Gutterford Burn

[NT 1595 5942]–[NT 1555 5795]

Introduction

This important site encompasses the banks of Gutterford Burn and the northern and eastern margins of the North Esk Reservoir. The locality is situated in the North Esk Inlier (Figure 4.72), which is the largest of three Silurian inliers in the Pentland Hills (Figure 3.82), about 25 km south-west of Edinburgh. The first description of the succession in the area was given by Howell and Geikie (1861), and the first detailed map was produced shortly afterwards (Brown and Henderson, 1867; Henderson and Brown, 1870). Subsequently, numerous geologists have described or commented on the rocks and fossils of the inlier. The area was remapped by Mykura and Smith (1962) and by Tipper (1976), and a palaeoenvironmental interpretation of the Silurian succession has been published by Robertson (1989).

Throughout the inlier the strata dip steeply or vertically with a strike of 030–040°; the succession youngs to WNW Henderson and Brown (1870) considered the rocks to be of Wenlock and Ludlow age, while Peach and Horne (1899) believed that they extended into the Downton (= P■ídolí). Lamont (1947a, b), however, used faunal evidence to show that much of the succession is of Llandovery age, with the youngest beds assignable to the Wenlock Series. Formal stratigraphical names were introduced for the succession by Tipper (1976), who defined a North Esk Group within which he identified four formations: the Reservoir Formation, the Deerhope Formation, the Wether Law Linn Formation and the Henshaw Formation. Robertson (1989) added the Cock Rig Formation between the Deerhope and Wether Law Linn formations, and subdivided the Wether Law Linn Formation into three members. Palaeontological evidence has been used to assign the strata spanning the Reservoir, Deerhope and Cock Rig formations to the Telychian Stage, along with much of the Wether Law Linn Formation (Tipper, 1976; Robertson, 1989). The base of the Wenlock Series has in recent years been regarded as occurring in the vicinity of the base of the Henshaw Formation, although Robertson (1989) considered it likely that the chronostratigraphical boundary lies within the upper member of the Wether Law Linn Formation.

The GCR site at Gutterford Burn (Figure 3.80) lies entirely within the Reservoir Formation, for which it forms part of the type section (Tipper, 1976). The base of the formation is not seen in the inlier, but more than 1000 m of alternating mudstones and siltstones outcrop below the base of the overlying Deerhope Formation. The boundary between the two formations is not exposed, but maps out as conformable (Tipper, 1976). Generally the Reservoir Formation is sparsely fossiliferous, but there are a few Shelly horizons and Gutterford Burn is famous for the occurrence of eurypterid and starfish beds (e.g. Laurie, 1892, 1899; Peach and Horne, 1899; Spencer, 1914–1940). Exposures of the upper part of the Reservoir Formation and of the Deerhope, Cock Rig, Wether Law Linn and Henshaw formations are available locally in the banks of Deerhope Burn, Wether Law Linn, Henshaw Burn and the North Esk River.

Description

The oldest beds exposed in this section occur at the south-east corner of the reservoir, where sandy bases to siltstone beds contain abundant fragments of the phyllocarid arthropod *Dictyocaris* (Mykura and Smith, 1962). Above this, on the shores of the reservoir and along Gutterford Burn, Mykura and Smith (1962, p. 14) recorded the following succession:

(iv) grey to olive mudstones with laminae of siltstone and thin beds of flaggy sandstone near the base	200 m +
(iii) flaggy buff or dark grey grits interbedded with grey mudstones (Gutterford Burn flagstones)	120 m
(ii) mudstones and silty mudstones with laminae of siltstone and rare beds of flaggy greywacke (Gutterford Burn mudstones)	125 m

(i) fine-grained grits and siltstones in units up to 20 m thick, alternating with units of interlaminated mudstone and siltstone	seen to 50 m

Strata near the base of the Gutterford Burn mudstones contain trace fossils, orthocones, and the brachiopods *Craniops implicates* and *Glassia compressa.* Graptolites are mostly recorded from the Gutterford Burn flagstones and from the lower 20 m of the overlying flaggy sandstones; the graptoloid assemblage (Robertson, 1989) is dominated by monoclimacids (referable to *Monoclimacis vomerina sensu lato*) with *Oktavites spiralis.* These indicate a *crenulata* Biozone age (Bull, 1987; Robertson, 1989). Dendroids, which generally outnumber the graptoloids, were described by Bull (1987). Near the top of the Gutterford Burn flagstones is a 20–25 cm thick impure limestone, the Gutterford Burn limestone, which contains numerous crinoid columnals, together with corals, brachiopods, bryozoans, tentaculitids, trilobites, orthocones, ostracods and graptolites; faunal lists have been given by Peach and Horne (1899, p. 595), by Mykura and Smith (1962, p. 14) and by Robertson (1989, p. 130). Samples of the limestone dissolved in acetic acid have yielded conodont elements, including specimens of *Pterospathodus amorphognathoides,* indicative of a horizon close to the Llandovery–Wenlock boundary (RJA, unpublished collections). The presence of the coral *Palaeocyclus porpita,* reported by Mykura and Smith (1962), is consistent with this age assignment.

Near the top of the Gutterford Burn flagstones there is a 30 cm band that contains abundant remains of well-preserved arthropods, whose skeletons or exuviae are often articulated. Known in the literature as the Eurypterid Bed (Figure 3.81), this has yielded a very diverse arthropod fauna, including many species of eurypterid, a scorpion, phyllocarids and problematical taxa (Laurie, 1892, 1899; Peach and Horne, 1899; Waterston, 1979). Peach and Horne (1899) published a full faunal list for this bed, which also contains calcareous algae, graptolites, corals, tentaculitids, crinoid fragments, brachiopods, gastropods, conulariids and orthocones.

There is a gradual transition from the flagstones into the overlying dominantly argillaceous beds. Within these transitional strata two starfish-bearing horizons have been identified (Peach and Horne, 1899; Mykura and Smith, 1962), from which Spencer (1914–1940) has described a diverse asteroid fauna. Other fossils in this part of the section include sparse brachiopods (especially *Lissatrypa atheroidea*), trilobites and graptolites.

Gutterford Burn is the type locality for numerous fossils, including the dendroid graptolite *Dictyonema pentlandica* Bull, 1987, twelve eurypterid species (Laurie 1892, 1899; Waterston, 1979), the scorpion *Palaeophonus loudonensis* (Laurie, 1899), the crinoids *Macrostylocrinus silurocirrifer* Brower, 1975, *Ptychocrinus longibrachialis* Brower, 1975, *Dimerocrinites pentlandicus* Brower, 1975, *Herpetocrinus parvispinifer* Brower, 1975 and *Dendrocrinus extensidiscus* Brower, 1975, the echinoid *Aptilechinus caledonensis* Kier, 1973, and the starfish species *Urasterella gutterfordensis* Spencer, 1916, *Schuchertia wenlocki* Spencer, 1920, *Protactis wenlockensis* (Spencer, 1922), *Lepyriactis nudus* Spencer, 1925, *Taeniactis wenlocki* Spencer, 1925, and *Crepidosoma wenlocki* Spencer, 1928.

Interpretation

The overall lithology of the Reservoir Formation comprises alternations of homogeneous mudstones and sandy siltstones, with the relative frequency varying considerably (Tipper, 1976). The siltstone beds have sharp lower and upper surfaces, and may show low-angle cross-lamination or convolute lamination. Robertson (1989) suggested that, at least in places, these sequences represent intervals Tbce, Tcde, or Tce of the Bouma turbidite sequence (Figure 3.40). Some of the siltstone and sandstone beds show tool marks on the lower surfaces and these, together with evidence from ripple marks, show a palaeocurrent direction from the east (Robertson, 1989); individual sandstone beds may also sometimes be observed to thicken eastwards.

Robertson (1989) interpreted the Reservoir, Deerhope and Cock Rig formations as representatives of different fades developed on a submarine fan depositional system. The sandstones in the Reservoir Formation are laterally continuous and display no signs of channelling, so a palaeoenvironmental setting on the mid-fan fringe, on the outer fan or possibly on the basin plain was envisaged. In normal conditions, only widely-distributed, fine-grained detritus would have been carried to these distal parts of the fan complex. The shelly fossils were probably washed out into this environment, perhaps during storms, but the articulated preservation of the eurypterids and the starfish indicates that they are

preserved in, or close to, their life habitats. The whole system appears to have been the site of remarkably rapid build-up of sediment. The strata from the upper part of the Reservoir Formation to the lower part of the Wether Law Linn Formation are all demonstrably within the *crenulata* Biozone, which may reach a total thickness of 2000 m (Bull, 1987). The presence of the conodont *Pterospathodus amorphognathoides* in the Gutterford Burn Limestone is indicative of a very high Telychian age for this part of the succession and, if the graptolite evidence is secure, this means that this entire thickness was probably deposited within the interval of the *P. amorphognathoides* Conodont Biozone. As a comparison, at the network site at Hughley Brook in Shropshire the *P. amorphognathoides* Biozone is represented by only 0.9 m of strata (Mabillard and Aldridge, 1985).

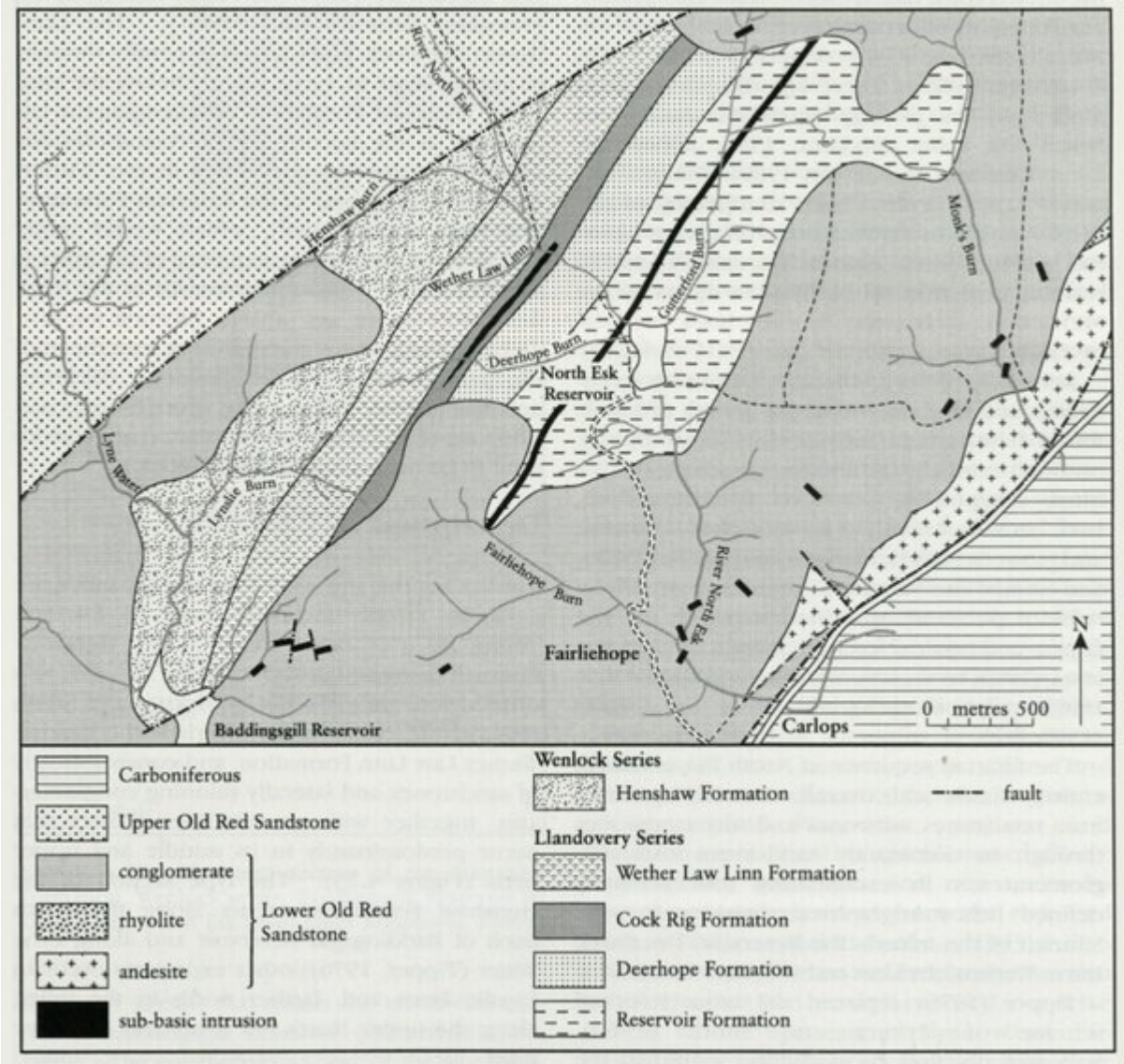
The Silurian succession in the North Esk Inlier accumulated near the southern margin of the Midland Valley graben, and records a regressive sequence from the offshore marine fan, through a shallow shelf environment (Wether Law Linn Formation) into the terrestrial, alluvial fan environment of the Henshaw Formation (Robertson, 1989). The source of the sediments is somewhat controversial. Leggett *et al.* (1979a) suggested that they originated from an emergent accretionary prism to the south, whereas Bluck (1983, 1984) considered that they were sourced in a volcanic terrane and deposited in an inter-arc basin. This debate is directly linked to the different models for the tectonic evolution of the Southern Uplands, outlined in the interpreta tion of the GCR site at Dob's Linn (Figure 3.68).

Faunally, the Silurian rocks of the Pentland Hills appear to be distinct from those of the Girvan area and of elsewhere in Britain. For example, the trilobites of the Reservoir and Deerhope formations are endemic, while those of the Wether Law Linn Formation have affinities with East Baltic faunas (Clarkson and Howells, 1981). These faunal similarities suggest there was an open marine connection between eastern Scotland and Balto-Scandia during the latest Llandovery.

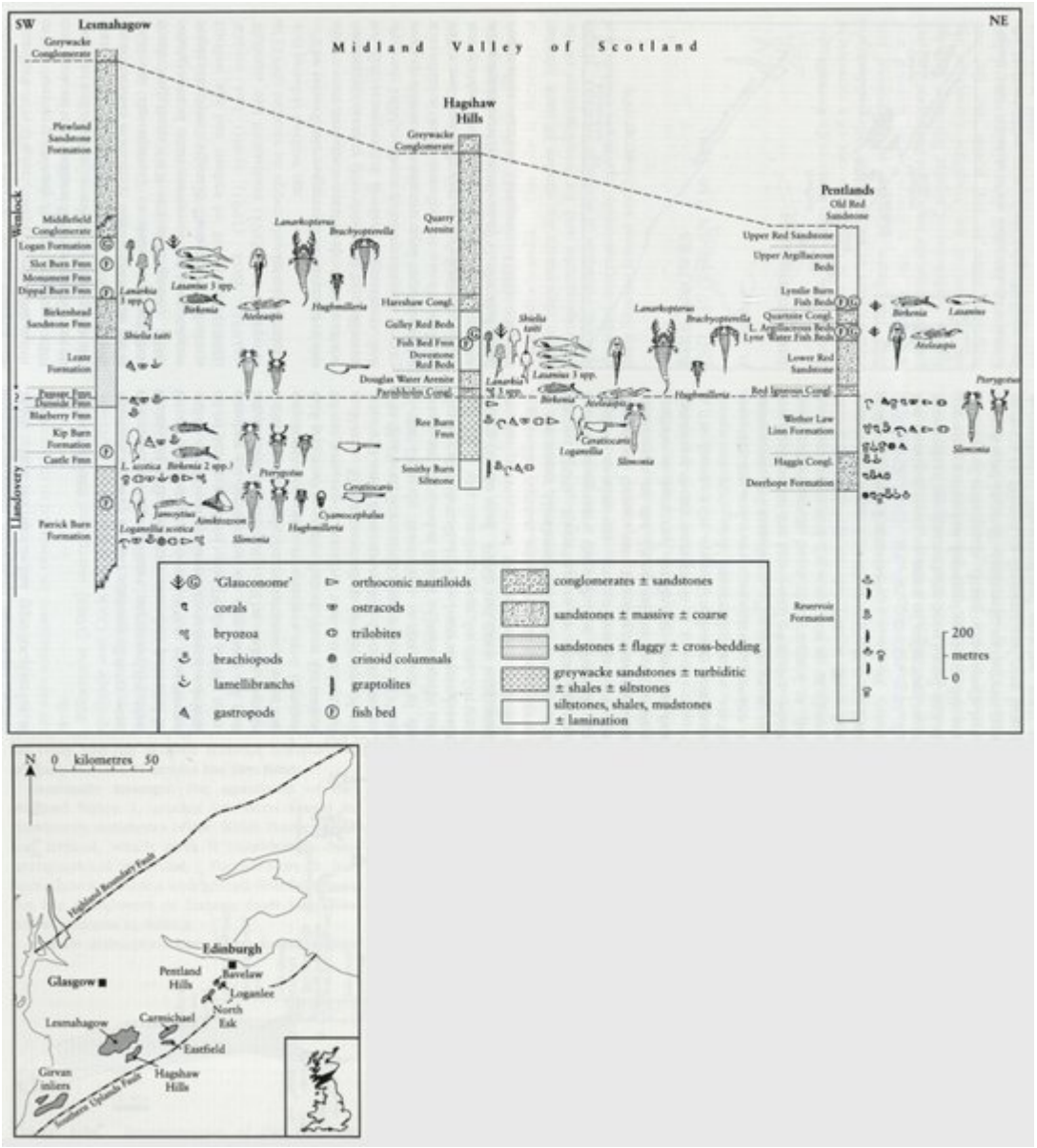
Conclusions

Gutterford Burn is an important locality in the Pentland Hills, providing a representative sedimentological sequence and containing characteristic endemic fossils. It is the type section for part of the Reservoir Formation, and the type locality for a large number of fossil species, including many eurypterids and starfish, for which the site is internationally renowned. The Pentlands area was physically or ecologically isolated from other parts of Scotland during the early Silurian, but retained marine connections with Balto–Scandia. This site is therefore of prime importance for studies of early Silurian palaeogeography and for investigations of the tectonic evolution of southern Scotland. It also provides internationally significant evidence of early Silurian faunas and biogeography.

References

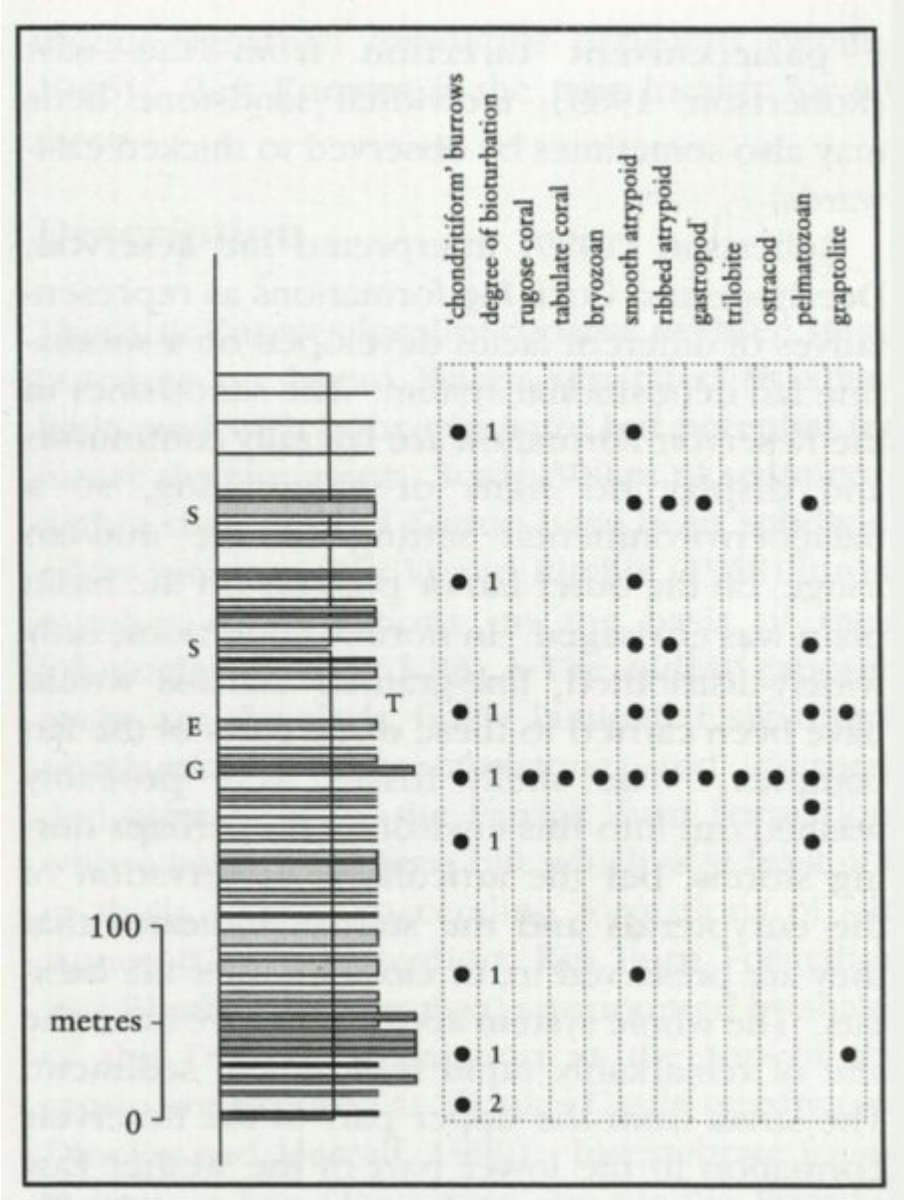


(Figure 4.72) Geology of the North Esk Inlier and location of Lyne Water and Lynslie Burn (after Robertson, 1986, and the British Geological Survey, 1977).

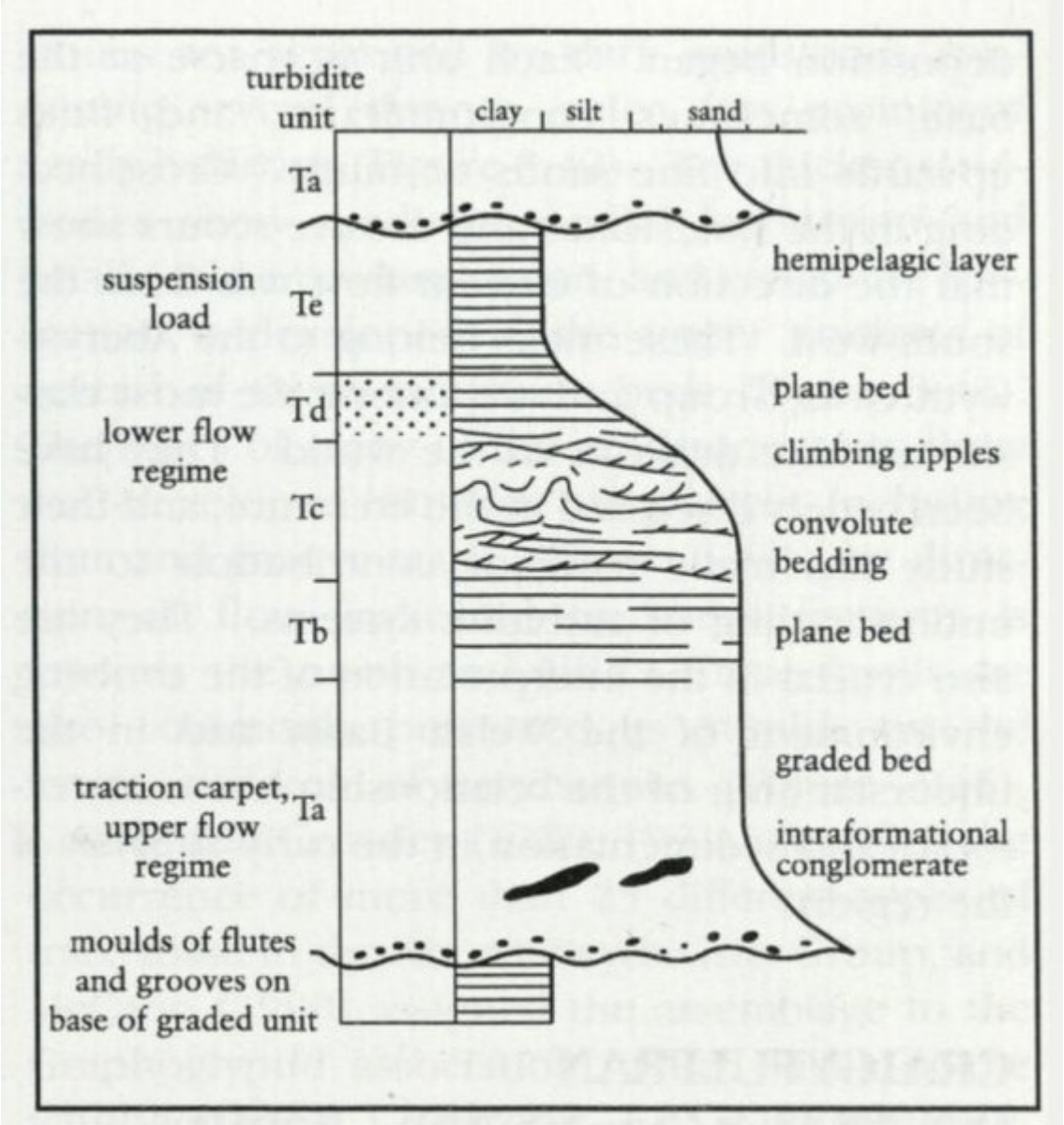


(Figure 3.82) Location of the main Silurian inliers of the Midland Valley of Scotland (after Wellman and Richardson, 1993).

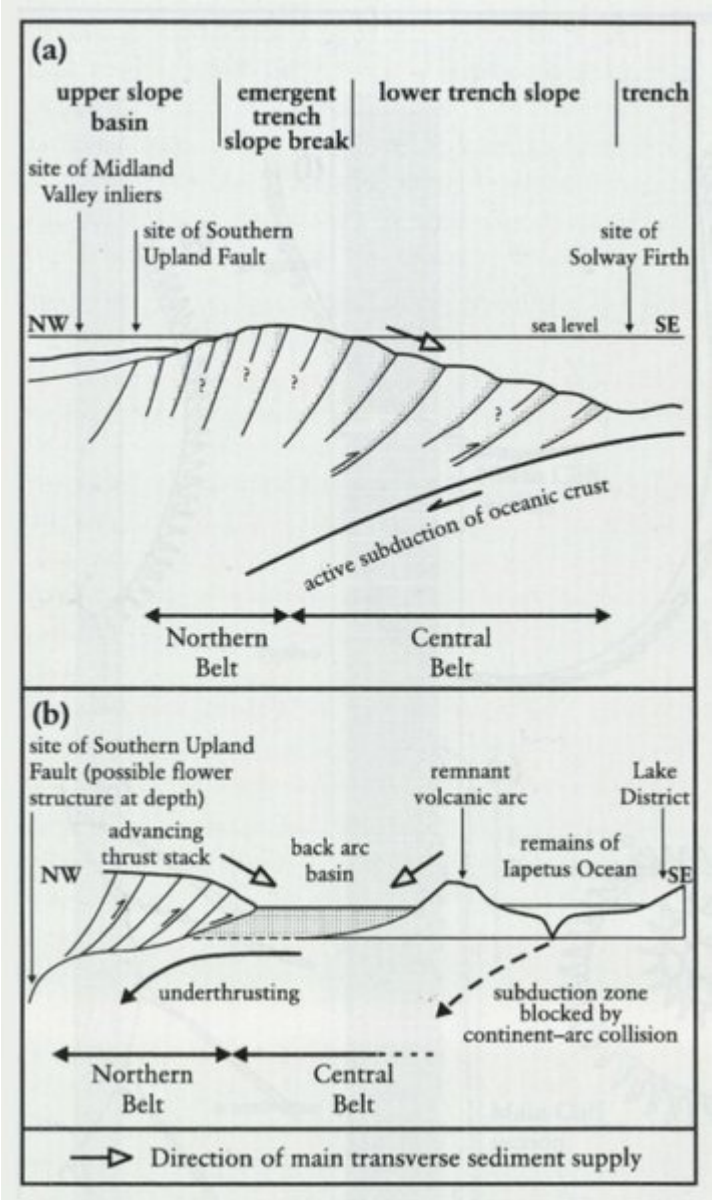
(Figure 3.80) Gutterford Burn, North Esk Inlier, showing patchy exposures of the Reservoir Formation. (Photo: E.N.K. Clarkson.)



(Figure 3.81) Measured section of the Reservoir Formation in Gutterford Burn (after Robertson, 1989). G = Gutterford Burn Limestone, E = Eurypterid Bed, S = Starfish beds.



(Figure 3.40) Idealized graphic log of the full Tabcde Bouma turbidite cycle (modified from Selley, 1978, after Bouma, 1962).



(Figure 3.68) Two models accounting for the structural and stratigraphical development seen in the Southern Uplands (from McAdam et al., 1992). (a) accretionary prism model of Leggett et al. (1979a); (b) back-arc basin model of Stone et al. (1987).