and some chalcedony. Quartz occurs as groups of parallel sheets in baryte form as pseudomorphs or cast epimorphs. This is a common feature of Lake District lead veins. The complex evolution of the veins involved the removal of baryte. A similar process in Pennine veins led to the formation of witherite. Barium mobilisation in the Lake District didn't form witherite because of the absence of carbon dioxide in the rocks. At the locality large quartz crystals and blue botryoidal hemimorphite can be seen.

A climb over the fell led to the spoil heap at the head of Silver Gill. The mine dates from Elizabethan times and worked lead and copper minerals. Some silver occurred in very low quantities in the galena. The 12th century "Carlisle Silvery" could refer to mines here or in the Pennines but interpretation of the historical accounts is very difficult.

The final stop was at the Red Gill mine which is very small but of international mineral significance.

GEOLOGY OF THE NORTHERN PART OF HIGH RIGG

Leader: Dr Alan Smith (CGS)

Wednesday 24th August 2005

17 members met at the Diocesan Youth Centre near Matterdale Church. The geology of the High Rigg area is basically quite simple and is well documented, but unfortunately at the critical locations the exposures are

relatively poor. Skiddaw Group, Borrowdale Volcanic Group and the Threlkeld microgranite rocks all come together here but tantalisingly the junctions and hence the relationships between the various materials are not easy to ascertain. Interpretations of the area by Hadfield and Whiteside in 1936 and by Moseley, in various publications more recently, were compared with the recent BGS mapping of the area.

The excursion started with a brief look at the exposure of the Threlkeld microgranite on a roche moutonnee feature south of Sykes Farm (NY 301224). The grey granite is seen to be both strongly jointed and containing a cleavage. Its composition was explained. On the SW corner of this exposure a small patch of Skiddaw Group rocks (Buttermere Fm) is exposed, but drift and alluvial material covers the lower ground below them so that their extent can only be extrapolated from this and other scattered exposures in the area. Within a few metres across a small depression from the Skiddaws, a conglomerate, which marks the base of the Borrowdale Volcanics, is seen in the slope beneath the roadside wall. The actual junction between the two formations is not visible but this conglomerate is seen at the base of the BVG on the other side of the Naddle valley and on Derwentwater. It is about 4m thick and dips around 25 degrees to the south. The clasts within it are rounded and sub-angular and predominantly of volcanic origin. Above this basal conglomerate lie unconformable sequences of andesitic lavas and tuffs.

Further outcrops of the granite intruded into Skiddaw Group rocks occur in the low ground below the track back to the youth centre at NY 023242 and NY 028243. Again there are no clear exposures of the junctions. The east - west running depression that the track follows is aligned along a fault which marks the SG/BVG junction. Its precise position has been mapped in different positions by Moseley, but the new BGS maps now place it on the north side of the track.

A start was made to then climb the slopes of High Rigg and examine the BVG sequences exposed. These have been well described by Moseley in his book on the Volcanic Rocks of the Lake District. All the beds dip southwards at moderate angles but unconformities exist between several horizons. Some sequences of tuffs and lavas were examined but with rain and the failing light it was decided that a proper examination of these rocks would need to be done on another occasion.

OTHER EXCURSION HELD IN 2005

Geology of the Maryport Coast, Leader: Dennis Dickins (CGS), Wednesday 22nd June 2005. This excursion followed the itinery described in Proc Cumb Geol Soc Vol 6, Part 2, pp258 – 259.

LECTURE REPORTS 2004 – 2005

REMOTE SENSING AND FIELDWORK ON ACTIVE VOLCANOES

A lecture by Professor Harry Pinkerton (Lancaster Univeristy)
at Newton Rigg Campus, Penrith
on October 27th 2004

Professor Pinkerton's talk concerned the use of modern techniques in fieldwork in Iceland, Montserrat and Etna. He began by showing a MODIS image of Iceland which is useful in identifying large scale structures. It is possible to home in to show much smaller features such as Grimsvotn. ATM imagery from aircraft provides very high resolution images down to 2 metres. Different wave band combinations can be used for different purposes, for example infra-red images indicate pixel-integrated temperatures of 35 – 40^{O}C at Grimsvotn. Ground measurements have confirmed the accuracy of the technique. The technique can potentially be used to determine when new magma is being erupted beneath Grimsvotn.

A series of dramatic photographs were used to show the development of recent volcanic features on Montserrat. These included a growing magma dome, an ash-filled swimming pool and the damaged airfield. Pyroclastic flows are often temporary features of the landscape and the loose material is often picked up by runoff to form lahars. A picture of a new delta formed by lahars was shown – such features provide an opportunity to study coastal evolution. Conventional surveying methods are traditionally used to produce digital elevation models of inaccessible volcanic features. Recently, Professor Pinkerton and colleagues have been developing and testing alternative surveying techniques. These include ground-based stereometric surveys and laser scans, both of which have been used to produce 3-D images and models of volcano development. However, these techniques require good visibility and, unfortunately, the summit of Soufriere Hills volcano on Montserrat is often obscured by cloud. To reduce the possibility of unexpected collapse of the dome when the dome is obscured, a millimetre waveband radar system has been developed by a joint as part of a NERC-funded St Andrews-Lancaster Reading project. This has been designed to produce distance and temperature profiles of the dome through cloud and rain, and it was used successfully on Montserrat during May 2004.

Professor Pinkerton then moved on to his research group's work on Etna. A series of images were shown to provide a picture of the general topography of the area. On Etna, magma travels to the surface via dykes – vertically, horizontally and even downhill. Many of the flows are accessible to the researcher and dramatic pictures were shown of surface flows and lava tubes, including an active tube with the wall broken away. The relationship between these features is the subject of ongoing research.

An eruption of Etna in 1999 involved a terminal eruption (one that takes when magma is at a high level in the summit craters), and large lava flows were shown emerging through the wall of the Bocca Nuova, one of the main craters on Etna. This was an example of an eruption that was dramatic, but which posed no major threat to the local population. By contrast, more recent flank eruptions during 2001 and 2002 caused significant damage to roads, the upper cable car station and tourist complexes on both the southern and the northern sides of the volcano. The role of defence walls during the 2001 eruption was discussed. Fourier transform infra-red spectroscopy was used during these eruptions to determine the ratio of gases emitted, particularly the HCl : SO_2 ratio. This changes before, during and after eruptions and is one of the tools that can potentially be used to predict when a new eruption is likely to take place. Images taken from a helicopter during the 2001 eruption were used to show the extent of the fissure system and the complex relationships between activity at the summit and the different eruptive vents. The difference in chemistry between the summit lavas and those on the flank, coupled with the presence of sandstone xenoliths in the flank lavas, suggests the presence of 2 feeding systems: one related to the central conduit system; the other to a vertical dyke system on the southern flank of Etna.

Dramatic pictures were shown of lava flows on the flanks of the volcano. It was revealed that there was discussion, during the 2001 eruption, of the possibility of diverting these lavas into large quarries to prevent or reduce damage to towns. At the end of the 2001 eruption, samples of 5 chilled margins were collected for AMS (anisotropic magnetic susceptibility) measurements. This has the potential to determine flow directions of lava in dykes and lava flows. This is particularly important as a tool in determine magma flow directions in the dykes that fed some of the large historic flank eruptions. The surface expression of most high-level dykes on Etna is a series of cinder cones. Interestingly, many of these have a diameter close to 1.5 metres, and the vents, in some areas are surrounded by bombs of similar size. A possible model for this relationship was proposed. Other pictures showed ash falls (soon washed away), 20m wide lava flows and large summit craters in the frequently changing landscape. The link between rising magma and gravitational instability of slopes is a major problem on Etna and another area of research.

The talk concluded with thermal images of lava flows. These images are currently being used to develop and test models of flow cooling, crustal thickening and breaching. This follows an extensive series of laboratory and field measurements by the Lancaster team which were designed to measure the emissivity of lava and the effect of viewing distance and viewing angle on apparent temperatures. Professor Pinkerton finished by using a 50 Hz simulated thermal imaging video to show how it is possible to determine the maximum temperatures of the interior of a lava flow and temperatures at the base of the crust of a lava flow, both of which are required for lava flow model validation.

THE BURGESS SHALE FAUNA: NEW LIGHT ON THEORIES OF EVOLUTION

A lecture by Professor Simon Conway Morris (University of Cambridge)
at Westlakes Institute, Whitehaven
on 10th November 2004

Professor Conway Morris began his talk by explaining that the Cambrian evolutionary explosion was difficult to explain. To a molecular biologist, man and the mushroom had a common ancestor, existing one billion years ago. The traditional geologists' view is that, in the absence of early Proterozoic fossils, diversification occurred in the late Precambrian. Molecular biologists have argued for diversification much earlier, using the "molecular clock method". A compromise view might be that diversification occurred some 600 – 800Ma.

The Ediacara fauna is difficult to understand in terms of evolution and is probably not related to the Cambrian explosion.

The appearance of hard skeletons may be due to the appearance of predators, and relates to the appearance of advanced nervous systems and brains. Fossil trilobites have been found with bite marks, usually on the right hand side. However the Cambrian explosion was also of soft-bodied organisms as seen in the Burgess Shales. The locality was discovered by Charles Walcott of the Smithsonian and re-investigated by a Canadian, Harry Withington, in the 1960s. Forty similar localities have been found around the world. For example in Greenland, a deposit found by accident consists, like the Burgess Shales, of a shale deposited against a limestone escarpment. The fauna includes a 4cm long armoured slug with posterior and anterior shells like a brachiopod. Other fossils could be related to earthworms.

There are three main groups within the Burgess shales: firstly, worms, brachiopods and molluscs; secondly, arthropods, trilobites, opabinia and other skeleton-shedding groups; and thirdly, a disparate group including sea urchins and vertebrates.

Deposits in south-west China are very important and include Lower Cambrian fish. Soft-bodied organisms with gill slits could be a precursor to the other groups. There is also what might be an early echinoid with a tail.

The speaker went on to develop the theme that mass extinctions postpone not cancel diversification and gave examples of new organisms filling niches following extinctions. He noted that vocalisation has happened twice and that the same evolutionary products can be reached by different routes.

Professor Conway Morris then went on to quote intriguing examples of evolutionary convergence including two sabre toothed cats – mammal and marsupial, and the camera eyes of squid and humans. These are both features

of intelligent, fast-moving predators. The amount of light captured by a compond eye is limited and humans would need an eye 1m across to give the vision of our camera eyes. The dolphin and human brains provide an example of cognitive convergence – both recognise themselves in a mirror. Homo sapiens and Neanderthals may have developed without contact and developed similar cultures. Therefore is man an evolutionary accident and how predictable is evolution?

The speaker was thanked by Steve Bradley, Principal of Westlakes Institute, for a particularly entertaining and thought provoking lecture.

OTHER LECTURES 2004 – 2005

A photographic portrait of the limestone scenery of Morecambe Bay - Dr John Jennings (formerly of the University of Central Lancashire), at the Friends'Meeting House, Cockermouth, on 22nd September 2004

Members Evening at the Friends' Meeting House, Keswick, on 10th December 2004

Cumbria Rigs Sites: an interactive evening - Dr Gordon Taylor (Chairman, Cumbria Rigs), at Newton Rigg Campus, Penrith, on 19th January 2005

Presidential address - Angela Marchant, at the Friends' Meeting House, Cockermouth, on 23rd February 2005

Palaeodentistry: probing the teeth of the earliest vertebrates - Dr Howard Armstrong, at Tullie House Museum, Carlisle, on 16th March 2005

LECTURE REPORTS 2005 – 2006

WINDOWS ON A GEOLOGICAL PROFESSION

A lecture by
Dr Dennis Jackson (Open University)
at Newton Rigg Campus, Penrith
on September 21st 2005

Dr Jackson's talk was an autobiographical one, tracing his geological career from his youth in Cockermouth through Durham University, the oil industry, the University of Alberta and the Open University. Dennis Jackson first encountered geology through the teaching of Donald Rigby at Cockermouth Grammar School. This inturn lead him to a geological degree course at Durham. His third year mapping project was on the Cockermouth lavas and through this he found graptolites in a new quarry at Setmurthy. This lead him to look at Elles' monographs which he disagreed with. His interest in graptolites and the Skiddaw Group developed and he collected many graptolites from 1000 feet of the Skiddaw Group close to the summit of Barf. At this stage he met Edgar Shackleton who encouraged him in this growing interest.

Upon graduation he stayed on at Durham to do research: a PhD on the Skiddaw Group. Finance was granted by Cumberland Education Committee, one of the selecting panel in Carlisle being Charles Edmonds.

On completion of his research Dennis went to Calgary, Alberta to work for Amoco. This was the pipeline building boom and winters were spent on well-site work and summers camping in groups in the Yukon. There have been four phases of development of Arctic America: the exploration of the north-west passage, the exploration of the north magnetic pole, the minerals and oil development and the development of tourism. This was the mining phase and the settlements of White Horse and Dawson City still had the feel of the frontier towns described in the work of Robert W. Service. Dennis' work centred around the Peel River area of the Richardson Mountains where there is a complete section along the river from Cambrian to Carboniferous. Summers were spent camped on the permafrost of the region.

In 1962 Dennis moved to the University of Alberta in Edmonton to carry out research on graptolites. Visits to other universities were much appreciated, including Prague at the time of the Russia invasion and Mexico City. During this time the number of graptolite zones was increasing greatly.

From here Dennis moved back to the UK to the newly developing Open University in Milton Keynes, where he worked on some of the first teaching units – a new concept at the time. He then returned to Amoco, this time in London. His work partly involved the technique of using modern environments to interpret

ancient oil-bearing rocks. He is now retired but continues to do work on the graptolites of the Yukon.

Dennis' talk ended with a presentation with pictures of exceptional three dimensional preservation of graptolites. The vote of thanks was proposed by Tony Rigby, son of Dennis' mentor at Cockermouth Grammar School.

IAPETUS – THE OTHER SIDE

Vice-Presidential Address by Dr Alan Smith
at the Friends Meeting House, Cockermouth
on March 15th 2006

The Lower Palaeozoic Iapetus Ocean is significant to the geology of the Lake District and much of Northern England. The ocean lay between the North American (Laurasia) and European continents. A reconstruction of the ocean from Moseley (1978) was shown. Opening took place in the Cambrian and Ordovician and closure in the Silurian, the ocean widening to over 1000km. Closure led to orogenesis and the formation of the Caledonides of eastern USA, northern Britain and Scandinavia. The newly uplifted mountains were subject to erosion until the mid-Jurassic when the Atlantic Ocean began to open. A subduction zone lay beneath the Lake District, with the Eycott Volcanic Group forming closer to the trench and the Borrowdalke Volcanic Group further away. The Skiddaw Group was deposited in the offshore region and granite formed from melting of the adjacent continental crust.

In the mid-1980s, this model was adapted to by Fortey and Cox, using faunal evidence. The European Plate was actually separate microplates with different faunal provinces. The Lake District was part of Eastern Avalonia which was separated from Baltica by the Tornquist Sea. This closed as the Iapetus Ocean closed.

Newfoundland comprises three different zones. The Avalon Peninsula in south-east Newfoundland has the same fossils as the Lake District and was part of the European continent. Central Newfoundland is formed from Iapetus Ocean floor sediments and island arcs – the Central Mobile Belt. The Great Northern Peninsula was part of the Laurentian continental margin.

The Avalon Peninsula, including St John's, is formed from sedimentary rocks equivalent to the Skiddaw Group and with similar physical appearance and fossil content. There are sandstones in the east. In "The Earth", Richard Fortey described a transect along the Trans Canada Highway across Newfoundland. The Central Mobile Belt is difficult to interpret. It is thrust over the Avalonian

rocks by the Dover Fault. Relief is generally higher and more irregular. On the North American side of the Iapetus Ocean, rocks formed at lower latitudes. Warm water fossils and shallow water limestones occur. Limestone breccias formed at the foot of the continetal slope and sea mounts formed over mantle hot spots. During the plate collision these deep sea rocks were thrust over the shallow water carbonates.

The Long Range Mountains in the east show complex Precambrian metamorphic rocks. Older sediments have been thrust over these. The west coast is fairly low-lying. Limestone breccias in a shale matrix have been dated by trilobites in the limestones and graptolites of a different age in the shales. Fortey worked on these rocks at Cow Head.

Dr Smith went on to describe the Cambrian – Ordovician global strato-type boundary at Green Point. Further slides showed the poorly vegetated Table Lands where black peridotite weathers brown.

The final part of the talk described the geomorphology of the fjord coast. Fresh water lakes in U – shaped valleys show the high rate of isostatic uplift. This has formed coastal lowlands, inland lakes and raised beaches at 75m which form settlement sites.

Alan Smith was warmly thanked by Nigel Courtman for stepping in at short notice due to the absence through illness of the President, Angela Marchant.

OTHER LECTURES 2005 – 2006

Volcanic earthquakes: signs of unrest - Dr Hugh Tuffen (University of Lancaster) at the Friends Meeting House, Cockermouth, on October 26th 2005

Stalagmites and climate change - Dr Andy Baker (University of Birmingham), at Westlakes Institute, Whitehaven, on November 9th 2005

Members' evening at the Friends Meeting House, Keswick, on December 7th 2005

The Society excursion to Cyprus - a lecture by Nigel Courtman + society members, at Newton Rigg Campus, Penrith, on January 18th 2006

Evaluating an ice stream model for the Irish Sea basin - Dr Dave Roberts (University of Durham), at Tullie House Museum, Carlisle, on February 22nd 2006

REVIEW

"Britain beneath our feet". An atlas of digital information on Britain's land quality, its underground hazards, resources and geology. Jackson I (Editor), Keyworth, Nottingham, British Geological Survey Occasional Publications, No 41. ISBN 0 85272 479 9. £5.00

The subtitle neatly summarises the aim of this well organised, attractive book, "a brief introduction to the wealth of digital information and knowledge that the BGS holds on the land beneath our feet." The book has been written with users in mind who are not necessarily geologists.

The book is divided into 5 sections, base data (essentially geology), land quality and groundwater, hazards, resources and finally offshore and coastal. Each section is divided into a series of themes discussed in two page spreads. These have a full page digital map of the theme in the UK, either a more detailed map of the distribution of the feature in a small area or a graph, colour photos and supporting text.

I found the treatment fascinating and stimulating, very much a taster indicating what is available. The wide range of topics illustrated agreeably surprised me. Inevitably it could be considered slight but that belies its purpose. It is very readable, clearly appropriate for individuals and companies who need to know where to find highly specialised data about the environment, natural and man-made. One criticism – a detailed table of contents or an index would enhance its value by making it easier to find the particular topic needed. At £5 it is a snip at the price besides being both eye catching and extremely useful.

Mervyn Dodd.

OBITUARY NOTICE

J G (JOE) CAPEWELL 1917 – 2005

To many of us, Joe Capewell was a Lake District geologist through and through. Although born in Whitley Bay, at an early point in his life, the family transferred to Leeds where he grew up and went to school. He completed his education at Leeds University (1935 to 1939) just before the Second World War. Called up in 1940, he saw service in the Royal Engineers in India and eventually, in Burma, where his background made him a technical expert on soils and constructional materials. He was discharged with the rank of Captain in 1947.

I am indebted to his eldest son, Richard, for most of these details, the rest stem from contact with Joe as a colleague teaching at University College London between 1954 and 1960. We both agree that Joe was almost totally silent on his school and war years.

Demobbed, Joe was recruited to University College by Sydney Hollingworth, himself newly appointed from Geological Survey to the Yates Goldsmid Chair at UCL. Like all of us, the initial appointment was as an Assistant Lecturer on probation, the very bottom of the ladder. Hollie was using all his Caldbeck and Carrock Fell experience in student courses which were heavy in fieldwork, so it was natural that Joe was drawn into this pattern and focussed on the Carboniferous basement series of Cross Fell and the margins of the Vale of Eden. Indeed, these were pencilled in as a fitting topic for a doctorate study which was completed in 1952 whilst he was also under the pressure of teaching sedimentology and supervising fieldwork and research students in the meantime. The latter was often based on Coniston or Appleby, work which figured in his papers in the Transactions of Leeds Geological Society and the Geologists' Association. Otherwise, he is probably best remembered for his mapping and analysis of the Mell Fell Conglomerates which Hollie introduced to the Geological Society when he was Secretary (QJGS 1955)

As a colleague, he made my arrival from the North East bearable until I got adjusted to London. Part of this was through brisk walks through Bloomsbury at lunch breaks before return to afternoon teaching, and flashes of conversation which now fall into context, thanks to Richard filling in those missing years of the War. We also shared a respect for old Leeds friends of Joe's pre-war years, particularly Selwyn Turner and Dorothy Rayner. In a relatively small department, we always had the benefit of feedback from students. Overseas students, mainly from India or Pakistan, when they reached research years, were warm in their response to someone they recognised as a real field geologist, who took them to map the Old Red Sandstone of South West Ireland, wide open spaces even freer than the Lake District fells.

All of this went into reverse around 1959, when Joe quit UCL to take up a field post with Attock Oil Company, working in the foothills of the North West

Frontier. Work in this tribal country required the protection of armed police escort. This produced a challenge to his respect as a teacher as he told it. Arriving at a typical fort to receive the escort, the guard were turned out with military precision, and when the officer in commandd to greet the field party, Joe was shocked to recognise a man who had failed Engineering Geology at UCL. To his great relief, Joe was greeted with warm words and recollections of Gower Street! His advice to us was 'Always be decent with your students, just in case...'.

When Attock failed in 1961, Joe came back to England to find an opening for an engineering geologist at Northampton College, soon to become the City University in Finsbury, North London. This was an appropriate recognition, again of a practical engineering geologist with real experience to pass on to trainee civil engineers. He stayed there to be Head of Department, retiring in 1980 to live in Latingham, North Yorkshire. In this last period, Joe was very important in the Geologists' Association, steering their policy of Field Guides of the simpler format between 1969 and 1980. In retirement, he served on the Council of the Yorkshire Geological Society between 1981 and 1984.

We could say that wherever life took him, Joe did an honest job with very little fuss, as a geologist and as a friend. He died in June 2005 in a nursing home in Sussex, close to two of his children.

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Eric Robinson

GENERAL MEETINGS

THE 44th ANNUAL GENERAL MEETING of the Society took place on Wednesday February 25th 2005, at the Friends Meeting House, Cockermouth. The President opened the meeting with 18 members present. There were no apologies for absence. The Minutes for the AGM held in February 2004 were read and approved, there were no matters arising. Two reports were tabled: a) an Annual Report to members from officers of the society, and b) A balance sheet of the Society Accounts for the year ended December 2005 from the Treasurer. Discussion followed regarding clarification of the accounts. Both were accepted by the meeting. The meeting approved the list of Officers as proposed by Council. There were no items under AOB and the meeting closed at 7.45 pm. After the formal business The President, Angela Marchant, delivered an address entitled "Edinburgh – a Geological City".

AN EXTRAORDINARY GENERAL MEETING of the Society took place on January 18th 1006 at Newton Rigg campus. The meeting was called to put a new constitution before the membership. This was approved unanimously and will be posted on the Society website.

THE 45th ANNUAL GENERAL MEETING was held at the Friends' Meeting House Cockermouth, on Wednesday 15th March 2006. The chair was taken by the Junior Vice President, as the President, Angela Marchant was unwell. Minutes of the 2005 AGM were circulated and accepted. The nominees for officers proposed by the council were elected. Officers of the Society were thanked for there work over the past year. It was decided that flowers be sent to the President on the day of the Annual Dinner, which she would not be attending. The meeting closed at 7.45pm and was followed by a lecture: Iapetus - the other side, by Alan Smith, an account of which appears on pages 244 and 245 of these Proceedings.

2005

The dinner was held in the Greta Suite of the Skiddaw Hotel, Keswick on Saturday March 19th. 2006. The President, Angela Marchant led the evening. A large number of members and their guests enjoyed a good meal. A geological quiz compiled by Alan Smith provided some light entertainment. Our guests for the evening were Charlotte Vye and Stu Clarke from BGS Edinburgh who provided an interesting after dinner talk on modern geological exploration and remote sensing. The Charles Edmonds Award was presented by Mervyn Dodd to David Kelly in recognition of his work for the Society and geological education in Cumbria.

2006

Another very successful dinner was held in the Greta Suite of the Skiddaw Hotel, Keswick on Saturday March 18th. 2006. Unfortunately our President, Angela Marchant could not be present owing to ill health, the Vice President, Alan Smith deputised and led the evening. 47 members and their guests enjoyed a very good meal. A quiz compiled by Ken Bond on a weather and geological theme proved an enjoyable test for the evening. The visiting speaker was Simon Webb from English Nature who gave a beautifully illustrated and thought provoking talk on 'The Future of Geological Conservation'. A vote of thanks was given by Eric Skipsey, who along with Simon Webb, had led the Cumbria Riggs Group for many years and had done much for geological conservation work in the County.

THE SOCIETY SMALL AWARDS FOR STUDENTS

The Cumberland Geological Society Small Awards for Students Fund was established in 2002 primarily to assist students who have limited funds, to undertake geological fieldwork. Preference will be given to students who have Cumbrian connections. Applicants will be required to outline their research and indicate how this funding will assist their project. Applications will be judged by a sub-committee of the Society.

Successful applicants will be required to deliver a presentation of their work to the Society.

The sum of money donated will be at the discretion of the Society and will be no more than £200.

Those who may be interested in applying for an award should, in the first instance, contact the General Secretary:

Nigel Courtman


More details and an application form will be provided.

OFFICERS AND COUNCIL

Officers and Council elected for 2005 and 2006 are listed below.

OFFICERS ELECTED FOR	2005	2006
President	Angela Marchant	Angela Marchant
Senior Vice-President	Alan Smith	Alan Smith
Junior Vice-President	David Kelly	David Kelly
General Secretary	Nigel Courtman	Nigel Courtman
Lecture Secretary	Nigel Courtman	Nigel Courtman
Council Secretary	Alan Smith	Rosemary Vidler
Excursion Secretary	Alan Smith	Alan Smith
Treasurer	Margaret Bennett	Margaret Bennett
Membership Secretary	Chris Thompson	Chris Thompson
Editor	David Kelly	David Kelly
Publicity Officer	Anne Freeland	Anne Freeland
Librarian	David Powell	David Powell
RIGGS Co-ordinator	Anne Freeland	Anne Freeland
Council Members	David Steele	David Steele
	Tony Rigby	John Rodgers
	Susan Beale	Susan Beale
	Judy Suddaby	Judy Suddaby
	Rosemary Vidler	Rosemary Vidler
Hon. Auditor		

In addition, R. J. Cockersole, T. Shipp, I. Gray, K. Bond and D. Dickins, past Presidents of the Society, are ex-officio members of Council.

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