Gutterford Burn, East Lothian and Midlothian

[NT 159 591]

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Introduction

This Midland Valley of Scotland site lies within the North Esk Inlier, the largest of three Silurian inliers in the Pentland Hills, some 25 km southwest of Edinburgh (see (Figure 2.5)). The other two inliers are those of Loganlee and Bavelaw. Old Red Sandstone clastic sediments and volcanic rocks surround the North Esk Inlier, which itself is composed of Llandovery and Wenlock series strata. Gutterford Burn cuts through deposits of Llandovery age, some 428 million years old.

Notes on the geology of the Pentland Hills, by Maclaren, were published as early as 1839. Subsequently, in the third quarter of the nineteenth century, Howell and Geikie (1861), Haswell (1865), Brown and Henderson (1867) and Henderson and Brown (1870) all contributed towards an understanding of the geological succession of the area, and the papers of the last two of these authors included publication of the first detailed geological map. Since then there have been numerous works on various aspects of the geology and palaeontology of the Pentland Hills. Amongst the more notable of these are comments in the benchmark work on the Silurian geology of Scotland by Peach and Horne (1899); the work of Lamont (1947a, 1947b, 1952) who determined much of the sequence here to be Llandovery in age and the youngest rocks to be Wenlock; remapping by Mykura and Smith (1962), and by Tipper (1976) who also established most of the modern lithostratigraphy for the Silurian of North Esk; palaeoecological work by Tipper (1975) and Robertson (1999); and the palaeoenvironmental interpretations of Robertson (1989, 1999) and Clarkson *et al.* (2001). The Silurian succession and fossils of the area have also featured in various field guides, such as those of Mykura (1986), Robertson (1983, 1986), and Clarkson and Taylor (1989), and historical overviews, for example that of Clarkson (2000).

Gutterford Burn has been known as an outstanding locality for fossil arthropods since Henderson and Hardie made excavations there in the 1890s, the abundant material from which was described and discussed at that time by Laurie (1892, 1893, 1899). A diverse eurypterid fauna dominates the non-trilobite arthropod fauna from this locality, of which the stylonuroids are perhaps the most notable, but it also contains one of the earliest scorpions, a xiphosuran chelicerate, a phyllocarid crustacean species, and arthropod material of uncertain affinity (Peach and Horne, 1899; Petrunkevitch, 1949; Lamont, 1955; Waterson, 1962, 1964, 1979; Plotnick, 1999; Anderson and Moore, 2004; Tetlie, 2006b). In July 2003 new excavations and collections were made at the site (Anderson, 2003; Anderson and Moore, 2004). The detailed results of this re-investigation of the Gutterford Burn Eurypterid Bed are contained in a paper by Anderson *et al.* (2007) that was in press at the time of writing, but it has not been possible to incorporate these into the present site report, nor the information contained in the field guide by Clarkson *et al.* (2007), nor, in the main, the conclusions from a new study of one of the eurypterids from here (Tetlie *et al.,* 2007).

In addition to its importance for the study of early arthropods, Gutterford Burn has significance for Silurian (Llandovery Series) geology in general within the Pentland Hills and thus the north-eastern part of the Midland Valley, and has been included in a GCR volume on Silurian stratigraphy (Aldridge *et al.,* 2000). In addition to the fossil arthropod importance of this site, the area is also independently selected for the GCR for the Palaeozoic Palaeobotany, Carboniferous–Permian Igneous Rocks, Carboniferous–Permian Fish/Amphibia and Westphalian selection categories (Cleal and Thomas, 1995, 1996; Dineley and Metcalf, 1999, Stephenson *et al.,* 2003).

Description

The Silurian strata of the North Esk Inlier dip steeply to vertically, they have a strike of 030–040°, and they young to the WNW (Figure 2.15). The succession is divided into five main lithostratigraphical units, which in ascending order are the Reservoir, Deerhope, Cock Rig, Wether Law Linn and Henshaw formations (Tipper, 1976; Robertson, 1989). The

boundary between the Llandovery Series and the Wenlock Series is generally considered to be at the base of the Henshaw Formation or within the top of the Wether Law Linn Formation, with most of the Silurian sequence being of late Llandovery Telychian Stage, *crenulata* Biozone age. IIowever conodont and coral evidence from a shell bed towards the top of the Gutterford Burn Flagstones in the Reservoir Formation indicates that this series boundary may even lie within this formation (Mykura and Smith , 1962; Robertson, 1989; Aldridge, 2000).

Gutterford Burn itself trends roughly north to south and runs into the north-east corner of North Esk Reservoir. The strata of the GCR site lie entirely within the Reservoir Formation, for which it forms part of the type section (Tipper, 1976). Although the base of the formation has not been observed in the inlier, over 1000 m of alternating mudstones and siltstones are exposed below the base of the overlying Deerhope Formation. The oldest exposed strata of the Reservoir Formation are found at the south-east corner of the reservoir, stratigraphically above which, along the east margin of the reservoir and in Gutterford Burn, lies (see Mykura and Smith, 1962) the following 500 m thick sequence:

	Thickness (m)
(iv) grey to olive mudstones with laminae of siltstone and thin beds of flaggy sandstone near the base	200 +
(iii) flaggy buff or dark grey grits interbedded with grey mudstones (Gutterford Burn Flagstones)	120
(ii) mudstones and silty mudstones with laminae of siltstone and rare beds of flaggy greywacke (Gutterford Burn Mudstones)	125
(i) fine-grained grits and siltstones in units up to 20 m thick, alternating with units of interlaminated mudstone and siltstone	50 +

Overall, the Reservoir Formation is sparsely fossiliferous but in addition to eurypterids and other arthropods there are some shelly horizons, there are graptolites that have enabled zoning of the formation (Bull, 1987; Robertson, 1989; Bull and Loydell, 1995), and it has yielded a diverse asteroid fauna (Peach and Horne, 1899; Spencer 1914–1940; Mykura and Smith, 1962). The oldest beds exposed are graded silt-sones whose sandy bases contain abundant fragments of material referred to the enigmatic arthropod *Dictyocaris.* Brachiopods, ortho-conic nautiloids and trace fossils are found near the base of the Gutterford Burn mudstones. The graptolites, both dendroids and graptoloids, the latter mainly monoclimacids, are mostly recorded from the Gutterford Burn Flagstones and the lower 20 m of the overlying flaggy sandstones.

The eurypterids are concentrated within the Eurypterid Bed, which occurs near the top of the Gutterford Burn Flagstones, some 25 m higher in the sequence than the shell bed mentioned above. The thickness of the Eurypterid Bed has historically been recorded as 30 cm, but more recently it has been reported as 0.5–1 m thick (Anderson, 2003; Anderson and Moore, 2004). Eurypterid skeletons and exuviae are commonly found articulated as carbonized cuticle compressions, and they occur here together with other non-trilobite arthropods, calcareous algae, graptolites, corals, crinoid ossicles, tentaculitids, brachiopods, gastropods, conulariids and orthocones. The eurypterids recorded are the stylonuroids *Parastylonurus ornatus* (Laurie, 1892) (see (Figure 2.16)), *Parastylonurus hendersoni* Waterston, 1979, *Hardieopterus macrophthalmus* (Laurie, 1892), *Laurieopterus elegans* (Laurie, 1899), *Drepanopterus lobatus* Laurie, 1899, *Drepanopterus pentlandicus* Laurie, 1892, *Drepanopterus bembycoides* Laurie, 1899, and *Kiaeropterus cyclophthalmus* (Laurie, 1892); and the non-stylonuroids *Carcinosoma scotica* (Laurie, 1899), *Nanahughmilleria conica* (Laurie, 1892), *Eurypterus minor* Laurie, 1899, and *Slimonia dubia* Laurie, 1899 (see Waterston 1962, 1979; Tollerton, 1989; Tetlie, 2006b; Tetlie *et al.,* 2007). The xiphosuran *Bembicosoma pomphicus* Laurie, 1899 (Figure 2.17), the scorpion *Dolichophonus loudonensis* (Laurie, 1899) (Figure 2.18), the phyllocarid *Ceratiocaris* sp. and the putative phyllocarid *Dictyocaris ramseyi* Salter, 1860 make up the non-trilobite arthropod fauna. Nearly all of these species have Gutterford Burn as their type — and in many cases only known — locality.

The asteroid fauna occurs in two horizons in transitional strata between the Gutterford Burn flagstones and the overlying, mainly argillaceous beds. Trilobites, brachiopods and graptolites are also known from these transitional beds.

Interpretation

Palaeoenvironmental analysis initially indicated that the Reservoir through to Cock Rig formations were essentially deposited as part of a submarine fan system (Robertson, 1989), though this interpretation is now thought to be at best equivocal, and that more probably this part of the sequence represents in general basin-fill or distal storm deposits of shallow-water origin, with the Cock Rig Formation representing the establishment of an offshore bar (Bull and Loydell, 1975; Clarkson *et al.,* 2001). Sedimentation, whatever, appears to have been rapid. The 2000 m of sediment of the Reservoir and the lower part of the overlying Wether Law Linn formations was all deposited within the *crenulata* Biozone. The recent detailed logging of the Gutterford Burn section has additionally indicated that volcanic activity in the form of volcaniclastic and individual ash-fall bands played a considerable role in the formation of the Eurypterid Bed (Anderson, 2003). The whole of the North Esk and Pentlands early Silurian succession, from Reservoir to Henshaw formations, represents a regressive sequence that changes from a marine to a terrestrial, semiarid desert setting, with all the sediments accumulating near the southern margin of the Midland Valley rift.

Within the context of chelicerate studies Scottish Siluro–Devonian localities have become renowned for yielding a diversity of stylonuroid eurypterids, and foremost among these sites is Gutterford Burn. Stylonuroids are characterized by their long fifth and sixth prosomal appendages, narrow abdomen, and long and styliform telson (Waterston, 1979), the form of their prosomal legs being considered a diagnostic character uniting the group in one overview of eurypterid classification (Tollerton, 1989).

They are claimed to have been able to walk on their long, stilt-like legs, and some species have even been suggested as capable of doing so on the shore, though undoubtedly most were aquatic (see Størmer, 1934; Waterston, 1979; Selden, 1984).

With the re-assignment of *Eurypterus cyclophthalmus* to *Kiaeropterus, E. minor* is now the earliest known species of *Eurypterus* and is almost certainly ancestral to all other *Eurypterus* species, which collectively span the Wenlock to P■ídolí (Silurian) time interval (Tetlie, 2006b; Tetlie *et al.,* 2007). The eurypterid fauna of the Pentlands was placed by Kjellesvig-Waering (1961) in his Hughmilleridae–Stylonuridae biofacies phase, purportedly the least marine of the three biofacies identified by him. However this does not appear to be consistent with the interpretation of the environment of deposition, as indicated above, for the Gutterford Burn sediments.

Bembicosoma pomphicus was recently shown to be a xiphosuran (Anderson and Moore, 2004), as Laurie (1899) originally suspected, even though he described it together with other species from the Pentland Hills that were undoubtedly eurypterids. It is now believed to be a 'synziphosurine', thus making it one of the earliest of this loose grouping of xiphosurans, and has been placed in the same family as *Bunodes, Limuloides* and *Pasternakevia. P. loudonensis,* similarly, is one of the earliest known scorpions. The phyllocarid assignment of *Ceratiocaris* is accepted, but *Dictyocaris* has, historically, only questionably been considered a phyllocarid and it remains essentially of unknown affinity.

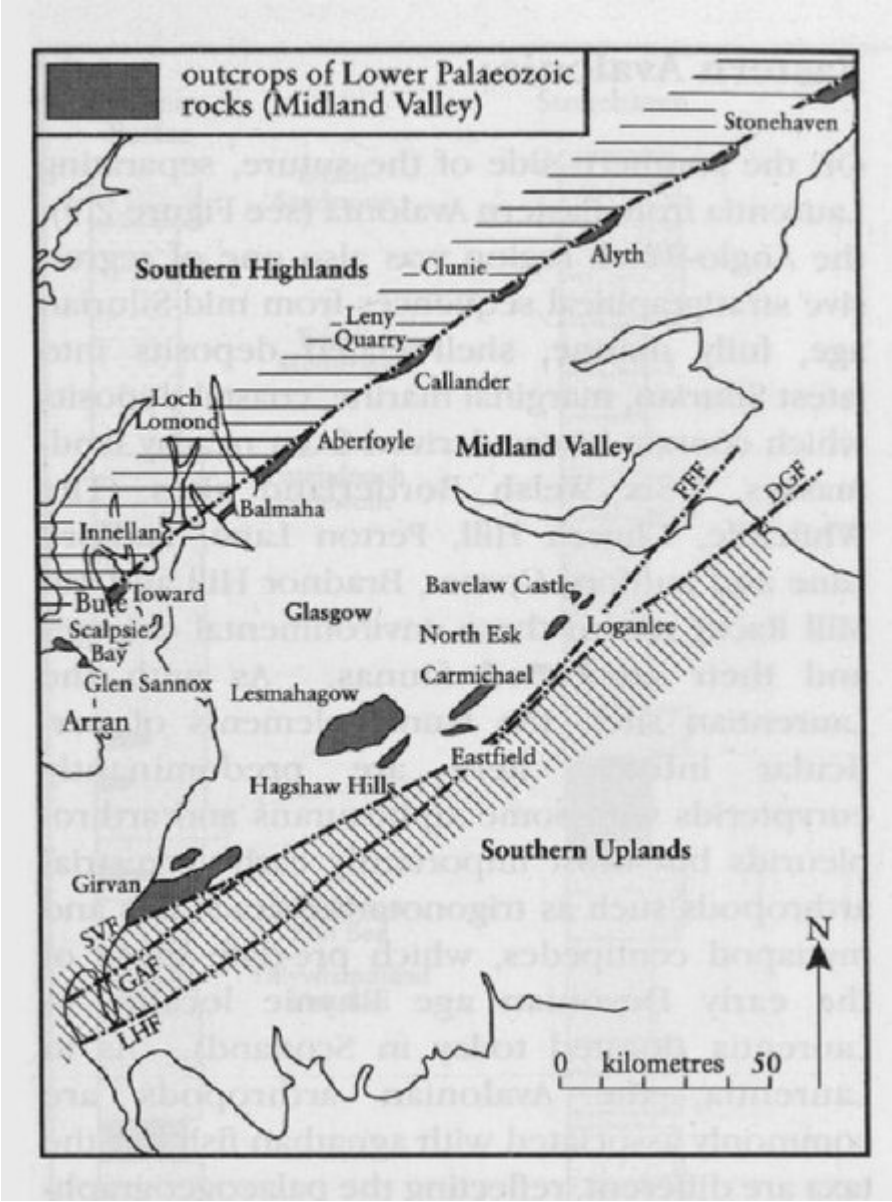
In general the invertebrate fauna of the Reservoir and Deerhope formations appears to be biogeographically discrete, as it is largely distinct from that found in the Girvan area to the west, and from elsewhere in Britain. The younger Wether Law Linn Formation has faunal connections with the Baltic region to the east, suggesting an open marine connection between there and eastern Scotland during latest Llandovery times.

Gutterford Burn has particularly close arthropod network links with the other eurypterid rich Siluro-Devonian Midland Valley sites of Slot Burn, Dunside, and Turin Hill. It contains, however, an especially rich stylonuroid fauna unmatched elsewhere. Ties are also present with the Ludlow through to P■ídolí series Anglo-Welsh arthropod sites of Church Hill, the Whitcliffe, Ludford Lane and Ludford Corner, Tin Mill Race, Perton Lane, and Bradnor Hill. All of these have important eurypterid faunas but stylonuroids are almost entirely absent from them.

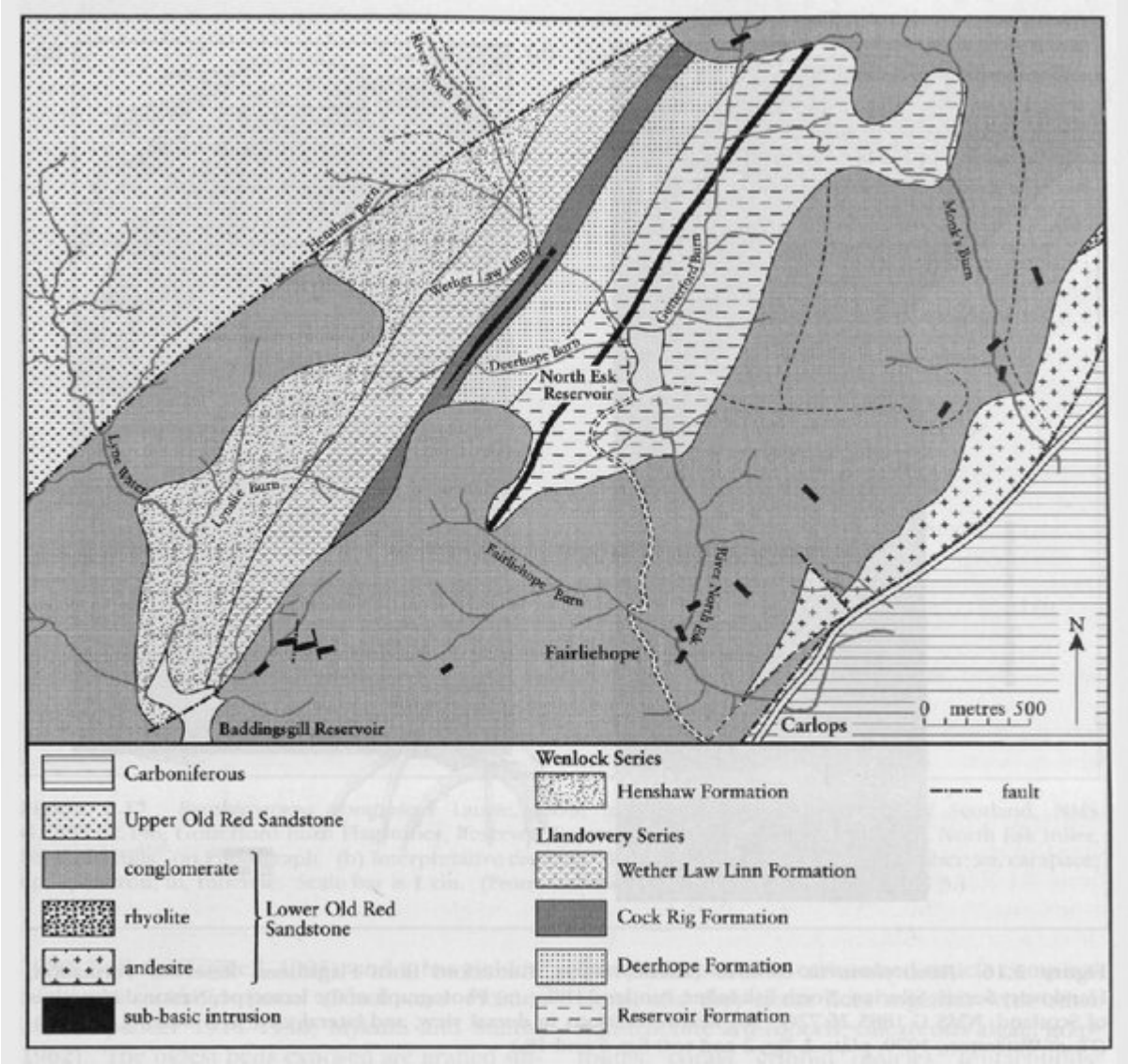
Conclusions

The Llandovery Series rocks of the Gutterford Burn site are extremely important for non-trilobite arthropod research in several respects. The site is a key historical locality with respect to such investigations, made famous through the late 19th century collecting of John Hardie and the scientific work of John Laurie. It has a diverse eurypterid fauna — there are some twelve species known from here and for all of these it represents the type locality, and among them it also boasts a particularly rich stylonuroid fauna. The site is also the type and only known locality for one of the earliest synziphosurine chelicerates and one of the earliest scorpions.

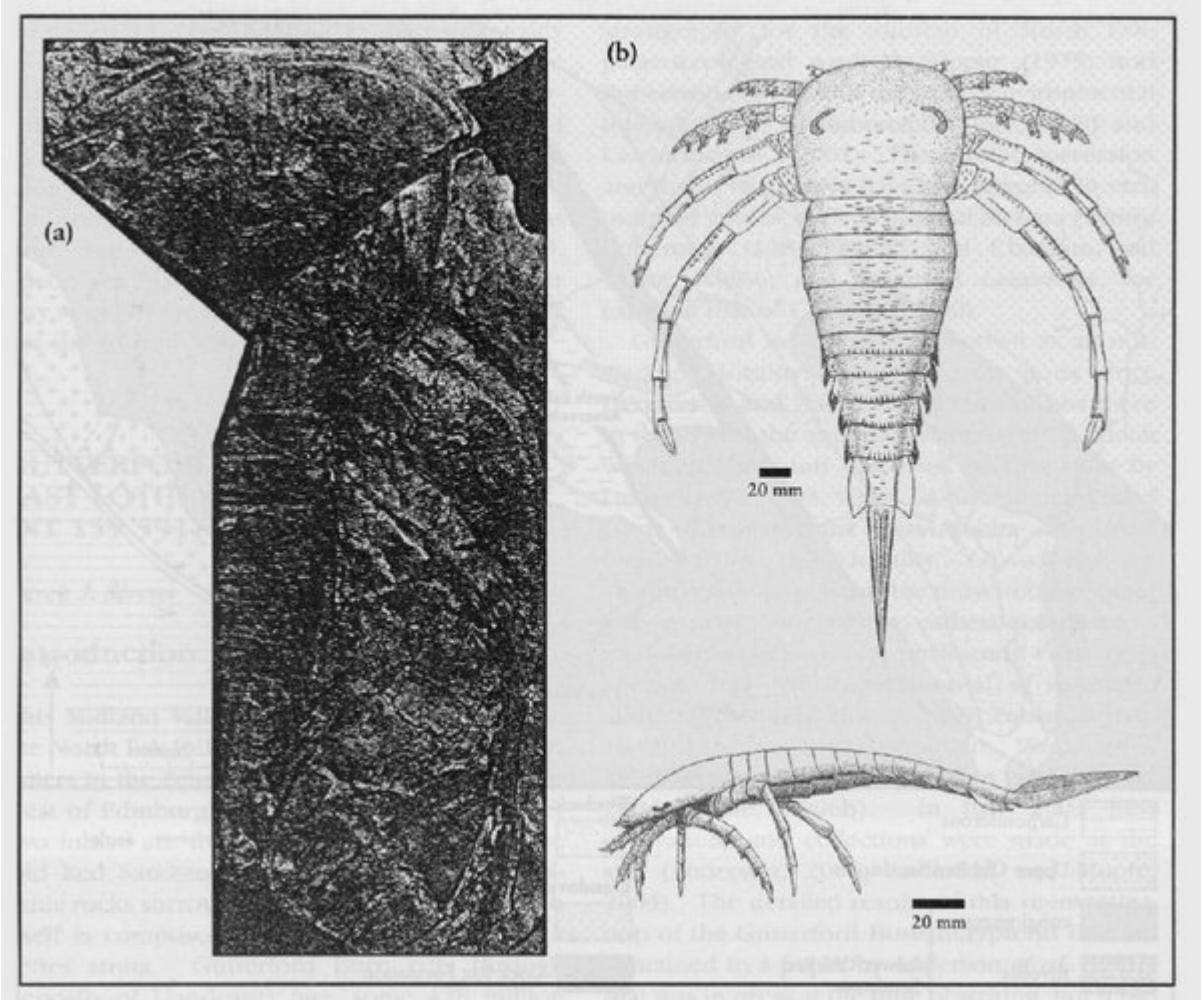
References



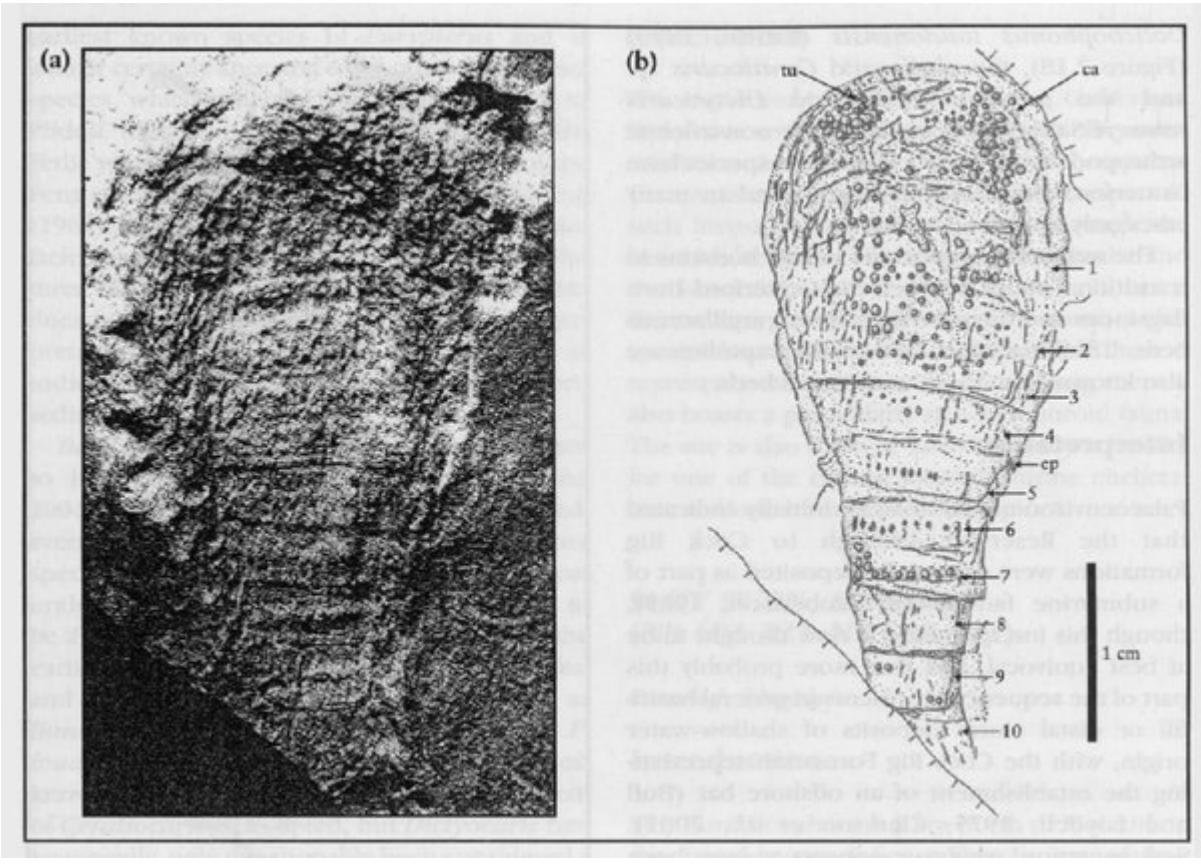
(Figure 2.5) Location of the main Silurian inliers of the Midland Valley of Scotland, and faults. SVF Stinchar Valley Fault; GAF Glen App Fault; LHF Leadhills Fault; FFF Firth of Forth Fault; DGF Dunbar–Gifford Fault; HBF Highland Boundary Fault. (After Palmer, 2000 and Bluck, 2002.)



(Figure 2.15) Geology of the North Esk Inlier. (After Siveter, 2000b.)



(Figure 2.16) Parastylonurus ornatus (Laurie, 1899); Gutterford Burn Flagstones, Reservoir Formation, Llandovery Series, Silurian, North Esk Inlier, Pentland Hills. (a) Photograph of the lectotype, National Museums of Scotland, NMS G.1885.26.72G. (b) Reconstructions in dorsal view, and lateral view in a walking position. (From Waterston, 1979, plate 2, fig. 2 and text-figs 6 and 18.)



(Figure 2.17) Bembicosoma pomphicus Laurie, 1899; holotype, National Museums of Scotland, NMS G.1897.32.146; Gutterford Burn Flagstones, Reservoir Formation, Llandovery Series, Silurian, North Esk Inlier, Pentland Hills. (a) Photograph. (b) Interpretative drawing. 1–10, opisthosomal segment number; ca, carapace; ep, epimeron; tu, tubercle. Scale bar is 1 cm. (From Anderson and Moore, 2004, figs 1b and 3.)

(Figure 2.18) Dolichophonus loudonesis (Laurie, 1899); holotype, National Museums of Scotland, NMSG.1897.32.196; Gutterford Burn Flagstones, Reservoir Formation, Llandovery Series, Silurian, North Esk Inlier, Pentland Hills. Almost complete specimen. (Lithograph from Laurie, 1899, plate 1, fig. 1.)