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# Tynet Burn, Moray

[NJ 383 618]

Potential ORS GCR site

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## Introduction

Tynet Burn, 5 km north-east of Fochabers, Moray is a classic Middle Old Red Sandstone fossil fish site, discovered in 1838. Since then, it has yielded about 14 species of fish, most of which are found in the upper of two beds of calcareous nodules within laminated shales and limestones deposited in a lake. The fish fauna is correlated with the Middle Devonian (Eifelian) Achanarras Fish Bed in Caithness and other Orcadian Basin equivalents in Orkney and Shetland. The fish-bearing nodule beds alternate with conglomerates and sandstones deposited by rivers on an alluvial plain at the southern margin of the Orcadian Basin (Trewin and Thirlwall, 2002). Periodic transgression of the lake over the alluvial plain resulted in lacustrine sediments being deposited at times of high lake level; the contractions and expansions of the lake were controlled by climatic changes with Milankovitch periodicities. The palaeogeographical and stratigraphical history of the Orcadian Basin has been summarized by Trewin and Thirlwall (2002). Trewin and Davidson (1999) provided details of the sedimentary environments and palaeoecology at Tynet on the southern shore of the Orcadian lake about 387 million years ago.

## Description

The geology of the site was described by Peacock *et al.* (1968). Gillen (1987) provided a brief field guide to the locality; and Wood and Norman (1991) described an excavation in the fish bed at Tynet in 1989–1990. Dineley (1999a) and Trewin and Davidson (1999) gave historical details of research at the site, and the latter gave an account of excavations made at the site in 1996, providing the main source for this account. The attractive pink, red and purple colours of the fossil fish, in contrast to the green or beige matrix of the nodules in which they occur, made the fossils very popular, and specimens from Tynet are widely dispersed in museums, university departments and private collections throughout the world.

The site (Figure 2.67) lies in the Tynet Burn below Lower Mills of Tynet [NJ 388 618], where the stream is incised into Old Red Sandstone through a cover of glacial till. The beds belong to the Middle Old Red Sandstone, which comprises about 200 m of red sandstones, conglomerates and mudstones in this area. The fish-bearing succession in the Tynet Burn consists of 28 m of conglomerates, sandstones, mudstones and limestones (Figure 2.68), fault-bounded at the top and bottom. The lowest bed [NJ 3837 6196] is a 0.9 m-thick conglomerate with numerous angular pebbles. The highest beds are faulted against a fining-upward succession of about 120 m of gently dipping beds that are exposed downstream. These comprise a basal red boulder conglomerate 39 m thick passing up through interbedded red sandstones and conglomerates into cross-bedded sandstones with subordinate conglomerate. The Lower Nodule Bed is exposed in the river [NJ 3837 197] just downstream of the 0.9 m-thick conglomerate.

The best section was formerly in a 12 m-high cliff (the 'Main Cliff') on the east bank of the stream [NJ 384 620]. The higher nodule bed (the Upper Nodule Bed) crops out along the top of this cliff but the disused quarry is covered by talus and the exposure is obscured. The bed is exposed and more accessible farther downstream in a meander scar on the west bank [NJ 3823 6203] close to the fault that forms the northern limit of the block. Excavations [NJ 3828 6205] near the 'Main Cliff' in 1989 and 1990 (Wood and Norman, 1991) and clearance of the exposure on the west bank [NJ 3823 6203] in 1996 (Trewin and Davidson, 1999) provided detailed sections of the strata here, although soft-sediment extensional and compressional structures, sandstone intrusions and minor tectonization of the beds in proximity to the main fault to the north disrupt the continuity of the beds.

The succession contains two main fish-bearing horizons (the Upper Nodule Bed and Lower Nodule Bed) and a third, intermittent horizon between them (the *Coccoosteus* Bed), the exact position of which is uncertain (Figure 2.68). These horizons represent lake deposition within the fining-upward fluvial to lacustrine cycles. The cycles are truncated by erosion surfaces and commence with conglomerates that contain rounded to subrounded pebbles up to 15 cm in diameter, predominantly of quartzite, but with some of metamorphic and igneous lithologies. The pebbles are set in a red, medium-to coarse-grained sandstone matrix and show sorting and imbrication. Lenses of laminated and cross-bedded sandstones also occur, and there are some cross-bedded conglomerate bodies up to 0.75 m thick.

The sandstones are red with minor patchy reduction zones. They are mainly fine- to medium-grained and micaceous, and occur in beds ranging from 5 cm to 40 cm thick. Parallel lamination is the dominant structure, although most beds are only weakly laminated. A few beds are trough cross-bedded and the tops of some are linguoid current-rippled. The sandstones pass up into brick-red, massive mudstones, with small (up to 10 cm) irregular to subspherical unfossiliferous diagenetic carbonate concretions (or nodules). The mudstones containing the Upper and Lower Nodule beds are red to chocolate-brown and drab grey-green. They are mainly massive to weakly laminated on a millimetre to centimetre scale, but the fish-bearing horizons are well laminated on a sub-millimetre scale. The carbonate concretions occur in several forms within the laminites and are commonly fish-bearing.

There are three types of limestone in the section. A massive white to pale pink limestone with red, hematite-stained limestone intraclasts and small spar-filled cavities forms a prominent bed up to 0.15 m thick immediately above the Upper Nodule Bed in the main exposure (Figure 2.68), (Figure 2.69). Secondly, white to dark red, irregularly stained, laminated, platy limestones form the middle part of the Upper Nodule Bed and are interlaminated with siliciclastic laminites, particularly at the top and base of the Upper Nodule Bed. These are typical carbonate, fish-bearing laminites, the fish being preserved in flat concretions as well as in the non-concretionary carbonate laminae. Thirdly, concretions and thin, laterally persistent non-laminated beds of green limestone occur in the mudstone-dominated beds above the Upper Nodule Bed and contain rare fish.

The laminated limestones in the Upper Nodule Bed and the massive limestone that caps it are extensively cut and disrupted by irregular, green to purple, medium- to coarse-grained, micaceous sandstone veins (Figure 2.68), (Figure 2.69). Their irregular nature is probably due to several factors, including deformation of the bed subsequent to the formation of the veins. Some containing sandstone intraclasts were probably sand-filled desiccation cracks that were subsequently deformed by differential compaction. Some sub-horizontal veins lacking intraclasts were probably intruded into weakly compacted muds as liquefied wet sand during movement of the sediment pile.

Calcite veins up to 5 mm wide cut the limestone layers and carbonate concretions, and fill cracks that post-date the initial compaction of the sediments. The calcite encloses filamentous and possible coccoid bacteria that invaded the sediment during lowstand events when the sediment was in the vadose zone, prior to crystallization of the calcite (Trewin and Knoll, 1999).

The Lower Nodule Bed has yielded unidentifiable fish scales (Peacock *et al.*, 1968), an articulated osteolepid, scattered osteolepid scales and a *Cheiracanthus* fin spine (Trewin and Davidson, 1999). The *Coccoosteus* Bed has not been traced recently, is probably lenticular, and apparently yielded only *Coccoosteus* and some scales. *Dipterus* (Malcolmson, 1859) and *Osteolepis* scales (Trewin and Davidson, 1999) have been recorded from the beds below the Upper Nodule Bed, both in sandstones, the latter in small nodules 1 m below the base of the nodule bed.

The Upper Nodule Bed (Figure 2.68)b is the main fish-bearing horizon. Many of the carbonate nodules are shaped like the fish they contain. Detailed sections from excavations were recorded by Wood and Norman (1991) and Trewin and Davidson (1999). Although only 50 m apart, the sections show a marked variation in thickness of the bed. Wood and Norman recorded a thickness of over 2 m, compared to 0.75 m recorded by Trewin and Davidson. The difference may be reconciled by invoking deposition of the bed on a channelled surface of the underlying sands, the irregular topography probably contributing to instability, soft-sediment slumping and disruption of the bed (Figure 2.69).

In detail, the Upper Nodule Bed comprises three horizons (Top, Middle and Bottom). The top and bottom units are chocolate brown, clastic laminites with sporadic fish-bearing concretions. The lower unit ranges from 0.05 m to 0.9 m in

thickness and has yielded a fauna dominated by osteolepids but including the acanthodians *Cheiracanthus* and *Mesacanthus*. Acanthodians (*Diplacanthus* and *Cheiracanthus*) dominate in the upper unit, which shows a similar thickness range. The intervening middle laminated limestone unit is 0.5 m thick and has yielded mainly acanthodians.

The complete faunal assemblage from the Upper Nodule Bed is listed by Dineley (1999a) and Trewin and Davidson (1999) as:

*Placodermi:*

*Coccosteus cuspidatus* Miller (1841)

*Rhamphodopsis trispinatus* Watson 1938

*Pterichthyodes milleri* (Miller 1841)

**Acanthodii:**

*Cheiracanthus murchisoni* Agassiz

*Cheiracanthus latus* Egerton 1861

*Diplacanthus crassisimus* Duff 1842 (= *D. striatus* Agassiz 1835)

*Mesacanthus pusillus* Agassiz 1844 (?= *M. peachi* Egerton 1861)

*Rhadinacanthus longispinus* (Agassiz 1844)

**Osteichthyes:**

*Cheirolepis trilli* Agassiz 1844

*Glyptolepis leptopterus* Agassiz 1844

*Glyptolepis paucidens* Agassiz 1844 ? (not seen in any collection by R.G. Davidson)

*Dipterus valenciennesi* Sedgwick & Murchison 1828

*Osteolepis macrolepidotus* Agassiz 1835

*Gyroptychius* spp.

The assemblage includes type specimens of *Diplacanthus striatus* and *Rhamphodopsis trispinatus* Watson 1938, and possibly that of *Cheiracanthus latus* Egerton 1861. The material is sufficiently well-preserved to distinguish the scale morphology of several acanthodians (Young, 1995). Wood (in Trewin and Davidson, 1999) carried out a statistical analysis of the assemblage of the Upper Nodule Bed, calculating that acanthodians comprise 82% of the assemblage of the Top Bed and sarcopterygians (mainly *Osteolepis*) 72% of the Bottom Bed. *Osteolepis*?, *Glyptolepis*, *Cheirolepis* and *Cheiracanthus* were collected between 1 m and 2 m above the Upper Nodule Bed by R.G. Davidson.

The preservation of the fish ranges from complete carcasses with full articulation to isolated scales and bones. The best material comes from the nodule beds and limestone laminites of the Upper Nodule Bed, in which the osteolepids at the base and the acanthodians in the Middle and Top beds are commonly articulated or suffered only minor disarticulation before burial. Isolated scales and coprolites also occur in the concretions alongside the whole fishes.

The striking pink, red and purple colour of the fish is the result of oxidation, probably by chemotrophic bacteria (Trewin and Davidson, 1999; Trewin and Knoll, 1999). Zones of iron oxide surround the fish, commonly permeating the scale and bone structure and infilling original canals in the bone. The phosphatic scales are commonly dissolved, leaving

calcite-filled cavities. Relics of internal organs and eyes have been recognized in some specimens, represented by dark red to black stains (Davidson and Trewin, 1999, 2002). Gut contents are preserved in one specimen of *Coccosteus*.

## Interpretation

Hamilton and Trewin (1988) and Trewin and Davidson (1999) provided a detailed analysis of the sedimentary environments and of the diagenetic processes by which the fish were preserved. (Figure 2.68) shows a summary of the range of sedimentary environments in which the succession was deposited.

The conglomerates at the bases of the cycles were the deposits of high-energy, gravel-bed (?braided) stream channels. The overlying mainly parallel-bedded laminated sandstones were probably deposited rapidly as unconfined sheet floods. Some of the finer, thinly bedded sandstones contain *Skolithos* and *Diplocraterion* burrows and may have been deposited in shallow floodplain lakes. Red mudstones with carbonate nodules record formation of incipient caliche soil profiles on the floodplain. On three, or perhaps four occasions, the alluvial plains were rapidly inundated from the north by lake waters, resulting in the deposition of the fish-bearing beds. These lake transgressions record two major lake highstand events, when the Orcadian lake reached its greatest extent and was deep enough for lacustrine laminites to form at Tynet during the deposition of the Upper Nodule Bed.

The massive limestone at the top of the Upper Nodule Bed is interpreted as a shallow-water lake-margin deposit, similar to that seen at the Red Point GCR site. Exposure followed its deposition, sand-filled desiccation cracks cutting the limestone.

The Lower Nodule Bed may represent a shallower water and/or shorter-lived lacustrine transgressive event, as may the problematic *Coccosteus* Bed (discussion in Trewin and Davidson, 1999). Lacustrine conditions were established several times at Tynet for long enough to allow carbonate deposition in low-energy environments in which articulated fish were preserved. The presence of channelized sandstones above some horizons may explain their lateral discontinuity, with fluvial incision removing all or part of the lacustrine interval.

The correlation of the Tynet Burn succession with the Achanarras horizon of Caithness and the Sandwick horizon on Orkney is based on the presence of at least seven species common to both, minor differences in the faunas being explained by ecological factors in their distribution or a slight age difference (Trewin, 1986). If the whole of the Tynet Burn fish-bearing succession is equivalent to the Achanarras Limestone Member, the three cycles here point to a situation more complex than at Achanarras, which was situated in a deeper area of the lake. The marginal position of the Tynet Burn locality, combined with greater clastic influence, made it more sensitive to lake level fluctuation.

The preservation of the fish is summarized by Trewin and Davidson (1999, fig. 12). The differentiation of their post-mortal and pre-burial disarticulation is made difficult because of soft-sediment deformation, sand mobilization, syndimentary faulting and calcite veining. Also, the carbonate nodules were not entirely nucleated on the fish, and where they are only partially enclosed, post-burial differential compaction and movement resulted in the in-situ breakage of the fish fossils.

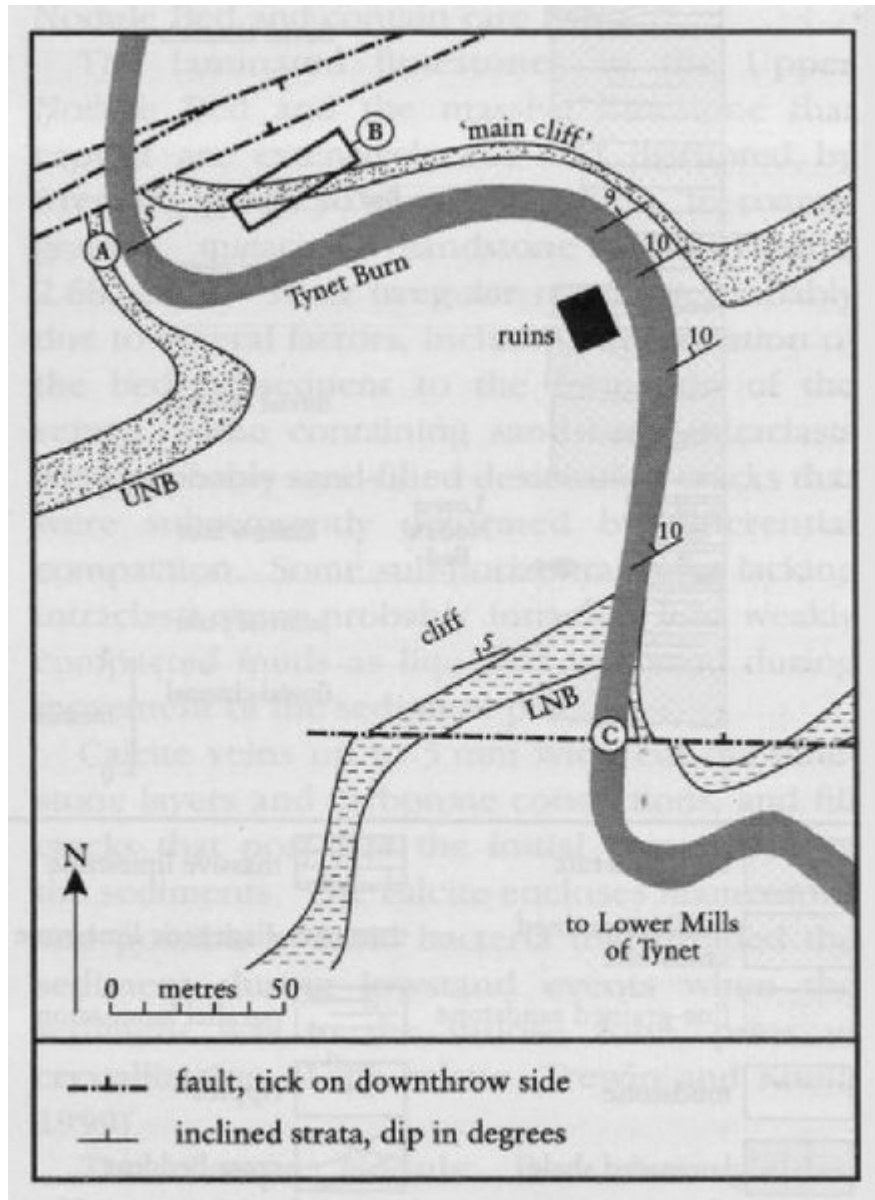
Covering of fish carcasses by lake-bed sediment and subsequent compaction was followed by wet sediment deformation and disruption, probably aided by its position overlying an irregular lake bottom. A drop in lake level exposed the lake bed, and desiccation resulted in cracking of the semi-consolidated sediment and infill of the cracks by sand. Further compaction and formation of the carbonate concretions took place in the vadose zone, followed by colonization of fractures in the nodules by chemotrophic bacteria. The selective deposition of iron oxide by the bacteria at haemoglobin-rich organ sites may be the cause of preservation of these soft parts as dark-stained traces.

## Conclusions

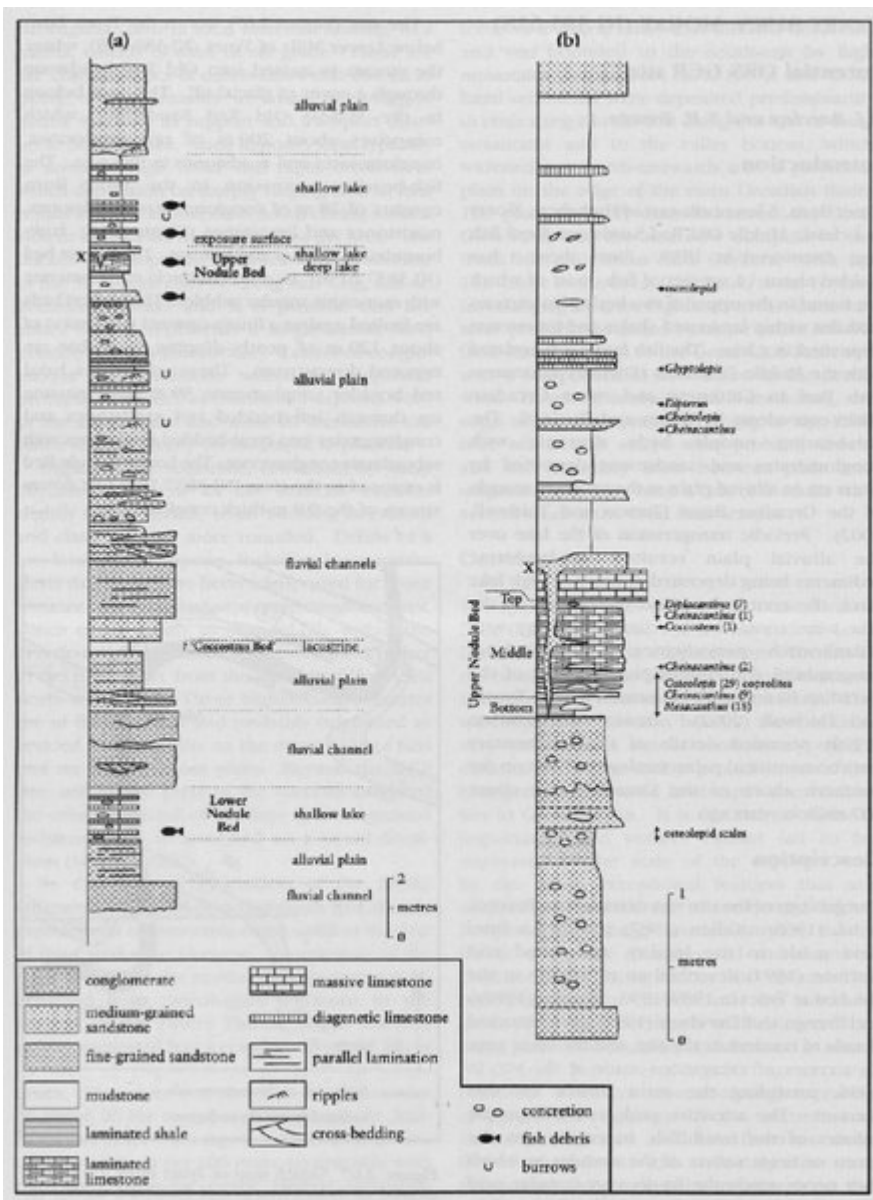
Tynet Burn is a classic Middle Old Red Sandstone fossil fish site, having yielded a rich fauna of acanthodians, placoderms and bony fishes since its discovery in 1838. The importance of the site lies in the remarkable preservation of the fish in carbonate nodules. The pink, red and purple colours of the fish, in contrast to the green or beige matrix of the nodules, have made the fossils very popular and specimens are widely dispersed throughout the world.

The fish beds were deposited as part of a cyclic fluvial and lacustrine succession on the southern margins of the Mid-Devonian Orcadian lake. The cyclicity was controlled by climatic fluctuations that influenced expansion and contraction of the lake. At times of lake expansion the alluvial plain on the shore of the lake was rapidly inundated by lake waters, which deposited laminated muds and carbonates. Bacterial oxidization in the subsurface preserved the fish in fine detail, including in some cases, traces of soft tissue. The material collected continues to provide new insights into the morphology and diet of Devonian freshwater fish and their lake habitat.

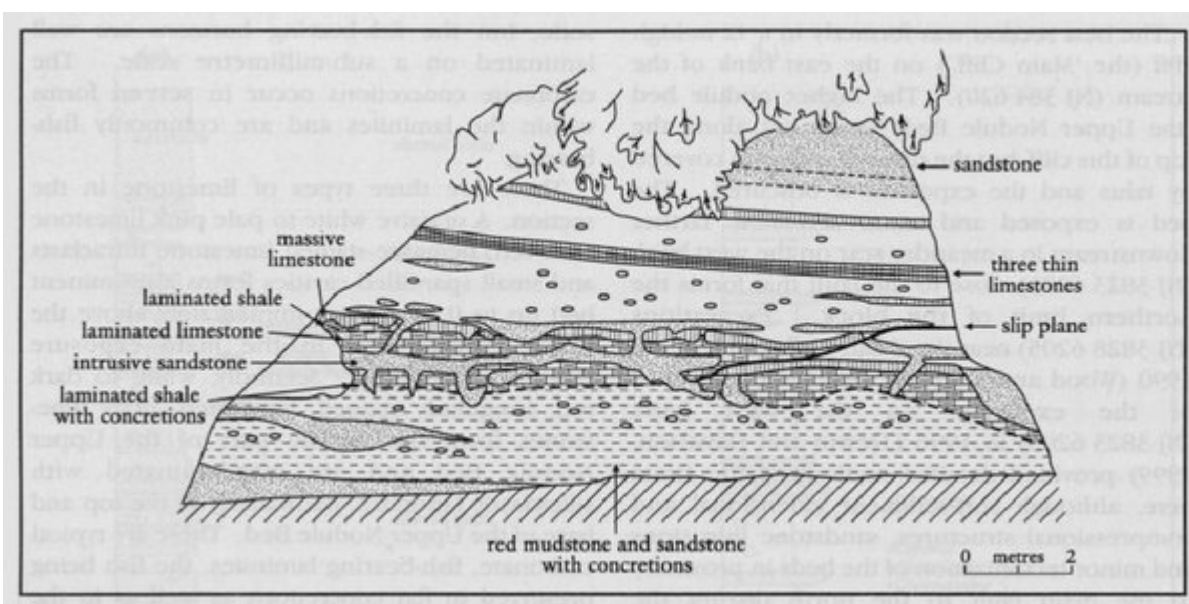
## References



(Figure 2.67) Sketch map of Tynet Burn: (A) section cleared in 1996 (Trewin and Davidson, 1999); (B) section excavated in 1989–1990 (Wood and Norman, 1991). Based on Peacock et al. (1968) and Davidson and Trewin (1999).



(Figure 2.68) (a) Composite log of succession in Tynet Burn between points (A) and (C) on (Figure 2.67). The position of the Coccosteus Bed is inferred. (b) Summary log of section excavated at Point (A). After Trewin and Davidson (1999).



(Figure 2.69) Field sketch of exposure at Point A in Tynet Burn showing the disrupted nature of the Upper Nodule Bed. After Trewin and Davidson (1999). This exposure is now largely obscured by talus and vegetation.