Tillywhandland Quarry, Angus

[NO 528 537]

Potential ORS GCR site

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Introduction

Tillywhandland Quarry on Turin Hill near Forfar (Figure 3.23) is one of the best Early Devonian fossil fish sites in Scotland; it is an established GCR site for fossil fishes (Dineley and Metcalf, 1999). The site also provides a reference section for the Dundee Flagstone Formation, allows the detailed examination of the lithofacies and sedimentation of a typical Early Devonian fish bed, and is unique in the Midland Valley in exposing a clastic-carbonate-organic laminite similar to those of the Mid-Devonian Orcadian Basin. Trewin and Davidson (1996) provided a detailed description of the quarry, summarized by Dineley (1999c). The fauna includes a rich assemblage of primitive acanthodians, with some cephalaspids, collected from this and other quarries on Turin Hill, which worked the sandstones of the Dundee Flagstone Formation for over 200 years. Richardson and MacGregor (1986) ascribed the beds to the *micrornatus–newportensis* Zone of early Lockhovian age.

Description

Tillywhandland Quarry exposes beds of the Dundee Flagstone Formation (of the Arbuthnott–Garvock Group). Working probably ceased over 100 years ago and the quarry at the time of writing was overgrown. The Dundee Flagstone Formation consists mainly of medium- to coarse-grained, cross-bedded, fluvial sandstones. Numerous distinctive deltaic and lacustrine units up to 30 m thick of thinly bedded sandstones and intercalated siltstones and mudstones are particularly characteristic of the formation. They include a number of fish beds, including the one exposed in this quarry that have also yielded arthropods and plant remains (Lang, 1927; Weston, 1951).

The quarry exposes a fish-bearing laminite (Figure 3.24) and underlying sandstone, having worked the latter for building stone. Powrie (1861, 1864) first described the laminite (the Forfarshire Fish Bed), considering it to be the only such horizon and correlating it with similar occurrences elsewhere. However, later workers (Hickling, 1912; Armstrong and Paterson, 1970) envisaged several discrete beds. Armstrong *et* al. (1978b) provided a brief description of the quarry. Trewin and Davidson (1996) recorded a detailed section of the fish bed and adjacent strata (Figure 3.25), and the following account is a summary of their work. Dineley's (1999c) summary emphasizes the fish fauna and its palaeoecology, Wilson and Anderson (2004) describe the invertebrate fauna.

About 3 m of red to pale brown, medium- to coarse-grained sandstone are exposed beneath the fish bed. The lowest beds exposed are massive and trough cross-bedded in sets up to 0.5 m thick, with two pebble-lined erosion surfaces. The massive sandstones contain scattered pebbles and soft-sediment de-watering structures. The topmost 1 m of sandstone are parallel-laminated with primary current lineation. Sandstone dykes penetrate up to 0.5 in into the overlying laminite; they are up to 0.1 m wide at their base and folded by soft-sediment compaction. The fish-bearing laminite has a sharp contact with the underlying sandstone, is about 1.3 m thick and contains a 60 mm-thick pale green to buff, sticky bentonitic clay 1 m above its base. The laminites comprise a stacked sequence of repeated quadruplets of clastic siltstone, carbonate, organic matter, and green claystone averaging about 5 mm in thickness.

Their colour varies from brown to green depending on the proportion of green claystone laminae present and the amount of carbonate and organic matter. Soft-sediment deformation produced folding and slide planes locally and there are some carbonate concretions. A very thin (0.01 mm) organic lamina commonly overlies the carbonate laminae and contains most of the fish fragments, with a few remains occurring also in the carbonate concretions. Coprolites appear to be concentrated in the organic-rich laminae and the finest laminae. The laminite grades upwards into green siltstones, which

contain minor laminites with a few organic laminae. The sequence coarsens upwards generally to coarse siltstone–fine sandstone, with thin (up to 20 cm) sheets of fine-grained, muddy, current ripple-laminated sandstone that are commonly rich in plant debris.

Dineley (1999c) gave full details and classifications of the fish fauna recovered from the site. It comprises *?Brachyacanthus scutiger, Cephalaspis pagei, C. powriei, C.* sp., *Climatius reticulatus, Euthacanthus macnicoli, Euthacanthus* sp., *Ischnacanthus gracilis* (Eger), *Mesacanthus mitchelli, M.* sp. and *?Uraniacanthus* sp.. Trewin and Davidson (1996) noted that acanthodians predominate, with *Mesanthus* and *Ischnacanthus* the commonest species, the other acanthodians and the cepha-laspids being limited to very few specimens. Preservation ranges from relatively complete specimens to disarticulated and fragmentary material. The invertebrates recovered are arthropods — the eurypterids *Parahughmilleria* sp. (Braddy, 2000) and *Pterygotus* and the millipede *Archidesmus macnicoli* (Wilson and Anderson, 2004). Trace fossils include small burrows and arthropod trackways (cf. *Diplichnites*).

Interpretation

The sandstones below the fish bed are interpreted as high-energy, fluvial channel deposits (Figure 3.22). The sharp contact with the fish bed represents a sudden end to fluvial deposition, the fish bed representing lacustrine deposition in a lake (or series of lakes) (named 'Lake Forfar' by Trewin and Davidson, 1996) subjected to a seasonally wet climate. Trewin and Davidson (1996) speculated that the sudden establishment of the lake may have been due to blocking of the drainage outflow to the south-west by the Ochil Lavas and progradation of alluvial fans from the north-west, probably fault-controlled, margin of the basin.

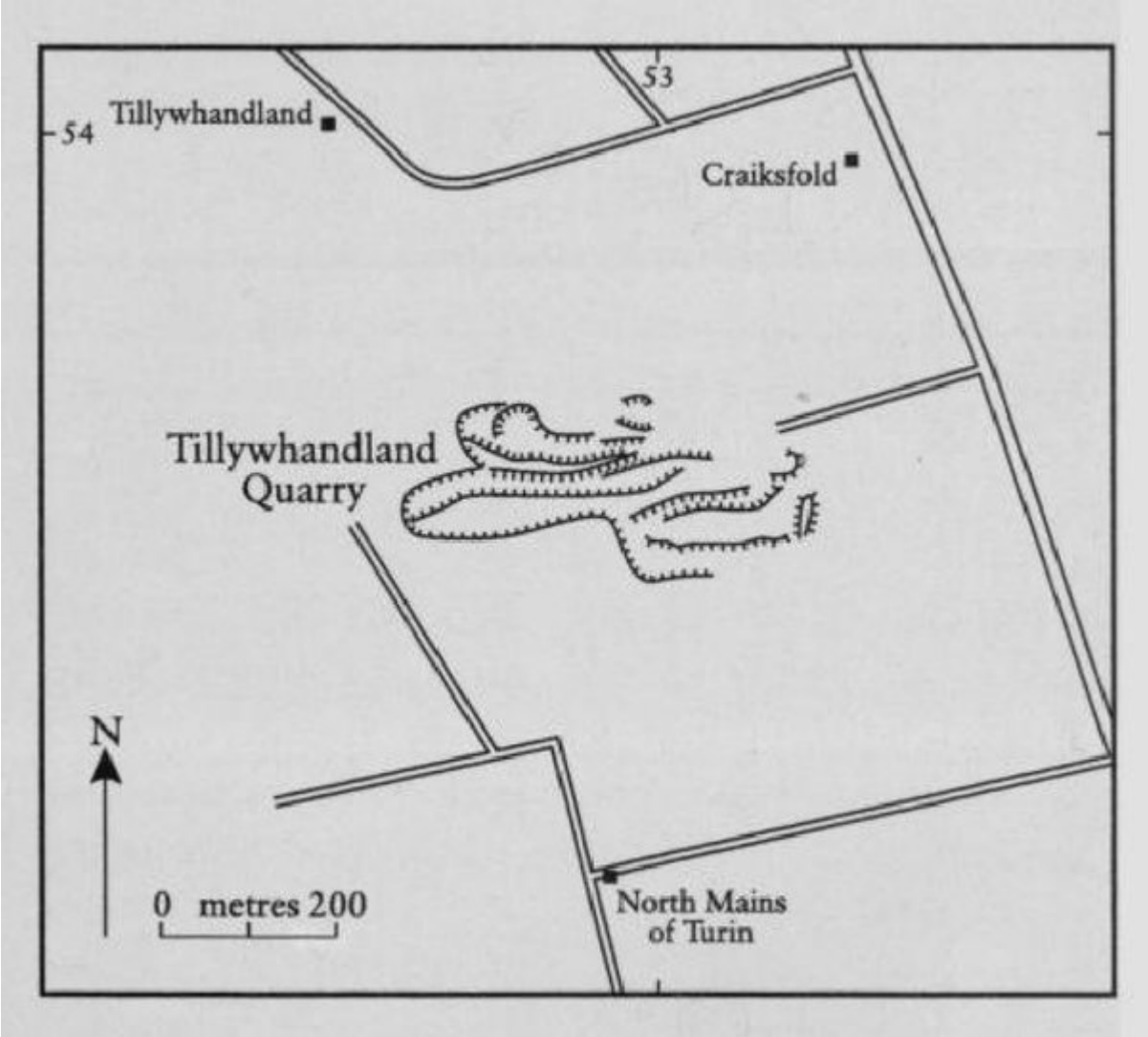
The laminites represent annual varved sediments, deposited from suspension in deep lake waters. They are similar to clastic-carbonate-organic triplets deposited in the hypolimnion of lakes in the Mid-Devonian Orcadian Basin (Donovan, 1980; Trewin, 1986), except that the green claystone laminae have not been seen in the Orcadian Basin and the dolomite laminae present there are absent in Lake Forfar. A period of about 2000 years is represented by the Tillywhandland laminite. The origin of the coarser laminae, whether by aeolian or distant fluvial input to the lake, remains unclear. The carbonate laminae were precipitated as a result of phytoplankton photosynthetic activity, the organic laminae were the product of seasonal decay of the phytoplankton, which settled on the lake bed to produce an organic sludge and the most anoxic bottom conditions.

The pale green to buff clay is an altered volcanic airfall tuff, and of potential use in correlation. Powrie (1864) correlated it, and thus also the Tillywhandland fish bed, with similar occurrences elsewhere, but Armstrong and Paterson (1970) recognized eight fish-bearing horizons. The coarsening-upward siltstones above the laminite record the infilling and shallowing of Lake Forfar, with the ripple-laminated sandstones indicating increased current activity.

Conclusions

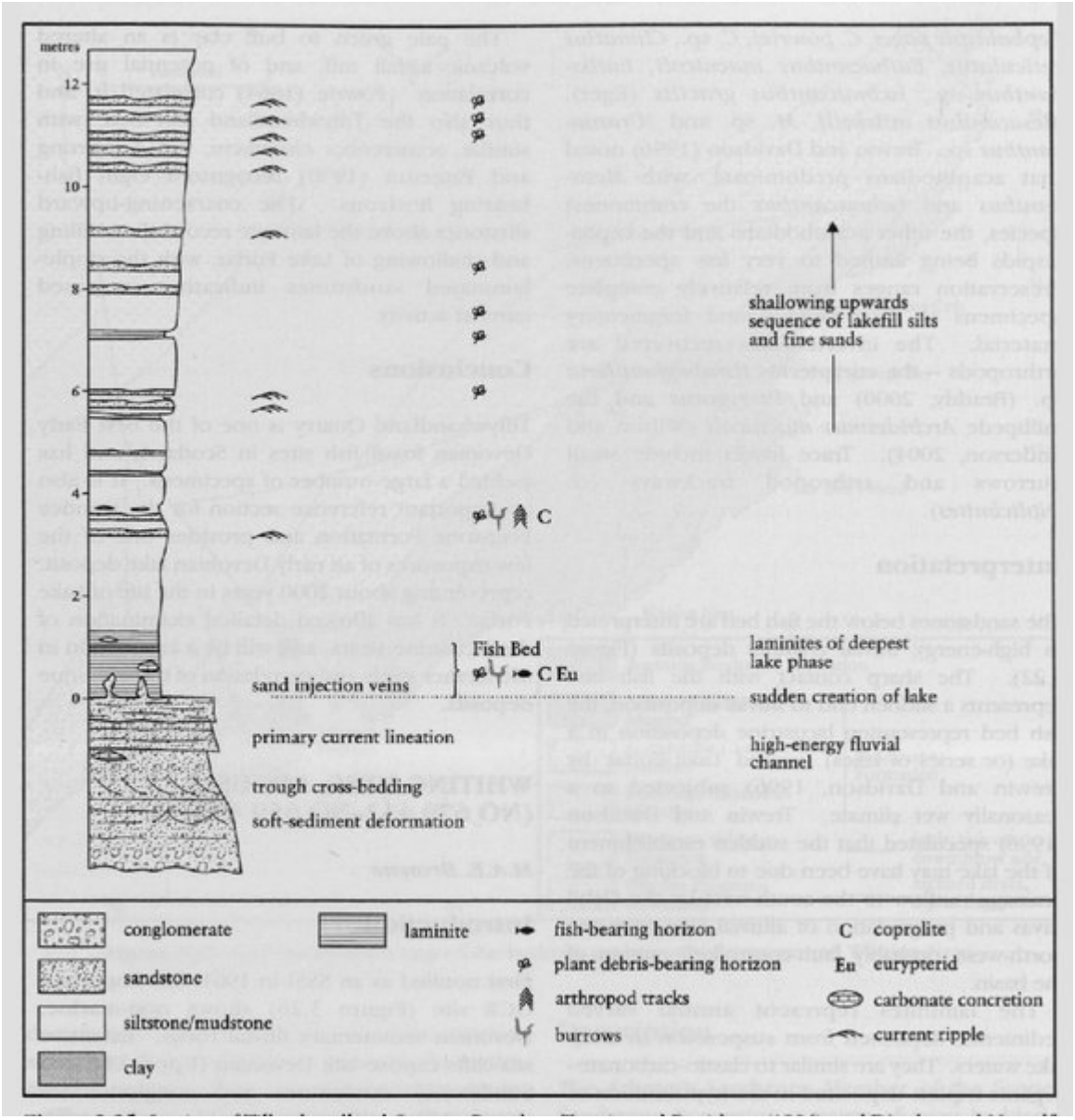
Tillywhandland Quarry is one of the best Early Devonian fossil fish sites in Scotland, and has yielded a large number of specimens. It is also an important reference section for the Dundee Flagstone Formation and provides one of the few exposures of an early Devonian lake deposit, representing about 2000 years in the life of Lake Forfar. It has allowed detailed examination of the lacustrine strata, and will be a key section in the further study and correlation of these unique deposits.

References



(Figure 3.23) Location of Tillywhandland Quarry, Angus.

(Figure 3.24) Part of Tillywhandland Quarry, showing lacustrine laminites. (Photo: M.A.E. Browne.)



(Figure 3.25) Section of Tillywhandland Quarry. Based on Trewin and Davidson (1996) and Dineley and Metcalf (1999).

(Figure 3.22) Aberlemno Quarry. Strike section in flaggy sandstones of the Dundee Flagstone Formation. (Photo: C.J. Cleal.)