7 Muckle Fergie Burn

[NJ 164 140]–[NJ 167 139]

J.R. Mendum

Published in: The Dalradian rocks of the north-east Grampian Highlands of Scotland. PGA 124 (1–2) 2013 https://doi.org/10.1016/j.pgeola.2012.07.011. Also on NORA

7.1 Introduction

The lower part of the Muckle Fergie Burn, a tributary of the River Avon 5 km south of Tomintoul, cuts through the basal units of the Islay Subgroup, which here include several metamorphosed diamictite beds that are readily correlated with the Port Askaig Tillite of Islay and the Schiehallion Boulder Bed of Perthshire. This section, together with other occurences in Upper Donside and farther north to within sight of the Banffshire coast, shows that the tillite unit recognized at the base of the Argyll Group in Connemara, Donegal and Islay can also be traced through the Grampian Highlands. The tillite unit was probably deposited over a relatively short period of geological time; hence, it is effectively considered to be a chronostratigraphical marker unit within the Dalradian succession. In addition, the section below the tillites in the Muckle Fergie Burn preserves the earliest record of mafic volcanism in the Argyll Group, whilst farther east in the section tuffs and lavas are also found higher in the Islay Subgroup and in the Easdale Subgroup (Figure 6.14).

The Muckle Fergie Burn section was first described by L.W. Hinxman during primary mapping for the Geological Survey in 1888-9. He recognized the existence of a ‘boulder bed’ akin to that described near Schiehallion and recorded the presence of granitic and dolomitic clasts in a greenish grey, sandy to silty matrix in the brief memoir for Sheet 75 (Hinxman, 1896). Gregory (1931) also included a description of the unit in his book on Dalradian Geology. Both authors failed to attribute a glacial origin to the beds, interpreting them as pebbly calcareous psammites. Morgan (1966) carried out more-detailed mapping over a wide part of the Muckle Fergie–Inchrory area and provided detailed descriptions of the stratigraphy and structure. Then, following the recognition of the glaciomarine origin of the Port Askaig boulder bed (Kilburn *et al*., 1965), Spencer and Pitcher (1968) extended the correlation and interpretation to the Muckle Fergie Burn section and published a stratigraphical log, as well as noting metadiamictite occurrences farther north-east near Fordyce. The Geological Survey remapped the area in the 1980’s during the revision of 1:50 000 Sheet 75W (Glenlivet, 1996) and this description uses material gathered during that work.

Spencer and Pitcher (1968) recognized the wider importance of metadiamictite units with regard to correlation along the whole Dalradian outcrop and more widely in the North Atlantic region, a concept that was extended to a worldwide scale by Hambrey and Harland (1981). A tentative correlation has long been made between the Port Askaig Tillite and the Varanger tillites of northern Norway (Spencer, 1971). Recent Rb-Sr illite age dating has bracketed deposition of the Varanger glacial deposits between 620 and 590 Ma (Gorokhov *et al*., 2001; Bingen *et al.*, 2005), which is more comparable with the top of the Argyll Group than the bottom. Hence, more-recent suggested correlations are with the older Marinoan (c. 635 Ma) or Sturtian (*c.* 720 Ma) glaciations. (See Stephenson et al., 2013a for a full discussion.)

7.2 Description

The lower part of the Muckle Fergie Burn flows through a wooded and shrubby gorge, some 240 m south of Auchnahyle. The burn provides a reference section for the Auchnahyle and overlying Kymah Quartzite formations (Islay Subgroup) and in its upper part passes through the overlying semipelitic, pelitic and basic metavolcanic units of the Easdale Subgroup. Generally the sequence dips at 30–70° to the east and is the right way up, although some overturned sections are present locally. Medium-scale, close to tight folding repeats some of the ‘boulder bed’ units.

The metadiamictite beds lie within the Auchnahyle Formation, an interbedded sequence of psammites and semipelites containing amphibolites in the lower part and beds of metalimestone and metadolostone in the upper part. The formation

maps out as a lensoid unit, faulted out on its northern margin, whose strike length is about 2 km and maximum thickness is of the order of 150 to 200 m (Figure 6.14). The contact of the Auchnahyle Formation with the underlying Glenfiddich Pelite Formation of the Blair Atholl Subgroup is not exposed in the Muckle Fergie Burn. However a rapid transition from graphitic pelites and semipelites conformably up into amphibolites is seen on a rocky bluff at [NJ 163 143], some 300 m to the north.

The exposed burn section (Figure 6.14) starts with 7 m of dark grey-green amphibolite that contains two cleavages and prominent quartz and minor calcite veining. Tightly folded, thin- to medium-bedded psammites and semipelites overlie the amphibolite and within these beds (at [NJ 1647 1401]) is a prominent coarse- to medium-grained amphibolitic unit with an internal structure resembling pillows. No vesicles are seen but the 'pillow structures' do contain radial cracks and show a crude textural zonation; features indicative of lavas. The micaceous and feldspathic psammite and semipelite sequence immediately upstream from the pillowed amphibolites contains some lenticular siliceous psammite units. Several psammite beds show cut-offs and grading implying younging to the east. A *c.* 4 m-thick sheet of foliated metadiorite intrudes the psammite-semipelite sequence here.

At [NJ 1655 1399] a *c.* 4 m-thick, thinly banded, grey, fine-grained crystalline metalimestone with thin biotite-rich pelitic interbeds is seen. Upstream for some 15 m, graphitic pelite and minor thin metalimestones are present in the thinly bedded psammite-semipelite sequence. They are succeeded by a *c.* 6 m-thick cream- to fawn-weathering, mottled white and pink, fine- to medium-grained metadolostone, which has a rubbly fragmental zone at its top. It passes up into a *c.* 5 m-thick, unbedded, grey-green, amphibole-bearing, highly micaceous psammite containing subangular to subrounded rusty brown-stained metadolostone clasts in its upper part. The metadolostone clasts are deformed with elongations as high as 7:1. This metadiamictite unit and others upstream are notably pyritic. A thin psammite bed separates the lower metadiamictite from the succeeding 5–7 m-thick metadiamictite that contains moderately abundant granitoid and metadolostone clasts in a slightly purplish grey matrix of highly micaceous psammite. These units are succeeded by psammite and a further 6 m-thick metadiamictite with quartz and rare granitoid pebbles and cobbles.

A thicker sequence of psammites follows eastwards. The lowest unit is an indurated recrystallized quartzite with pyrite and minor chlorite giving it an unusual translucent dark bluish green-grey colour, but the higher parts vary from pink siliceous psammite to feldspathic and micaceous psammite. Thin amphibolite sheets are present. A further 4–5 m-thick metadiamictite unit is exposed at the second waterfall (at [NJ 1657 1396]). It contains scattered granitoid clasts in a grey-green amphibole-bearing semipelitic matrix grading up to a grey semipelite with small metadolostone clasts (Figure 6.15). A 4 m-thick sheet of metadiorite could be the same intrusion as that seen in the lower part of the section. An upper metadiamictite, some 5m thick and consisting of green-grey highly micaceous psammite with scattered small granitoid and rare metadolostone pebbles, occurs at [NJ 1661 1395].

There is a lack of exposure for some 300 m in the burn section above this lower part until the more-massive cross-bedded siliceous psammite of the Kymah Quartzite Formation is reached. This forms a major scarp feature with the prominent small crags of Sìdh Beag and Sìdh Mòr above the burn (Figure 6.14).

The metadiamictite units are invariably matrix supported. The matrix is normally a highly micaceous psammite, which in thin section is seen to be markedly inequigranular with angular to subrounded clasts of quartz, plagioclase and potash feldspar, and clots of chlorite, partly overgrown by biotite. Apatite is a common accessory and zircon is also present. The matrix is dominated by chlorite but locally it is rich in carbonate or amphibole, the latter now mainly altered to chlorite and biotite. The matrix is normally structureless, although a crude ill-defined lamination can be discerned in places.

The majority of clasts are of pebble size with a few cobbles up to 26 cm and a white granite boulder some 41 cm by 26 cm was recorded by Morgan (1966). White to pale-yellow metadolostone is the predominant sedimentary variety of clast, although grey metalimestone (Blair Atholl Subgroup), quartzite, gritty psammite and slate have also been recorded (Gregory, 1931; Morgan, 1966). The igneous clasts are largely granitic and range from white to pink granite to quartz-syenite and granodiorite, with diorite less abundant.

Although the exposure in the Muckle Fergie Burn does not allow full documentation of the structure, open to tight minor folds are seen at various points and bedding dips range from near horizontal to near vertical, implying the presence of

small- and medium-scale folds. Minor fold axes plunge gently to the south-east, corresponding approximately with a lineation (L2). A crenulation cleavage (S3) that dips steeply to the north-east is developed locally in the more-pelitic units (Morgan, 1966). Two major fold phases (F2 and F3) are well displayed in Blair Atholl Subgroup metalimestones in the Little Fergie Burn 3 km to the south-south-east, where F2-F3 fold interference patterns are present. There, F2 and F3 fold axes mainly plunge gently to the east-south-east, but some F2 axes plunge gently to the north-west.

7.3 Interpretation

The true thickness of the Auchnahyle Formation in the Muckle Fergie Burn is unclear. Morgan (1966) alluded to repetition by folding, but confusingly included the repetition in his stratigraphical sequence. Similarly, the stratigraphical log given by Spencer and Pitcher (1968) shows nine metadiamictite beds, but does not allow for or even reflect the fold repetition. Allowing for dips varying from 30° to near vertical, the sequence would be 250 m to 280 m thick, but fold repetition probably reduces this to nearer 150 m.

The metadiamictite beds are interpreted as marine glacial tillites (Spencer and Pitcher, 1968) and are correlated with the more-extensive and less-deformed Port Askaig Tillite Formation documented by Spencer (1971) from Islay and the Garvellach Islands (see the *Garvellach Isles* GCR site report in Tanner et al., 2013a). The lowest fragmental metadolostone unit represents the start of glacial deposition in this area, recording the scouring of the immediately underlying unit, presumeably by ice and/or meltwater. The overlying tillite bed contains some metadolostone clasts but also includes granitoid cobbles and represents input from a wider area.

Abundant amphibolite sheets and some amphibole-rich metadiamictite units occur in the upper part of the succession, whereas thicker amphibolite sheets and basic pillow lavas are found below the metadiamictite beds. These features, together with the ubiquitous presence of pyrite, suggest that input from a mafic volcanic source coincided with the glacial episode. Much of this altered amphibolitic material could be derived either from erosion of basic volcanic units or relate directly to volcanic activity. In the Ladder Hills area to the north-east, the lowest Islay Subgroup sedimentary sequence is considerably thicker than in the Muckle Fergie Burn and tuffaceous and lava units occur within the turbiditic psammite-semipelite succession (see the *Kymah Burn* GCR report). This volcanic association is prominent only in the tillite units of the North-east Grampian Highlands (Harris *et al*., 1994; Fettes *et al*., 2011).

There is also a close association of metadiamictite with metadolostone units in the Muckle Fergie Burn, in Upper Donside and in the Ladder Hills, suggesting that the dolomitization and glaciation are closely related.

The tillite unit is generally accepted to be a chronostratigraphical marker and could have formed at either *c.* 635 Ma (Marinoan tillites) or at *c.* 723 Ma (Sturtian tillites). Adoption of either age creates problems in trying to understand the depositional history and palaeogeography of the Dalradian succession. The older age allows little time, possibly only 30 Ma, for the deposition of the Grampian and Appin groups but gives a period of *c.* 120 Ma for the deposition of the Argyll Group. The more likely younger age, however, allows 120 Ma for deposition of the Grampian and Appin groups and *c.* 30 Ma for deposition of the Argyll Group (see Stephenson et al., 2013a).

7.4 Conclusions

The lower part of the Muckle Fergie Burn section contains several poorly sorted, matrix-supported ‘boulder beds’, similar to those found near the base of the Argyll Group at Schiehallion, the Garvellach Isles and on the Isle of Islay. The ‘boulder beds’, more-precisely termed ‘metadiamictites’, represent marine glacial tills and form a small relict fragment of a unit that can be traced intermittently from Connemara in the west of Ireland to the Banffshire coast. They record the presence of glacial conditions during a finite time period in the late Neoproterozoic and hence form a chronostratitigraphical marker unit that is possibly the most reliable and the most widespread in the whole Dalradian succession; the Muckle Fergie Burn provides the most north-easterly detailed section through this crucial unit.

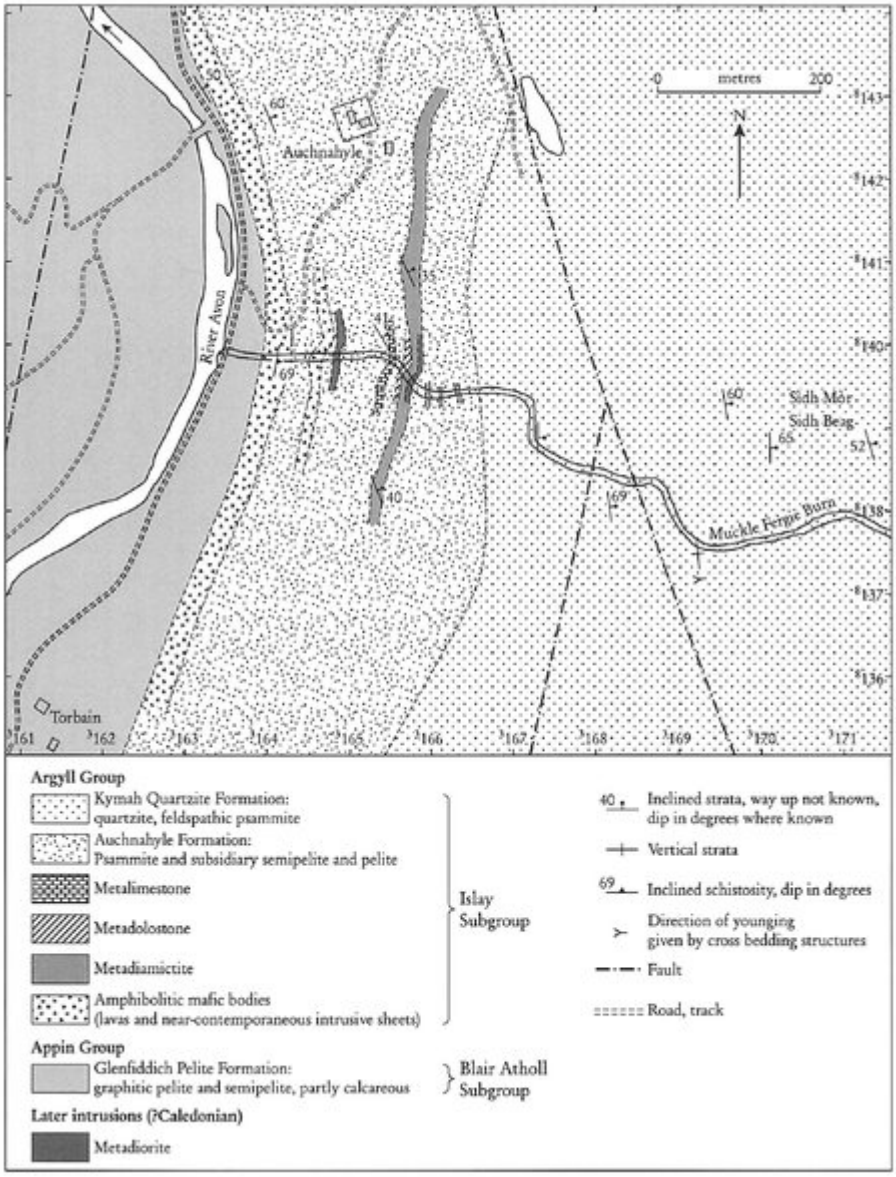
In the Muckle Fergie Burn section, the lowest metadiamictite rests upon an erosion surface and is dominated by clasts of metalimestone and metadolostone that were most likely derived quite locally from the underlying Appin Group rocks. But,

as is the case elsewhere, higher metadiamictites contain an increasing proportion of granitic clasts reflecting a much more-widespread source area.

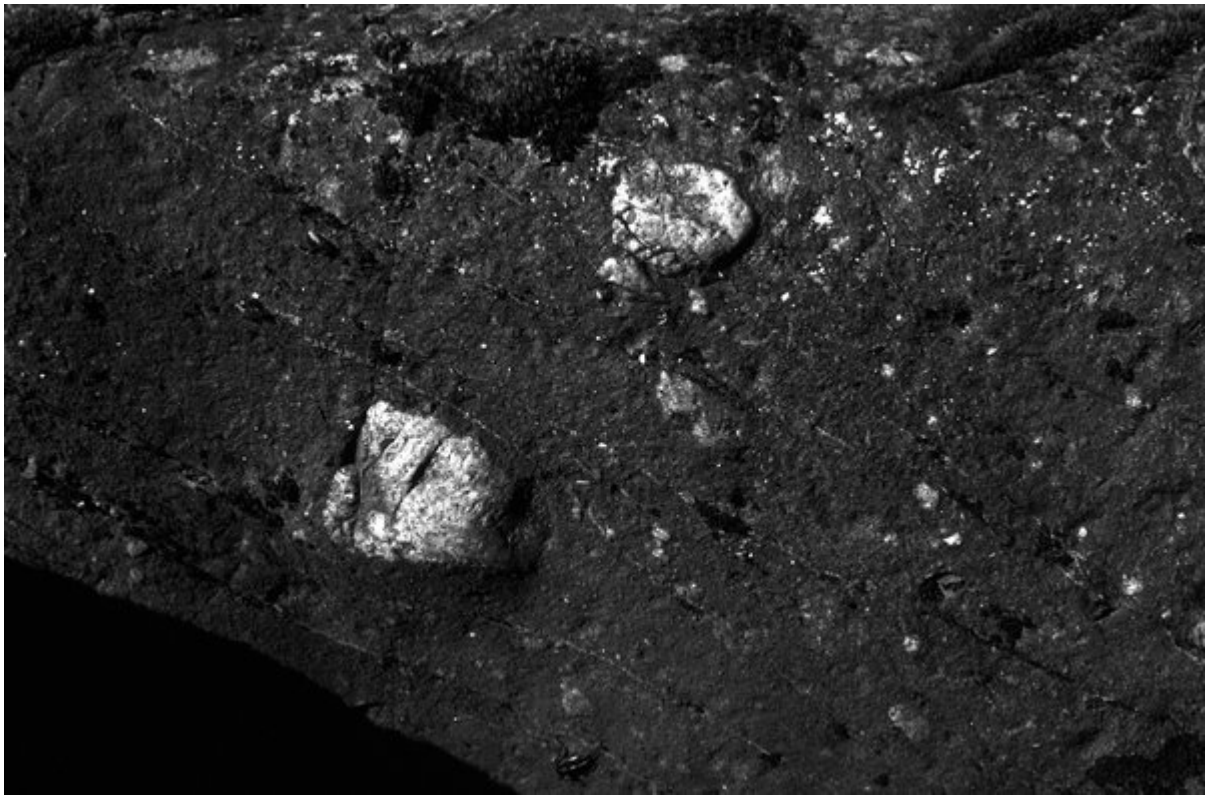
The section also contains poorly preserved pillow lavas, which provide evidence of basic volcanism coeval with the glaciation. Not only is this the only area in the whole strike length of the tillite unit where volcanic rocks are found but it is also the earliest evidence for basic igneous activity anywhere in the Dalradian succession; volcanism subsequently continued throughout Argyll Group and much of Southern Highland Group times.

These tillites and related lithologies clearly consititute vital evidence for a major glacial period in the Earth's history and hence are of great international importance. Much interest is currently focussed upon correlation with other, dated, glacial deposits in the North Atlantic region and worldwide. Possibilities include the Marinoan tillites at *c.* 635 Ma or even the Sturtian tillites at *c.* 723 Ma. The correlation has vital implications for the history of Dalradian sedimentation and for global reconstructions of the Neoproterozoic Era.

References



(Figure 6.14) Map of the Muckle Fergie Burn section, Glen Avon, based upon British Geological Survey mapping, 1982–88.



(Figure 6.15) Granitic cobbles, typically up to 10 cm across, in metadiamictite in the lower part of the Muckle Fergie Burn [NJ 1657 1397]. The smaller clasts include granite, quartz and ochreous yellow-brown-weathering metadolostone (see example at bottom right). (Photo: J R Mendum, BGS No. P 726597)