Den of Findon, Gamrie Bay and New Aberdour, Aberdeenshire

[NJ 796 635]–[NJ 882 650]

Potential ORS GCR site

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Introduction

The Den of Findon near Gamrie, Banffshire has been independently selected for the GCR for fossil fishes (Dineley and Metcalf 1999). It is the easternmost occurrence of the Mid-Devonian Achanarras fauna and has yielded 12 species of fossil fishes. The fish bed (the Gamrie Fish Bed) lies within the upper part of the Findon Group of the Middle Old Red Sandstone and the site is important historically as the first prolific Scottish Old Red Sandstone fish site to be exploited. The section is now rather inaccessible and poorly exposed in a steep, overgrown ravine and no collection or excavation is permitted, but the opportunity is taken to describe briefly the important Old Red Sandstone coast sections nearby at Gamrie, and farther east at New Aberdour (Figure 2.70). The following account summarizes that of Dineley (in Dineley and Metcalf, 1999), Sweet (1985), Trewin and Kneller (1987a-c) and Trewin (1987a).

Description

Dineley (1999a and references therein) gave a detailed account of the discovery and history of fish discoveries at the Den of Findon. The fish bed lies up to about 17 m above the base of the Findon Group. The basal unit of the group is a conglomerate comprising rounded clasts of quartzite, felsite and local Dalradian lithologies. Within 0.15 m, the conglomerate fines up into red clay, above which are 1.25 m of grey, laminated mudstones containing fish-bearing calcareous concretions. The parts of the fish within the nodules are preserved complete or with only slight disturbance. The species recovered here include the acanthodians *Diplacanthus striatus, D. tenuistriatus, D.* (*Rhadinacanthus*) *longispinus, Cheiracanthus murchisoni,* and *C. latus;* the placoderms *Pterhthyodes milleri* and *Coccosteus cuspidatus;* the actinopterygian *Cheirolepis trailli;* and the osteolepids *Glyptolepis leptopterus, Osteolepis macrolepidotus* and *Gyroptychius* n. spp.. Red clays and shales (0.6 m thick) overlying the laminites are truncated by an erosion surface at the base of a breccia/conglomerate of local Dalradian clasts.

The site lies at the northern end of the Turriff Basin, the fill of which comprises Lower Old Red Sandstone strata (the Crovie Group) resting unconformably on Dalradian basement and unconformably overlain by Middle Old Red Sandstone (the Findon Group). In Gamrie Bay to the north of the Den of Findon, the Afforsk Fault forms the western margin of the basin (Figure 2.70). Conglomerates in the Crovie Group to the east of the fault [NJ 7922 6448] contain locally derived clasts of Dalradian Southern Highland Group lithologies, but also further-travelled clasts of hornblende schist and cleaved greywackes.

A succession of sandstones and conglomerates of the Crovie Group is exposed along the foreshore and in the sea cliffs of Gardenstown between the Afforsk Fault and the Findon Fault to the east. Cut by numerous small faults,' the succession is a fine example of a coarsening-upward fluvial sequence, with mudstones and thin sandstones at the base and conglomeratic sandstones at the top (Trewin and Kneller, 1987a). The sandstones are markedly porous and permeable; their red colour is due to the breakdown of large quantities of detrital biotite (Archer, 1978; Donovan *et al.,* 1978). The lowest part of the succession [NJ 802 651], seen on the wave-cut platform between the Findon Fault and the breakwater at the east side of the harbour, comprises thinly bedded grey-green sandstones and mudstones. The sandstones are generally less than 5 cm thick, with parallel lamination and ripple-lamination, as well as small load structures and disrupted beds with detached sandstone balls. Calcrete nodules occur in the mudstones and polygonal desiccation cracks are common at the lowest level exposed, and also near the harbour wall, where the sandstones are thicker and contain more current ripples and ripple-drift lamination.

Immediately west of the harbour wall [NJ 799 648], the succession continues with interbedded micaceous sandstones, mudstones and siltstones. The beds display a range of colours, the sandstones being brown and green and the mudstones red, grey and purple. The sandstones are in beds 5–30 cm thick, with current ripple-, continuous ripple-drift-, parallel-and convolute lamination present. Desiccation cracks are present at the tops of the mudstones, and rip-up clasts occur in the bases of some sandstones.

To the west, the beds flatten into a small syncline, in which there are fine examples of arthropod-produced trace fossils in red, micaceous, rippled sandstones. The traces are *Diplichnites, Beaconites, Isopodichnus, Diplocraterion* and *Rusophycus* (Carroll, 1991; Trewin and Thirlwall, 2002). Continuing up-sequence [NJ 798 647], the succession becomes coarser and the sandstones thicker bedded and redder. Cross-bedding, in sets up to 50 cm high, appears as current ripple-lamination rapidly dies out up-section. Red mudstone occurs in sporadic, thin, desiccation-cracked interbeds and as burrow-fills in the sandstones.

Where small pebbles appear first, they lie mainly in the bases of small channelized, medium-grained sandstone bodies [NJ 796 646], with mudstone interbeds virtually absent. The succession continues to coarsen upwards from the last house on the harbour wall to the cliffs [NJ 7940 6445], with conglomerate lenses lining the bottoms of channels up to 2 m deep. Cross-bedded and parallel-bedded sandstones completing the channel-fills are variously bright red and green as a result of a complex diagenetic history of oxidation and reduction. Dark brown to black zones in some paler sandstones are rich in vanadium. A small fault in the cliff east of the burn mouth [NJ 7925 6445] brings down a conglomeratic sandstone containing angular blocks of red sandstone.

East of the Findon Fault, the Crovie Group outcrops on the foreshore to Crovie and is unconformably overlain by basal conglomerates of the Middle Old Red Sandstone Findon Group. The outcrop of the Crovie Group is much faulted, and Trewin and Kneller (1987a) made no attempt at a correlation of the succession with that to the west of the Findon Fault, as had been proposed by Read (1923) and Donovan *et al.* (1978) (Trewin and Thirlwall, 2002). There is a complex relationship between the conglomerates of the Findon Group east of the Findon Fault and the red conglomeratic sandstones on the foreshore. To the east of The Snook [NJ 803 651] the contact is sharp and probably unconformable, although disturbed by faults. West of The Snook, the contact is a fault in the foreshore exposures.

From The Snook north-eastwards to Crovie, a broadly coarsening-upward succession is traversed down-sequence to Crovie. There, the Crovie Group is faulted against Dalradian basement of Troup Head by the Crovie Fault, which is probably a continuation of the Findon Fault. The Crovie Group comprises red, cross-bedded, mainly channelized sandstones and red mudstones with calcrete nodules. The basal beds of the Findon Group are conglomerates containing a large proportion of rounded pebbles and some boulders of quartzite, vein quartz and felsite. Around The Snook, these are overlain with low-angle discordance by locally derived breccias of Dalradian slate clasts.

The unconformity between the Lower Old Red Sandstone and Middle Old Red Sandstone is best seen in the impressive cliffs to the west of Pennan [NJ 846 655] (Trewin, 1987a). Deposition of the Crovie Group appears to have been controlled by synsedimentary faulting. Re-activation of these faults and erosion before deposition of the Findon Group produced a complex unconformity, the basal conglomerate of the group draping and filling hollows in the underlying eroded surface (Figure 2.71).

At New Aberdour, the Crovie Group is represented by a westward-dipping succession of conglomerates, sandstone and siltstone over 400 m thick and divisible into a lower sandstone–conglomerate unit and an upper mudstone-dominated unit with sandstone lenses in its upper part (Sweet, 1985; Trewin and Kneller, 1987b). The unconformity at the base of the succession is magnificently exposed at the east end of the section [NJ 898 652], where coarse breccia at the base of the Crovie Group rests on an eroded surface of Dalradian andalusite schists and psammites. The unconformity surface dips from 45° to near-vertical, the breccia mantling a highly irregular topography in which resistant greywacke ridges protruded. The breccia is up to about 10 m thick and consists mainly of locally derived psammitic clasts along with some vein quartz and felsite. Westwards, the breccia is absent [NJ 897 651] and sandstones with conglomerate lenses and granitic debris of angular quartz and feldspar grains overlie the unconformity. Conglomeratic red sandstones rich in granitic debris dominate the succession up-sequence until a marked, but punctuated change into fine-grained sandstones [NJ 894 649]. These fine upwards and pass up into red and green mudstones with calcrete nodules, which

locally coalesce to form thin, continuous beds (Stage III calcrete) with pseudo-anticlinal structures. Polygonal arrays of desiccation cracks appear to have controlled the development of the calcrete nodules. Thin sheets of laminated and ripple-laminated sandstone interrupt the mud-prone succession.

The fine-grained succession is seen to a point on the wave-cut platform [NJ 839 649] where thin, coarse-grained sandstones appear again and persist upwards. A remarkable feature is the presence of pink felsite pebbles and boulders up to 60 cm in a sandstone or mudstone matrix. They were clearly derived from nearby outcrop and may have slid gently onto the mud- or sand-flat. Another striking feature of this part of the succession is the abundance of *Beaconites* burrows. The succession is terminated by the Dundarg Fault, which throws down to the east, and a similar succession of conglomeratic sandstones [NJ 889 647] and mudstone-dominated beds [NJ 886 648]–[NJ 882 650] is seen to its west.

Close to the east of New Aberdour, exposures on the east side of Quarry Haven [NJ 9081 6578] reveal a small outlier of Old Red Sandstone rocks, faulted against Dalradian schists and psammites on their western margin and unconformably overlying them to the east (Trewin and Kneller, 1987c). In contrast to New Aberdour, there is no thick development of basal conglomerate facies, the mudstone facies lying much closer to the unconformity.

Interpretation

The Turriff Basin developed in Early Devonian times, its Lower Old Red Sandstone alluvial fill (the Crovie Group) comprising conglomerates and sandstones. Basal breccias mantled the irregular land surface of Dalradian meta-sedimentary basement, infilling valleys and hollows and forming accumulations at the faulted basin margins. Sweet (1985) gave a detailed interpretation of the facies at New Aberdour. The basal conglomerates there filled two SSW-draining palaeovalleys. They represent debris-flow and flash-flood deposits, passing upwards and distally into alluvial-fan braided stream, sheet-flood and fluvial channel sands and gravels. The basal conglomerates are absent at Gamrie Bay, the Crovie Group being faulted against basement and comprising a coarsening-upward fluvial sequence of mud-dominated floodplain deposition succeeded by alluvial-fan progradation. The basal conglomerate is thin to absent at Quarry Haven, its restricted clast suite confirming that there was only limited fan progradation at this point on the basin margin (Trewin and Kneller, 1987c).

The floodplain deposits comprise mudstones with thin sheets of sandstone, the latter probably representing unconfined sheet-flood deposition. Sweet (1985) and Trewin and Kneller (1987a,b) favoured a playa-lake environment for the mudstone deposition, impermanent, shallow lakes forming after flood events. Periods of exposure and low rates of aggradation produced desiccation cracking of the mudflats, with prolonged carbonate soil formation producing calcrete nodules, and in some cases, mature calcrete horizons. A semi-arid, hot climate with seasonal rainfall is inferred. The impressive range of burrows and trails at Gamrie Bay were probably made mainly by arthropods. The mudflats were succeeded by sandy alluvial plains which were combed by rapidly migrating stream channels.

Spores from the Crovie Group at Gamrie Bay are of late Early Devonian (Pragian–Emsian) age (Weston, 1977). Correlation of the sequences on both sides of the Findon–Crovie Fault in Gamrie Bay was attempted by Read (1923) and Archer (in Donovan *et al.,* 1978). Similarly Sweet (1985) correlated the New Aberdour and Quarry Haven sections. Trewin and Kneller (1987a) adopted a more cautious approach, pointing out that rapid facies variations in the locally derived sediments in the basal part of the succession (probably controlled by synsedimentary faulting), and numerous faults between The Snook and Crovie at New Aberdour make correlation tentative.

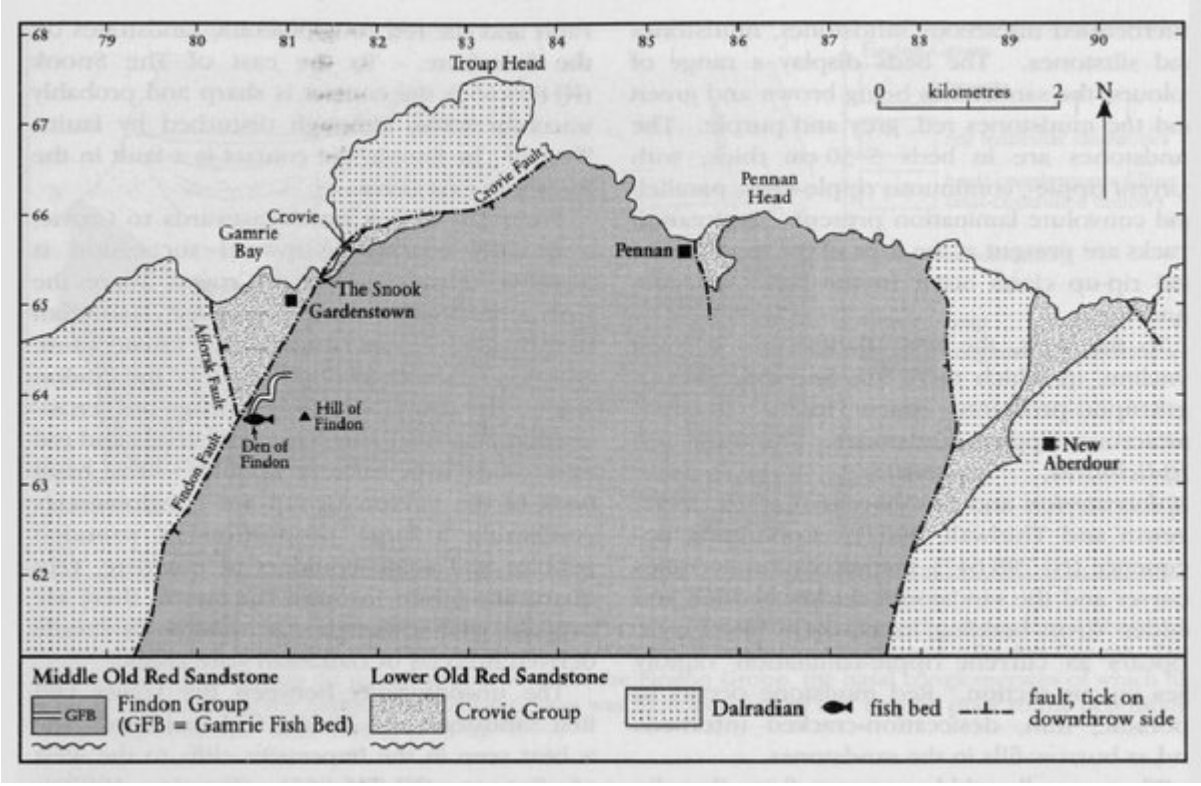
Inversion and erosion of the basin-fill followed deposition of the Lower Old Red Sandstone (Crovie Group), represented by a major unconformity overlain by the Middle Old Red Sandstone (Findon Group), spectacularly seen at Pennan. The basal conglomerates and breccias seen at The Snook in Gamrie Bay represent the progradation of two discrete alluvial-fans from different valleys, with two sediment sources involved, although the fans interfingered at times. The earlier one deposited rounded, far-travelled quartzite boulders, although these may have been reworked from older conglomerates. The later fan was of much more local derivation, from perhaps no more than 2 km, depositing angular clasts of Dalradian slate (Trewin and Kneller, 1987a).

The Gamrie Fish Bed at the Den of Findon represents an interruption to alluvial deposition, when the Orcadian lake reached maximum development (at the end of the Eifelian Age) and transgressed over the alluvial plain on the southern margin of the basin (Trewin and Kneller, 1987a). Lake deposition occurred over a period of at least about 4000 years, based on the interpretation of the fine laminations as annual, seasonally controlled varves. The bed is correlated on its fish fauna with the Tynet Burn fish bed (see Tynet Burn GCR site report this chapter), the Achanarras Fish Bed of Caithness and the Sandwick Fish Bed of Orkney. There are differences, however, between Gamrie and the other sites, with, for example, *Dipterus,* which is common elsewhere, being absent. Subsequent uplift and erosion took place prior to deposition of the locally derived fan breccia seen at the Den of Findon. The fish bed was probably removed by erosion in Gamrie Bay and Pennan, where the basal Findon Group breccia rests with angular discordance on the conglomerates at the top of the Crovie Group (Dineley, 1999a).

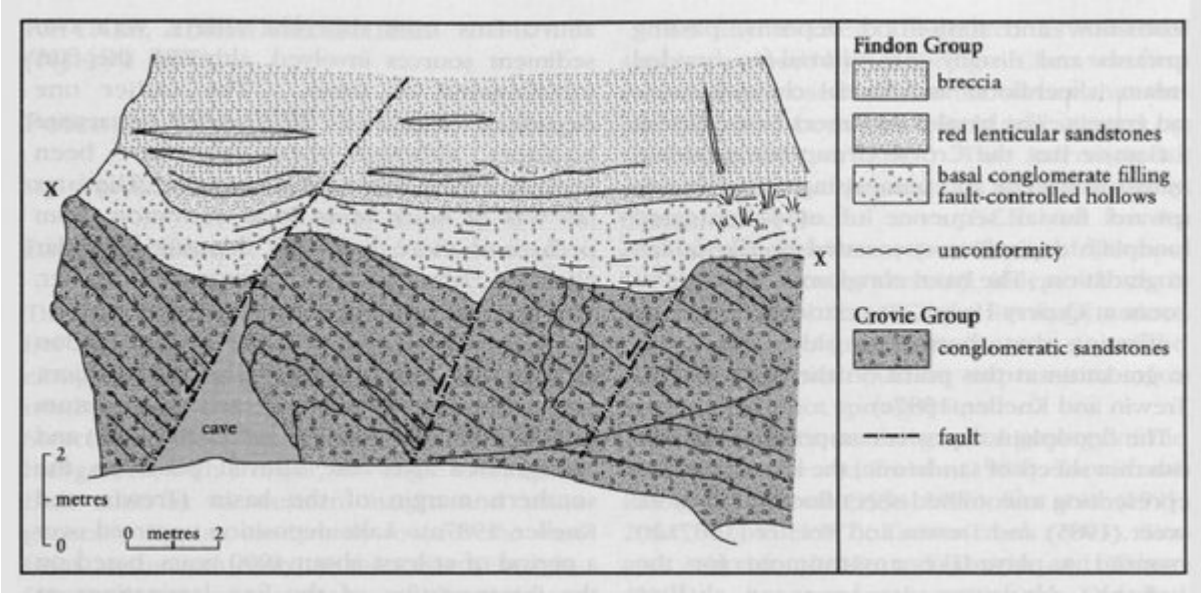
Conclusions

The Gamrie Fish Bed is historically important as one of the first prolific Scottish Old Red Sandstone fossil fish sites. The Den of Findon GCR site is overgrown, but magnificent cliff and foreshore sections nearby in Gamrie Bay, and to the east at Pennan and New Aberdour provide the best sections available of the Turriff Basin. Lower Old Red Sandstone and Middle Old Red Sandstone successions, and the intervening unconformity, are completely exposed, allowing detailed analysis of the sedimentary rocks and the environments in which they were deposited. Of particular importance are the trace fossil assemblages, the variations in facies and the bounding faults with the Dalradian, all spectacularly displayed in these sections.

References



(Figure 2.70) Geological map of the Gamrie–New Aberdour area. Based on Institute of Geological Sciences 1:50 000 Sheet 96 (Scotland), Banff (1955) and British Geological Survey 1:50 000 Sheet 97 (Scotland), Fraserburgh (1987).



(Figure 2.71) Sketch of the lower part of the cliff near Pennan [NJ 842 658] showing the unconformity between the Lower Old Red Sandstone (Crovie Group) and overlying Middle Old Red Sandstone ((Findon Group). The faults in the Crovie Group do not all appear to affect the Findon Group, the basal conglomerates of which fill hollows eroded along the faults. The Crovie Group was therefore faulted and eroded prior to the deposition of the conglomerates. After Trewin (1987a).