
Excursion 18 Graptolites: Ordovician and Silurian biostratigraphy

By A.W.A. Rushton and S.P. Tunnicliff

By far the most commonly found fossils in the Lower Palaeozoic sequences of Southwest Scotland are graptolites. Unlike the Girvan area to the north, the region offers no localities where rich Shelly fossil assemblages can be found; but for the graptolite collector there is as wide a selection of fossiliferous horizons as anywhere in the British Isles, ranging in age from the Arenig to the Wenlock.

The collecting of fossils, especially the zonal collecting of graptolites, is not a task to be rushed. Time and perseverance are needed to locate the fossil-bearing layers, especially those with the best-preserved specimens, and a fair number of fossiliferous slabs are needed if a fully representative fauna is to be obtained. Most of the localities described here require a day's study (or longer) to do justice to their biostratigraphy, and in each there is every possibility that new discoveries will be made. The graptolite zones recorded so far from each of the localities are shown in (Table 3). Some of the mid-Ordovician to early Silurian species likely to be found are illustrated in (Figure 59) and (Figure 60). Graptolites of Arenig (early Ordovician) age can be collected at Ballantrae, as described in Excursion 8, and additional fossiliferous localities with zones of the Wenlock Series (mid-Silurian) are visited in Excursions 5 and 11 to the Kirkcudbright area. The general stratigraphy of the Moffat Shale Group and the graptolite zones is summarised in (Table 4).

If planning a fossil-collecting excursion, note that the entry and parking should always be sought. General advice on the collecting of graptolites is given in Chapter 11 of *Graptolites* edited by Palmer and Rickards (1991).

1 Glenkiln Burn [NY 007 895]

OS 1:50 000 Sheet 78 Nithsdale & Annandale

BGS 1:50 000 Sheet 10W Lochmaben

Route map: (Figure 61) with locality numbers referenced in the text

The exposures of Moffat Shale in the Black Linn section of Glenkiln Burn are historically important because they furnished Lapworth with one of his typical sections of their lowest unit, namely the Glenkiln Shales (Table 4). Typically the Glenkiln Shales yield fossils of the *Nemagraptus gracilis* and *Climacograptus peltifer* biozones, and at this locality they are seen to underlie the Lower Hartfell Shales of the *Climacograptus wilsoni* biozone. The section at Black Linn is not recommended for excursion parties because many of the exposures are small and lie in the banks of a ravine above deep pools in the stream; there are larger and more accessible exposures of correlative strata at the Loup of Kilfeddar (Locality 2), Morroch Bay (Locality 3) and Hartfell Score (described by Rushton in McAdam et al., 1992). A brief guide to Black Linn is given here for the specialist who may be interested in this historic locality. The account is based on those of Lapworth (1878) and Peach and Horne (1899) and, for the lower end of the section, that of Williams (1994, (Figure 3)).

Take the A701 (Dumfries–Moffat) road to Kirkmichael Mains, and then the turning to Ae Village. After 1.5 km there is limited roadside parking near the bridge west of the chapel at Townhead [NY 004 884]. Access is via the farm track towards Kirkmichael Fell (obtain permission at Townhead). Follow the track for about 1 km, until it begins to ascend the flank of Kirkmichael Fell, whereupon leave the track and fork left, descending to Glenkiln Burn. Upstream lie inliers of Moffat Shale faulted among the outcrops of Gala Group greywackes, fine-grained interbeds of which contain late Llandovery graptolites of the *guerichi* Biozone (= lower part of the *turriculatus* Biozone). The type locality for the Glenkiln Shales, however, is downstream, past a right-hand bend, in the ravine known as Black Linn [NY 007 895].

Downstream of the bend, on the left (south) bank, is a bluff of Glenkiln Shales, deformed but locally fossiliferous (1a). Hereabouts Lapworth's map shows an open shaft in the black shales where someone had 'foolishly excavated ... in search of coal' (Lapworth, 1878, p. 287). For about 50 m downstream the burn exposes unfossiliferous grey flaggy mudstones, but at the next left-hand bend, near the confluence of a tributary stream on the right bank, near-vertical

fossiliferous black mudstones are seen striking approximately parallel to Black Linn (1b). Many strongly flattened graptolites of the *Nemagraptus gracilis* Biozone can be collected, including *Climacograptus bicornis*, *Dicellograptus sextans* and *N. gracilis* itself. Downstream of the tributary the banks of the ravine become steep, and access is precarious. At about 40 m downstream the Glenkiln Shales pass up (=downstream) into grey mudstones of the Lower Hartfell Shales. These contain thin black beds that may locally yield well-preserved fossils of the *wilsoni* Biozone, including *C. wilsoni* and *Pseudoclimacograptus scharenbergi* (1c). Farther downstream is a faulted outcrop of Lower Hartfell Shale with fossils representing the *Dicranograptus clingani* Biozone (1d).

2 Loup of Kilfeddar [NX 152 674]

OS 1:50 000 Sheet 82 Stranraer; Glen Luce & surrounding area

BGS 1:50 000 sheets 1 and 3 The Rhins of Galloway

Route map: (Figure 62) with locality numbers referenced in the text

The thick siliceous greywacke succession of the Kirkcolm Formation has been dated by the faunas collected from a number of graptolitic interbeds. One of the thickest and most fossiliferous of these interbeds occurs in the Main Water of Luce near a waterfall called the Loup of Kilfeddar, at the contact between the Kirkcolm Formation and the pyroxenous greywackes of the Galdenoch Formation.

From New Luce [NX 175 645], 8 km north of Glenluce, cross to the west side of the river and take the minor road that follows the west bank northwards. The Loup of Kilfeddar is reached after about 4 km; it is about 600 m east of Cairnerzean, where the Main Water of Luce makes a sharp bend to the left [152 674]. The main waterfall exposes part of the Kirkcolm Formation which, on the east bank below the waterfall, has yielded a few graptolites including *Pseudoclimacograptus scharenbergi*. Much more promising for the collector is the section upstream of the main waterfall on the west bank which exposes a succession of black graptolitic mudstone units for about 100 m. The beds are fossiliferous at several places and large faunas typical of the *Nemagraptus gracilis* Biozone can be collected.

At the broken footbridge, and just upstream of it, outcrops of black shale (2a) contain species of *Cryptograptus*, *Dicellograptus*, *Dicranograptus*, *Didymograptus*, *Diplograptus*, *Glossograptus*, '*Glyptograptus*', *Lasiograptus*, *Nemagraptus* and *Orthograptus*. Some of the shales appear disturbed but in their midst are blocks of coherent shale with well-preserved graptolites.

Upstream the river broadens into a pool without exposure, but above this, where the river forms rapids, is a broad exposure of grey and black shale 15–20 m thick. Here the succession is interrupted by zones of disturbance (representing faulting and minor folding?) but graptolites including examples of *Thamnograptus* can be collected at places where the shale is less disturbed, for example near the downstream (2b) and upstream (2c) ends of the exposure.

Upstream of the rapids is a reef in the river where disturbed shales at the base of the overlying Galdenoch Formation again contain blocks of graptolitic black shale (2d) of the *gracilis* or *peltifer* Biozone.

3 Morroch Bay [NX 017 525]

OS 1:50 000 Sheet 82 Stranraer, Glen Luce surrounding area

BGS 1:50 000 sheets 1 and 3 The Rhins of Galloway

Route map: (Figure 63) with locality numbers referenced in the text

Morroch Bay displays the largest outcrop of the Moffat Shale in south-west Scotland. When the tide is out, mudstones and associated cherts of the Glenkiln and Lower Hartfell formations are exposed for nearly 400 m across strike and, at the north end of the bay, are interbedded with and overlain by the basal greywacke beds of the Portpatrick Formation. It

is possible to collect graptolites representative of the *gracilis*, *peltifer*?, *wilsoni* and *clingani* biozones, and to use their distribution to infer the presence of structural imbrication. Peach and Horne (1899, pp.40 1–408) described the section in detail and their account and collections form a component of the present account. However, their structural interpretation for the northern end of the bay, of interfolded greywackes and shales is rejected here in favour of simple interbedding.

If using a car, take the minor road from Portpatrick towards Knockinaam and Port of Spittal. About 3 km SE of Portpatrick [at [NX 023 527]] there is a track down to the south end of the bay; park by the roadside and walk 1.5 km down the track to the bay. There is no room to park a bus. Morroch Bay can also be reached on foot from Portpatrick by the cliff-top path, a pleasant walk of about 3 km in each direction, but involving an arduous scramble down steep overgrown slopes into the north end of the bay. The tide is not dangerous at this locality, but when it comes in, the bedrock geology is largely obscured.

The intertidal zone exposes a thick sequence of mudstone dipping steeply and striking roughly SW, out to sea. There are several intrusive igneous dykes, more or less concordant with the bedding, and these can serve as useful landmarks when studying the mudstone succession. The mud-stones generally become younger from south to north but the distribution of fossil zones indicates at least one major structural repetition, whilst the anomalous thickness of some units, together with the presence of minor folding and faulting, shows that the structure is complicated in detail.

At the south end of the bay, black mud-stones (3a), associated with cherts and red and green mudstones have yielded a relatively diverse fauna of the *N. gracilis* Biozone, including a dozen species referable to *Climacograptus*, *Cryptograptus*, *Dicellograptus*, *Dicranograptus*, *Hallograptus*, *Nemagraptus* and *Orthograptus*. Conodonts have been recovered from red mudstones here.

The succession to the north consists largely of red and green mudstones with beds of chert, but about 100 m north of the cottage at the south end of the bay (3b and 3c) you can collect faunas of the *gracilis* and possibly '*peltifer*' biozones from black Glenkiln Shales.

The *wilsoni* Biozone is found in black shale (3d) about 150 m NW of the cottage, between chert beds and a large dyke near the middle of the bay. *Climacograptus wilsoni* is associated with *Amplexograptus perexcavatus*, *Dicranograptus nicholsoni*, and *Glossograptus hincksii*. Close to the dyke is a bed (3e) with *Dicellograptus angulatus* and other graptolites.

Further north the mudstones are associated with some greywacke beds, and beside one of these (3f), about 50 m south of the northerly cottage, a fairly diverse *D. clingani* Biozone fauna can be found, with species of *Climacograptus*, *Corynoides*, *Leptograptus*, *Neurograptus* and several of *Orthograptus*.

The localities referred to so far are progressively younger northwards. However, a major strike fault to the north of here truncates the Hartfell Shale and reintroduces chert and Glenkiln Shale (3g) with fossils of the *gracilis* and '*peltifer*' biozones.

The northern end of the bay shows very clearly the interbedding of black mudstone with the basal greywackes of the Portpatrick Formation. Many of the mudstone beds (3h and 3i) are fossiliferous, and faunas of the *clingani* Biozone, including *Climacograptus spiniferus*, *Dicellograptus morrisi*, *Dicranograptus ramosus*, *Neurograptus margaritatus* and various *Orthograptus* spp., are easy to collect. This locality shows that the base of the Portpatrick Formation lies within the *clingani* Biozone, whilst the top of the formation exposed some 5 km to the NW in Killantringan Bay (see Excursion 15) appears to lie within the overlying *linearis* Biozone (Figure 46).

4 Grennan Point and Drumbreddan Bay [NX 075 437]

OS 1:50 000 Sheet 82 Stranraer, Glen Luce surrounding area

BGS 1:50 000 Sheets 1 and 3 The Rhins of Galloway

Route map: (Figure 64) with locality numbers referenced in the text

Intertidal exposures around Grennan Point (about 13 km SE of Portpatrick) afford an opportunity to examine the Upper Hartfell Shale and several zones of the Birkhill Shale, and to see how they relate to the overlying greywackes of Grennan Point (Gala Group 6: (Figure 46)).

Approach on the A716 from Stranraer; 4 km south of Sandhead turn right, pass Ardwell House, and after 1.5 km turn left down the minor road to Drumbreddan [NX 084 440]. From the farm a walk of about 800 m takes you to Drumbreddan Bay.

There are two principal exposures of Moffat Shale, separated by the greywacke beds that make up Grennan Point. The northerly exposure is much the larger and displays a wider range of strata; the southerly exposure shows the relationship with the greywacke particularly well. Structural aspects of this locality are described in Excursion 15.

North of Grennan Point (Grennan Bay)

The Moffat Shale Group is well exposed at low tide but largely covered when the tide is in. The structure is broadly an anticline—syncline fold pair, though complicated in detail (Figure 64). Somewhat north of the middle of the bay, the unfossiliferous grey 'barren' mudstones (4a) that typify the Upper Hartfell Shale are found [NX 0748 4383]. They include thin black beds, and although these contain fragments of graptolites, it has yet to be shown whether they are referable to the *complanatus*, *anceps* or *extraordinarius* biozones.

Working north from the grey mud-stones, the first black beds encountered are basal Birkhill Shales (4b). Here you can collect fossils of the *persculptus* Biozone. Further to the north, 5 m from the faulted contact with the Gala Group greywackes (4c), the succeeding zone of *Parakidograptus acuminatus* is present. The *atavus* Biozone is proved close to the greywackes, though the effects of strong faulting makes the collection of satisfactory material more difficult.

Turning south from the pale barren mud-stones, the centre of Grennan Bay is occupied by a considerable thickness of Lower Birkhill Shale — massive black mudstones described by Lapworth as the *vesiculosus* Flags'. They yield fossils of the *acuminatus* Biozone in the centre of the bay (4d) and several species of the *atavus* Biozone (including species of *Atavograptus*, *Coronograptus*, *Dimorphograptus* and *Normalograptus*) within 10 m of the greywackes of Grennan Point (4e). Closer still to the greywackes (4f), you can collect diverse faunas of the *convolutus* Zone, including species of *Coronograptus*, *Glyptograptus*, *Petalolithus*, *Rhaphidograptus* and several *Monograptus* species (*Margutus*, *M. clingani*, *M. convolutus*, *M. limatulus*). Deformation associated with strong nearby faulting hampers collecting but excellent specimens were collected last century and the source of those remains to be rediscovered. The pale greenish or whitish beds of soft claystone interbedded in the Birkhill Shale are metabentonites (altered volcanic ash). These indicate frequent and large-scale eruptions, but the position of the volcanic source is unknown.

Drumbreddan Bay

On the south side of Grennan Point a relatively narrow exposure of the Birkhill Shale (4g) extends along the base of the greywacke cliffs. Despite the presence of a strike fault, some of the graptolites found here are well preserved. Examples representing the *cyphus* Biozone? and the *magnus* Biozone have been recorded.

The Birkhill Shale passes up into a few metres of thinly bedded grey shale and laminated siltstone (4h) followed conformably by massive greywackes. The thinly bedded unit contains thin black mudstone seams and with patience you can collect rare but well-preserved graptolites of the *convolutus* Biozone which serve to date the onset of greywacke deposition.

5 Clanyard Bay and Grennan Quarries [NX 101 380]

OS 1:50 000 Sheet 82 Stranraer, Glen Luce ea surrounding area

BGS 1:50 000 sheets 1 and 3 The Rhins of Galloway

Route map: (Figure 65)

The Moffat Shale Group is exposed at both the north and south margins of Clanyard Bay. The northern exposure youngs to the north, as is generally the case in Moffat Shale inners, but the southern exposure is unusual in that it seems to young towards the south. This was formerly taken as evidence for a major anticlinal structure centred on Clanyard Bay, but more recently the complex thrust-related structure has become apparent. This is described in some detail as part of Excursion 15.

Grennan Quarries, nearby, afford an opportunity to collect graptolites from interbeds in the greywacke succession and can be visited at times when the tide covers exposures in Clanyard Bay.

Clanyard Bay

Take the A716 south from Stranraer and Sandhead towards Drummore, but about 2 km north of Drummore [NX 128 383] take the minor road to Clanyard, from which Clanyard Bay is a short walk (800 m). The exposures can only be studied in detail at low tide. The northern outcrop is the larger. The beds farthest from the northern margin of the bay are Upper Hartfell Shale, typically developed as grey 'barren' mudstone. They include black mudstone interbeds that have yielded *Dicellograptus*. Working towards the greywackes at the northern edge of the bay, you find Birkhill Shale, and from various beds in a general south-to-north sequence can collect graptolites of the *atavus*, *acinaces*, *triangulatus?*, *convolutus* and *sedgwickii* biozones. In addition, an old collection contains well-preserved fossils indicating a low level in the *turriculatus* Biozone; the exact locality is unknown but it is possible that, if careful collecting were undertaken, the *torriculatus* locality might be rediscovered and evidence obtained for the presence of other zones.

On the south side of the bay, the Birkhill Shale is exposed with associated beds of bentonite. Graptolites of the *cyphus* Biozone have been collected about 20 m from the base of the cliffs. Farther south, about 10 m from the cliff, the presence of the *convolutus* Biozone provides evidence for southward younging here.

Grennan Quarries

These quarries are situated just west of the A716, 3 km north of Drummore. One on the west of the track to Grennan [1267 3943] displays greywackes of Gala Group 8 (or Port Logan Formation), which here includes shaly interbeds. From these you can collect well-preserved graptolites of the *crispus* Biozone, including *Monograptus crispus*, *M. discus*, *M. marri*, *M. priodon* and *Streptograptus exiguus*. A larger quarry in the greywackes slightly farther SW [1258 3932] yields *M. crispus* and, on some bedding planes, an abundance of *S. exiguus*.

6 Gillespie Burn [NX 257 539]

OS 1:50 000 Sheet 82 Stranraer, Glen Luce & surrounding area

BGS 1:50 000 Sheet 4 W Kirkcowan

Route map: (Figure 66) with locality numbers referenced in the text

Gillespie Burn exposes an interesting succession of Upper Hartfell and Birkhill Shales. The Upper Hartfell 'Barren Mudstones' include richly fossiliferous black mudstone beds of the *D. anceps* Biozone, overlain by Lower Birkhill Shale which, unusually, here contains several beds of greywacke.

From Glenluce take the A747 south towards Port William. About 3 km SE from Glenluce, turn left down the minor road, past Whitefield Loch and Machermore, towards Culroy [NX 253 540]. A car may be parked near the track-junction [NX 252 543] and Gillespie Burn approached over land farmed from Culroy, where prior permission for access and parking must be sought. From Culroy walk due east to the tributary stream which flows down to join the Gillespie Burn [NX 257 539] where it flows through a small ravine.

Silurian

About 40 m upstream of the place where a stone wall crosses this tributary, the left (NE) bank displays greywacke beds with shale interbeds (6a). Graptolites from these interbeds include climacograptids (*Normalograptus* spp.) and *Atavograptus* spp. which represent the *atavus* Biozone and possibly also the *acinaces* Biozone. A few paces downstream greywackes on the right (SW) bank contain *Cystograptus vesiculosus* and *Parakidograptus acuminatus* which indicate that these greywackes are discernably older (*acuminatus* Biozone); it is noteworthy that nearer to Culroy a poorly exposed shale bed has yielded younger graptolites of the *typhus* Biozone. On this evidence the ground between Gillespie Burn and Culroy is interpreted

as being underlain by Lower Birkhill Shales which, exceptionally, here include beds of greywacke deposited during the *acuminatus*, *atavus* and possibly *acinaces* biozones. These are apparently overlain by massive greywackes of Gala Group 4 (the Sinniness Formation) deposited during *typhus* Biozone times (Rushton and Stone, 1991).

Ordovician

Go downstream to where the stone wall crosses the tributary stream. Black Upper Hartfell Shales can be seen a few paces both upstream and downstream of the wall (6b). Graptolites of the *anceps* Biozone, particularly *Orthograptus abbreviatus*, can be collected from each outcrop.

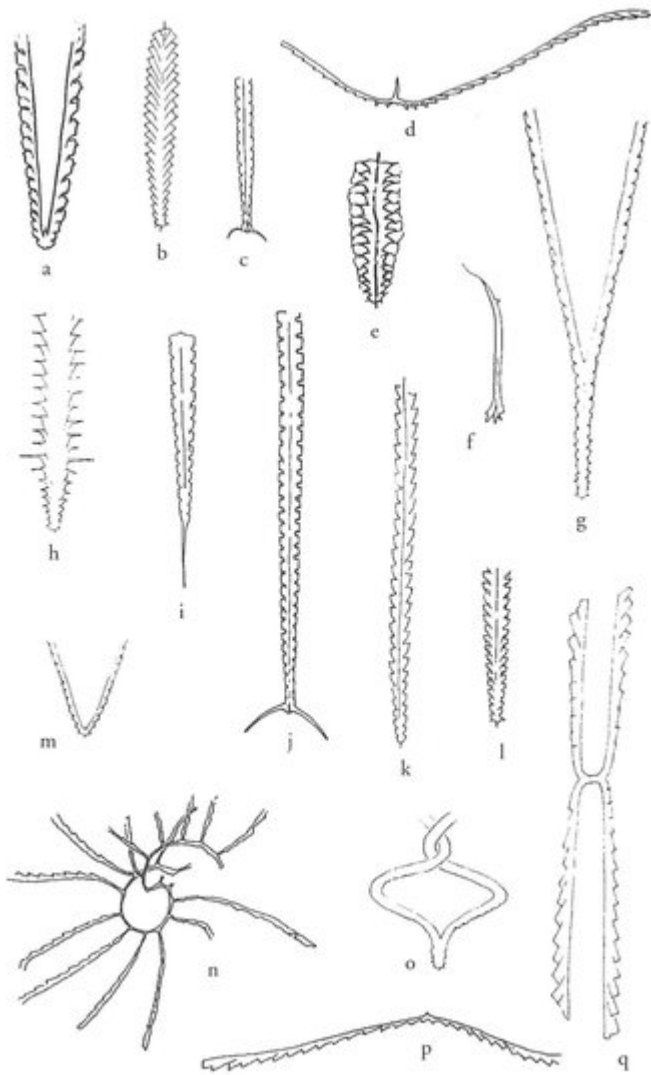
Now descend the tributary to Gillespie Burn itself. It enters the ravine at a waterfall, below which the grey 'Barren Mudstones' of the Upper Hartfell Shales are well seen. For about 50 m downstream from the confluence of Gillespie Burn and the tributary, the 'Barren Mudstones' show interbeds of black mudstone (6c) from which faunas of the *Dicellograptus anceps* Biozone can be collected, most commonly *Climacograptus supernus* and *Orthograptus abbreviatus*. Further downstream, at a right-hand bend (6d), graptolites of the Lower Hartfell Shale (*clingani* or *linearis* Biozone) can be collected; the same strata are also seen in small exposures high on the east bank of the burn (6e). *Orthograptus* spp. are most commonly found but their preservation is not very good.

About 150 m SE of Gillespie Burn the ground rises where the greywackes of Gala Group 5 make a topographical feature. There are small exposures of Lower Hartfell Shale (6f) along the track at the foot of this slope and better-preserved graptolites of the *clingani* and *linearis* biozones can be collected.

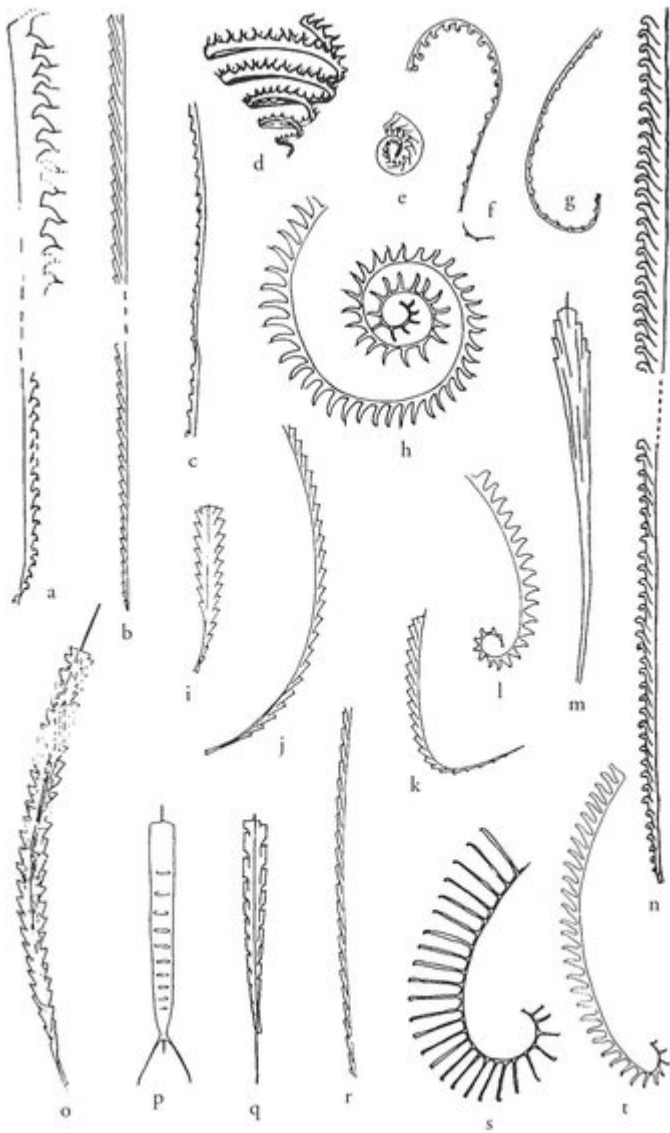
[References](#)

biozone	1	2	3	4	5	6
<i>crispus</i>					(+)	
<i>turriculatus</i> s.l.	+				+	
<i>sedgwickii</i>					+	
<i>convolutus</i>				+	+	
<i>leptotheca</i>						
<i>magnus</i>				+		
<i>triangulatus</i>				+	?	
<i>cyphus</i>				?	+	+
<i>acinaces</i>					+	?
<i>atavus</i>				+	+	+
<i>acuminatus</i>				+		+
<i>persculptus</i>				+		
<i>extraordinarius</i>						
<i>pacificus</i>						+
<i>anceps</i>					?	
<i>complexus</i>						+
<i>complanatus</i>						
<i>linearis</i>						+
<i>clingani</i>	+		+	?		+
<i>wilsoni</i>	+		+			
' <i>peltifer</i> '	+	?	?			
<i>gracilis</i>	+	+	+			
	1	2	3	4	5	6

(Table 3) Graptolite biozones recorded from: 1. Glenkiln Burn 2. Loup of Kilteddar 3. Morroch Bay 4. Drumbreddan Bay and Grennan Bay 5. Clanyard Bay and Grennan Quarries (+) 6. Gillespie Burn.



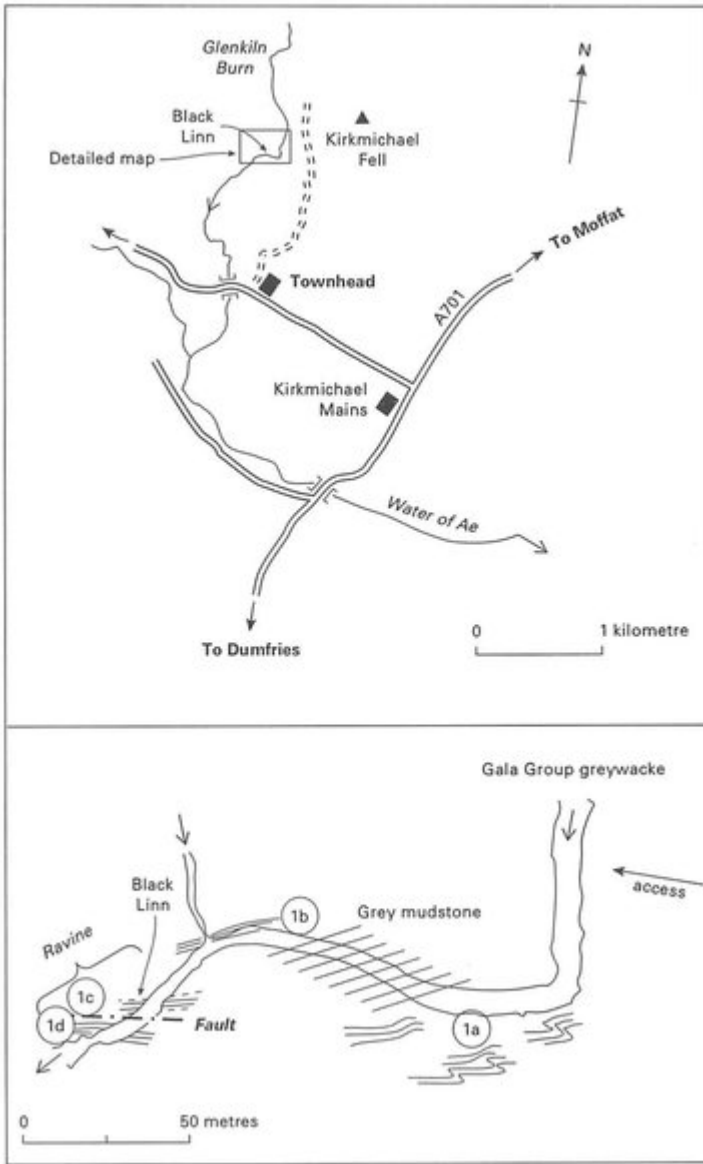
(Figure 59) Examples of some of the Ordovician graptolites found in south-west Scotland, all about twice natural size. a. *Dicellograptus anceps* (Nicholson) —anceps Biozone. b. *Orthograptus abbreviatus* Elles & Wood chiefly anceps Biozone. c. *Climacograptus supernus* Elles & Wood anceps Biozone. d. *Leptograptus fiacidus* (Hall) — clingani and linearis biozones. e. *Neurograptus margaritatus* (Lapworth) clingani Biozone. f. *Corynoides calicularis* Nicholson — peltifer?and wilsoni biozones to clingani Biozone. g. *Dicranograptus ramosus* (Hall) — chiefly clingani Biozone. h. *Orthograptus quadrimucronatus* (Hall) clingani and linearis biozones. i. *Climacograptus caudatus* Lapworth —lower clingani Biozone. j. *Climacograptus bicornis* (Hall) — upper gracilis to wilsoni biozones. k. '*Glyptograptus*' euglyphus (Lapworth) chiefly gracilis to peltifer biozones. l. *Amplexograptus leptotheca* (Bulman) chiefly peltifer Biozone. m. *Dicellograptus sextans exilis* Elles & Wood — gracilis and peltifer biozones. n. *Nemagraptus gracilis* (Hall) — gracilis Biozone. o. *Dicranograptus ziczac* Lapworth — chiefly peltifer Biozone. p. *Didymograptus superstes* Lapworth —chiefly gracilis Biozone. a. *Tetragraptus approximatus* Nicholson — approximatus Biozone, from the Arenig of the Ballantrae Complex.



(Figure 60) Examples of some of the Llandovery (lower Silurian) graptolites found in south-west Scotland, all about twice natural size. a. *Monograptus sedgwickii* (Porrlock) —sedgwickii Biozone. b. *Pristiograptus regularis* (Trnquist) —chiefly sedgwickii Biozone. c. *Diversograptus' runcinatus* (Lapworth) —lower turriculatus Biozone. d. *Monograptus turriculatus* (Barrande) — turriculatus Biozone to lower crispus Biozone. e. *Monograptus discus* (Törnquist) — crispus to crenulata biozones. f. *Monograptus crispus* Lapworth — crispus Biozone. g. *Streptograptus exiguus* (Nicholson) —uppermost turriculatus Biozone to griestoniensis Biozone. h. *Monograptus convolutes* (Hisinger) —convolutus Biozone. i. *Dimorphograptus swanstoni* Lapworth — acinaces Biozone. j. *Coronograptus gregarius* (Lapworth) —typhus to convolutus biozones. k. *Monograptus limatulus* Törnquist —chiefly convolutus Biozone. l. *Monograptus triangulatus fimbriatus* (Nicholson) — magnus Biozone. m. *Cephalograptus cometa* (Geinitz) — upper convolutus Biozone. n. *Monograptus priodon* (Bronn) — griestoniensis Biozone? to lower Wenlock. o. *Parakidograptus acuminates* (Nicholson) acunzinatus Biozone. p. *Climacograptus trifilis* Manck — acuminatus Biozone. q. *Rhaphidograptus toernquisti* (Törnquist) top atavus to basal sedgwickii biozones. r. *Atavograptus atavus* (Jones) — chiefly atavus to typhus biozones. s. *Rastrites longispinus* Perner — triangulatus ro convolutus biozones. t. *Monograptus triangulatus triangulatus* (Harkness) — triangulatus Biozone. Note that whereas Gala unit 7 overlies the highest Birkhill Shales, units I–G are laterally equivalent to the Birkhill Shales; The Leadhills Group is laterally equivalent to the Hanfell and Glenkiln shales.

		Gala Group (unit 7)	<i>turriculatus</i> s.l. (base) to <i>triangulatus</i>	SILURIAN
MOFFAT SHALE GROUP	Birkhill	Upper		
	Shale	Lower	<i>cyphus</i> to <i>acuminatus</i> <i>persculptus</i>	
	Hartfell	Upper (‘Barren mudstones’)	<i>extraordinarius</i> <i>anceps</i> <i>complanatus</i>	ORDOVICIAN
	Shale	Lower	<i>linearis</i> <i>clingani</i> <i>wilsoni</i>	
	Glenkiln Shale		<i>‘peltifer’</i> <i>gracilis</i>	
chert and pillow basalt (base not seen)		(base not recognised)		

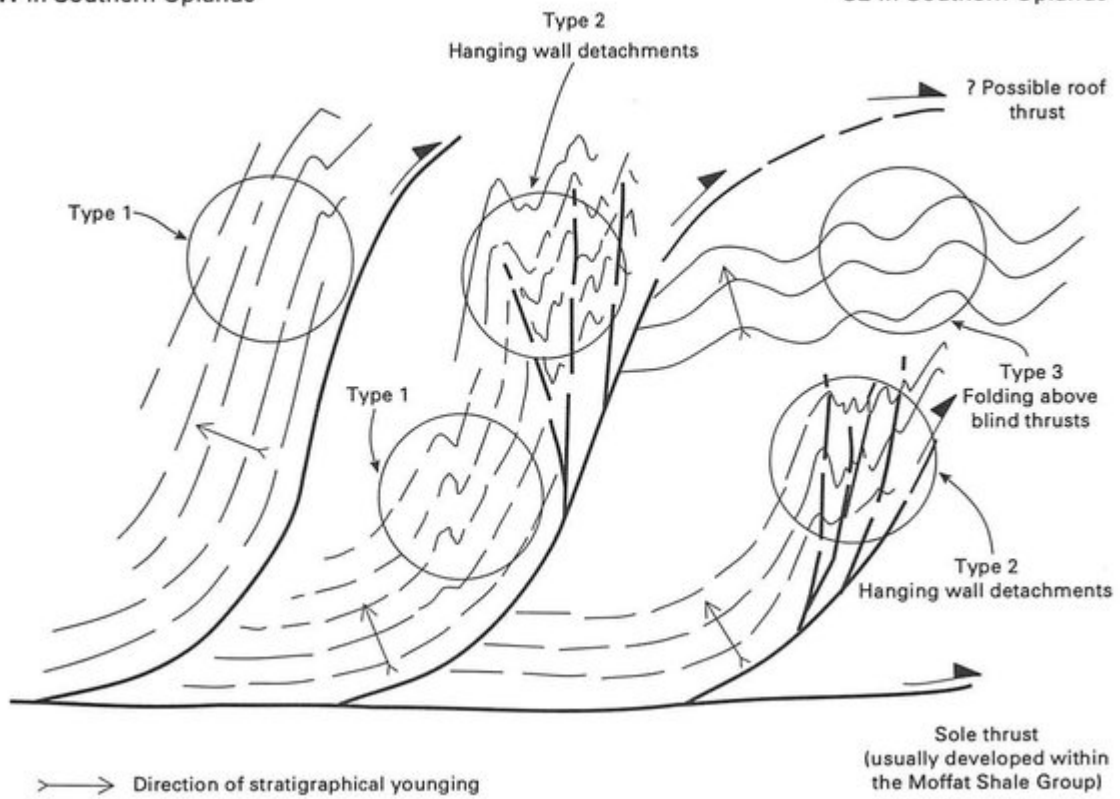
(Table 4) General succession of the Moffat Shale Group, correlated with the sequence of graptolite biozones (Figure 5).



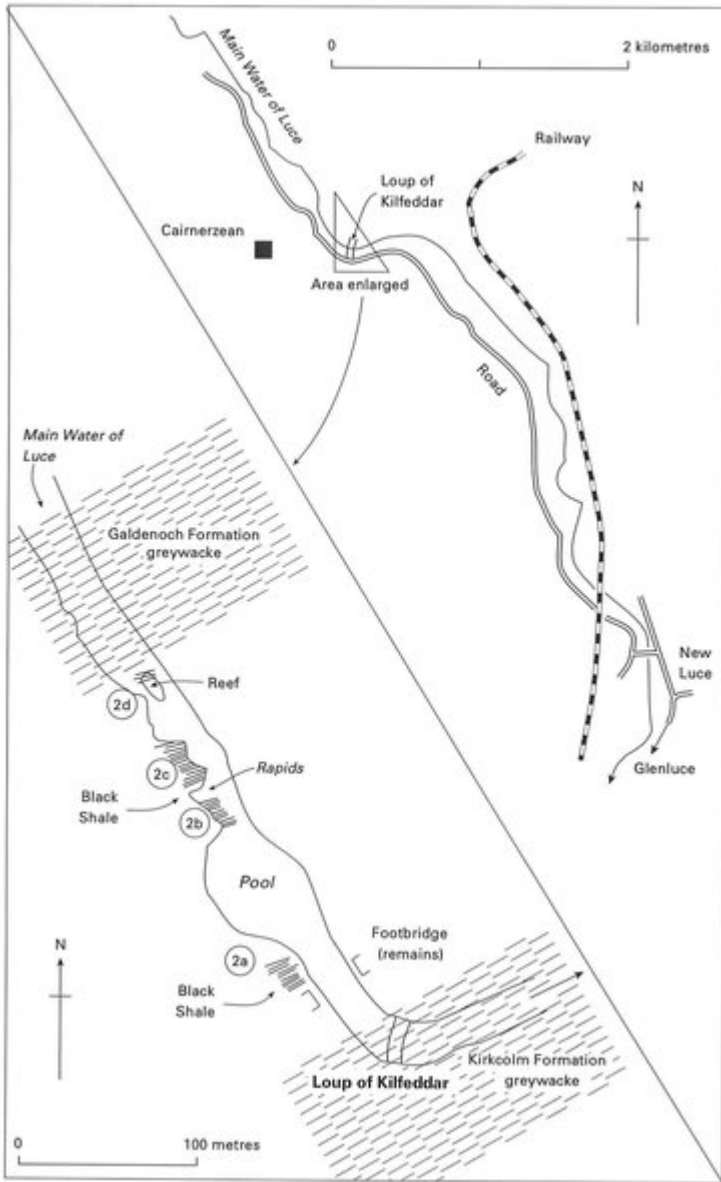
(Figure 61) Locality map for Glenkiln Burn (Locality 1).

NW in Southern Uplands

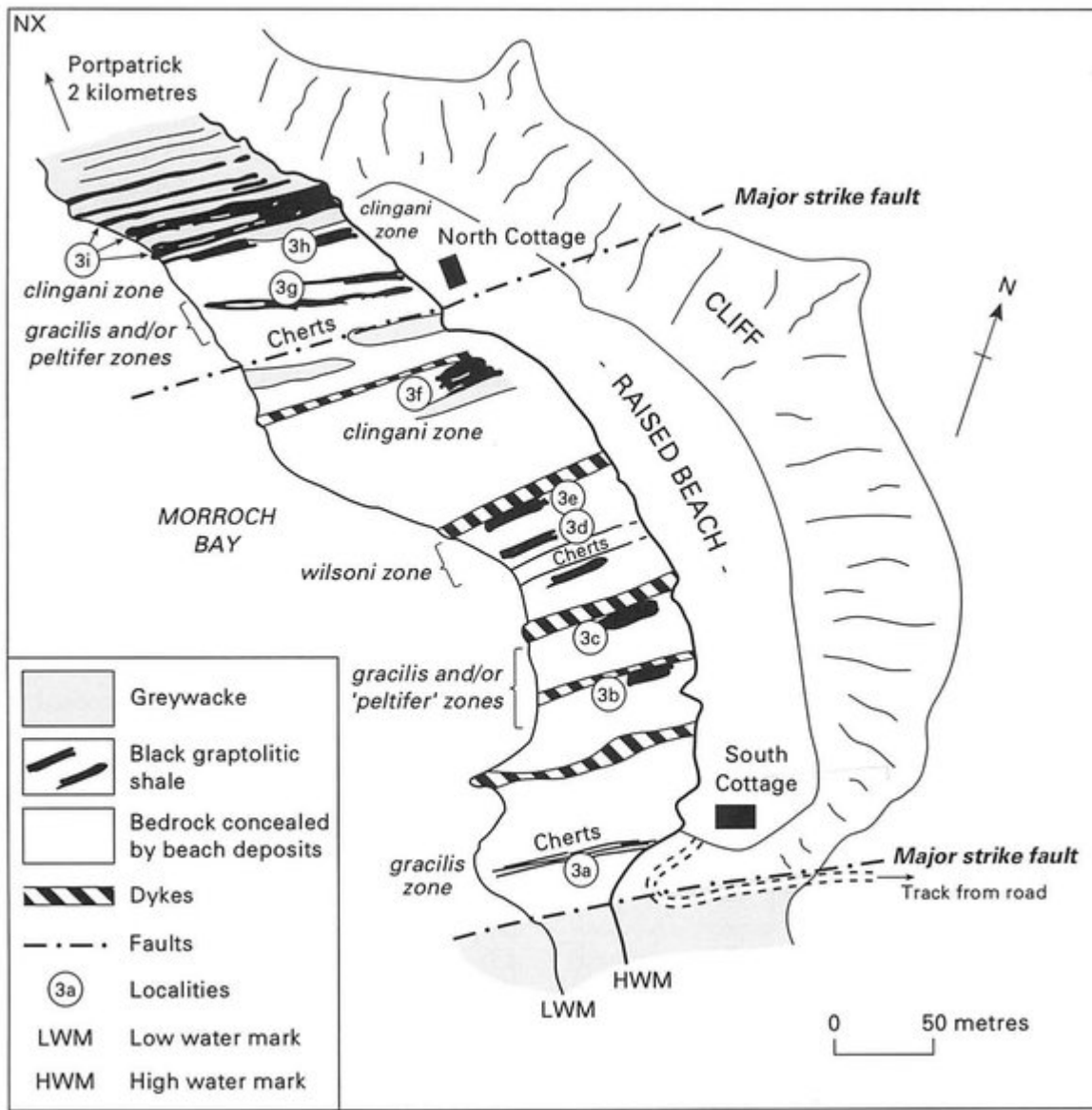
SE in Southern Uplands



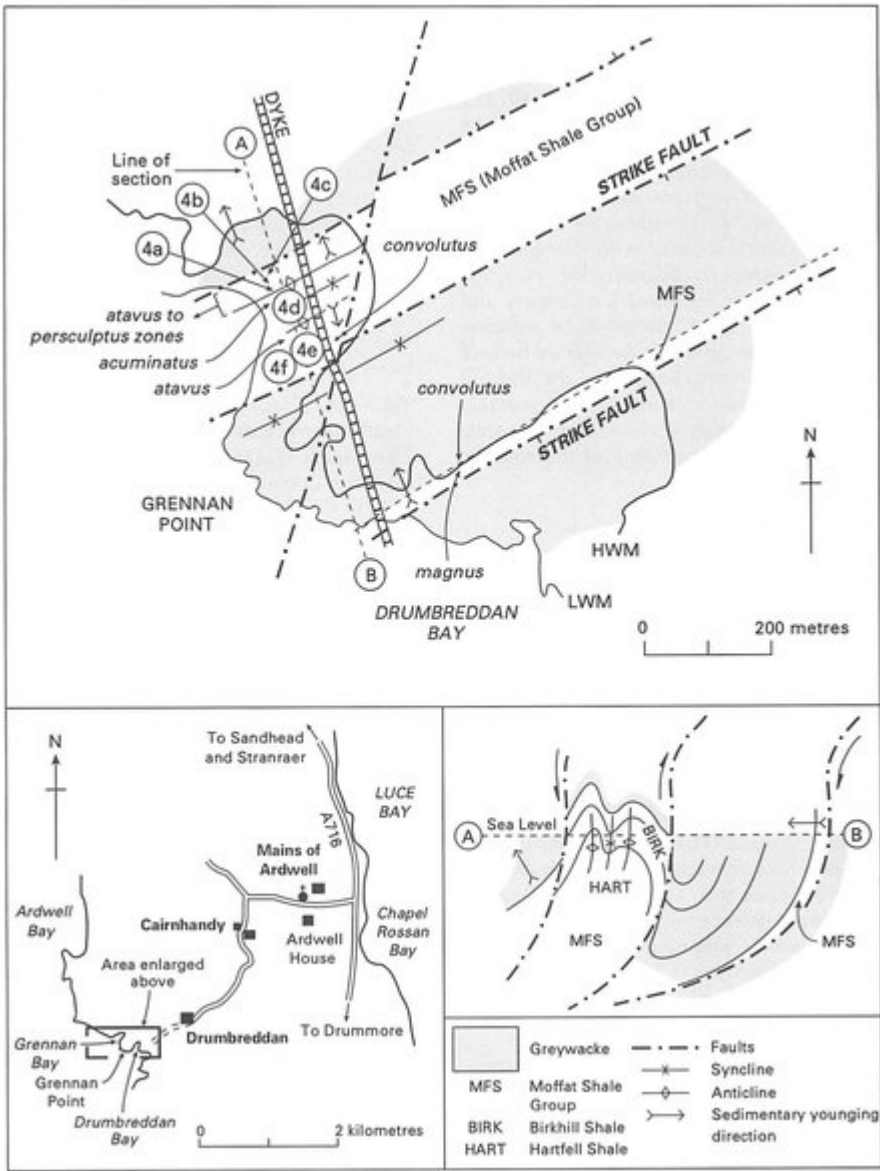
(Figure 3) Variable fold style developed within an idealised thrust sequence: examples are seen in the Southern Uplands.



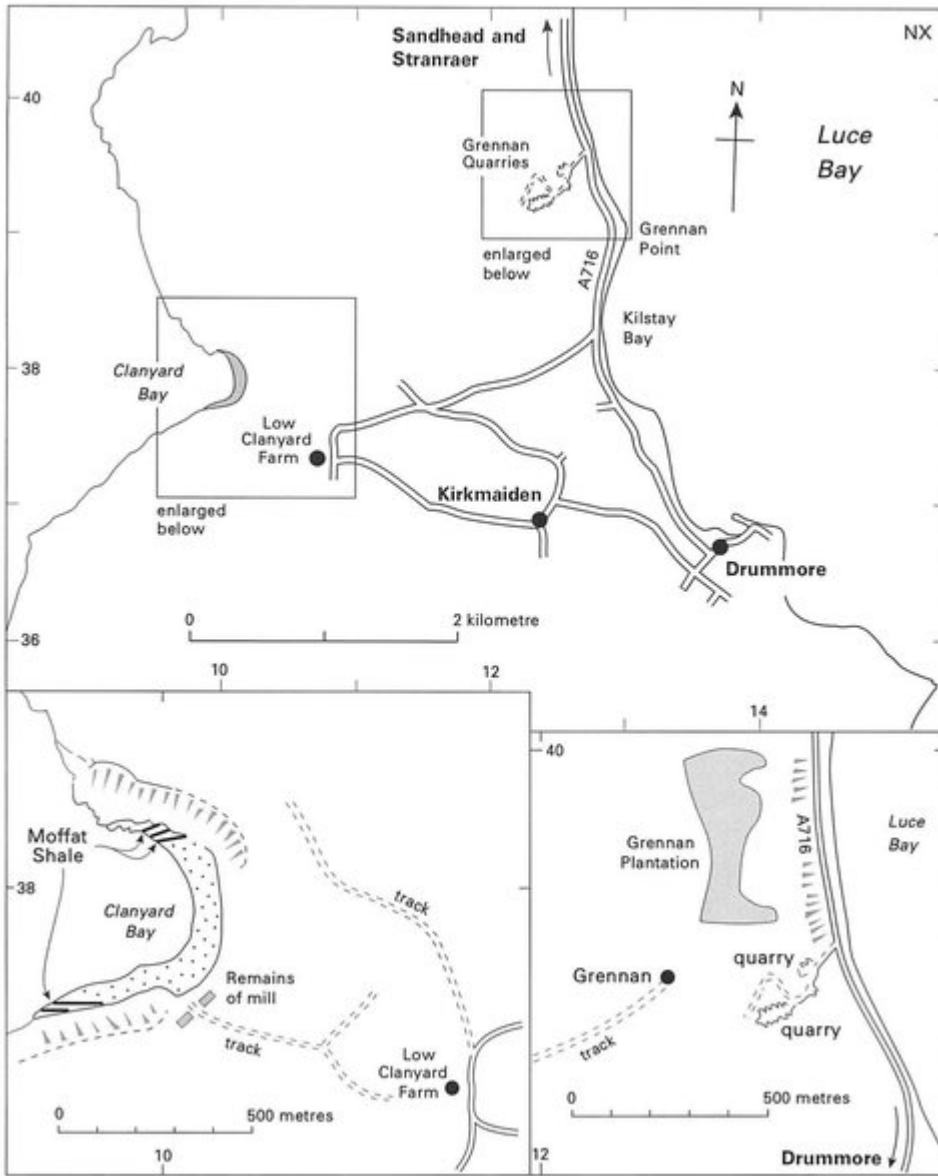
(Figure 62) Locality map for Loup of Kiffeddar (Locality 2).



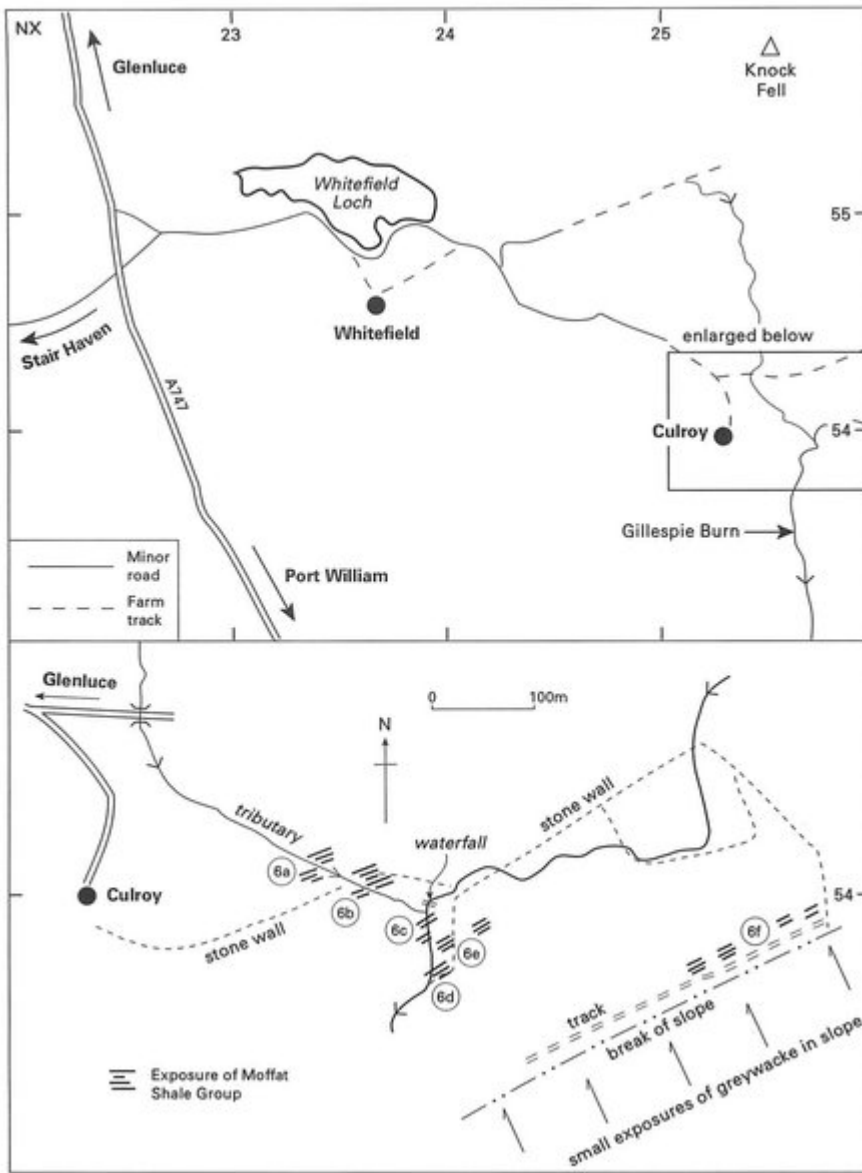
(Figure 63) Locality map for Morroch Bay (Locality 3).



(Figure 64) Locality map and geological cross-section for Drumbreddan Bay (Locality 4).



(Figure 65) Locality map for Clanyard Bay and Grennan quarries (Locality 5).



(Figure 66) Locality map for Gillespie Burn (Locality 6).