Dob's Linn, Moffat

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O.S. 1:50000 Sheet 79 Hawick & Eskdale

B.G.S. 1.50000 Sheet 16W Moffat

Introduction

Some 19 km north-east of Moffat lies Dob's Linn, a spectacular gorge and waterfall deeply cut into the Ordovician and Silurian shales and greywackes of the Southern Uplands. The well-exposed, virtually continuous Caradoc to Llandovery sequence of graptolite-bearing strata, with its intercalated 'barren beds' was distinguished in the classic researches of Charles Lapworth (1878) as 'the only section of the Moffat Series which allows us to determine with certainty the sequence and palaeontological characteristics of its component beds, and at the same time exhibits the relationship of the group as a whole to the surrounding greywackes'. Dob's Linn was named after a Scottish Covenanter, Halbert Dobson, who hid from the English Dragoons in the small cave above the waterfall. It is an easily accessible section and abundantly fossiliferous, though at certain critical exposures the visitor is asked to refrain from hammering. Dob's Linn has been the subject of much research (Lapworth 1878, Toghill 1968, 1970, Williams 1982–88) and is now renowned as the global boundary stratotype for the Ordovician/Silurian boundary (Williams & Ingham 1989). This lies within a black shale sequence (the Moffat Shale Group) extending from the peltifer graptolite zone of the early Caradoc (Ordovician) to the maximus subzone of the late Llandovery (Silurian). Interbedded volcanic ash horizons are common; Merriman and Roberts (1990) describe 135 metabentonite beds cumulating to about 6 m and representing up to 20% of the strata in some biozones (Figure 41). Following Lapworth the Moffat Shale Group is divided into four units with informal formation status: in ascending stratigraphic order these are the Glenkiln Shales, the Lower Hartfell Shales and Upper Hartfell Shales and the Birkhill Shales. The latter are abruptly but conformably overlain by greywackes of the Gala Group, locally assigned to the Queensbury Formation.

Dob's Linn is conveniently adjacent to the A708 Mofat–Selkirk road. An appropriate starting point for a visit is the watershed some 5 km south-west from the Loch of the Lowes and St. Mary's Loch. Here on the wall of Birkhill Cottage [NT 202 158] is a plcque erected by Scottish geologists in 1930 commemorating Lapworth's residence therein at various times during 1872 and 1878, and his discovery of the uses of graptolites in unravelling the stratigraphy and structure of the Southeren Uplands. Some 700 m. west of the cottage are two parking spaces on the north side of the road and conveniently situated for leaving cars or coaches prior to the descent into the Linn. Follow the streamlet from the parking space down to the main burn. Crossing the burn is normally very easy though it can be hazardous after heavy rain.

The floor of the valley follows the line of a major fault (the Main Fault of Lapworth). It is still worth noting that to the east of this line the rocks (Birkhill shales) are intensely crushed and folded, and little of stratigraphical value can be determined. All the instructive exposures lie to the west of the fault, the total sequence there is summarized below in descending order. The common graptolites in each zone are indicated, some are illustrated in the illustrations.

Gala Group (Queensberry Formation)

Thick greywacke beds with sole marked bases, interbedded thin shale bands. Top not seen here.

Birkhill Shales (Llandovery–Ashgill) 43 m.

***Rastrites maximus* zone (6.6 m)**

Grey mudstones with thin, sparsely fossiliferous black shales.

Rastrites maximus, R. linnaei, R hybridus ,R. fugax, Monograptus sedgwickii, M. halli, M. attenuatus, M. spiralis.

***Monograptus sedgwickii* zone (8.4 m)**

Black and grey mudstones, highly fossiliferous.

Monograptus sedgwickii, M. involutus, M. decipiens, Pristiograptus regularis, P. jaculum, Climacograptus scalaris, Petalograptus tenuis.

***Monograptus convolutus* zone (5.4 m)**

Black and grey mudstones, highly fossiliferous.

Monograptus convolutus, M. lobiferus, M. clingani, M. limatulus, M. communis, Monoclimacis crenularis, Rastrites hybridus, Cephalograptus cometa, C. tubulariformis, Glyptograptus tamariscus, Orthograptus bellulus.

***Monograptus gregarius* zone (8 m)** Some workers divide this into three zones, termed in descending order the *leptotheca*, *magnus,* and *triangulatus* zones. Soft black shales, highly fossiliferous.

Coronograptus gregarius, Monograptus triangulatus, M. fimbriatus, M. communis, M. revolutus, Pribylograptus leptotheca, Rastrites peregrinus, K longispinus, Diplograptus magnus, Petalograptus spp., Clyptograptus tamariscus, Rhaphidograptus toernquisti, Orthograptus cyperoides.

***Monograptus cyphus* zone (7.3 m)**

Hard black shales, highly fossiliferous. The basal part is sometimes separated off as the acinaces zone.

Coronograptus cyphus, Atavograptus atavus, Lagarograptus acinaces, Monograptus revolutus, Dimorphograptus confertus, D. erectus, Cystograptus vesiculosus, Glyptograptus tamariscus, Climacograptus spp., Pribylograptus sandersoni.

***Cystograptus vesiculosus* zone (1.3 m)**

Hard black shales, highly fossiliferous.

Cystograptus vesiculosus, Dimorphograptus elongatus, Atavograptus atavus, Climacograptus spp. (e.g. *C. normalis, C. medius, C. rectangularis*), *Rhaphidograptus extenuatus*.

***Parakidograptus acuminatus* zone (5 m)**

Black shales, fossiliferous.

Parakidograptus acuminatus, Akidograptus ascensus, Diplograptus modestus, Climacograptus spp. (e.g. *C. normalis, C. angustus, C. medius, C. trifilis*), *Atavograptus ceryx*.

Base of Silurian

***Glyptograptus persculptus* zone (0.6 m)**

Black shales with grey-green mudstone at base.

Glyptograptus persculptus, Climacograptus angustus.

A thin band with *Climacograptus extraordinarius* occurs about 1 m below the base of the *persculptus* zone. Below this *extraordinarius* band a thin horizon of grey calcareous siltstone contains the blind trilobite, *Mucronaspis* sp.

Upper Hartfell Shales (Ashgill)

***Dicellograptus anceps* zone (3.5 m)**

Grey-green 'barren mudstones', unfossiliferous, except near the top where there are 5 thin 'anceps bands' of black shale.

Dicellograptus anceps, D. ornatus, D. minor, Climacograptus supernus, Amplexograptus latus, C. normalis, C. miserabilis, Orthograptus abbreviatus, 'O'. fastigatus, Pleurograptus lui, inarticulate brachiopods.

***Dicellograptus complanatus* zone (8 m)**

Grey-green 'barren mudstones', unfossiliferous, except for two thin 'complanatus bands' in the lower part.

Dicellograptus complanatus, *Orthograptus socialis*, inarticulate brachiopods.

Lower Hartfell Shales (Upper Caradoc)

***Pleurograptus linearis* zone (5 m)**

Black shales, highly fossiliferous.

Pleurograptus linearis, *Orthograptus quadrimucronatus*, *O. quo spinigerus*, *O. pauperatus*, *O. calcaratus basilicus*, *Dicellograptus morrisi*, *D. carruthersi*, *D. elegans*, *D. pumilus*, *Leptograptus flaccidus* macer, *L. capillaris*, *Climacograptus mohawkensis*, *C. tubuliferus*, *C. miserabilis*, *Amphigraptus divergens*.

***Dicranograptus clingani* zone (c. 8 m)**

Hard, black, thin-bedded shales, highly fossiliferous.

Dicranograptus clingani, D. ramosus, D. nicholsoni, Dicellograptus caduceus, D. flexuosus, D. morrisi, D. moffatensis, Climacograptus spiniferus, C. dorotheus, Orthograptus calcaratus, O. cal. basilicus, O. pageanus, O. amplexicaulis, Leptograptus flaccidus, Corynoides calicularis, Neurograptus margaritatus, Lasiograptus harknessi, Glyptograptus daviesi.

***Climacograptus wilsoni* zone (c. 7 m)**

Black shales with pale grey cherty horizons, sparsely fossiliferous. Some beds yield graptolites very well preserved in relief.

Climacograptus wilsoni, Climacograptus bicornis, C. bi. tridentatus, Orthograptus calcaratus vulgatus, Dicellograptus forchhammeri, D. moffatensis, Glossograptus hincksi, Dicranograptus nicholsoni, Pseudoclimacograptus scharenbergi, Corynoides curtus, C. calicularis.

Glenkiln Shales (Lower Caradoc)

***Climacograptus peltifer* zone (5 m, base not seen).**

Hard cherty black shales, sparsely fossiliferous.

Climacograptus bicornis peltifer, C. antiquus, Dicranograptus ziczac, D. nicholsoni, Dicellograptus cyathiformis, Orthograptus whitfieldi, Hallograptus mucronatus, Pseudoclimacograptus scharenbergi, Didymograptus superstes, Cryptograptus tricornis, Amplexograptus perexcavatus.

The first three recommended sites for investigation lie at the foot of the Main Cliff on the west side of the valley (Plates 2 and 3), the others are along the Long Burn and the Linn Branch.

1. Glenkiln age shales

The oldest beds at Dob's Linn are dark grey, poorly fossiliferous shales of Glenkiln age. These beds are not well exposed but fragments showing the characteristic lithology can be picked up from the scree slope. This is the only locality where the *peltifer* zone is exposed at Dob's Linn.

2. The Main Cliff

The Main Cliff is formed by shales ranging from the *clingani* zone upwards into the Birkhill Shales. Post-glacial surface creep has rotated the beds from the regional near-vertical attitude to the sub-horizontal. This cliff thus enables several zones to be studied in ascending sequence.

The *clingani* zone is now largely covered by scree, but the linearis zone is well represented in a projecting bluff. The black shales here yield abundant *Orthograptus* and the zone fossil *Pleurograptus linearis*. PLEASE DO NOT HAMMER THIS FRAGILE EXPOSURE; excellent specimens can be conceted from the scree, though they may be mixed with higher Ordovician and Silurian material derived from further up the cliff. Above the *linearis* zone the Barren Mudstones with their characteristic grey-green colour, form a substantial cliff, and the highly fossiliferous *anceps* bands may be located at the top of this barren sequence by those prepared to undertake the somewhat hazardous ascent. Still higher in the section are the lower zones of the Birkhill Shale, hard black shales yielding abundant graptolites. At the base of the Birkhill Shales here is seen the thin *persculptus* zone, with the zonal fossil and associated climacograptids, and above this the base of the Silurian is marked by the *acuminatus* zone in which are the first small monograptids *Atavograptus ceryx*. Before leaving this locality, turn round and examine the eastern cliff which is formed of highly contorted Birkhill Shales. In these the fossils are very poorly preserved. Small recumbent isoclinal folds are clearly seen some two or three metres above the river bed; the ubiquitous presence of such folds at various scales in the Southern Uplands may have influenced Lapworth and his contemporaries in the conception that isoclinal folding was the dominant structural control. Notice also the presence of 'head' on the ground surface; a fossil scree consisting of shale fragments and consolidated by a ferruginous cement during the post-glacial period.

3. Barren mudstones

A small crag here exposes Barren Mudstones which were deposited during the late Ordovician Ice-age. At this time ice may have extended to quite low latitudes, and the Barren Mudstones may have been deposited beneath an ice-covered sea. Within this sequence are two thin *complanatus* bands which presumably signify a local warming episode during an otherwise glacial event. This is another fragile exposure and IT IS REQUESTED THAT YOU DO NOT HAMMER IT.

4. Birkhill Shales

Ascend to the prominent shaly scree slope just north of the junction of the Linn Branch and the Long Burn. From here one may look southwards to see the disturbed Birkhill Shales on the eastern bank of the main stream. The vertical bedding in the lower slopes close to the burn has been rotated by near-surface hill creep in the higher part of the cliff. Westwards along the Linn Branch one is confronted by the magnificent waterfall of Dob's Linn which plunges down a near-vertical series of bedding planes to the Linn Branch gorge. A large curving tool-mark is evident on the lower facing surface of the main greywacke unit. This was cut into the underlying mud, possibly by a flat skating pebble, immediately before deposition of the overlying greywacke sediment. The beds on the North Cliff, as seen at locality 2, have been overturned and inverted. Despite faulting they preserve a sequence consistently younging towards the waterfall (Figure 42).

5. Long Burn

For the moment, however, proceed along the western side of the Long Burn until a small tributary is reached. This is usually choked with large blocks of shale from the *clingani* zone with exquisitely preserved, and often large, graptolites such as *Dicranograptus ramosus* and *Orthograptus calcaratus* on the fissile bedding surfaces.

6. *clingani* zone

The source of this material is a bowl-shaped depression, much higher in the slope, which may be reached by direct ascent and via a narrow defile through which the tributary emerges. The depression is floored by masses of loose shale and is probably the best collecting ground for the graptolites of the *clingani* zone. The somewhat folded shale is exposed in situ in the walls of the depression.

7. Top *clingani* zone.

It is possible to climb out, though with care, to this locality, a trench dug in the late 1970s by Henry Williams. He collected in meticulous detail through the top *clingani* zone and the full extent of the *linearis* zone to establish the order of succession of graptolite faunas as firmly as possible (Williams, 1982).

8. *anceps* bands

Descending to the Long Burn once more one may see a further exposure of the *anceps* bands just east of the Main Fault in a second trench cut by Williams and Ingham. Here the succession is, remarkably, about twice the thickness seen in localities to the west of the Main Fault. This is one reason for believing that the Main Fault is a major tectonic thrust which has juxtaposed rock units which may have originally been deposited a long distance away from each other. The *anceps* zone faunas are here both abundant and well preserved.

9. *cyphus* zone of the Birkhill Shales

An energetic scramble up the Long Burn eventually gains a small waterfall some 3 m high (locality 9). Here is exposed a greywacke horizon, the first known in the sequence, lying within the *cyphus* zone of the Birkhill Shales (Rushton & Stone 1991); it can actually be traced some distance along the burn southwards. Above it, just south of the waterfall, are exposed shales of the cyphus and gregarius zones; they are highly fossiliferous and this is one of the best locations for seeing strata from these lower zones of the Silurian in an undisturbed state. Note, too, the soft pale metabentonites characteristic of this part of the sequence. (Figure 41).

10. Lower to Upper (Barren) Hartfell Shales

Return to the junction of the Long Burn and the Linn Branch and now proceed westwards via a rough footpath above the Linn Branch, towards the waterfall and locality 10. The succession in the north face of the Linn Branch is near vertical to slightly overturned, younging is constant towards the west and this traverse first passes from Lower to Upper (Barren) Hartfell Shales. Further west a conspicuous eroded gully marks the line of the West Fault which downthrows to the north. Downthrow on this fault causes the aneeps zone at the top of the Ordovician to crop out at the level of the footpath, and the next few metres expose the critical Ordovician/Silurian boundary stratotype section.

This section, which spans strata containing evidence of a major extinction episode, was carefully excavated and documented by Henry Williams; his paper of 1988 (from which (Figure 40) was taken) records the succession in great detail. The five *anceps* bands are clearly shown, highly inclined in the eastern part of the trench within the upper part of the Barren Mudstone sequence. The fauna in these bands is remarkably rich, up to 18 species, including *Dicellograptus anceps*, having being recorded. The thin *extraordinarius* band lies a metre higher than the top *anceps* band in the succession (and just above a nodular limestone which contains rare blind dalmanitid trilobites). Only three diplograptid species occur in the *extraordinarius* band, a dramatic drop from the rich fauna of the *anceps* bands. After a further metre of barren beds, black shales resume with abundant graptolites of the uppermost Ordovician *perseulptus* zone, and the Ordovician/Silurian boundary is taken at the base of the succeeding *aeuminatus* zone.

11. *vesieulosus* and *gregarius* (*triangulatus*) zones

On moving into the Corrie, strata from two further zones may be examined on the eastern wall, the bedding is now overturned by hill creep. These are the flaggy beds of the *vesieulosus* zone, and the hard blocky shales of the *gregarius (triangulatus)* zone in which abundant and finely preserved *Rastrites peregrinus* are found. The thin shale bands with numerous interbedded bentonites may be followed right up to the top of the Corrie. Bentonites are especially abundant in the Birkhill Shales and represent successive episodes of volcanic ash-fall which, at least in some instances, have been correlated with successive episodes of graptolite extinction (Batchelor & Weir 1988). Shales of the *sedgwickii* zone are exposed in the floor of the Corrie and form a flat plane along its western wall. This zone, however, is better exposed on the south face of the Linn Branch.

12 *maximus* subzone

Towards the foot of the waterfall the shales and mudstones become increasingly grey, with only a few black shale bands containing graptolites indicative of the *maximus* subzone. Fossils are, however, extremely rare at this locality. The overlying greywacke beds display a variety of turbidite features such as graded bedding and various sale structures.

13. *sedgwickii* zone

Having examined the Gala greywackes an ascent may be made up the south face of the Linn Branch to the shales of the *sedgwickii* zone. The beds curve sinuously up the cliff, and fine specimens of this fossil and attendant faunas may be collected from near the top. However, this ascent is hazardous and is not recommended for large parties. We stress that a direct ascent from locality 12 to locality 15 should NOT be attempted.

14. The corrie

It is recommended that an ascent be made up the Corrie to the top, where the major features of the geology can be seen from the grassy meadow. From here Birkhill Cottage is clearly visible and also the valley excavated along the line of the great strike fault to the south-west.

15. Hartfell and Birkhill Shales

Then proceed west and south crossing the stream above the waterfall, and descending eastwards to the flat platform above the south face of the Linn Branch where the spectacular panorama of the north bank of the Linn Branch can be compared with (Figure 42). Note the overturned succession of the Hartfell and Birkhill Shales, Williams' two excavations, the West Fault, and several thrusts in the shales and the greywackes. From the corner just above the north end of the Main Cliff good specimens of *Cephalograptus corneta* may be found in the *convolutus* zone. Descend from this point to valley floor, either down the scree slope or along the top of the Main Cliff, and thence return to the road.

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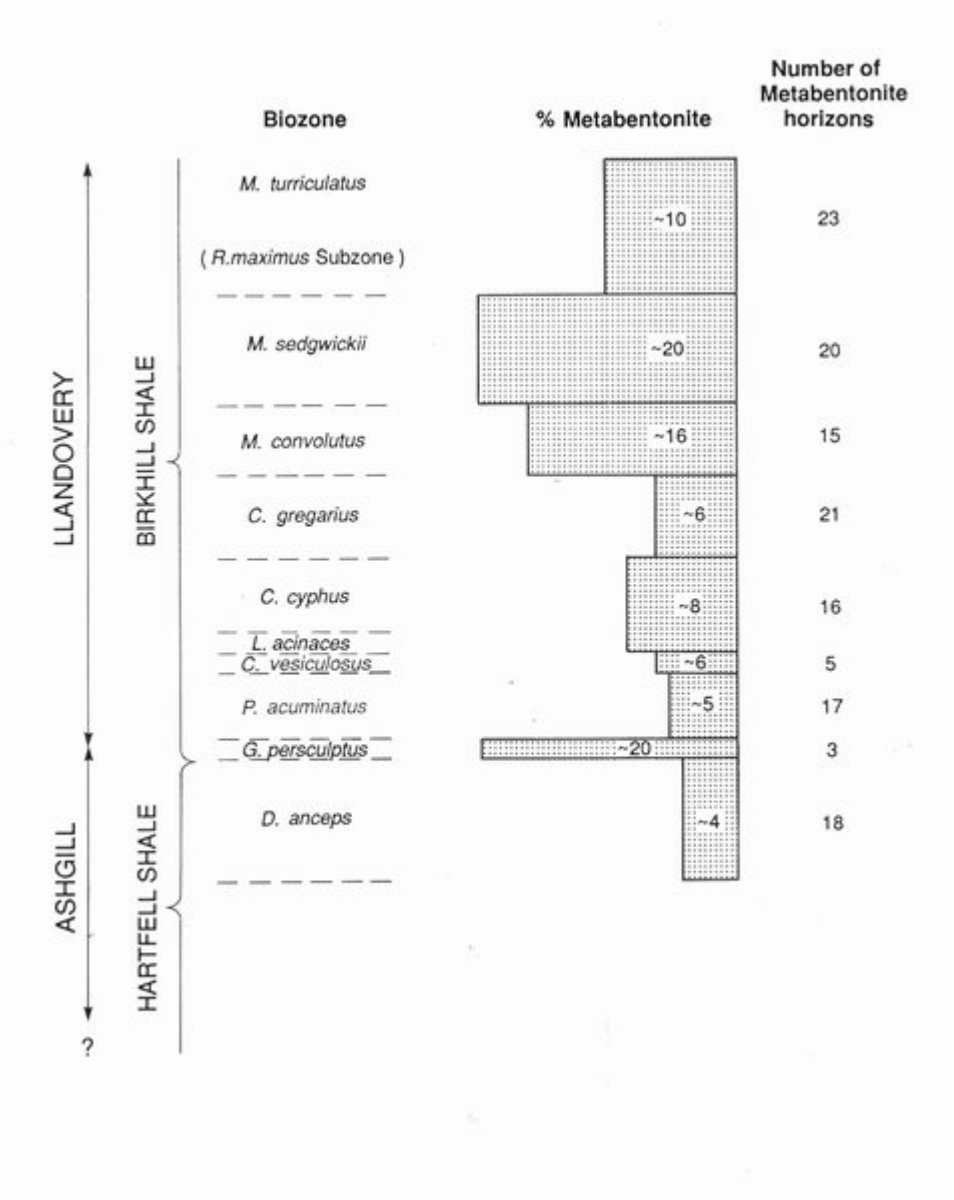
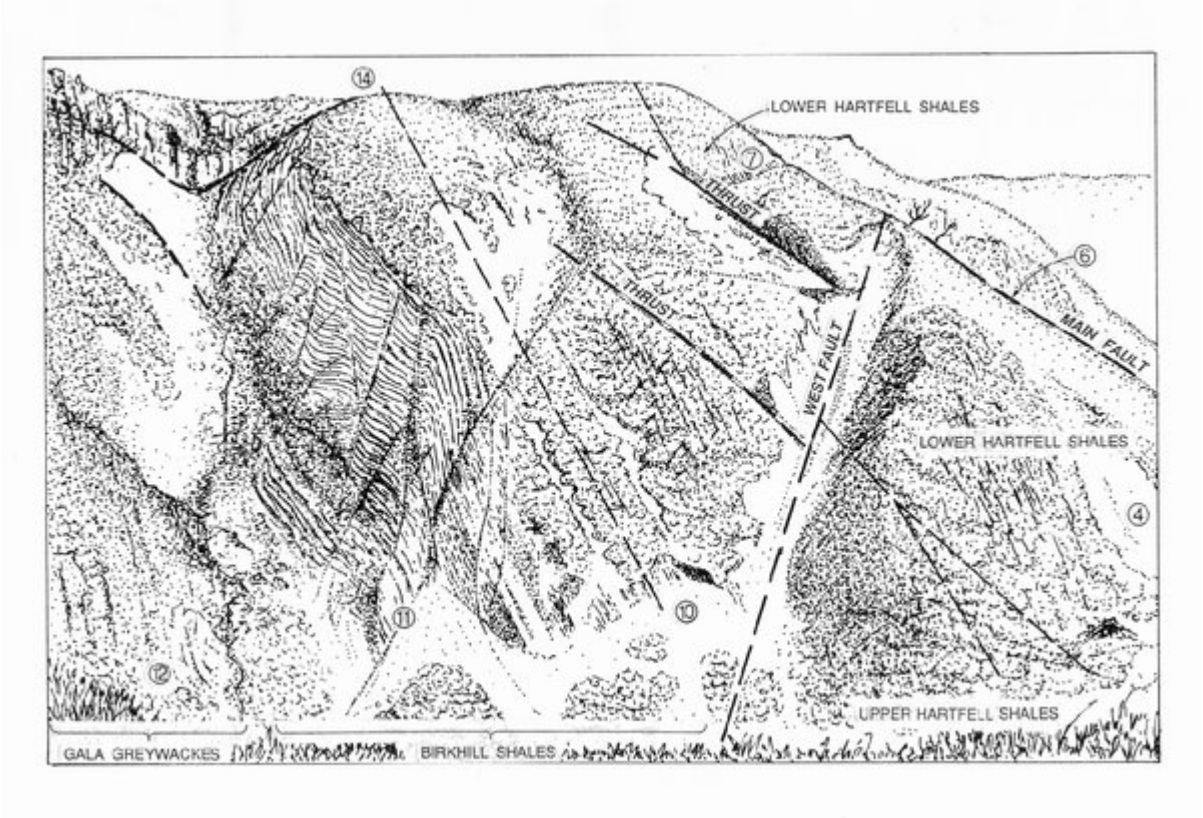
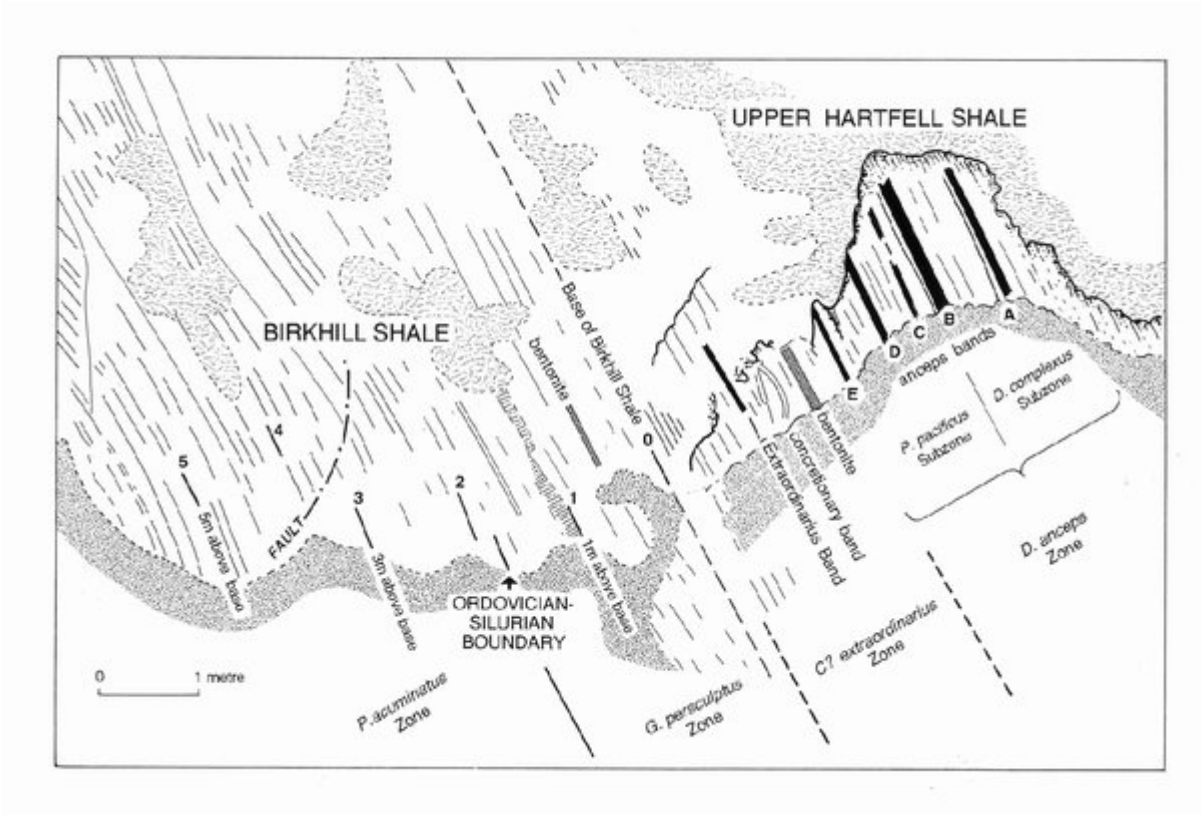


(Figure 41) Biostratigraphical distribution of metabentonite horizons at Dob's Linn and amounts and proportion of metabentonite in graptolitic zones.



(Figure 42) Panoramic view of North Cliff from locality 15.



(Figure 40) The anceps bands and Ordovician/Silurian boundary stratotype in Linn Branch tranch (modified after Williams 1983).