Excursion 21 Hagshaw Hills

Key details

Author	W.D. Ian Rolfe
Theme	Transition from marine to terrestrial deposits in one of the Silurian inliers of the Midland Valley of Scotland.
Features	Turbidites, graded greywackes with sole markings and shelly fossiliferous bases, lower Wenlock resedimented faunal assemblage, Caledonian sills, Llandovery-Wenlock siltstones with fossil crustaceans in concretions, Tertiary dyke, alluvial fan conglomerates and playa sediments, lacustrine fish bed yielding some of the oldest, most complete fossil fish known, industrial archaeology of Muirkirk.
Maps	O.S. 1: 63 360 Sheets 67 Ayr and 68 Biggar, Moffat and Sanquhar 1: 50 000 Sheet 71 Lanark & Upper Nithsdale B.G.S. 1: 63 360 Sheets 23 Hamilton and 15 Sanquhar
Terrain	Exposures in burns and loch-sides: some easy walks, some rough hill walking with occasional scrambling: wellington boots recommended.
Short Itinerary	Omit localities 13, 14.
Distance and Time	The road distances between different parts of the excursion are 15.3 km (9.5 miles), and on foot 5.4 km. (4.5 miles). One day is recommended, but the excursion can be rushed through in 5 hours. The short route is 5.4 km (3.3 miles) on foot and can be covered in 4 hours.
Access	The Ree Burn section is now an SSSI and permission must be obtained from the owner, Mr.E.Renwick at Debog Farm [NS 775 280]. This is on the A70 one mile east of Parish Holm.

Collecting is listed as a Potentially Damaging Operation (P.D.O.) by the Nature Conservancy Council at localities 9 and 12, which are also SSSIs.

It is therefore essential to obtain a permit from the N.C.C. before attempting to collect at these sites, lest the site-owner be responsible for permitting unauthorised collecting. Such permits should be applied for at least three weeks in advance of the intended visit giving an indication of the reason for collecting at these sites, e.g. to obtain teaching, museum or research material. A package of information detailing local access arrangements will then be given. Write to NCC, 2 Beresford Terrace, Ayr, KA7 2EG or to Dr D. Norman, Earth Science Division, NCC, Peterborough, PE1 1UA.

Cars may be left in the turn-off to Monksfoot [NS 786 284].

Introduction

This excursion examines the transition from marine Llandovery to Old Red Sandstone terrestrial deposits that typifies sequences in the Silurian inliers of the Midland Valley of Scotland. Prior to the plate tectonic interpretation, this transition was thought to represent the end of the marine phase of the Caledonian geosyncline in Scotland. Currently, opinion differs on how to interpret the significance of this sequence of rocks. The Glasgow School of thought (Bluck 1983, 1984 and Ingham) suggests the sequence represents a passage from deposits in an older, fore-arc basin to the silting up of an inter-arc basin by sediments eroded northward from the upthrusting Midland Valley basement. This upthrusting was an

early manifestation of the collision of two continental plates: the Anglo-Welsh Avalonia with the southern margin of the Scottish Laurentia. As the oblique collision continued, emergent greywackes of the Scottish Uplands accretionary prism were obducted over the by-then-eroded upthrust basement. The eroded fragments of that prism form the Greywacke Conglomerate that is taken as the local base of the Lower Red Sandstone.

Up until comparatively recently, the Silurian Milers of the Midland Valley were variously dated, ranging between the extremes of Carboniferous and Ludlow /Downtonian of the Silurian. Recent refinement, largely initiated by the late Dr. Archie Lamont, has established that the lowest beds of the sequence are in fact much older—of uppermost Llandovery to lower Wenlock age. Evidence for secure dating of higher beds in the succession is lacking since the fossils that do occur, fish and arthropod species largely unique to these areas are clearly strongly facies controlled, and correlation with beds elsewhere is scanty. It is suspected that these higher beds are of Wenlock/Ludlow age, partly by overall comparison with the similar fauna of Ludlow age in Norway, and partly because they are overlain by the Lower Old Red Sandstone which has yielded the Lower Devonian fish *Cephalaspis* in Ayrshire.

Itinerary

Walk through the farmyard to the south front of Parish Holm (Figure 21.1) and follow the north bank of the Douglas Water 330 m (360 yds) upstream to the first side stream on the south bank, the Ree Burn. Proceed up the Ree Burn (noting en route at [NS 761 279] the grassed-over walls of the large ree or sheepfold from which the burn takes its name), walking along the top of the west (le ft) bank for 460 m (500 yds), before descending to the valley floor to Locality 1.

Locality 1. Quarry Arenite

Red sandstones of the Quarry Arenite are here seen to be vertical, and further upstream they are overturned to dip northwest at 40°. These sandstones underlie the thick Greywacke Conglomerate that constitutes the local base of the Lower Old Red Sandstone, and which forms the high ground south of this locality. The sandstones are best studied at this locality, since they are not so well seen later on: they are mainly subgreywackes, and show good cross-stratification. According to McGiven (1958) these rocks were laid down by braided streams, the intercalated mudstones being due to deposition of overbank fines during floods. Subsequent subaerial exposure produced mudcracks and mudflakes, the latter now found in desiccation breccias (intraclast conglomerates).

The Quarry Arenite and Greywacke Conglomerate make up the southern limb of the Hagshaw Hills NE—SW ('caledonoid') trending anticline. This structure is mainly asymmetrical, having an axial plane dipping steeply northwest, the northern limb dipping up to 70° northwest, and the southern limb dipping from 50° southeast, through verticality to overturned beds dipping up to 40° northwest. Locally therefore the structure is isoclinal.

About 46 m (50 yds) north of Locality 1, dark grey siltstones, mudstones and shales of the Smithy Burn Siltstone, which forms the local base of the succession, are brought up by the major north-dipping reverse or thrust fault which runs along the axis of the anticline. A small exposure of the Hareshaw Conglomerate may be found on the south side of the reversed fault, which is here intruded by a small dyke. Henceforward, the remainder of the section to be examined ascends the succession on the northern limb of the anticline.

The succession is as follows:

(f) Greywacke Conglomerate (base of terrestrial Lower Old Red Sandstone).

(e) Quarry Arenite

(d) Hareshaw Conglomerate

(c) Glenbuck Group iv Gully Redbeds

iii Fish Bed Formation

ii Dovestone Redbeds

i Douglas Water Arenite

(b) Parishholm Conglomerate

(a) Hagshaw Group

ii Ree Burn Formation (marine Silurian)

i Smithy Burn Siltstone

Locality 2. Smithy Burn Siltstone [NS 761 275]

This formation contains few fossils. The following graptolites have been collected at this locality, however, which suggest the *crenulata* Zone of the topmost Llandovery: *Monoclimacis* [*Monograptus*] ?*crenulata*, *M.* ?*griestonensis*, *M.* ?*vomerina*, *Monograptus* ?*spiralis*, *M. priodon*, *M.* ?*marri*. Unfortunately, the specimens upon which the list was based were lost before their significance was appreciated or their determination verified, so that any graptolites found in the Hagshaw Hills should be carefully preserved and deposited for public reference in a museum.

Locality 3a. Ree Burn Formation: sedimentary structures

Moving downstream, hard bands of greywacke and siltstone characterise the succession, and alternate with medium grey shales and mudstones. These 280 m (900 ft) of 'grits and shales' constitute the Ree Burn Formation. Many of the greywackes show graded bedding. The bases of individual coarse greywackes are commonly full of large angular fragments of igneous and metamorphic rocks, whereas the tops of them are of shale with conspicuous black laminae. Such grading originates from large debris-charged clouds of sediment which are thrown into suspension. These high density tongue-like masses of water (turbidity currents) flow rapidly down the slope, transporting material from shallower water areas, eroding the plastic sediments over which they travel and depositing their suspended grains en route–coarse grains and fossil shell fragments first and fine last as the weaker tail of the current passes by.

Collecting is easiest from the bases of greywackes which have been decalcified: these are obvious since they are dark brown and soft, the fossils consisting of casts and moulds. A partial list of the fossils is as follows (fuller list given by Rolfe 1962a, and some new forms described by Lamont 1965). Brachiopods–*Lingula*, *Atrypa reticularis*, *Glassia*, '*Catazyga' pentlandica*, *Protochonetes* aff. *edmundsi*, *Leptaena rhomboidalis*, *Howellella*, *Dicoelosia*, dalmanellids and rhynchonellids; bivalve molluscs–*Nuculites*, *Ctenodonta*, *Orthonota* cf. *scotica*, *Pteronitella*, ?*Grammysia*; snails -?*Holopella*, *Bellerophon*, ?*Pycnomphalus*, *Hormotoma*; conoidal fossils–*Cornulites*, *Tentaculites*, *Hyolithes forbesii*; water flea–*Beyrichia* cf. kloedeni; trilobites–*Calymene* aff. *carlops*, *C.* aff. *nodulosa*, cheirurid, *Hemiarges rolfei*, *Encrinurus hagshawensis*, *E. knockgardnerensis*, *Eophacops* aff. *sufferta*, *Phacops* aff. *stokesi*, *P. straitonensis*, proetid.

This fossil assemblage is probably identical to that which occurs at Knockgardner near Girvan, and which has been identified by Cocks as the lower Wenlock *Howellella–Protochonetes* assemblage, an assemblage that characterises shallow water in Wales and the Welsh Borderland. Acritarchs from the highest units beneath the Knockgardner redbeds are also of early Wenlock age (Doming 1982). Most of the fossils are fragmentary or disarticulated which, together with their shallow water nature, suggests that they have been resedimented by turbidity currents to their present position, in deeper water downslope.

Locality 3b. Sole markings [NS 762 277]

South of the sharp bend in the stream, the under sides of the greywacke units should be inspected for their variety of sole markings. Some of these linear structures have bulbous ends which indicate the up-current direction. These are casts of flutes formed by the scouring vortex action of the current (flute casts). Others are casts of grooves cut by angular particles dragged along by the flow (groove casts). On the right bank of the burn [NS 762 277], 73 m (80 yds)

downstream from the Smithy Burn Siltstone and 130 m (140 yds) upstream of the junction with the Douglas Water, an 18 cm thick greywacke carries orthocone prod and skip casts—casts of impact marks left by the empty shells of or thoconic nautiloids borne along by the turbidity current. Greywackes in the vicinity also yield casts of orthocone fragments that presumably lay on the sea floor until whisked away by an incoming current.

All these sole markings indicate that the currents responsible for their formation must have originated to the south. This turbidite sequence and its southerly derivation have been taken as evidence that a ridge-like land area—Cockburnland—appeared in upper Llandovery times, running NE–SW along the southern margin of what was then the Midland Basin of deposition. Currently 'Cockburnland' is interpreted as possibly emergent greywackes forming the Southern Uplands accretionary prism.

Locality 4. Thick sill of amygdaloidal plagiophyre

Continue downstream for 82 m (90 yds), where running up the left bank is a 1.5 m (5 ft) thick sill of amygdaloidal plagiophyre. This is only one of eight such Caledonian sills intruded into the Ree Burn Formation, some of them thin enough to confuse with greywacke units.

Locality 5. Pod-shrimp concretions

Approaching the junction of Ree Burn with the Douglas Water the greywackes disappear from the sequence, and the sediment is a striking laminated siltstone. Calcareous septarian concretions occur which may contain the fossil pod-shrimp Ceratiocaris papilio (Figure 22.1) preserved 'in the round'. Both small and large moult stages of this 60 cm (2 ft) long crustacean occur, and the smallest microstructures of its cuticle are preserved. The large and heavy mandibles of this animal may be found isolated in some concretions, and local thin siltstones may contain concentrations of the toothed cutting edges of these mandibles. Such pod-shrimps characterise a group from which evolved many later groups of crustaceans (e.g. the shrimps and their allies). The concretions also contain plant fragments and orthoconic nautiloids, and one specimen of the fish Logania [Thelortus] has been found; the mineral wax hatchetite also occurs, but rarely.

Cross over the Douglas Water and follow the north bank downstream to the 20 m (65 ft) thick tholeiitic quartz dolerite dyke which forms the waterfall 150 m (160 yds) SW of Parish Holm. This Tertiary dyke was quarried for road metal in the north bank, and John Smith observed (in his 1897 notebook) the local baking of the siltstones to Lydian stone. Six subsidiary dykes (locally sills) may be traced above and below the main intrusion.

Locality 6. Load cast structures

Whilst walking towards Parish Holm, notice the Hareshaw Conglomerate feature striking across the south face of Hareshaw Hill [NS 764 287], above Glenbuck Loch. About 18 m (60 yds) downstream from the Tertiary dyke, large bulbous sole markings can be seen on the thick sandstones forming a bluff on the left bank of the Douglas Water (at locality 6). These are load cast structures. The sandstones may represent a shallowing of the depositional basin.

Locality 7. Parish Holm: alluvial fan conglomerates

Turn left through the gate, westwards, before reaching the gate into Parishholm farmyard, and take the track that leads along the wall towards Glenbuck Loch. Parishholm Conglomerate (the Igneous Conglomerate of Peach and Home) forms the bluff along the south side of this track (Locality 7). This is the first of three such conglomerates that will be encountered, and which have been studied by McGiven, whose results are summarised here. All three conglomerates contain the same six main groups of rock types, but in different proportions, reflecting changes with time in the composition of the source area. These groups are, 1—fine grained igneous rocks (soda rich rocks–spilites, keratophyres, quartz-feldspar porphyries, together with andesites and tuffs) 2—medium-coarse grained igneous rocks (microperthi tic a d amellites and alkali granites, granodiorites, quartz monzonites and diorites) 3—sedimentary rocks (greywackes and rare limestones) 4—metamorphosed sedimentary rocks (quartzites, schis ts and phyllites) 5—chert and cherry mudstones 6—vein quartz. The Parishholm Conglomerate is composed of 80 per cent igneous fragments, 74 per cent of

them of group 1 above. Some of these rock types can be matched with Ordovician igneous rocks exposed at the surface today within 20 km (12 miles) to the south, southwest and southeast, and which are old enough to have been the sources of such pebbles. Such close sources are also indicated by the angularity of the pebbles. Other igneous rock pebbles such as rhyolite cannot be matched with rocks exposed in the present Southern Uplands. Their source rocks may be buried beneath the Southern Uplands accretionary prism, subsequently obducted over them by continued plate collision. The conglomerate was probably deposited as a terrestrial alluvial fan or series of fans with their heads lying to the south-east. The sediments were deposited by sheetfloods and to a lesser extent by violent streamfloods. Rare limestone pebbles have been found in this conglomerate, 320 m (350 yds) west of the Ree Burn. They contain stromatoporoids and bryozoans, suggesting derivation from a source rock of Wenlock age.

The Parishholm Conglomerate is not present in the gradational sequence of beds of the Lesmahagow inlier, only 6.5 km (4 miles) to the north-west. Correlation suggests that ~310 m (1, 000 ft) of beds in Lesmahagow are not represented in the Hagshaw Hills succession, and several lines of evidence suggest that this time gap is represented by a paraconformity at the base of the Parishholm Conglomerate. Relatively gradual uplift to produce terrestrial conditions in the Lesmahagow area was therefore probably contemporaneous with more pronounced uplift in the Hagshaw Hills area.

Cross the Douglas–Ayr road and walk along the top of the dam forming the east end of Glenbuck Loch. This loch was created in 1802 by James Finlay and Co. as a reservoir for their cotton mills down the River Ayr at Catrine. Machinery at the mills was powered by waterwheels which remained the most powerful wheels in Scotland until their demolition in 1947.

Locality 8. Dovestone Redbeds

The first beds encountered on the east shore of the loch are the Dovestone Redbeds, chocolate-coloured mudstones and siltstones. Their colour and the presence of abundant mudcracks suggest a terrestrial environment. McGiven has found that much of the Redbeds is made up of ~25 cm thick cycles, bounded below by a fine-grained sandstone, commonly rich in mud pellets, fining up through rippled and cross-stratified silts tones to mudcracked mudstone above. Such cycles probably result from deposition by successive floods, initially moving rapidly and erosively on to an exposed playa, and then slowly spreading out on the flat surface to give areally extensive sheets of sediment. Between floods the playa dried out, forming the mudcracked layers. Deposits such as these are probably the lateral equivalents of alluvial fans developed elsewhere.

Locality 9. The Fish Bed Formation

Continuing north along the shore of Glenbuck Loch, to a point 110 m (120 yds) from the dam, a 6.5 m (20 ft) thick light grey subgreywacke marks the base of the Fish Bed Formation (Locality 9). This Formation consists of cycles of grey-green sandstones, sometimes with sedimentary breccias at their bases, grading up into siltstone or muds tone. The rarity of mudcracks, the colour, and the lateral and vertical uniformity of the Formation suggest a more permanent body of water than was responsible for depositing the underlying or overlying Redbeds, and a lagoon or lake is envisaged. Within this Formation are two beds of finely laminated siltstone which yield a rich fauna of fish. One of the beds lies immediately above the basal subgreywacke of the formation, and the other is 12 m (40 ft) above this. Fish can be more readily collected at Locality 12, however, but it is worth collecting briefly from the coarse micaceous siltstones in the purplish mudstones, ~3.1 m (10 ft) below the base of the overlying Redbeds proper. These contain disarticulated fragments of the eurypterid *Lanarkopterus* and of the fish *Lasanius*, as well as the calcareous tubes of the worm *Spirorbis* and fronds of a small, regularly branched organism which may be a calcareous alga. This distinctive fossil, long misidentified as the bryozoan *Glauconome*, has recently been found with other characteristic Fish Bed fossils in the Silurian of Clew Bay, Ireland (Palmer et al. 1989). This suggested the fault bounded Irish outcrop might be a displaced terrane that formerly adjoined the Midland Valley of Scotland inliers. Structural analysis suggests that this is not the case, implying a 500 km aquatic connection between the two areas.

Above the Fish Bed Formation are the Gully Redbeds, which are almost identical to the Dovestone Redbeds, and indicate a return to the terrestrial playa conditions of those beds.

Locality 10. Hareshaw Conglomerate

Further along the shore, where the boundary wall comes down to the loch are many blocks of Hareshaw Conglomerate (Quartzite Conglomerate of Peach and Home) fallen from the nearby exposures. Coarse grained beds of this conglomerate will be seen to be composed almost exclusively of large, well rounded quartzite pebbles. The nearest metamorphic quartzites to this area are in the Dalradian, 80 km (50 miles) north, in an opposite direction to the southerly derivation indicated by the cross-stratification in the upper part of the conglomerate. Furthermore, the maximum particle size increases in typical alluvial fan style towards the source—southeastwards. McGiven has therefore suggested that the quartzite and vein quartz pebbles of this conglomerate were derived from a pre-existing conglomerate in the Southern Uplands. The explanation for this vanished source is probably the same as that given above for the Parishholm Conglomerate (Locality 7). The conglomerate was probably built up by alluvial fan sheetfloods and violent streamfloods.

A return to the transport should now be made, and vehicles left as close as is consistent with safety to the disused railway station at Inches [NS 788 284]. Proceed on foot up to the exposure of Greywacke Conglomerate to the right of the path leading northwest out of Monksfoot (Locality 11).

Locality 11. Monksfoot: Greywacke Conglomerate [NS 786 286]

This conglomerate, here dipping 70° SSE on the southern limb of the Hagshaw Hills anticline, is taken as the base of the Lower Old Red Sandstone. At this locality, 88 per cent of the pebbles between 16 and 32 mm diameter are of greywacke, similar in composition and grain size to greywackes of the Southern Uplands. In detail, the pebbles show a relative lack of basic fragments when compared with greywacke pebbles in the underlying two conglomerates, suggesting that Silurian rather than Ordovician greywackes were the source rock. The proportion of greywacke pebbles in this conglomerate falls towards the northwest, throughout the Midland Valley inliers. Greywackes are the least resistant to wear of all the constituents of the conglomerates, and their reduction towards the NW reflects increasing distance of transport from a SE source, as does also the increase in the proportion of disc-shaped greywacke pebbles. The conglomerate shows striking changes in thickness at right angles to its depositional strike. It reaches its maximum thickness of 460 m (1, 500 ft) near the present locality, thinning westward to 25 m (80 ft) near Muirkirk and northwestward to 7.5 m (25 ft) near Darvel. The source of detritus for this fan-shaped body therefore lay SE of the present outcrop. Once again, the maximum size of particles increases with the thickness of the conglomerate towards the SE, confirming that the source lay in that direction. These and other properties suggest that the Greywacke Conglomerate formed an alluvial fan deposited by sheetfloods. The source was probably the obducted Southern Uplands accretionary prism.

Locality 12. Fish Bed Formation [NS 777 291]

Follow the path north for 1, 000 m (1, 100 yds) until the Shiel Burn enters the Monks Water on its right (southwest) bank. Cross over Monks Water and walk 110 m (120 yds) along the north bank of the Shiel Burn until the head of the waterfall is reached. A further 18 m (20 yds) upstream from this point a NE–SW slot excavated in the left (NW) bank of the Shiel Burn marks the position of the higher of the two fish beds in the Fish Bed Formation. The bed consists of 1.2–1.5 m (4–5 ft) of dark grey finely laminated siltstone. Good collections of the complete fossil fish for which this region is famed may be obtained here, together with the other rarer elements of the fauna (Figure 21.2). Large flags of the laminated silts tone should be extracted, using large chisels or crowbars, and carefully split parallel to the lamination. The fossils are difficult to discern in this bed unless weathered to ochre, but immersion of the split surfaces in water improves contrast between the black fossils and their grey matrix. Specimens should be well wrapped to prevent abrasion.

The 'varved' nature of the Fish Bed suggests deposition in a region of a lake where dissolved oxygen was absent and where no bottom feeders lived that could work over the sediment and disturb the lamination. Under such conditions, the abundance and perfection of preservation of the fish may be explicable by mass killing off due to rapid (?seasonal) overturning of the thermally stratified waters of the lake bringing up anaerobic waters.

The fish from this bed are some of the oldest complete fossil fish known in the world; older complete fish are known from the Jamoytius horizon, Lesmahagow (see Excursion 22). All these fish are jawless (agnathan), like the living lamprey,

and characterised by poorly developed fins and by external armour. Anaspid fish (laterally compressed fish usually with elongated bony scales) from this bed are *Birkenia elegans*, which is relatively common, and the largely naked *Lasanius probletnaticus*, L. armatus and *L.* sp. nov. Ritchie. The earliest cephalaspid fish, *Ateleaspis tessellata*, occurs here; fragments of the characteristically spilled trunk scales are sometimes found, but complete individuals (up to 20 cm long) are very rare. Several thelodont fish also occur, and although isolated thelodont denticles had long been known from other localities these were the first completely articulated thelodonts to be discovered. The typically broad, vertically compressed thelodont head of *Logania* [*Thelodus*] *taiti* causes the front part of the fish to be preserved squashed flat on the bedding plane, whereas the laterally compressed tail becomes twisted sideways during burial so that both upper and lower lobes come to lie on the same plane. The whole body surface of thelodonts is armoured with minute tooth-like denticles, whose shape varies according to their position on the body. Around the mouth of *Logania*, for example, the denticles are sub-circular, crenulated and interlocking, whereas posteriorly they become more elongate and spined (Fig. 22.1 c-e). The thelodonts *Lanarkia horrida*, *L. spinosa* and *L. spinulosa* are similar to Logania in body form, but their dentides are distinctive in being relatively long, hollow, conical spines (Fig. 21.2 a,b).

Remains of the up-to-60 cm (2 ft) long eurypterid (water-scorpion) *Lanarkopterus* [*Mixopterus*] *dolichoschelus* are not uncommon, although they are very difficult to discern. Other eurypterids also occur, but are very rare: Parastylonurus [*Stylonurus*] *ornatus*, *Brachyopterella ritchiei* Waterston (1979) and *Hughmilleria* sp. Fragments of the ?pod-shrimp *Dictyocaris* also occur. Crushed, carbonised and sometimes calcified spheres ~5 mm across are colonies of the blue-green alga *Pachytheca*, which probably rolled about freely during life on the lagoon or lake floor. *Taitia* [?*Hormosiroidea*] catena is also thought to be algal, and fragments of other plants also occur.

The overall similarity of this fauna to the Ludlow fauna of Ringerike, Norway is remarkable, even though only one species and five genera of fish and arthropods occur in common. It suggests that both faunas were similarly related to their environment, which sedimentological criteria (Locality 9) suggest was a lagoon or lake.

If time permits, a visit can be paid to air-heave structures in the Lower Old Red Sandstone overlying the Greywacke Conglomerate. These structures can be seen in the northeast face of the now-disused railway cutting at [NS 793 281] north of Carmacoup. The cutting should be approached by the track across the field, on the north side of the A70 at Carmacoup. The structures are 82 m (90 yds) northwest of the point where this track meets the cutting. Such air-heave structures are thought to have been made by formerly entrapped air being forced out of sediment by a rapid rise in water level up the shore of an inland lake.

On the return journey, an archaeological diversion to Muirkirk [NS 695 272] is worthwhile. As a promoter of the Muirkirk Iron Works explained 'Nothing can induce us to go into such a Desert and Inland Place as Muirkirk but the absolute Certainty of having the coal and ironstone and limestone very cheap'. This attraction, coupled with the relatively inexpensive local land feus, led to the establishment in 1787 of the most important iron works in Ayrshire, and one of the earliest in Scotland. Coal and ore were readily obtained locally from the Limestone Coal Group, and later on haematite from Auchinlongford mine, 9.7 km (6 miles) to the west, was used. The furnaces were closed in 1923, but the spectacular neogothic furnace tower was only destroyed in the 1970s. Few traces of the extensive works, other than furnace slag, can now be seen. It was in this Iron Company's workshops that the first successful use of gas was made for lighting in Scotland, in the late 1790's.

Coke needed to smelt the clayband ironstones was provided by the British Tar Company after the extraction of tar, lampblack and varnish, from local coals. This company was established by Archibald Cochrane, Lord Dundonald, the pioneer of coal distillation in Scotland, and tar kilns were built at Springhill, Muirkirk in 1786. The kilns were bought in 1790 by J.L.McAdam, that 'Colossus of roads'. As Trevelyan has written—'Few people realise what McAdam did for this country. Had it not been for his roads the industrial revolution could not have taken place.' This can be seen in microcosm at Muirkirk where the early macadamisation of the turnpikes to Ayr, Glasgow and Sanquhar enabled the transport of minerals in and of iron products out to markets. Such roads permitted the development of the iron works, and thus the creation of the village of Muirkirk, on low-cost land and minerals in a remote area, which previously would have been impossible.

The tar kilns were abandoned in 1829, but in 1931 stones from the ruined kilns were used to build a cairn to commemorate McAdam. Grassed-over foundations of thirty-four kilns may still be seen at [NS 695 256]. In the vicinity, too, numerous depressions in the ground mark the sites of collapsed bell-pits, sunk centuries ago to shallow coal seams in the Limestone Coal Group.

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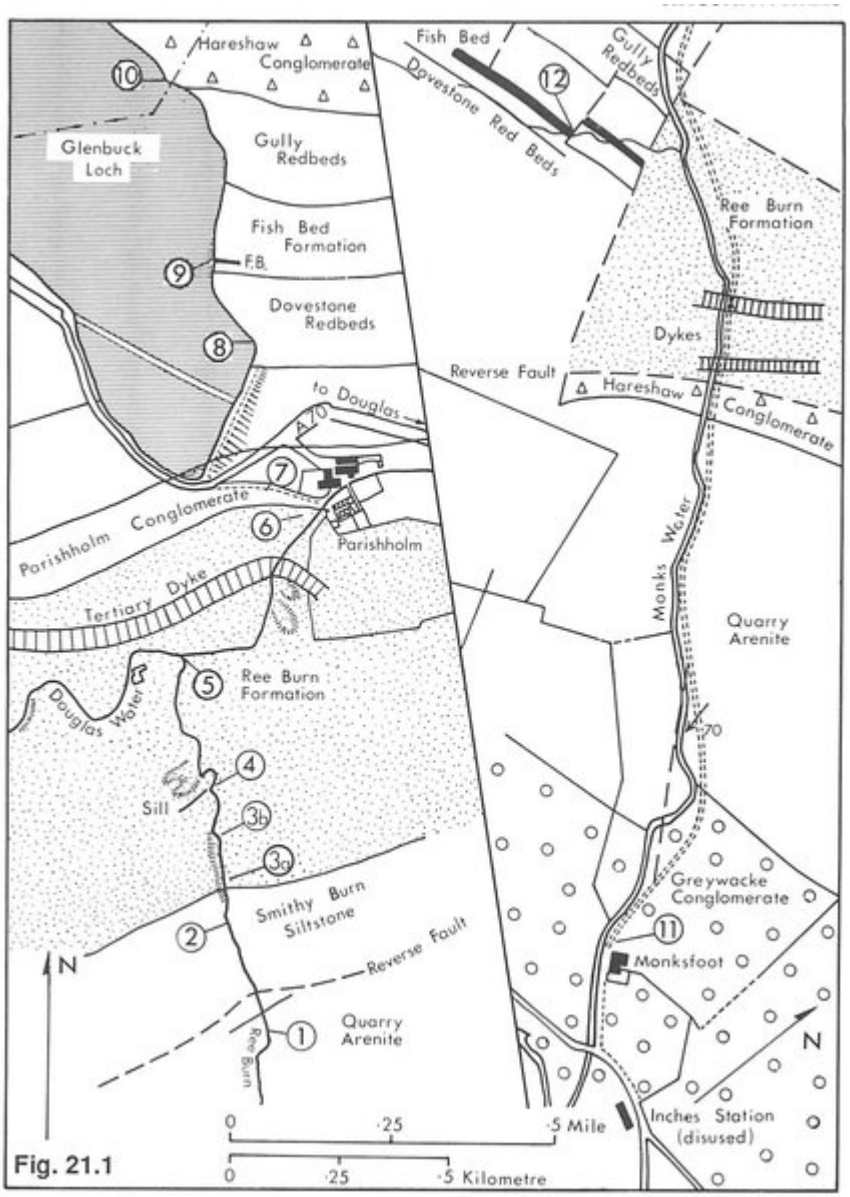
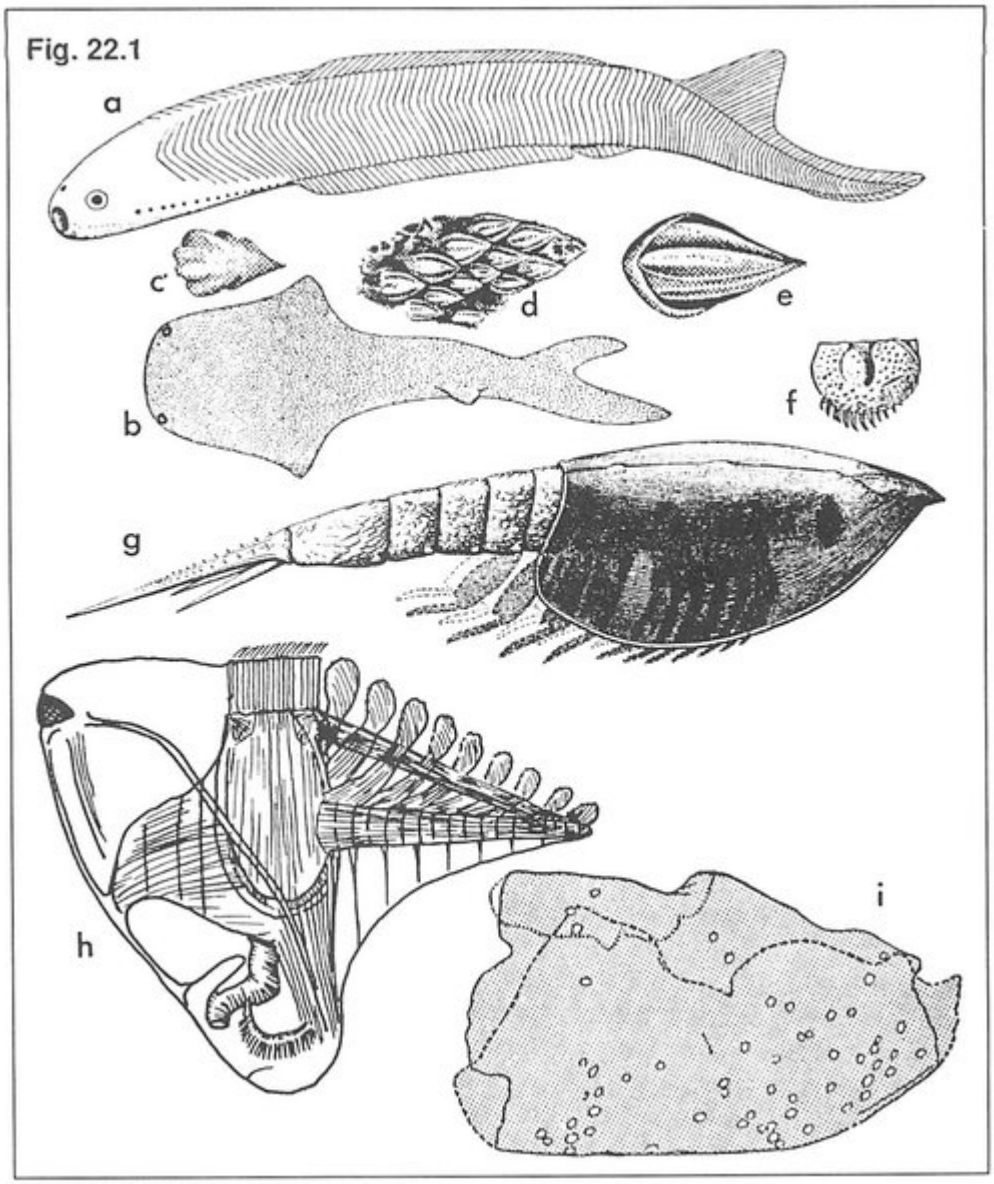
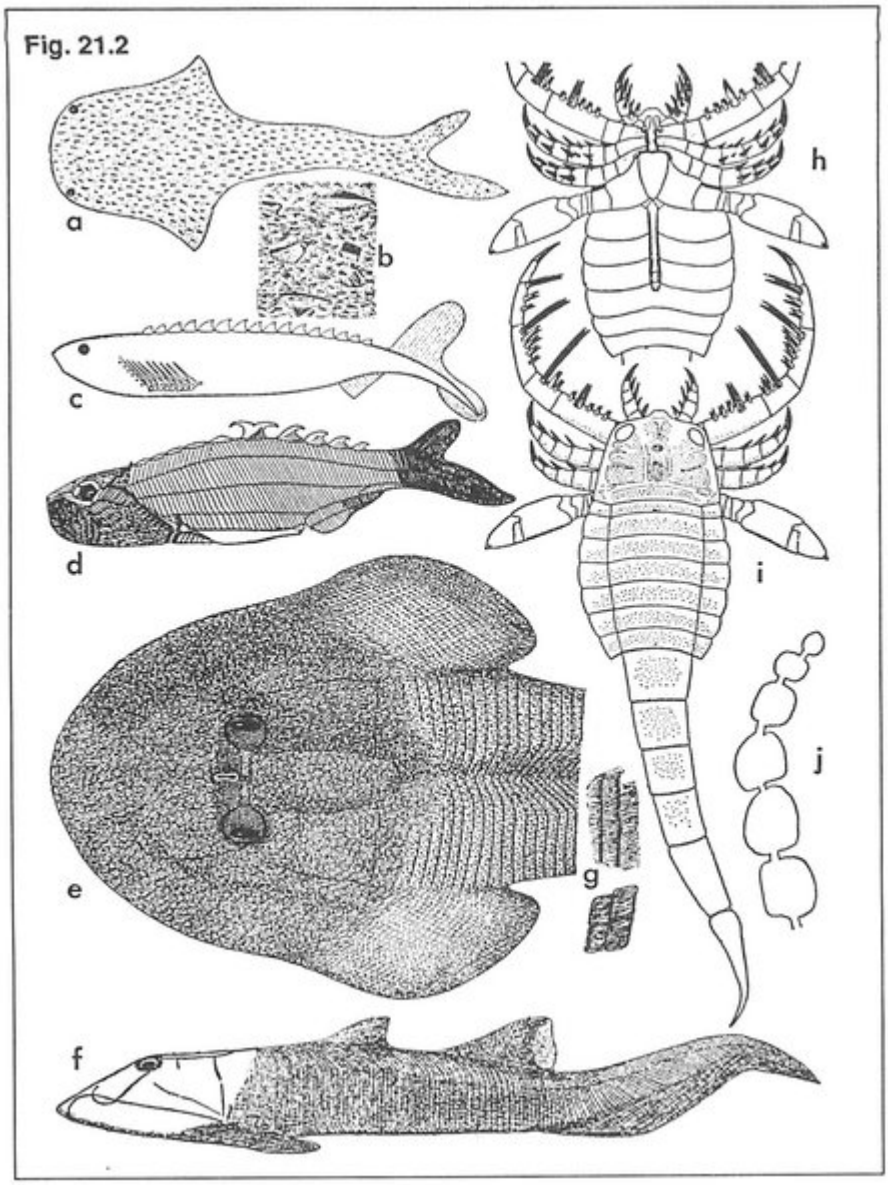


(Figure 21.1) Sketch maps of geological section seen in the Ree Burn–Glenbuck Loch traverse (le ft) and of position of Shiel Burn Fish Bed locality (right).



(Figure 22.1) Some of the fossils at the Jamoytius horizon: two-thirds natural size unless otherwise indicated. a-e, jawless fish: a, anaspid Jamoytius kerwoodi (after Miles and Ritchie); b-e, Logania [Thelodus] scotica, b, dorsal aspect as it appears flattened in the rock, (after Traquair); c-e, details of skin denticles; c, head denticle, × 24; d, e, trunk denticles; showing d, how they occur on the body, × 8, e, × 24 (c, e, after Gross; d, after Traquair) f, g, crustaceans; f, water-flea Beyrichia cf. kloedeni. × 6 (modified from Henningsmoen); g, pod-shrimp Ceratiocaris papilio, (after Rolfe); h, ?sea-squirt Ainiktozoon loganense (after Ritchie; i, fragment of the possible crustacean Dictyocaris × 114 (after Størmer), stipple indicates network ornament.



(Figure 21.2) Some of the fish (a-g), eurypterids (h, i) and plant (j) fossils that occur in the Fish Bed: all natural size unless otherwise indicated. a, b, thelodont Lanarkia spinosa (after Traquair), a, as it appears flattened in the rock (Logania taiti also occurs here–compare with (Figure 22.1) b); b, detail of trunk denticles (× 6); c, unarmoured anaspid Lasanius problematicus (after Parrington and Miles); d, armoured anaspid Birkenia elegans (after Stetson, Heintz and Ritchie) denticles are sub-circular, crenulated and interlocking, whereas posteriorly they become more elongate and spined ((Figure 22.1) c-e) The thelodonts Lanarkia horrida, L. spinosa and L. spinulosa are similar to Logania in body form, but their denticles are distinctive in being relatively long, hollow, conical spines ((Figure 21.2) a, b).