Heriot and Innerleithen

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OS1:50000 Sheet 73 (Galashiels & Ettrick Forest)

BGS. 1:50000 Sheets 24 E (Biggar), 25 W (Peebles) and 32 E (Edinburgh).

Introduction

The excursion is designed to show a variety of Lower Palaeozoic rock types (greywackes, shales, cherts and tuffs), their associated sedimentary and tectonic structures, and their depositional relationships. Graptolites and trace fossils can also be collected. A small granitoid pluton is included and, in addition, the excursion affords excellent illustrations of geological control over the topography (Walton 1975). It is designed as a circular tour and can be started from Middleton as described or Innerleithen or Caddonfoot. Some localities can conveniently be combined with parts of the Tweedsmuir, Dob's Linn or Hartfell Score excursions.

From Middleton take the A7 Edinburgh-Dalkeith-Galashiels road for 2 km towards Galashiels and then turn right on to the B7007 road to Innerleithen. This road runs over flat, low-lying land, underlain by relatively soft Carboniferous sedimentary rocks of the Inverclyde and Strathclyde groups, southwards towards the Lammermuir Fault. The fault itself is not exposed but the resistant Ordovician greywackes form a prominent scarp on the south side of the fault, especially impressive from this approach.

1. Wull Muir: viewpoint

The road curves sharply southwest into the line of the fault, and climbs obliquely for about 100 m to the top of the scarp, whence it again turns sharply southwards. At this point [NT 349 544] advantage should be taken of the very fine view across the southern half of the Midland Valley. Lower Carboniferous sedimentary rocks underlie the flat moorland in the foreground, but the topography becomes more varied to the north and west where the Lower Limestone Group crops out. Beyond, scattered colliery bings indicate the outcrops of the Limestone Coal Group ('Edge Coals') and the Coal Measures In the distance, beyond the Pentland Fault and the Carboniferous terrain rise the Pentland Hills. These are composed of Silurian and Old Red Sandstone rocks; the lower, rounded hills are formed of sandstone, whereas the higher steep-sided hills to the north consist of lavas. The height of the range decreases towards the north-east and the city of Edinburgh with its Castle Rock, a glacial crag-and-tail feature formed around a Carboniferous volcanic neck. The Salisbury Craig Carboniferous teschenite sill forms the prominent scarp feature to the right which, in turn, merges with the rugged mass of Arthur's Seat, another Carboniferous volcanic neck. Under favourable conditions the view extends across the Firth of Forth to Fife and westwards to the Ochil Hills, another range formed of Old Red Sandstone lavas and separated from the Pentland Hills lavas by a second major Carboniferous basin. In Fife, especially, this basin is dominated by the Midland Valley Sill of Permo-Carboniferous quartz-dolerite, which forms the distant ridge of the Lomond Hills to the north-east. Two prominent summits superimposed on this ridge are the Permo-Carboniferous vents of West and East Lomond. On an exceptionally clear day the southern margin of the Grampian Highlands, beyond the Highland Boundary Fault, may be seen.

2. Broadlaw Quarry: granodiorite

Leave the road and continue west along the scarp for 1 km where there is a disused quarry [NT 339 539] in the Broadlaw Granodiorite, one of a number of small, Late Caledonian granitoid intrusions ranged along the southern side of the Southern Upland Fault. The granodiorite body is not more than 1 km in length (NE–SW) and about 100 m in maximum width, elongated roughly parallel to the regional strike of the Ordovician greywacke country rocks. The contact of the granodiorite with the greywackes is nowhere exposed but an intrusive relationship was confirmed by Mould (1947) who

reported a small roadside exposure of thermally metamorphosed and hornfelsed mudstones and greywackes.

The granodiorite exposed in the quarry is grey in colour except in the south-east corner of the quarry where it is red. Both colour variations consist essentially of quartz, plagioclase and orthoclase feldspar, and biotite; accessory minerals include zircon, pyrite and apatite. The grey granodiorite is porphyritic, with phenocrysts of plagioclase (oligoclase with labradorite cores) set in a finer-grained matrix and brown biotite mostly altered to chlorite. The slightly more acidic red granodiorite is medium-grained with plagioclase, somewhat more sodic and generally sericitized. The intrusion appears to be zoned with the granodiorite surrounded by a fine-grained quartz-diorite, sporadically exposed north-cast of the quarry. Shale and mudstone xenoliths have been converted to a hornfels consisting of quartz, andesine and biotite. Mould (1947) also reports the occurrence of hornblende, actinolite, corundum and, rarely, sillimanite. Jointing is well developed in the granodiorite, and a number of planes of shearing and crushing can be seen. Quartz veins are fairly common, and other thin veins are filled with pyrite and more rarely with arsenopyrite.

3. Broadlaw: Ordovician chert inlier

Chert and graptolitic shale crop out in an inlier originally considered to include Arenig and Caradoc horizons (Peach and Horne, 1899), in a road cutting [NT 347 533] 1 km south of the granodiorite. There is exposure on both sides of the road for about 200 m and, according to Peach and Horne (1899), black radiolarian cherts are overlain by grey mudstones with black shale interbeds, and these in turn by greywackes with black shale partings (belonging to the early Caradoc Portpatrick Formation). The grey mudstones were thought to be equivalent to the Clenkiln Shale (Llandeilo-Caradoc) of the Moffat Shale Group, whilst one black shale band in the overlying greywacke succession yielded a slightly younger fauna including Diplograptus foliaceus, Lasiograptus margaritatus and Dicellograptus more characteristic of the Hartfell Shale (Caradoc-Ashgill).

The rocks currently exposed are represented in (Figure 30), although the section has deteriorated considerably through slippage and weathering. Small-scale faulting and folding can be readily seen, but Peach and Horne's (1899) interpretation of an anticlinal structure cannot be confirmed. Instead, a stack of small imbricate thrusts appears to be associated with isoclinal folds in which the uninverted limbs have been partly or wholly sheared out. The shales in particular are affected by recumbent folds of about a metre amplitude which verge south-eastwards. This style of imbricate thrusting associated with attenuation of uninverted fold limbs is a typical deformation pattern within the, Southern Uplands (Webb 1983). Small normal faults oblique to the imbricate thrusts are probably late tensional features.

The exposures, though restricted and discontinuous, are adequate to demonstrate that black cherts are not confined to one horizon in the core of an anticline. The best exposure of chert is at point A in (Figure 30) where a stratigraphic thickness of more than 1 m is visible wherein the chert, dominantly black, occurs as bands and lenses up to 10 em thick, separated by pale greenish-grey mudstone partings up to 4 cm thick; some at least of which may be bentonites (altered air fall tuffs). Individual chert bands may become very pale grey towards their margins. Scarce and fragmentary graptolites in the black shales include Climacograptus brevis, Corynoides incurvus and an indeterminate diplograptid (identifications by I. Strachan). These indicate a high Glenkiln or low Hartfell horizon, i.e. basal Caradoc and possibly a little lower than was deduced by Peach and Horne (1899). Records of *Amplexograptus perexcavatus* and *Dicranograptus d. nicholsoni* (Walton and Weir 1974) are considered less reliable, though suggesting a comparable age.

Pale grey mudstones with interbedded black shale horizons underlie the cherts in inverted succession in the same exposure. The pale grey mudstones are hard and blocky, and weather to a mottled brown and yellow appearance. Fresh surfaces of the grey mudstone commonly have a brecciated aspect, with patches of contrasting shades of grey, and may be intraformational microconglomerates. Large aggregates of pyrite (up to several cm across) also occur. North of the fault (B on (Figure 30)) the grey mudstones are in normal contact with interbedded greywackes and shales and it is of particular significance that 25 mm bands of undoubted chert occur within the shales. It is evident from this interbedding that the cherts are of an age with the other sedimentary rocks here, rather than being of an entirely different (Arenig) age as suggested by Peach and Horne. (1899, Some chert bands are coarser-grained and ashy (e.g. at C on (Figure 30)) and in this respect it is significant that ashy bands and radiolarian cherts also occur in the Glenkiln succession of the Moffat district (e.g. Peach and Horne 1899, p. 103).

Southwards the route traverses a typical Southern Uplands landscape of well-rounded moorland with a uniformity of summit levels indicating a dissected peneplain, and deeply incised streams with flat valley floors. A small glacial meltwater overflow channel may be observed on the north side of the road near Windy Slack [NT 352 523]. Further exposures of the cherts and shales may be visited opposite Garvald farmhouse [NT 354 513] some 200 m up the hillside; no fossils have as yet been reported from this locality.

4. Raeshaw Wood Quarry: Llandovery sedimentary rocks

Steeply inclined and strongly jointed, pebbly greywacke and siltstone beds are exposed in a large roadside (B 709) quarry at Raeshaw Wood [NT 357 504]. The coarse-grained greywackes, which represent a conglomeratic development, the 'Raeshaw Conglomerates', within the Kilfillan Formation (Figure 30), consist of quartz grains and generally quartzo-feldspathic rock fragments together with larger clasts of lightly cleaved black shale, all contained in a fine-grained matrix. The shale clasts have yielded graptolites, including *Climacograptus scharenbergi*, *C. bicornis*, *Cryptograptus tricornis*, *Dicellograptus* and *Didymograptus superstes.* (Peach and Horne 1899, p. 270) denoting a Llandeilo-Caradoc age and suggesting an association with the Glenkiln Shale. Their cleaved state indicates that these clasts are not intraformational, but are earlier, and were subsequently incorporated into the conglomerate. The basiclastic matrix conforms compositionally to Kilfillan arenites. McKerrow (in Hutton & Murphy 1987) notes the occurrence of Glenkiln clasts in other Southern Uplands Silurian conglomerates. The clasts were derived by erosion of sea-floor mud by strong turbidity currents carrying the detritus forming the coarse greywackes. Such sequences typify inner-channel deposits on a submarine fan (Mutti and Ricci-Lucchi 1975). Grading is sufficiently well-developed to allow the direction of upward stratigraphical sequence to be determined, a process of the utmost importance in lithologically uniform successions such as this, which have undergone severe folding. Grading is only one of a number of features which can be used and other sedimentary structures useful in this respect will be seen at the remaining localities.

5. Hazelbank Quarry: Llandovery sedimentary rocks

The road east from Raeshaw Wood Quarry leads past Ladyside to Heriot village and the main road to Hawick and Carlisle (A7); Hazelbank Quarry [NT 425 505] is on the east side of this road 5.5 km south of Heriot. It is currently being worked in thick greywacke beds, with intervening partings of shale and siltstone, dipping ESE at 70–90°. Advance permission must be obtained from the quarry manager in order to visit the site, and hard hats are required.

The greywackes contain abundant andesitic volcanic fragments, including pyroxene and amphibole grains, and have relatively low quartz content. They are assigned to the lowest part of the Gala Group, and the quarry is the type locality for the Hazelbank Formation (Kassi 1984); this is partially equivalent to the Kilfillan Formation, (Gordon 1962) which corresponds to the Pyroxenous 'Group' of Walton (1955). The greywackes are strongly jointed, and are cut by a number of small normal and reverse faults. The sequence is dominated by greywacke units up to several metres thick, many of which display amalgamation. They are coarse-grained, poorly graded, and carry a profusion of large, dark grey mudstone clasts. Some greywacke units display reversed grading towards their base and normal grading towards their top. The remaining greywacke beds (about 20% of the total sequence) are thinner and well-graded 'classic' turbidites. Taken as a whole the Hazelbank sequence represents a channelized mid-fan association (Mutti and Ricci Lucchi 1975)[12], probably less proximal than that of Raeshaw Wood Quarry. The siltstone interbeds (about 12% of the sequence) are, in effect, thin base-absent' turbidite sequences. These form 'packets' 40 cm to 2 m thick, and are interpreted as overbank deposits, laid down on and beyond levees flanking the submarine channels.

Grading in the steeply-inclined greywacke beds indicates south-eastward younging, confirmed by small-scale cross-lamination in the siltstones, which are also ripple-marked on their top surfaces. In addition, undersides (sales) of many of the greywacke beds carry more or less elongated convex impressions (sole-markings) of various kinds. Many have a lobate appearance, deepening towards rounded ends (flute casts). These may be aligned to form longitudinal ridges, or may occur as alternating rows (scaly patterns). Flute casts are formed by the moving, turbulent current scooping out small hollows in the mud of the sea bed to form moulds which are then filled by the deposited sand. Erosion strips away the softer shale leaving the casts as projections on exposed bed bases. Other sole-markings present include straight or curved narrow ridges, often not seen to terminate. These are variously termed groove casts, drag marks or

tool marks and are fillings of grooves cu t in to the sea-floor mud by objects dragged by the moving current. The unifying feature of all these sedimentary phenomena is that they only occur on the bases of the greywacke beds and so they can be used to establish way-up; at Hazelbank these sole-markings confirm the SE younging direction.

6. Bower Quarry: Kilfillan Formation

This quarry [NT 429 501] is some 450 m south of Hazelbank Quarry, and is also in andesitic-rich greywackes of the Gala Group (Kilfillan Formation). Graptolites have been recorded; these include *Climacograptus normalis, Diplograptus* and other fragmentary forms, indicating a horizon within the zone of *Parakidograptus acuminatus*, the lowest biozone of the Llandovery Series. Thus, the great (though indeterminate) thickness of greywackes and finer sediments in the present area is laterally equivalent to, at the most, a few tens of metres of black and grey shales and mudstones within the Birkhill Shale sequence at Dob's Linn and elsewhere in the Moffat area (Dob's Linn Excursion). This demonstrates the rapid facies change from continental margin clastic scdimentation to pelagic oceanic sedimentation farther out into the original depositional basin.

Sedimentary features in the greywackes of Bower Quarry indicate that the beds, which dip at 85° to the NW, are the right way up. Particularly prominent are well-developed transverse and interference-ripple patterns on the upper surfaces of many beds. The dip and younging direction are both opposite to that in Hazelbank Quarry to the north, and indicate that a synclinal axis must lie in the unexposed ground between the two quarries.

The greywackes in the two quarries show a contrast in colour, those of Hazelbank being a pale greenish-grey whereas those of Bower are distinctly red. This red colour is due to iron oxide staining, and is presumably caused by the proximity of Old Red Sandstone strata. The greywackes are otherwise compositionally and texturally identical. Larger particles include pebbles of granite, quartz-porphyry, keratophyre, spilite and andesite, together with accessory quartz and alkali feldspar clasts, shale, red mudstone and chert. These lithologies also contribute to the sand-grade assemblage but in this fraction quartz and andesitic grains are more abundant, the latter including pyroxene and amphibole crystals. Chlorite and mica-schist grains are occasionally present.

7. Craigend Quarry: Llandovery greywackes

Farther south-east along the A7 this quarry [NT 444 461] exposes thick and massively-bedded Gala Group greywacke sassigned by Walton (1955) to the Garnetiferous 'Group'. This youngest subdivision of the Gala Group was originally termed the Buckholm Grits by Lapworth and Wilson (1870) and the name was lately resurrected as the Buckholm Formation (Kassi 1984). This is now regarded as an interdigitating lithofacies of the Queensberry Formation of Geikie (1871). Folding and imbricate thrusting replicate the formation and give it a wide outcrop which encompasses most of the remaining Silurian localities to be visited during this excursion. The greywacke beds have a gentle dip towards the NW, shale partings are poorly developed, and internal sedimentary structures are scarce. These are again typical inter-fan channel deposits. Accessory garnets are the characteristic detrital component although they are mostly microscopic. Otherwise the greywackes are quartz-rich with minor amounts of quartzo-feldspathic and schistose rock fragments.

8. Caddonfoot Quarry: Llandovery greywackes

Continue south along the Galashiels road (A7) to Bowland, thence turn south-west on to the B710 and follow this road through Clovenfords. The quarry [NT 450 351] is situated on the east side of the road about 200 m north of the T-junction with the Selkirk road (A707) at Caddonfoot. This locality is again in garnetiferous Queensberry Formation greywackes of the upper Gala Group, though here they are thinly-bedded, with graded bedding and occasional sole-markings. The latter are best developed in an especially thinly-bedded sequence in the south corner of the quarry where small-scale tool-markings, including brush and prod moulds, can be observed. The upper surfaces of many thin beds are ripple marked, and ripple-cross-lamination occurs throughout. Scour marks are absent, indicating a low-energy input and a relatively deep depositional environment. Sporadic graptolites include Monograptus turriculatus and M. crispus, zonal forms for a high level within the Llandovery. They are most readily recovered from the cutting on the east side of the road, between Caddonfoot cottage and the quarry.

9. Thornylee: trace fossils in red shale

From Caddonfoot follow the A707 and then the A72 towards Innerleithen for about 6 km and then park in a lay-by on the SW side of the road beside the River Tweed. Interbedded Gala Group greywackes and shales (Queensberry Formation; garnetiferous lithofacies) are exposed in a quarry [NT 420 363] in the steep slope across the road and north from the lay-by, and in 300 m of abandoned railway cuttings between the quarry and the road. The greywackes are medium-grained and well-graded, and display a range of erosional sole-markings and tool-markings. These are on a small scale, indicating a moderate energy input, higher than at the previous locality but still in deep water, probably within a middle or lower fan environment. The red shale bedding surfaces are covered by traces of the meandering feeding burrow *Dictyodora,* including both the larger and regularly meandering *D. scotica* and the smaller and more irregular *D. tenuis*. This meandering pattern is typical of organisms scavenging a food source efficiently, keeping in contact with earlier-formed parts of the burrow and, when these are lost, making a 180-degree turn to re-establish contact and to resume feeding. The burrows extend upwards as narrow striated walls, each possibly created by a siphon maintaining contact with the sea bed above. Other trace-fossils present include the narrow and almost straight *Caridolites wilsoni*, which may represent a juvenile stage of *Dictyodora.* In general, meandering burrows are typical of deep-water marine trace fossil associations (Benton and Trewin 1980).

10. Pirn Quarry: Llandovery turbidites with sole-markings

Continue along the A72, through Walkerburn and to the outskirts of Innerleithen where a large lay-by on the north side of the road is adjacent to the overgrown quarry [NT 339 373]. A succession of Gala Group greywackes belonging to the Intermediate 'Group' of Walton (1955)[16] is exposed at this locality and has been correlated with the Fountainhall Formation of the Gala Water valley (Kassi 1984)[17] now, like the Garnetiferous 'Group' considered as an interdigitating siliciclastic lithofacies of the Queensberry Formation. The quartzo-feldspathic greywackes are bedded in units up to about 3 m thick. Delayed grading is typical, with isolated mudstone clasts up to 5 cm long concentrated towards the bases of several units. The succession dips steeply towards the south-cast but is overturned, thus exposing the bases of beds, and a spectacular range of sole-markings including longitudinal ridge casts, 'scaly-pattern' flute casts, drag marks, channel fills and other rarer types (Dzulynski and Walton 1965). The main surface exposed in the south-west corner carries two intersecting sets of groove casts. Dragging relationships indicate consistent relative ages for the sets, and so denote a marked change in the current direction. The plastic mud displaced from the grooves has been rucked up into rope-like structures. Immediately below (though stratigraphically above) the grooves, one internal surface within the greywacke displays smaller grooves. These rare structures are internal grooves, the origin of which is revealed by the presence of small shale clasts which terminate a few of the structures. The bed is otherwise a pale grey, graded greywacke typical of the Gala Group at this locality. Further east another sole carries, in addition to continuous groove casts, discontinuous tool-markings including prod marks and brush marks. The outcrop of the first horizon continues into the middle of the face, and reveals numerous shale and siltstone clasts up to 20 cm across, which may be the tools responsible for inscribing many of the markings. Groove casts also occur in the north-east corner of the quarry, which is otherwise noteworthy for channel fills. These generally have a fluted structure, though one wide example lacking significant fluting is seen high up on the quarry face.

Characteristic of the greywackes here is delayed grading. A thin basal zone of coarse grains with large and dispersed shale clasts is succeeded upwards by uniformly medium-grained greywackes containing only sporadic shale clasts. This in turn is succeeded by a thin, graded top which terminates in cross-laminated and laminated siltstone and merges into the overlying pelite interval.

11. Cowpeel Bridge: Llandovery turbidites with flute casts

Continue to Innerleithen (0.5 km) on the A72; there join the Hawick road (B709) and follow it southwards for 4 km through Traquair. A cutting face on the west side of the road [NT 314 310] exposes the slightly overturned soles of several steeply-inclined, quartzo-feldspathic Gala Group greywacke beds (=Queensberry Formation: garnetiferous lithofacies.) These show a mass of well-developed 'scaly' flute casts which have been slightly exaggerated by load casting, i.e. by the

heavy turbidite sand, laid down suddenly, sinking into the underlying soft mud. and so creating downward bulges. Nevertheless they unequivocally indicate current flow from the NNW (vertically upwards on the exposed bed base), and normal to the regional strike. These greywackes are deposits of high-energy turbidity currents, directly down-slope on the submarine fan.

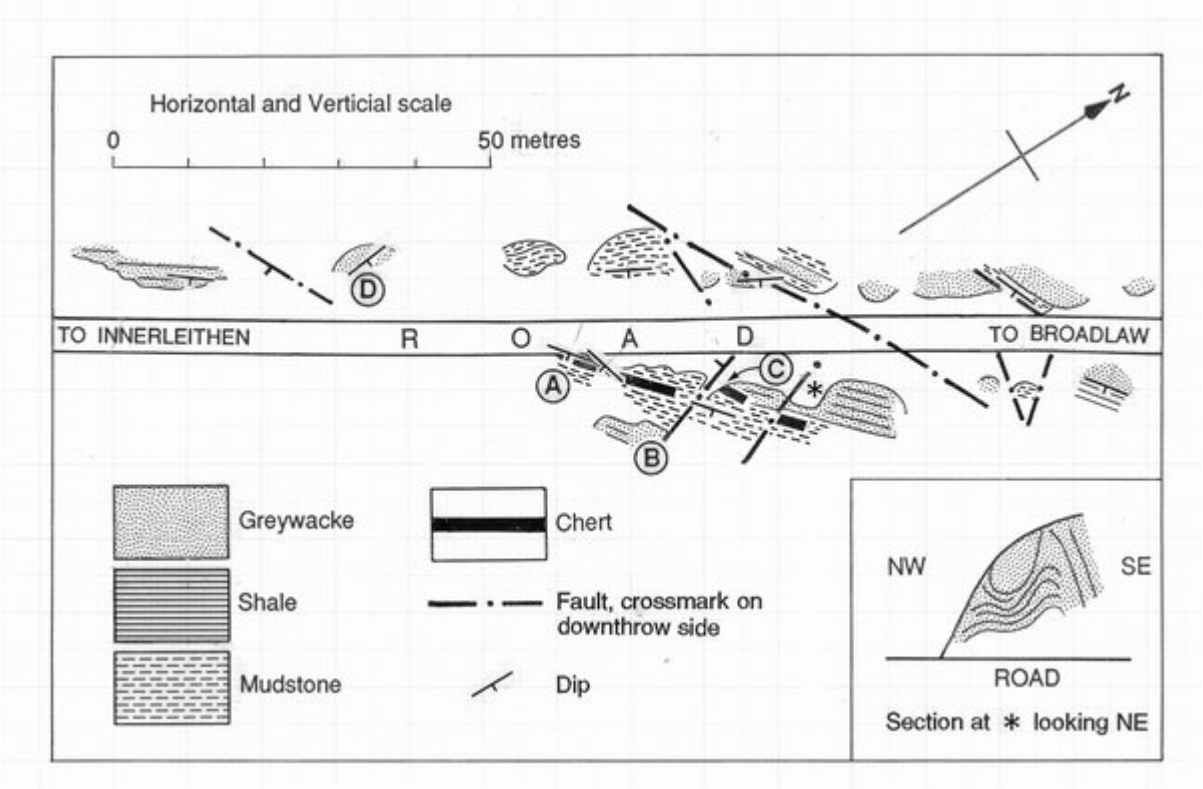
12. Grieston Quarry: Llandovery distal sedimentary rocks

Return to Traquair and follow the old Peebles road (B7072) for 1.7 km northwestwards to Howford. Grieston quarry [NT 316 539] is reached via a rough track which leads south-west from the B7062 on the south side of Howford farm. The thinly-bedded and fine-grained greywackes are interbedded with shales which were originally worked for roofing slates. Graptolites were first recorded by Nicol (1848, 1850) and were subsequently described in modern terms by Toghill and Strachan (1970). About 43 m of well laminated, thinly-bedded flaggy greywackes, siltstones and mudstone are exposed, and have a NW dip of 60–65° and abundant small-scale sole-markings, showing that the succession is the right-way up. Parallel, cross and convolute laminations are frequently seen in the thinlybedded (5 cm) sandstone and siltstone beds. The fine grain size, thin beds and sedimentary structures indicate a very low energy-distal environment of deposition. Graptolites occur in situ in fine-grained bluish-grey greywackes 3.7 m above the base of the succession in the east end of the quarry, and in a less prolific horizon a metre above the base. The commonest species are *Monoclimacis griestoniensis*, *Monograptus priodon* and *M. spiralis*, with rarer *M. discus*, *Rastrites* geinitzianus angustidens and Pseudoplegmatograptus obesus. Micaceous greywacke slabs in the quarry talus have not been located in place, and contain a slightly different assemblage, adding common *Monograptus drepanoformis*, *Pristiograptus nudus* and *Clyptograptus? nebula*, having only rare *M. griestoniensis*, and lacking *M. discus*. Both assemblages indicate a horizon within the *griestoniensis* Zone, and represent the highest horizon yet recorded within the Gala Group; localities to the E and SE, including Caddonfoot and Thornylee, yield graptolites of the underlying *crispus* and *turriculatus* zones (Lapworth 1870[22]; Peach and Horne 1899). The presence of relatively young strata this far north in the Southern Uplands is anomalous in terms of the regional structure and its implications have not yet been fully assessed. It is possible that the Grieston strata were originally deposited in an isolated perched basin unconformably above the developing Southern Uplands accretionary complex.

13. Craigburn Quarry: haggis rock

Continue to Peebles on the B7062. If returning through Eddleston, Craigburn Quarry [NT 237 544] just before Leadburn is worth a visit to see the Haggis Rock. This quarry is described as the first locality in the next excursion (Noblehouse, Lamancha).

References



(Figure 30) Broadlaw.