ACHANARRAS QUARRY

OS Grid Reference: ND150544

Highlights

Achanarras in Caithness (Highland) is one of the most famous fossil fish sites in Britain. There are many fish-bearing beds in the quarry, and 15 species have been found in huge abundance there. Achanarras Quarry represents a sample of the rich fish fauna from the south-western quarter of the great Orcadian Lake.

Introduction

The quarry was opened in 1870 (Traquair, 1894a) and since then has yielded many fossil fishes, which may be seen in museums not only throughout Britain, but also elsewhere in the world. By 1914, very little quarrying had taken place for several years (Crampton and Carruthers, 1914). Since that time it has yielded fossils to several collectors, notably C. Forster-Cooper (1937), and has been quarried recently for scientific studies (Trewin, 1986). A field excursion guide has recently been published (Trewin and Hurst, 1993). The quarry is now flooded and the fish bed crops out under water (Figure 6.7).

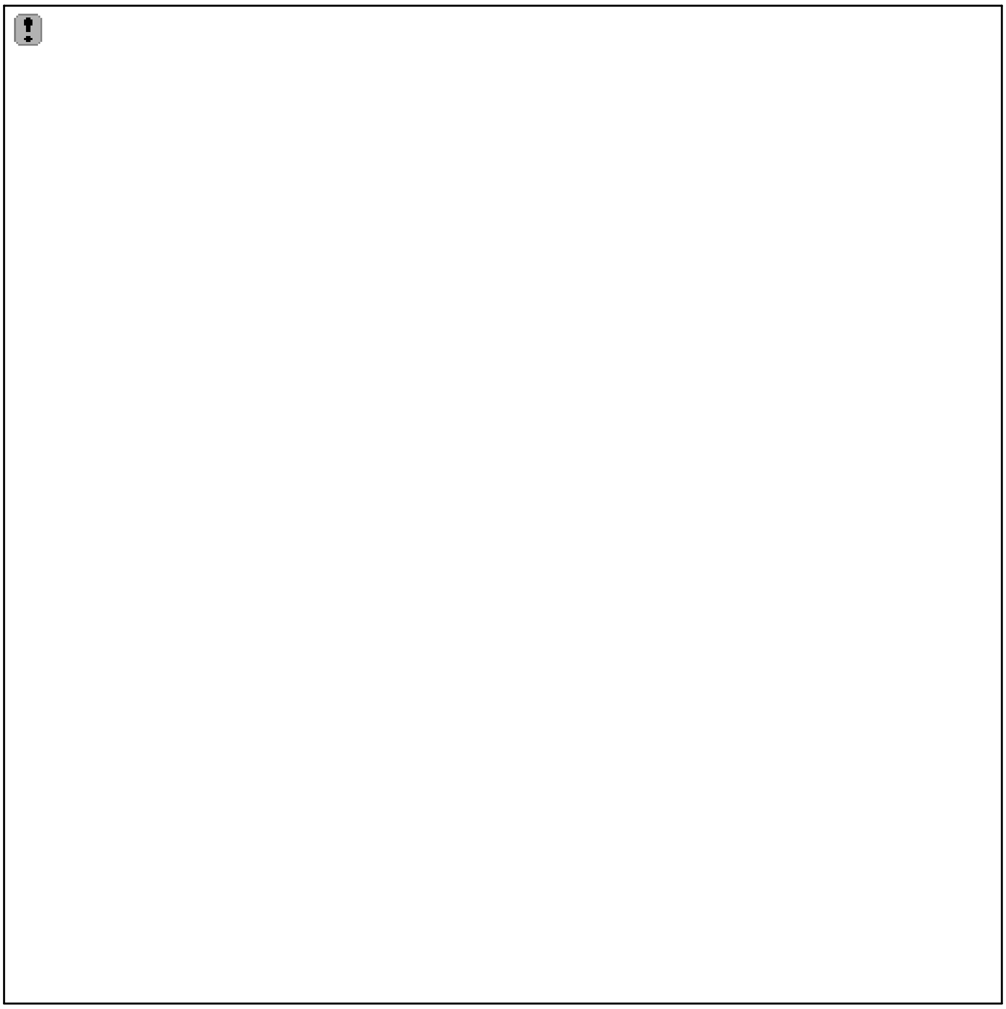


Figure 6.7: Achanarras Quarry (photo: D.L. Dineley).

Description

The Achanarras Limestone is a relatively pure limestone laminite at the top of the Robbery Head Subgroup (top of the Lower Caithness Flagstone Group), and the Achanarras Limestone

Member probably marks the Eifelian–Givetian boundary (Donovan *et al.*, 1974). Trewin (1986) defined the base of the Achanarras Limestone Member as the upper limit of rippled silty laminae within the laminites, and the top of the Achanarras Limestone Member as the base of the first non-laminite bed above the fish bed, a total thickness of 3.6 m (Figure 6.6; Trewin 1993, p. 130). Above the fish bed at Achanarras are thin-layered laminites consisting of alternating microcrystalline carbonate with clastic laminae, which result from sequential annual rhythms in a stratified lake. They appear as a repetition of couplets of thin light and dark laminae, 1–2 mm thick. A third type of lamina is rich in organic material. These are very thin (< 0.1 mm) and are largely of algal origin. The fish bed itself is rather more complicated, being made up in part of triplets of carbonate, clastic and organic material. It is estimated that it took 4000 years for deposition of the whole sequence (Rayner, 1963; Trewin, 1986).

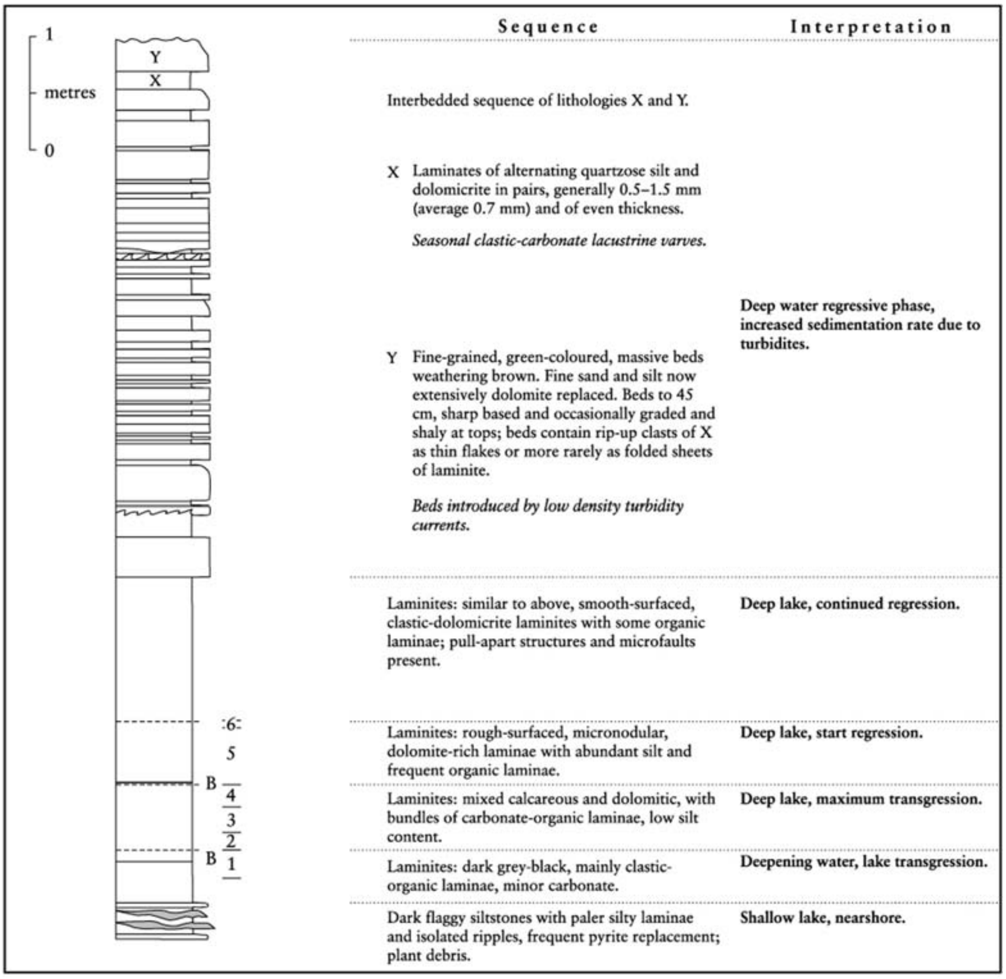


Figure 6.6: The section of Achanarras Quarry, after Trewin (1986). Numbers 1–6 are the main fossiliferous horizons.

The fish bed at Achanarras is about 1.95 m thick, and can be examined in the north-east corner of the quarry. The quarry was drained in 1980 and a representative continuous column of rock collected through the full thickness of the fish bed. Etched laminae from the edges of fish-bearing slabs from museum collections could be matched with the patterns exhibited by the total section, and enabled Trewin (1986) to produce detailed information about changing species abundances in the fish bed (Trewin, 1986, figs 2, 3). Trewin (1986) found six clearly defined horizons, with marked changes in diversity and relative abundance between them, and the divisions between the faunal horizons frequently coincide with episodes of low fish abundance. *Dipterus* is abundant at the top and bottom of the bed (Ahlberg and Trewin, 1995); *Osteolepis*, *Glyptolepis*, *Coccosteus* and *Cheirolepis* appear after *Dipterus*, *Pterichthyodes*, *Mesacanthus* and *Palaeospondylus* in the second division, but *Rhamphodopsis* and the larger acanthodians do not enter until near the top of division three.

The fossil fishes tend to lie together on certain bedding planes, often with limited signs of disturbance. Many acanthodians, for example, show no signs of putrefaction before burial. Other fossils show evidence of decomposition, as in poorly preserved*Dipterus* which are bent backwards with bloated bellies, features typical of many dead fish today. Some larger fishes apparently floated around in the upper waters of the lake, buoyed up by decomposition gases in the body chamber, for long enough for parts of them to drop off. Osteolepid specimens are often broken up, and partly scattered around the area of the main body of the fossil (Figure 6.8).

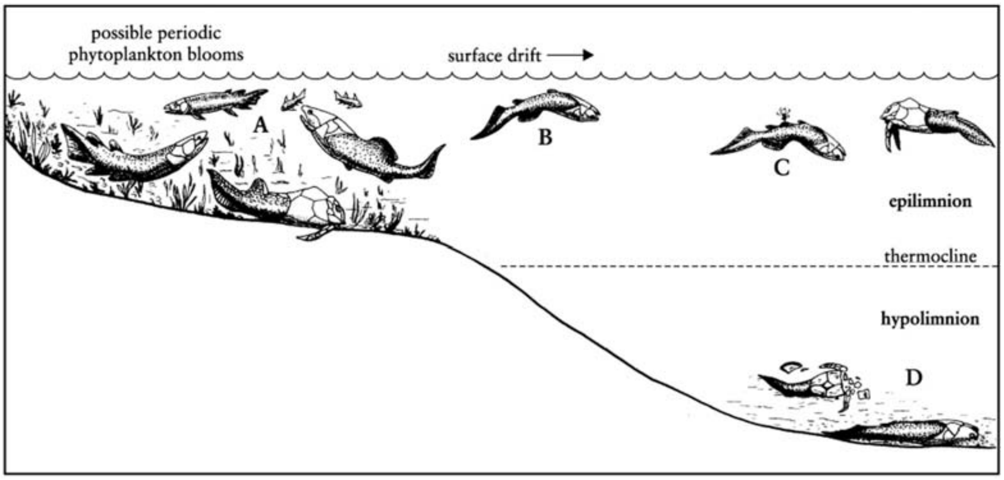


Figure 6.8: Particularly fossiliferous horizons with well-preserved fishes may result from mass mortality events induced by planktonic blooms. The axonic conditions extend throughout the shallow marginal areas (A); following this, carcasses drift into deeper water in a bloated conditions (B); after further decay (C), they sink through the thermocline and are preserved in laminites in the anoxic hypolimnion (D). The depth of the thermocline may have been no more than a few tens of metres (after Trewin, 1986).

Fauna

Acanthodii: Climatiformes: Diplacanthidae

Diplacanthus striatus

D. tenuistriatus Traquair, 1894

D. (Rhadinacanthus) longispinus (Agassiz,

1844)

Acanthodii: Acanthodiformes: Acanthodidae

*Mesacanthus peachi*Egerton, 1861

*Cheiracanthus murchisoni*Agassiz, 1835

Placodermi: Antiarchi: Pterichthyodidae

Pterichthyodes milleri Miller, 1841

Placodermi: Arthrodira: Coccosteidae

Coccosteus cuspidatus Miller, 1841

Placodermi: Arthrodira: Homosteidae

Homosteus milleri Traquair, 1888

Placodermi: Ptychtodontida: Ptychtodontidae

Rhamphodopsis threiplandi Watson, 1938

Incertae sedis Palaeospondylus gunni Traquair, 1890

Osteichthyes: Actinopterygii: Cheirolepidae

*Cheirolepis trailli*Agassiz, 1835

Osteichthyes: Sarcopterygii: Osteolepidiformes: Osteolepididae

Glyptolepis paucidens Agassiz, 1844

*Osteolepis macrolepidotus*Agassiz, 1835

Osteichthyes: Sarcopterygii: Porolepiformes (Holoptychiida): Holoptyiidae

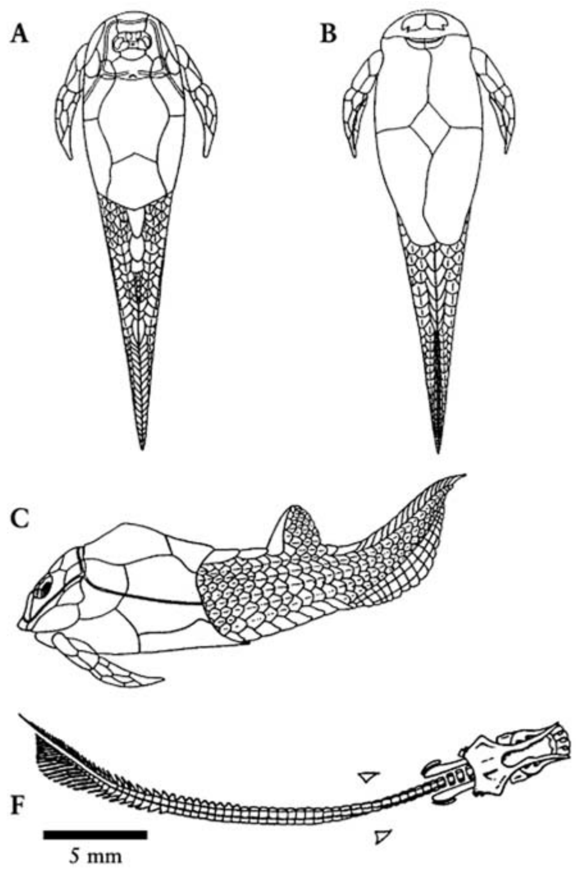
'*Holoptychius*' sp.

Osteichthyes: Sarcopterygii: Dipnoi: Dipterida: Dipteridae

Dipterus valenciennesi Sedgwick and

Murchison, 1828

These fishes are described in the introduction to the chapter. Achanarras Quarry is the type locality of two species, *Rhamphodopsis threiplandi* Watson, 1938 and *Palaeospondylus gunni* Traquair, 1890 (Figure 6.9). Trewin (1993) noted the absence of *Gyroptychius* from the Achanarras list. This genus is common in the equivalent Sandwick fish bed in Orkney.



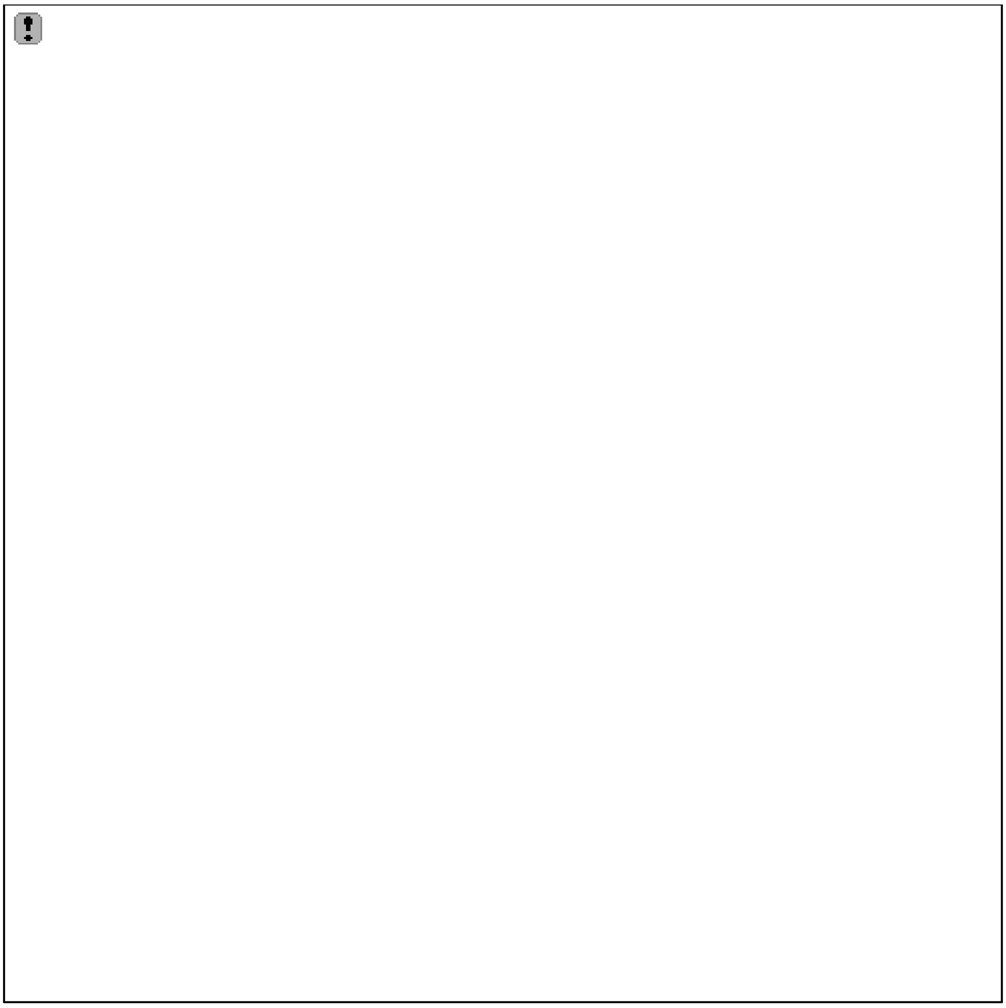


Figure 6.9: Common fishes at Achanarras Quarry: Pterichthyodes milleri (Miller) reconstructions in (A) dorsal, (B) ventral and (C) lateral aspects, × 0.33 approximately. (D) Palaeospondylus gunni Traquair in characteristic preservation with the head and anterior end in dorsal view but the posterior part of the vertebral column in lateral view, after Moy-Thomas (1940). (D) Photograph GLAHM V7015 showing typical compression preservation, c. × 0.8 (Photo: courtesy of Hunterian Museum, Glasgow). (F) T05399/A, with an early model of the animal, × 0.5 (Photo: courtesy The Natural History Museum, London). (G) Palaeospondylus gunni Traquair in characteristic preservation with the head and anterior end in dorsal view but the posterior part of the vertebral column in lateral view, c. × 6 (Photo: courtesy of the Hunterian Museum, Glasgow). (H) Dipterus valenciennesi Agassiz Photograph GLAMH V3656 showing the commonly well-preserved nature of this fossil lungfish, c. × 0.75 (Photo: courtesy of the Hunterian Museum, Glasgow).

Interpretation

Carbonate laminae may have formed as a result of increased pH following photosynthesis, hence causing carbonate (dolomite or calcite) deposition (Donovan, 1975; Trewin, 1986). Studies at Lake Balaton in Hungary indicate that calcite is precipitated at times of high lake level and low evaporation. The laminites from Achanarras, however, are thought to have been caused by a seasonal climate, with each dark organic-rich band representing the silts deposited during the rainy season, and the light band the carbonates that came out of solution during a dry summer. Each light and dark pair can be counted. They have been interpreted as the products of annual algal blooms. Trewin (1986) concluded that the ‘calcitic' laminites of the central part of the fish bed represent the period of highest lake level, with greatest faunal diversity because of the stable environments, and the possibility of maximum migration around the lake. He suggested that they are the equivalent of the nodule beds at the basin margins, which must also have been deposited at times of maximum lake extension.

The fossil fishes tend to lie together on certain bedding planes, representing catastrophes that killed off schools of fish. Postulated causes of mass mortality include not only salinity crises, but also storms stirring up toxic deeper waters, algal blooms leading to eutrophication of surface waters, or shock mixing of cold deep waters with the warmer surface water (Figure 6.8).

There is a series of phases of faunal introduction. *Dipterus* is abundant at the top and the bottom of the fish bed, suggesting that it was the first fish to colonize an area and the last survivor. *Dipterus* may have tolerated lower oxygen levels than the other fishes (Trewin, 1986; Ahlberg and Trewin, 1995) and was environmentally more hardy than the other fishes. *Pterichthyodes*, *Mesacanthus* and *Palaeospondylus* then appear and become abundant within the calcareous laminites of divisions 2, 3 and 4. *Osteolepis*, *Glyptolepis*, *Coccosteus*, and *Cheirolepis* all appear in division 2, but *Rhamphodopsis* and the larger acanthodians do not appear until the top of division 3. In a recent discussion of the palaeoecology of the porolepiform fishes of Scotland, Ahlberg (1992) noted that only adult specimens of *Glyptolepis* are present, and that *G. paucidens* was restricted to the marginal shallow water. A major change occurs at the top of the calcareous laminites, which coincides with the top of division 4. *Palaeospondylus* and *Cheirolepis* disappear, and there is a major expansion of *Coccosteus* in the overlying dolomitic laminites. Other species linger on in small numbers. Thus, changes in conditions which gave rise to dolomite, rather than calcite precipitation, were not equally tolerated by all species. Finally, division 6 contains only *Dipterus* (Figure 6.6).

The Achanarras horizon fauna consists of the same species throughout the area, but significant differences occur in the proportions present at each site, and these may correspond to different ecological areas of the lake. Achanarras Quarry has yielded the greatest number of species, possibly because it was more centrally placed within the lake, whereas sites in the Moray Firth area were on the margin, and contain a sparser fauna (Figure 6.1). The lake margin locations may sample smaller diversities of fish species, but preserve them close to their natural habitats, whereas sites much farther from the lake margins, such as Achanarras Quarry, may show a death assemblage of fishes that had mainly drifted in from some distance, and would therefore include specimens from a larger source area. A similar pattern can be discerned in the fossil plant assemblages from Achanarras horizon sites. The localities bearing the Achanarras fauna were noted by Hamilton and Trewin (1988) as illustrating the major extent of lacustrine spread to the point of basin overflow.

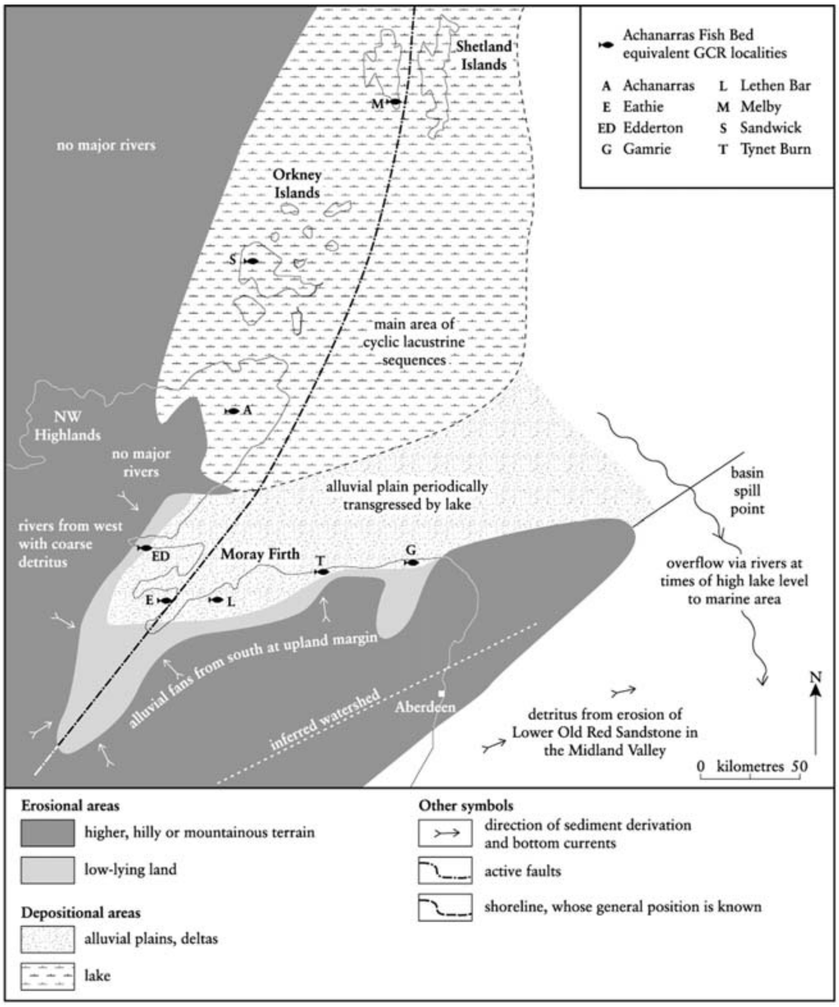


Figure 6.1: Palaeogeography of the Middle Devonian, 380–375 Ma, of Scotland and adjacent North Sea (after Bluck et. al., 1992).

The Achanarras Fish Bed is near or at the Eifelian–Givetian boundary (Paton, 1981). The spores of *Dinsosporites devonicus* are abundant in this bed and date it as belonging to the *devonicus–naumovii* Zone of Richardson and McGregor (1986). House (1991, 1996) recently suggested that the Achanarras Fish Bed may represent the mid-Devonian Kacak event. More than 10 Devonian extinction events were marked by reductions or changes in ammonoid faunas worldwide and linked to hypoxic sedimentary events (House, 1985). Sea-level changes, oceanic circulation and extreme climatic factors may all have influenced intense planktonic blooms and deoxygenation of marine and lake waters. The wide spread of the Achanarras Fish Bed and similar horizons with abundant remains in calcareous and carbon-rich seams suggests sharp, brief episodes of environmental change throughout the Orcadian Lake. Resulting mass or increased rates of fish mortality occurred in waters near to, or directly linked to a marine embayment (Marshall, 1992).

Conclusions

The Achanarras Quarry is flooded for most of the time, so the fish bed may not be exposed above the water. Nevertheless, it is world famous as perhaps the richest Old Red Sandstone fish site in Britain. It represents the richest sampling of Middle Devonian fish diversity in the Orcadian Lake, having been located in quiet open waters, removed from the littoral. Many thousands of specimens of fossil fishes, collected over the years, include well-preserved representatives of at least 15 species. Recent sedimentological work has enhanced the conservation value of the site, in linking high-resolution biostratigraphy with models of ancient lake development, and the fluctuations of the fish populations. Exploratory excavations have proved the immense abundance of fish specimens at Achanarras Quarry, and its potential seems undiminished.

Reference list

Agassiz, J.L.R. (1835) On the fossil fishes of Scotland. *Report of the British Association for the Advancement of Science*, British Association for the Advancement of Science, Edinburgh.
Ahlberg, P.E. (1992) The palaeoecology and evolutionary history of the porolepiform sarcopterygians. In *Fossil Fishes as Living Organisms* (ed. E. Mark-Kurik), Academy of Science, Estonia, Tallinn pp.71–90.
Ahlberg, P.E. and Trewin, N.H. (1995) The postcranial skeleton of the Middle Devonian lungfish *Dipterus valenciennesi. Transactions of the Royal Society of Edinburgh: Earth Sciences*, **85**, 159–75.
Crampton, C.B. and Carruthers, R.G. (1914) *The Geology of Caithness*. Memoirs of the Geological Survey of Scotland.
Donovan, R.N. (1975) Devonian lacustrine limestones at the margin of the Orcadian Basin, Scotland. *Journal of the Geological Society, London*, **131**, 489–510.
Egerton, P. de M.G. (1861) British fossils. (Descriptions of *Tristichopterus, Acanthodes, Climatius, Diplacanthus, Cheiracanthus*.) *Memoirs of the Geological Survey of the United Kingdom (British Organic Remains)*, Dec. **X,** 51–75.
Forster-Cooper, C. (1937) The Middle Devonian fish fauna of Achanarras. *Transactions of the Royal Society of Edinburgh*, **59**, 229–39.
Hamilton, R.F.M. and Trewin, N.H. (1988) Environmental controls on fish faunas of the Middle Devonian Orcadian Basin. In *Devonian of the World, III, Proceedings of the Second Symposium on the Devonian System, Calgary, Canada* (eds N.J. McMillan, A.F. Embry, and D.J. Glass), Canadian Society of Petroleum Geologists, Memoirs 14, pp. 589–600.
House, M.R. (1985) Correlation of mid-Palaeozoic ammoniod evolutionary events with global sedimentary perturbations. *Bulletin de la Societé Belgique de Géologie*, **98**(2), 99–107.
House, M.R. (1991) The Devonian System. In *Encyclopedia Britannica*, **19**, 804–14.
House, M.R. (1996) The Middle Devonian Kacak event. *Proceedings of the Ussher Society*, **9,** 79–84.
Marshall, J.E.A. (1992) The Orcadian Basin, Scotland: external correlations and marine incursions. *Palynology*, **16**, 225–6.
Murchison, R.I. (1828) Supplementary Remarks on the Strata of the Oolite Series and the Rocks associated with them, in the Counties of Sutherland and Ross, and in the Hebrides. *Transactions of the Geological Society*, **2,** 353–68.
Paton, R.L. (1981) A catalogue of fossil vertebrates in the Royal Scottish Museum, Part 6, Placodermi. *Royal Scottish Museums, Information Series, Geology*, **9,** 1–70.
Rayner, D.H. (1963) The Achanarras Limestone of the Middle Old Red Sandstone, Caithness, Scotland. *Proceedings of the Yorkshire Geological Society*, **34**, 117–38.
Richardson, J.B. and McGregor, D.C. (1986) Silurian and Devonian spore zones of the Old Red Sandstone continent and adjacent regions. *Geological Survey of Canada, Bulletin*, **364**, 1–79.
Traquair, R.H. (1894a) Notes on Palaeozoic fishes No. 1. *Annals and Magazine of Natural History*, **14**, (6), 368–74.
Trewin, N.H. (1986) Sedimentology and palaeontology of the Achanarras fish bed of the Middle Old Red Sandstone, Scotland. *Transactions of the Royal Society of Edinburgh: Earth Sciences*, **77**, 21–46.
Trewin, N.H. (1993) The Old Red Sandstone of Caithness, Excursion 5. In *Excursion Guide to the Geology of Eastern Sutherland and Caithness*, (eds N.H. Trewin and A. Hurst). Scottish Academic Press for the Geological Societies of Aberdeen and Glasgow, Edinburgh, 123–66.
Trewin, N.H. and Hurst, A. (eds) (1993) *Excursion Guide to the Geology of Eastern Sutherland and Caithness*. Scottish Academic Press for the Geological Societies of Aberdeen and Glasgow, Edinburgh, 123–66.