North Esk River, Aberdeenshire

[NO 595 719]–[NO 604 703]

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Introduction

The North Esk River section in the Gannochy Gorge (Figure 3.16) is in the Strathmore Group of the Lower Old Red Sandstone in the northern Midland Valley, about 500 m south-east of the Highland Boundary Fault. The Strathmore Group is the youngest Lower Devonian succession of the area and comprises a sequence of alluvial siltstones, sandstones and conglomerates. This GCR site provides the best sections in which to examine the variations in lithology and thickness of the strata, as well as the pebble content of the conglomerates. The change in clast content along the gorge reflects movements along the Highland Boundary Fault and the history of erosion of the Dalradian Supergroup, which formed land to the north during this part of the Devonian Period. This is also an important section for understanding the tectonic development of the Midland Valley and its relationship to the Grampian Highland Terrane at that time. The sedimentology and fluvial architecture of the succession can be studied in this impressive gorge, which is 20 m to 30 m deep.

Description

The North Esk River cuts through the Strathmore Group on the steep north-west limb of the Strathmore Syncline. To the north of the site, poorly exposed, reddish brown siltstones and poorly sorted fine- to medium-grained, argillaceous sandstones are correlated with the coarser-grained facies of the Cromlix Mudstone Formation, which is truncated against the Highland Boundary Fault. The Cromlix Mudstone Formation is the basal formation of the Strathmore Group and because it is relatively soft it is generally poorly exposed. To the south, the formation passes conformably up into the 250 m-thick Gannochy Conglomerate Formation, which is more resistant and forms the northern part of the gorge.

The sandstones and conglomerates upstream of Gannochy Tower [NO 6021 7065] were formerly correlated with the Garvock Group (Campbell, 1913; MacGregor, 1968), but later re-assigned to the Strathmore Group on the faulted north-west limb of the Strathmore Syncline (Armstrong and Paterson, 1970; MacGregor, 1996b). Armstrong and Paterson defined the Gannochy Conglomerate Formation at this site, extending from the base of the lowest conglomerate [NO 5947 7199] north of the disused Loups Bridge to the highest pebbly sandstone beds near Gannochy Tower [NO 6020 7064]. They calculated the total thickness of the formation in the gorge to be 1400 m. Subsequent geological surveys (British Geological Survey, 1995; Carroll, 1995c) confirmed the correlation with the Strathmore Group, and refined the lithostratigraphical classification. Red, argillaceous beds of the Cromlix (formerly Edzell) Mudstone Formation are overlain by the Gannochy Conglomerate Formation, which is in turn overlain by the Teith (formerly Edzell) Sandstone Formation (Browne *et al.,* 2002). Carroll (1995c) re-defined the Gannochy Conglomerate Formation in the North Esk River, placing the top of the formation at the top of the clast-supported orthoconglomerate beds immediately downstream of Loups Bridge [NO 5948 7164].

The clast-supported conglomerates of the Gannochy Conglomerate Formation (Figure 3.17) appear to occur in lenses within pebbly sandstones, which dip almost vertically in this section. Locally, 50 m north of an E-W-trending Permo-Carboniferous dolerite dyke [NO 5951 7156], the beds are overturned, dipping 86° to the north-west. The conglomerates are weakly stratified and poorly sorted, and contain rounded to subrounded pebbles in a medium- to coarse-grained sandstone matrix. Cross-bedded pebbly sandstone lenses occur within the conglomerate lenses and some of the sandstone bodies have basal, pebbly lags. Conglomerates continue south of Loups Bridge [NO 5948 7164], and are conformably overlain by fine- to medium-grained, pebbly sandstones of the Teith Sandstone Formation. The conglomerates have a decreasing proportion of quartzite and quartz pebbles in their upper part (MacGregor, 1968, 1996b).

The Teith Sandstone Formation forms the bulk of the gorge section and is relatively coarse-grained, containing several thick conglomerates within red-brown sandstones and mudstones. The sandstones are commonly trough cross-bedded, pebbly to medium-grained and include large detrital micas. Red mudstone beds up to 2.5 m thick and dipping about 60° to the southeast are well exposed about 230 m north of Gannochy Bridge. The conglomerate interbeds are polygenetic and although quartzite is the most common pebble type, vein quartz, porphyry, andesite, granite, gneiss, felsite and sedimentary types are also present (MacGregor, 1968, 1996b). The overlying part of the Teith Sandstone Formation south of Gannochy Tower, and about 270 m downstream from Gannochy Bridge, consists of mainly fine- to medium-grained, red sandstones, with some coarse-grained to pebbly sandstones with mudstone intraclasts. The beds dip about 30° to the southeast. Some of the finer-grained sandstones are cross-bedded or ripple cross-laminated, and there are thick, planar-bedded, silty sandstones with very thin mudstone interbeds (Carroll, 1995c).

Interpretation

The sequence of sandstones and conglomerates north of Gannochy Tower was originally placed in the Garvock Group (Campbell, 1913), but Armstrong and Paterson (1970) re-assigned it to the Strathmore Group on structural grounds, considering its position on the north-west limb of the Strathmore Syncline. The Strathmore Group exposed in Gannochy Gorge is coarser grained than that on the south-east side of the Strathmore Syncline, probably due to its proximity to the source of the detritus to the north.

The depositional environment of the Cromlix Mudstone Formation has been inferred from exposures at Mid Mains of Balfour [NO 624 740], a few kilometres to the north-east, to be an alluvial floodplain that periodically dried out, as indicated by local desiccation cracks. Trace fossils include *Skolithos, Arenicolites* and *Beaconichnus* (Carroll, 1995c), indicating a habitat suitable for burrow-feeders, possibly close to a lake shoreline. The Gannochy Conglomerate Formation marks the progradation of a high-energy alluvial-fan system, with reduced fluvial energies being represented by the overlying Teith Sandstone Formation. Only the lower part of the Teith Sandstone Formation is seen in this section, but it appears to fine upwards overall. Its base is probably coarser grained here, as it is gradational from the Gannochy Conglomerate Formation, and the facies on the north-west limb of the Strathmore Syncline is typically laterally variable and coarser grained than the more distal fades to the south-east. In the younger parts of the formation exposed elsewhere, the plant remains *Arthostigma* sp. and *Psilophyton* sp. are locally common, indicating plant colonization of the less active floodplains. Spores from plant beds in the Strathmore Group indicate an Early to Mid-Emsian age (Richardson *et al.,* 1984).

Haughton and Bluck (1988) recognized two alluvial styles in the Strathmore Group. Fine-grained alluvium was deposited in axial systems by very large rivers that probably drained areas of Scandian uplift. First-cycle conglomerates were deposited in fans dose to the Highland Boundary Fault and derived from the north-west. The textural immaturity of the conglomerates suggests flash-flood deposition. The Strathfinella Hill Conglomerate Member, which crops out to the north-east, contains clasts of metamorphic rock of garnet- and higher grades. Haughton and Bluck (1988) related these grades to the Barrovian zones in the adjacent Dalradian rocks of the Grampian Highland Terrane, to the northwest, inferring little displacement on the Highland Boundary Fault since Emsian times. Comparison of Lower Old Red Sandstone sequences immediately to the north and south of the Highland Boundary Fault (Bluck, 2000) suggests that the Grampian Highland Terrane pushed southwards, either during or after Lower Old Red Sandstone deposition, effectively removing the northern part of the Strathmore Basin and generating the steep northern limb of the Strathmore Syncline.

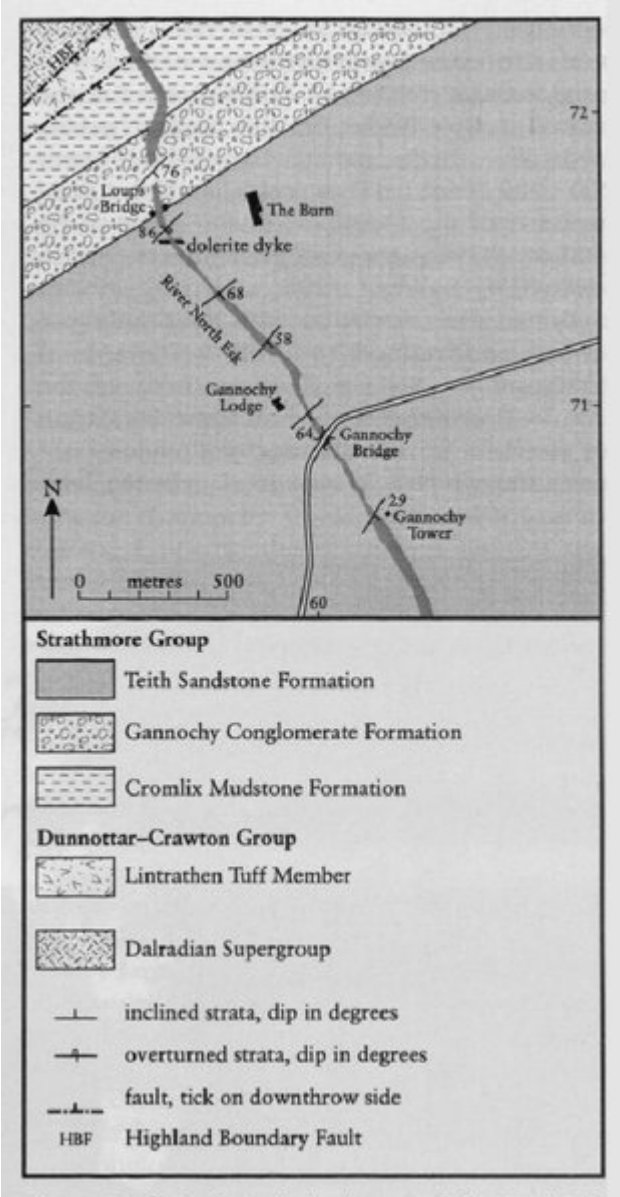
Peacock (1961) suggested that significant uplift of the source area caused the influx ofconglomerates of the Gannochy Conglomerate Formation and noted a decrease in its maturity upwards (MacGregor, 1968, 1996b). The upper, less mature conglomerates contain gneisses (about 25%), as well as 'porphyry', 'granite' and sedimentary pebbles, presumed to have been derived from the highlands to the north. Armstrong and Paterson (1970) considered that the Gannochy Conglomerate Formation continued north-eastwards to link with the Strathfinella Hill Conglomerate Member, but detailed mapping by Carroll (1995c) indicates that they are the deposits of separate alluvial fans. The Lintrathen Tuff Member (Dunnottar–Crawton Group), which is exposed in a faulted wedge within the Highland Boundary Fault Zone farther north in the North Esk River section, also occurs to the north-west of the fault zone. Its presence there has been interpreted (Trench and Haughton, 1990) as confirmation that only a limited amount of lateral movement on the Highland Boundary

Fault has occurred since the tuff erupted at 415.5 ± 5.8 Ma (Thirlwall, 1988).

Conclusions

The North Esk River GCR site is the best-exposed section through the Strathmore Group on the north-western side of the Strathmore Syncline and the type section for the Gannochy Conglomerate Formation. It provides good exposures of the conglomerate formation, as well as the underlying and overlying finer-grained formations. The pebbles in the conglomerate are mainly from the Grampian Highland Terrane to the north-west, in contrast to the older Lower Old Red Sandstone rocks sourced from more distant areas of Scandian uplift. The depositional model envisaged for these sedimentary rocks comprises an interplay of a large, axially draining alluvial system flowing to the south-west and the lateral build up of alluvial-fans draining southeast across the Highland Boundary Fault Zone during Emsian times. Because of its proximity to the clastic source, the fades of the Strathmore Group in this section is coarser grained than that on the south-east limb of the Strathmore Syncline. Detailed sedimentological and provenance studies at the site, compared to studies at Strathfinella, would test this simple model and provide important data on fault control on sedimentation and the timing of exhumation of the Grampian Highland Terrane.

References



(Figure 3.16) Geological sketch map of the North Esk River section.

(Figure 3.17) Coarse clast-supported orthoconglomerate of the Gannochy Conglomerate Formation at Loups Bridge, North Esk River. (Photo: BGS No. D5347, reproduced with the permission of the Director, British Geological Survey, © NERC.)