
SLOT BURN

OS Grid Reference: NS680321

Highlights

One of the richest fossil fish localities in the Silurian of Scotland, this site in Strathclyde has produced about ten fossil species of fishes of widely varying groups, and much information about their habitats and palaeobiology.

Introduction

This locality, in the Lesmahagow inlier, is the best known of the mid-Silurian Scottish fish beds, and is the locality from which much of the original vertebrate material was collected by the Geological Survey (Traquair, 1899b, 1905a). It is probable, therefore, that Slot Burn was the site from which most of the type material came for Traquair's descriptions, although he gave no type localities. The site is known also as Segholm or Seggieholm. The problem of the locality of the collecting sites of many specimens in old collections recurs frequently.

Description

The fishes come from beds within the Slot Burn Formation of the Waterhead Group. The upper fish bed both here and at Birkenhead Burn (q.v.), is in two discrete units, which were recognized by Peach and Horne (1899, pp. 578–9). It is revealed in this exposure as red shaley mudstone grading up into the laminated siltstones of the main fish bed, which is 1–1.3 m thick and topped by thinly bedded mudstone bed. The second productive layer of the fish bed is 14–18 m upstream and is 1 m thick, lying above a yellow sandstone, and succeeded by olive-green mudstones.

The vertebrate fossils are preserved as thin carbonaceous films or as the denticles of articulated thelodonts, and these remains represent an indigenous fauna. The fishes are more readily seen when the rock is slightly weathered; where the rock is really fresh it appears to be virtually unfossiliferous and smaller specimens are almost invisible. They are predominantly fragmented in the marginal parts of the fish bed, where the well-laminated siltstones grade upwards or downwards into a poorly laminated siltstone or mudstone.

Traquair (1899b) was first to note that in all the mid-Silurian fish localities, bar Segholm (Slot Burn), the actual substance of the fossil is preserved, but here the shale is decayed and soft and the scales and plates of the agnathans have rotted. Once the badly preserved remains of bone have been removed, the impressions which are left provide finely detailed moulds, and the study of casts from this site has provided important information (Parrington, 1958; Ritchie, 1967). The fossils are commonly less than 10 cm long.

Ritchie made a large collection from trenches here in the early 1960s, and he attempted a study of relative abundance through the fish bed (1963, p. 5). Most forms were present throughout the fish bed in approximately similar proportions, with only three exceptions where one or other species dominated a horizon. Particularly important was a pyritiferous siltstone 50 mm thick within the mudstone succession that yielded many well-preserved ostracoderms associated with the articulated arthropod *Lanarkopterus*. It also produced several specimens of the ?petromyzontid *Monkolepis maculatus*.

Fauna

For comparison the fish fauna of Slot Burn (and of the nearby Shiel Burn, Birkenhead Burn, and Dippal Burn) is listed here. AGNATHA

Thelodonti: Thelodontida: Loganellidae

Lanarkia horrida Traquair, 1898

Common at all four sites; syntype: Birkenhead Burn and Slot Burn

Lanarkia spinosa Traquair, 1898

Common at all four sites; syntype: Birkenhead Burn and Slot Burn

Lanarkia spinulosa Traquair, 1898

Rare at all four sites; syntypes: Birkenhead Burn and Slot Burn

Shiella taiti (Stetson, 1931)

Common at all four sites; type locality: Shiel Burn

Anaspida: Birkeniiformes: Birkeniidae

Birkenia elegans Traquair, 1898

Common at all four sites; syntypes: Dunside, Slot Burn, Birkenhead Burn, Dippal Burn, Shiel Burn and Lynslie Burn (Pentland Hills inlier)

Anaspida: Birkeniiformes: Lasaniidae

Lasanius altus Smith, 1958

Rare; recorded from Shiel Burn, Slot Burn and Birkenhead Burn

Lasanius armatus Traquair, 1899

Rare, probably present at all four sites; type locality: Slot Burn

Lasanius problematicus Traquair, 1898

Common at all four sites; syntypes: Birkenhead Burn, Slot Burn, Dippal Burn, Shiel Burn, Smithy Burn (Hagshaws) and Lynslie Burn

Osteostraci: Ateleaspidiformes: Ateleaspididae

Ateleaspis tessellata Traquair, 1899

Rare; recorded at all four sites.

Lectotype: selected by Heintz (1939) from Slot Burn

Incertae sedis

Monkolepis maculatus Ritchie, 1963

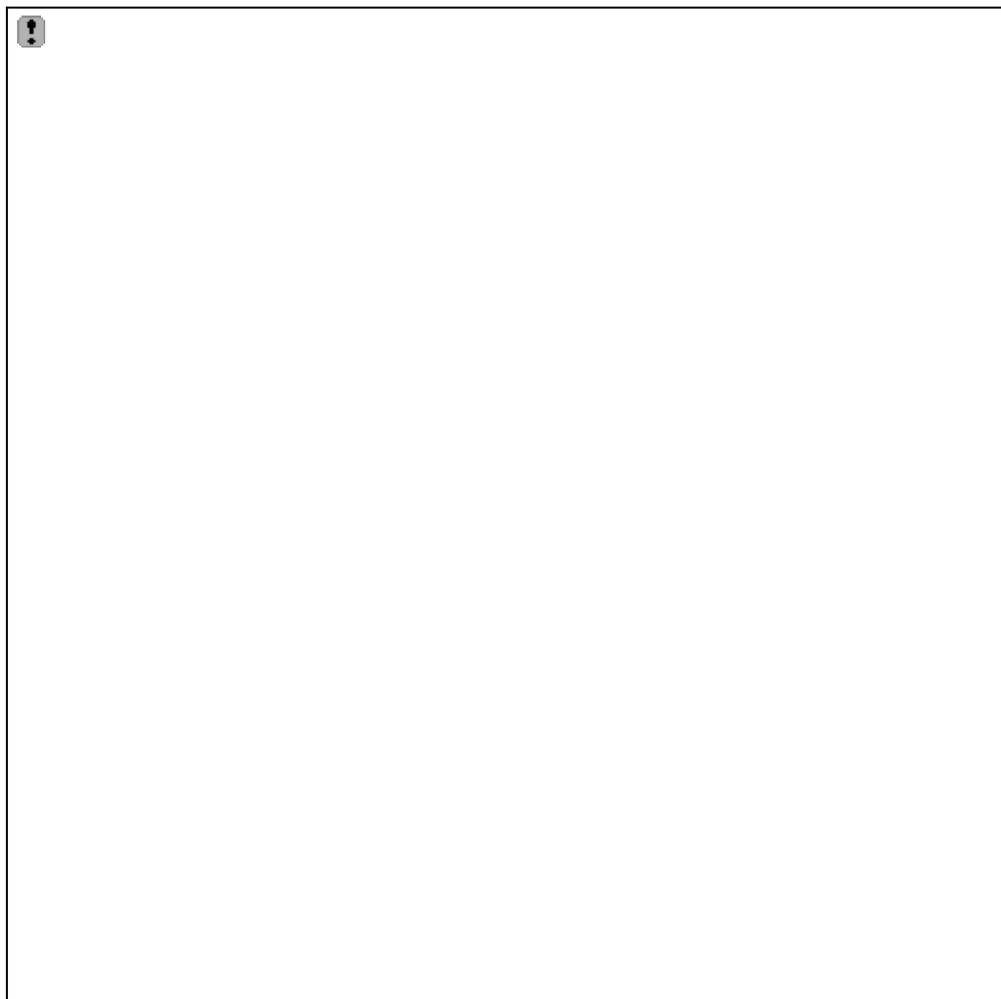
Rare; recorded only at Shiel Burn and Slot Burn; ?type locality

The Waterhead Group and the Glenbuck Group fish beds all have a comparable fauna with similar diversity. The first descriptions were usually based upon Geological Survey collections from all the sites on the two horizons, and rarely has a species been given a single type locality in subsequent work.

The upper fish beds of the Lesmahagow and Hagshaw Hills inliers contain two genera of complete thelodont animals. Other known articulated thelodonts are from the Silurian and Devonian of north-west Canada (Wilson and Caldwell, 1993) from the Devonian of New Brunswick, Canada (*Thelodus macintoshi*), from the Upper Silurian of Oesel in the Baltic (the Phlebolepididae), and undescribed forms from Ringerike, Norway (Ritchie, 1967) which are similar to *Shiella taiti*.

Shiella taiti (Stetson, 1931) is common in the Dippal Burn and the Fish Bed formations. These were first recognized by Traquair (1899b) as small poor specimens of *Thelodus scoticus* (Figure 2.14A) which might constitute a new species. Stetson (1931) obtained new material from the

collector, Tait, and named the new species after him, choosing a type specimen from Shiel Burn which had been figured by Traquair (1899b, plate 1, fig. 4). This type specimen is particularly important because it shows traces of internal structure. Eight black streaks were interpreted as branchial bars by Stetson (1931), and discussed by Westoll (1945) and Stensiö (1958) who thought that they represent extrabranchial atria. Ritchie (1963) discovered similar structures in *Loganellia scotica*, and decided that they represent branchial pouches, and that the thelodonts were therefore very different from the Heterostraci with which they had previously been linked (Ritchie, 1968). In a specimen of *Shiella taiti* from Shiel Burn, the orbit is visible as a distinct circular hole. *Shiella taiti* is usually 70–100 mm long, but sometimes larger specimens, over 150 mm long, have been found. *Shiella taiti* has also been recorded from the late Silurian of Ringerike (Norway), Siberia and Pennsylvania (Giffin, 1979).



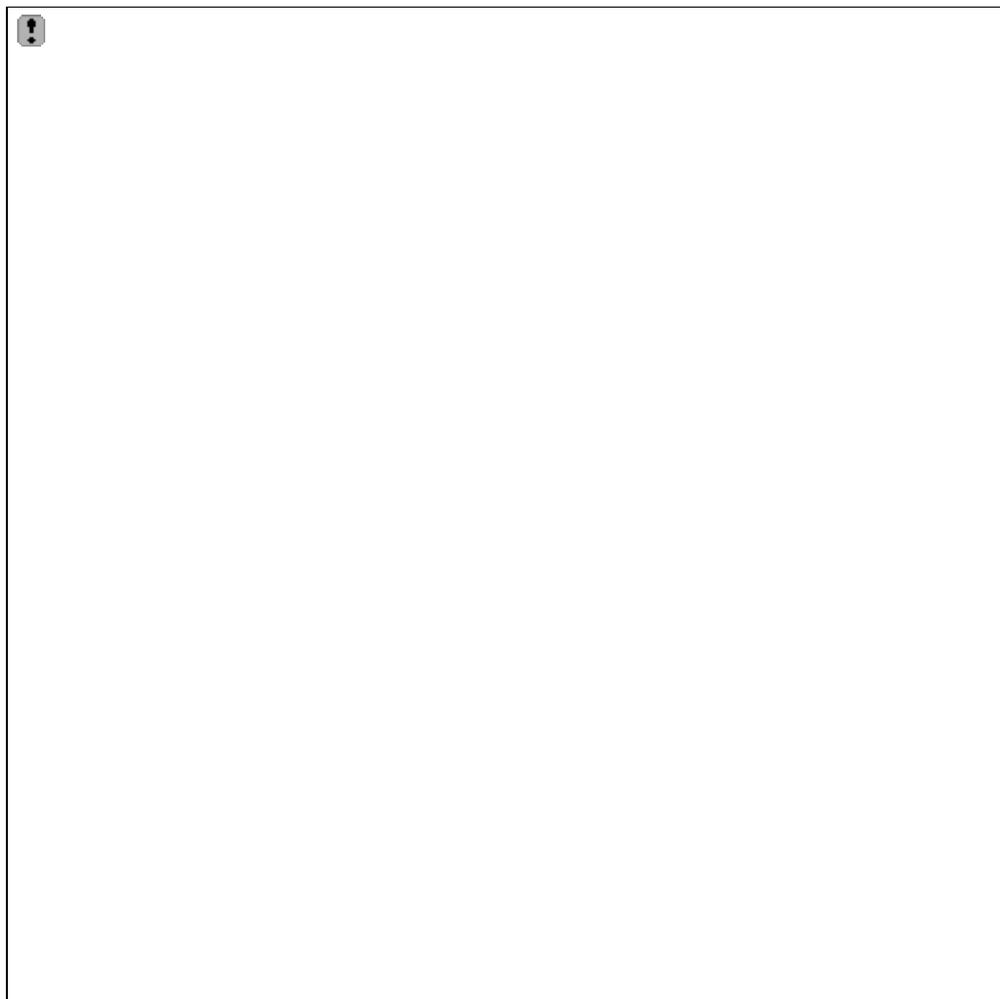


Figure 2.14: (A) The thelodont *Thelodus scoticus* (GLAHM V8304), ?Upper Llandoverly at Birk Knowes, c. $\times 1$ (Photo: courtesy of the Hunterian Museum, Glasgow). (B) The thelodont *Lanarkia horrida* (GLAHM V2302), ?Wenlock at Seggholm, ?Slot Burn; at about natural size (Photo: courtesy of the Hunterian Museum, Glasgow).

Lanarkia species are distinguished from *Loganellia* by their sharp, hollow, conical spines which lack a basal plate (Traquair, 1899b). *L. horrida* and *L. spinosa* are both fairly common, *L. spinulosa*, the largest form at 200 mm long, being rare. Ritchie (1963) identified possible small (20–30 mm long) young *Lanarkia* sp. in the weathered lithology of Slot Burn. These had large eyes but all the other adult features were present. Turner (1992) suggested that *L. 'horrida'* and *L. spinosa* were different growth stages and that *L. spinulosa* was a possible sexual dimorph of *L. spinosa* (Figure 2.14B).

The anaspid *Birkenia* is 20–100 mm long, and is typically found laterally compressed (see Figure 2.11A). It is one of the most common and well-preserved forms in the fish beds of Slot Burn, Dippal Burn and Glenbuck. The body is covered with dorso-ventrally elongated scales and the fifth and ?adjacent median dorsal scutes are distinctively double-hooked. The dorsal flank scales of *Birkenia* slope downward and backward in the posterior half of the body, instead of downward and forward as in the other scaled anaspid genera, and clearly do not reflect the form of the myotomes (see Birk Knowes report). There is evidence that in *Birkenia* the size, but not the number, of scales increased with age (Parrington, 1958).

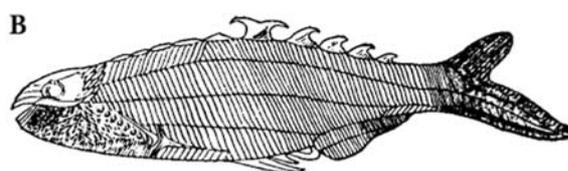
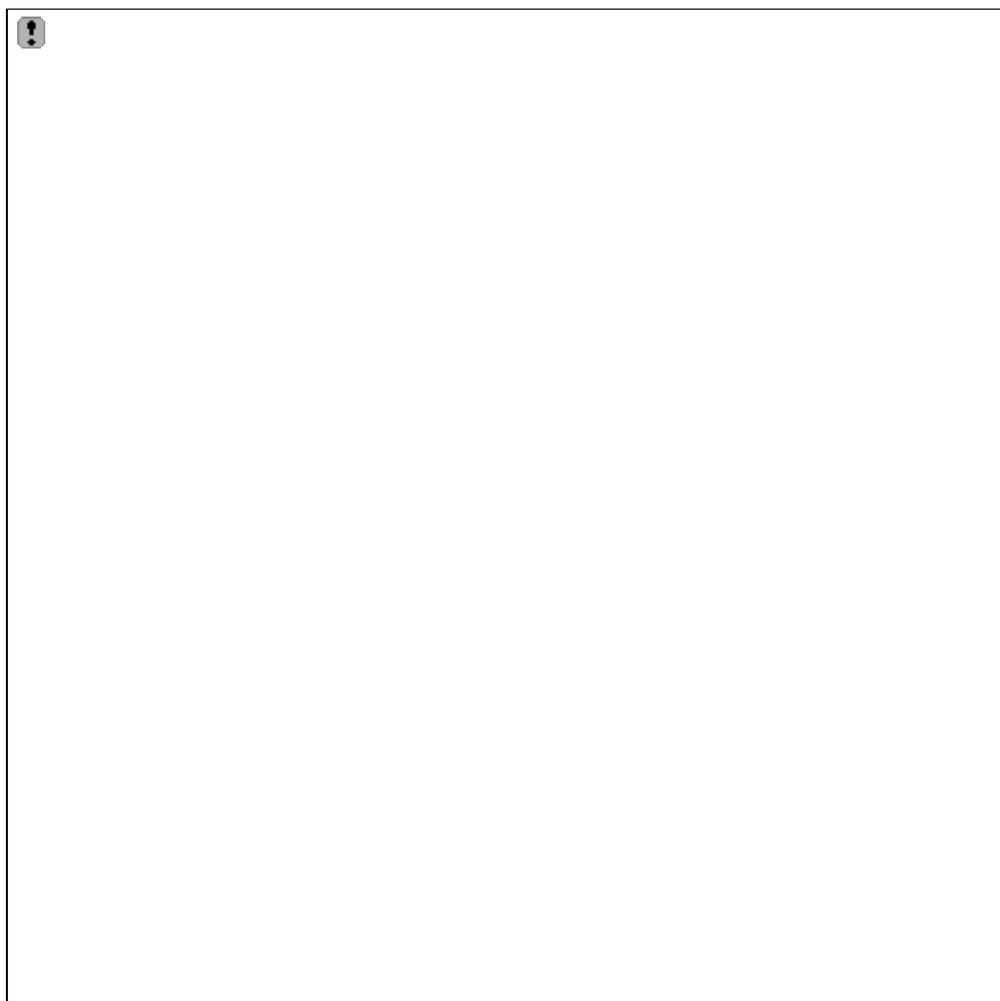


Figure 2.11: (A) *Birkenia elegans* Traquair. Well-preserved specimen from the ? Wenlockian of Birkenhead Burn, Shanks Castle, photographed under water, $\times 2$, GLAHM V 8384 (Photo: courtesy of the Hunterian Museum, Glasgow). (B) *Birkenia elegans* Traquair. A restoration of this anaspid, the original fossil being c. 10 cms long (after Stetson, 1927).

Anaspids have a hypocercal tail, but when Traquair (1899b, 1905a) first reported *Birkenia*, he assumed that the tail was heterocercal, and so he figured *Birkenia*, and the other anaspids from southern Scotland, upside down. He did not identify the orbital openings or discuss the position of the mouth, both of which have a peculiar orientation in his reconstruction. Anaspids were correctly orientated by Kiaer (1924), following research on better-preserved anaspids from Ringerike, Norway, which showed the position of the pineal and nasal openings. Stetson (1928) redescribed *Birkenia elegans* using new material collected by Tait and by Strachan (Museum of Comparative Zoology, Harvard), basing his reconstruction on the Ringerike anaspids.

Heintz (1958, p. 77) reconstructed the head of *Birkenia*, which is covered with small plates and scales, and which has a distinctive, large Y-shaped pineal plate containing the pineal opening and forming the posterolateral margin of the single nasal opening. The arrangement of plates is similar to that of *Pterygolepis* from Norway, although Smith (1957) compared it with the cephalic shield of cephalaspids. A paired 'round patch' defined by scale pattern and antero-ventral to the orbit is a distinctive feature of *Birkenia*, but its function is unclear.

There has been some debate about the nature of the mouth of anaspids, and this has a bearing on whether recent Cyclostomata (with suctorial mouths) descended from anaspid-like primitive forms (Stensiö 1927, 1939b; Obruchev, 1949; Balabaj, 1956). Heintz (1958) suggested that the mouth of *Birkenia* was a vertical split or ovoid opening at the bluntly rounded front end of the head similar to that of other known Agnatha, as was also independently proposed for anaspids generally by Parrington (1958) and Stensiö (1958). Heintz (1958) concluded that *Birkenia* did not have a suctorial mouth, but rather one like *Branchiostoma* that was adapted to microphagous feeding with cirri, mucous glands, cilia and an endostyle. Denison (1961) thought that this was unlikely, and suggested that some kind of suctorial device was present in anaspids. He also disputed the idea that the anaspids sucked up food from the sea floor (Parrington, 1958) because the hypocercal tail would give lift to a fish whose other features suggest an active lifestyle rather than one specialized for bottom-feeding.

Jarvik (1959) described the caudal fin of *Birkenia*, and Ritchie (1964) described a specimen possessing a fin membrane extending beyond the scale-covered portion, and also a possible membranous lateral fin comparable with those of *Rhyncholepis* from Norway. Ritchie (1980) perceived fin-folds preserved in Ringerike anaspids, and produced a model for anaspid stability and lifestyle in which he regarded the anaspid as being active and free-swimming, feeding anywhere between the surface and the bottom.

The other anaspid genus in these fish beds, *Lasanius* (Figure 2.15A, 2.15B), lacks a scale covering and its only hard parts are a row of 17–24 spinous dorsal scutes, an oblique row of six ossicles associated with the branchial openings and 5–10 post-cephalic rods immediately behind the branchial ossicles. The remainder of the animal may be preserved as a carbonized stain. Since Traquair's (1899b, 1905a) original account, *Lasanius* has been redescribed by Simpson (1926), Stetson (1927), Bulman (1930), Parrington (1958) and Ritchie (1963) and discussed by many authors. Two species were recognized by Traquair, *L. problematicus* (Figure 2.15A, B), which is common, and the smaller, rarer *L. armatus*.

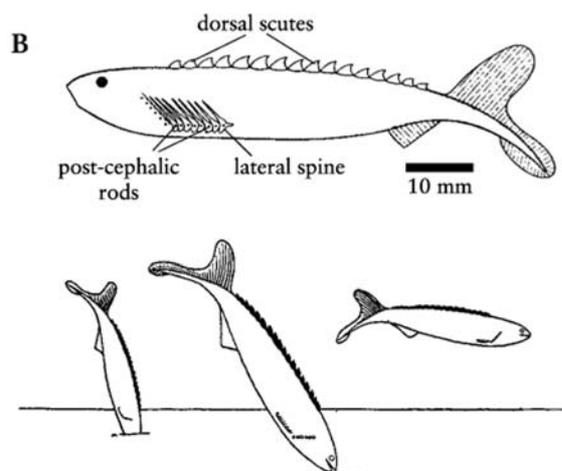
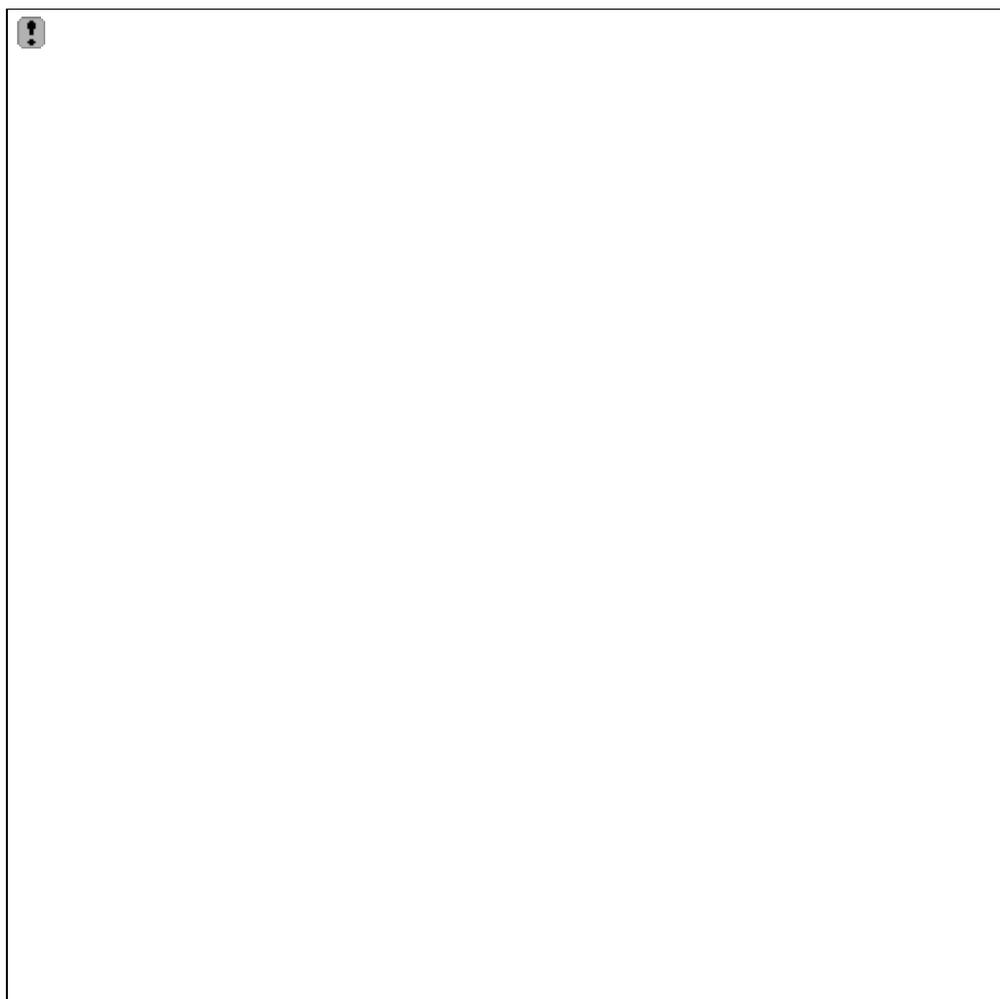


Figure 2.15: (A) The anaspid *Lasanius problematicus* Traquair. Specimen from an unidentified horizon, Segholm (Slot Burn), c. $\times 2$, GLAHM V 2286 (Photo: courtesy of the Hunterian Museum, Glasgow). (B) The anaspid *Lasanius problematicus* Traquair. Restoration in lateral view and possible feeding and swimming positions as suggested by Parrington (1958).

Lasanius has six branchial ossicles, representing the number of branchial pouches, but the number of dorsal scutes and of post-cephalic rods varies between and within species. The post-cephalic rods, behind the branchial ossicles, may vary in number even between the two sides of an individual. Stetson (1927) thought that these L-shaped structures supported the gills, but Bulman (1930) suggested that the rods were inserted between myotomes. Parrington (1958) showed that *L. problematicus* had between seven and nine rods, and that this number was not based on size or maturity of an individual. He also showed that each L-shaped structure

supported a lateral spine, and supported the suggestion of Bulman (1930) and Stensiö (1939b) that the lateral spine in turn supported a primitive pectoral fin or a fin-fold.

Little is known about the structure of the head of *Lasanius*. None of the anterior parts of the head has ever been found, and reconstructions have been based on other anaspids. Parrington (1958) identified paired lens-shaped structures on the head of *L. problematicus* that he interpreted as the remains of the eyes.

Parrington (1958) regarded *Lasanius* as an active swimmer, which used its hypocercal tail to acquire an inverted vertical position in order to 'hoover' through the bottom mud using its a suctorial mouth to feed on minute organisms. Phylogenetic relationships of the Anaspida and Petromyzontida were discussed by Arsenault and Janvier (1991). *Lasanius* and *Birkenia* are very closely related, based on maximum convergence of derived characters.

Ateleaspis tessellata Traquair, 1898 is the earliest relatively complete British cephalaspid known, pre-dating the more typical cornuate forms of the Devonian by many millions of years. *A. tessellata* was discovered in 1897 by Macconochie and Tait (Traquair, 1898a, p. 74). Using specimens from Slot Burn, Birkenhead Burn and the Pentland Hills, Traquair named and then described and figured it in 1899. Better material was subsequently discovered, allowing further details (Traquair, 1905a) to be added to the original description. Heintz (1939) compared the species to *Aceraspis* and *Hirella* from younger rocks at Rudstangen, Norway. He selected a lectotype from Slot Burn. Unfortunately, after over 40 years of collecting, only 20 specimens of *Ateleaspis* were known, consisting mostly of small fragments. It is one of the rarest elements in the vertebrate fauna from these fish beds (Ritchie, 1967). All the known material of *Ateleaspis* is distorted and flattened, which emphasizes the polygonal pattern of the mucous canal system across the head shield (Figure 2.16). Traquair (1899b) and Parrington (1958) thought that this represented incomplete ossification of the headshield. Parrington (1958) suggested that *Ateleaspis* was therefore an immature cephalaspid. The cephalaspid headshield is described in more detail in Chapter 3.

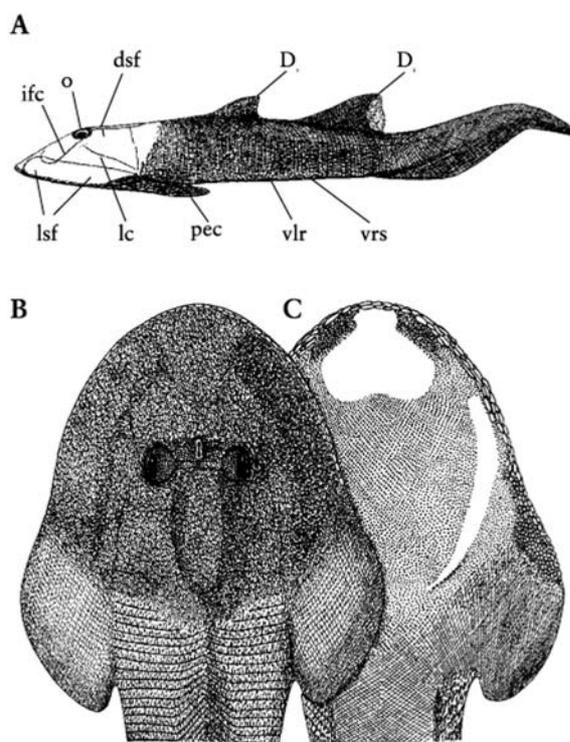


Figure 2.16: *Ateleaspis tessellata* Traquair. (A) Reconstruction in lateral view, c. $\times 0.3$; and of the headshield and front part of the trunk; (B) in dorsal and (C) ventral view, c. $\times 0.5$, (after Ritchie, 1967): cmm, transverse sensory canals; D1 and D2 anterior and posterior dorsal fins; dsf, dorsal sensory field; ifc, infra-orbital sensory canal; lc, lateral sensory canal; lsf, lateral sensory field; o, orbit; pec, left pectoral fin; vlr, ventro-lateral ridge; vrs, ventro-lateral scales.

Ritchie (1967) gave an account of the genus based on new material from Slot Burn, Birkenhead Burn, Shiel Burn and Smithy Burn. His reconstruction is based mainly upon a fairly complete mould from Slot Burn, which allowed latex casts to be produced. The pectoral fins were shown to have a sinus separating them from the trunk, which was similar enough to *Aceraspis* for Ritchie (1967) to decide that they represented the same genus. Previously, the mistaken belief that *Ateleaspis* lacked such a sinus had led to the idea that it was at a very early stage in the development of fins (Heintz, 1939; Westoll, 1945, 1958). Janvier (1980, 1981), on the other hand, thought that *Aceraspis* showed several characters which were more derived than *Ateleaspis*, and he retained the distinction between the two genera.

Monkolepis maculatus Ritchie MS is a long, narrow segmented organism, possibly over 90 mm in length, with no trace of fins or a branchial apparatus. Three carbonized circular structures towards the end of the fossil are interpreted as the remains of an annular buccal cartilage and sclerotic cartilages, similar to those in *Jamoytius*. The original specimen of this agnathan was first referred to *Jamoytius kerwoodi* (Ritchie, 1960), but new material indicated that it was a different organism. Janvier (1981) removed *Jamoytius* from the anaspids, and made it a possible sister-group of the Petromyzontida, the modern lampreys, and the annular buccal cartilage seen in *Monkolepis* might suggest that this species also was related to the lampreys.

Interpretation

The upper fish beds of the Lesmahagow and Hagshaw Hills inliers are finely laminated pyritiferous siltstones indicating stagnant bottom conditions and deposition within large bodies of quiet water. The entire section at Lesmahagow can be regarded as showing a gradual decrease in salinity upwards from the marine Patrick Burn Formation into fluvial and deltaic conditions by the time of the Waterhead Group. These environmental changes may explain the differences between the faunas of the lower and the upper Lesmahagow fish beds.

The stratigraphical relationships among the mid-Silurian fish sites of the Hagshaw Hills and Lesmahagow inliers (Shiel Burn, Slot Burn, Birkenhead Burn) are complex (see Figure 2.4). They were first identified as exposures of the 'Passage' or Downtonian Fish Bed (Peach and Horne, 1899), hence probably late Ludlow in age, but Jennings (1961) showed that the upper fish beds represented two horizons, not one. Dippal Burn in the Lesmahagow inlier is approximately stratigraphically equivalent to Shiel Burn in the Hagshaw Hills inlier, and these are 100 m or so below the Slot Burn and Birkenhead Burn fish beds (both in the Lesmahagow inlier).

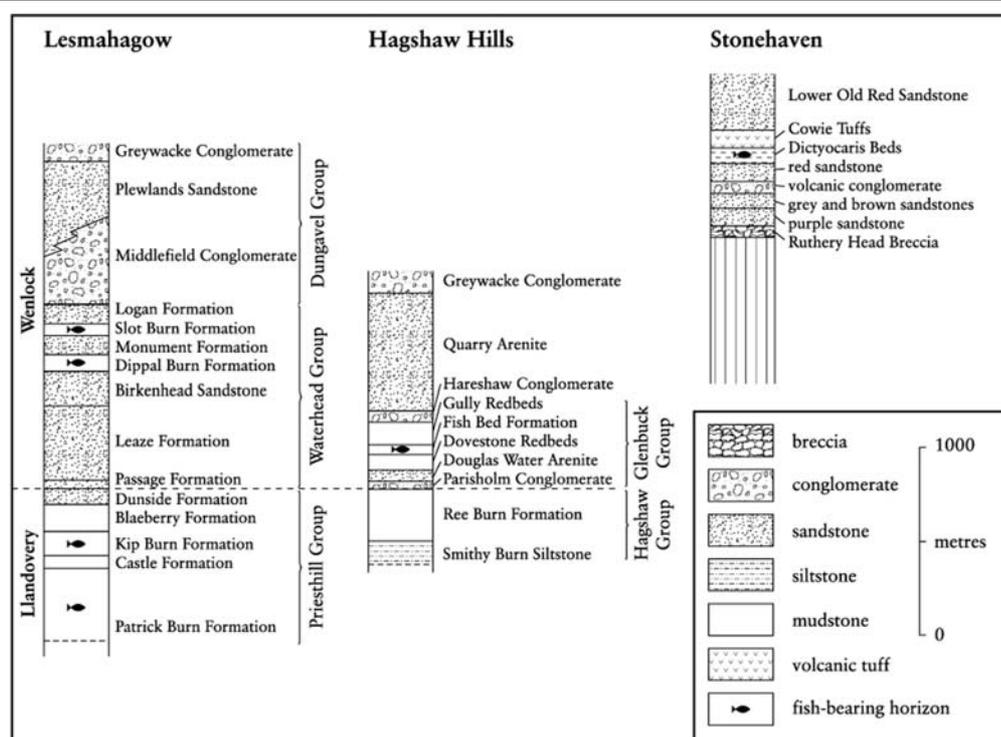


Figure 2.4: Silurian successions in the inliers of the Midland Valley (after Cameron and Stephenson, 1984).

Debate has persisted about the dating of these Silurian fish beds, there being little upon which to correlate them to the type Silurian sections. The detailed collecting and field research by Rolfe (1960, 1961, 1973a, 1973b) and Ritchie (1960, 1967, 1985) finally distinguished between these discrete horizons and indicated that there were four clearly distinguished fossiliferous horizons in the Lesmahagow inlier: (1) the *Jamoytius* horizon, (2) the *Ceraticaris* Bed, (3) the Dippal Fish Beds and (4) the Slot Burn Fish Beds. These upper two horizons have a very similar fauna of almost equal diversity, and were referred to the Upper Wenlock or Middle Ludlow (Ritchie, 1967; Janvier, 1985a), but may have an older Wenlock age (Cocks *et al.*, 1992). As stated above, Wellman and Richardson (1993) have found microfloras giving an early Wenlock date.

Conclusions

Over the years, at least 14 localities in the Lesmahagow inlier have yielded fishes, but so far many of these cannot be accurately correlated one to another. The conservation value of the fish beds in Slot Burn is largely historic in that they have been some of the most prolific and important within the system in Britain. Today they yield less material than previously, which may be due to the rock being too fresh for the remains to be seen.

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