8 Bridge of Brown

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8.1 Introduction

The river section at Bridge of Brown, on the A939 between Tomintoul and Grantown-on-Spey, provides one of the few coherent sections through the transition from the Grampian Group up into the Appin Group. The section spans the uppermost psammite and quartzite units of the Grampian Group, the interbedded psammites, semipelites and highly calcareous semipelites of the Lochaber Subgroup, and lower Ballachulish Subgroup metalimestone, calcareous semipelite, and graphitic pelite–semipelite units. Within the Lochaber Subgroup is a distinctive gneissose kyanite-garnet-muscovite-biotite semipelite unit that can be traced northwards as far as the Banffshire Coast. The sequence is deformed but no evidence is seen for a major slide, such as occurs at this stratigraphical level in the Schiehallion and Glen Tilt areas of Perthshire to the south-west.

The Bridge of Brown GCR site is complementary to the adjacent *Bridge of Avon* GCR site in that it extends the stratigraphical section down through the lower part of the Appin Group and into the Grampian Group. It also continues the structural cross-section to a lower level. The bedding dips moderately to the south-south-east throughout the section and, although minor folds are seen locally, there is no evidence for significant fold repetition or inverted bedding. Similarly, although the bedding appears to be somewhat attenuated, lineations and strong planar fabrics are conspicuously absent. The transition from the thick, competent, lithologically relatively uniform, psammite-dominated Grampian Group to the mixed pelite–metalimestone–quartzite Appin Group sequence must act as a focus for enhanced deformation. An early slide is interpreted to lie at or near the base of the Ballachulish Subgroup over much of the Glenlivet district to the south but in the Burn of Brown section only a small part of the stratigraphy appears to be excised. South of the Cairngorm Granite Pluton, ductile sliding is focussed along the Grampian–Appin group boundary (see the *Glen Ey Gorge* and *Gilbert's Bridge* GCR site reports) and farther north around Ben Rinnes mylonitic rocks are also developed at this level. On the Banffshire Coast section, west of Sandend a stratigraphical transition is well seen (see the *Cullen to Troup Head* GCR site report), but there the Lochaber Subgroup is abnormally thick.

The Bridge of Brown area was originally mapped by L.W. Hinxman during the primary geological survey but was not deemed worthy of particular mention in the Sheet 75 memoir (Hinxman, 1896). The area was remapped by the Geological Survey as part of the revision of the bedrock geology of the Glenlivet district (1:50 000 Sheet 75W, Glenlivet, 1996) and that work forms the basis for this account.

8.2 Description

The Burn of Brown flows through a narrow incised gorge, where the original, General Wade road crossed the burn; the more-recent road bridges occur a few hundred metres downstream (Figure 6.16). The incised section probably represents capture of the Glen Brown drainage basin by the Burn of Lochy, with the former drainage flowing eastwards to the River Avon via Fodderletter.

8.2.1 Stratigraphy

The Grampian Group rocks are seen near the ruin of Blàr an Lochain [NJ 1213 2110], where they comprise feldspathic, siliceous and micaceous psammite with semipelite interbeds with rare calcsilicate-rock lenses and lenticular bands. These mixed lithologies form part of the Strathavon Psammite Member of the Tormore Psammite Formation. Individual

semipelite units reach 2 to 3 m in thickness and show evidence of two penetrative cleavages. The semipelites contain garnet, muscovite and biotite and the calcsilicate-rock lenses contain garnet and hornblende. These metamorphic mineralogies are characteristic of the lower amphibolite facies. Upstream, at around [NJ 1207 2100], thin- to medium-bedded psammites are dominant with bed thicknesses normally ranging from 2 cm to 30 cm, but reaching up to 50 cm in the coarser grained units. Good examples of cross-bedding and slump folds with prominent cut-offs show that the beds are right way up. Slump fold axes plunge to the south-east. Upstream, thinly bedded feldspathic and micaceous psammites with minor semipelite beds and partings are dominant with thin quartzite beds present locally.

Just below Bridge of Brown, flaggy, thinly bedded to laminated semipelite and micaceous psammite become dominant and constitute the basal Lochaber Subgroup unit, the Dalvrecht Slate Formation. These rocks have a strong penetrative planar fabric and a slaty parting. In thin section they contain quartz, plagioclase feldspar, muscovite and biotite, with garnet common in parts. The abundant micas define three separate cleavages in some of the specimens. Thin bands of calcsilicate rock are also present. Between the present bridge and the Wade bridge greenish grey micaceous and highly micaceous psammites with minor calcsilicate-rock bands crop out. They pass upstream into flaggy, sparsely garnetiferous, micaceous psammites with thin siliceous psammite interbeds. Calcsilicate-rock bands are common and quartz veins are present. The Dalvrecht Slate Formation is some 120 m thick here.

Upstream the beds become grey-green in colour and consist of thinly bedded but lithologically more-uniform, calcareous semipelite and highly micaceous psammite with abundant lenses of white and green calcareous quartzite. Locally the calcsilicate-rock lenses overgrow bedding features showing that they were formed during diagenesis or perhaps even later. In parts darker green amphibolitic beds (originally marls) are seen. These calcareous units constitute the Fodderletter Calcareous Flag Formation. In thin section the calcsilicate rocks contain much tremolite but relict diopside is present locally. At [NJ 1266 2034], a massive gneissose kyanite-muscovite-biotite-(garnet) semipelite bed, some 5 m thick, forms a small waterfall. This is the Fireach Beag Kyanite Gneiss Member and contains elongate laths of blue-grey kyanite up to 2 cm long. Under the microscope the gneiss consists of coarse-grained, well-formed muscovite laths intergrown with more-ragged biotite enclosing coarse-grained aggregates of quartz and plagioclase (oligoclase). Kyanite forms laths up to 5 mm long and is partly altered to fine-grained muscovite with chlorite common locally. Garnets are altered to quartz-feldspar-biotite-ilmenite aggregates and fractured staurolites up to 1 mm long are present. Ilmenite is common and rutile, apatite and tourmaline are also present. Above the gneiss the formation is lithologically more variable and consists of thinly bedded calcareous and non-calcareous micaceous psammites, semipelites and biotitic pelite units. Calcsilicate-rock units remain abundant and are locally pyritic. At [NJ 1267 2027], graded units are seen and possible slump folds occur at [NJ 1268 2023]. The highest lithology exposed in the GCR site consists of slaty micaceous psammite and semipelite, which show tight folding locally. The overlying Mortlach Graphitic Schist Formation is not exposed in the burn section but a block of silicified metalimestone has been recorded in the nearby till and graphitic pelite that characterizes the formation is seen widely in the float, together with dark-grey tremolitic material representing graphitic calcareous mudstone.

8.2.2 Structure

The Grampian and Appin group units form an ordered succession that dips between 20 and 45° to the south-east. Although minor folding has duplicated the succession locally, the sequence is essentially right way up and youngs to the south-east (Figure 6.17). The best examples of tight F2 folds and open to tight F3 folds are seen in the interbanded psammites and semipelites of the Grampian Group at the northern end of the section. Above the Allt an Doruis, at [NJ 168 2139], gritty quartzite beds and intervening semipelites are tightly folded, with the axes of tight recumbent F2 folds plunging gently to the east-north-east and axial planes dipping moderately to the south-east. A quartz mineral lineation also plunges gently to the east-north-east, near-coincident with the F2 axes. The fine S2 cleavage is best seen in semipelite units in the F2 hinges. Higher in the stratigraphy, very little evidence is seen for minor F2 folds, with only isolated examples reported. The F3 folds vary from open to tight and are also best seen in the mixed Grampian Group lithologies. Examples are recorded at the Allt an Doruis and around [NJ 1198 2109], where layers of calcsilicate rock show excellent NW-verging close F3 folds, whose axes plunge gently to the north-east. A penetrative axial plane crenulation cleavage that dips steeply to the south-east is developed in the adjacent semipelite layers. The F3 folds refold an earlier easterly plunging L2 lineation.

Although minor folds are rare in the Lochaber Subgroup rocks, several cleavage generations can be recognized in hand specimen and in thin section these show discordant relationships. In the laminated psammite-semipelite units of the Dalvrecht Slate Formation, an early fine-scale mica cleavage, S1, is preserved locally in the 0.5 to 2 mm microlithons between the dominant spaced muscovite-rich lamellae that form the main S2 spaced/crenulation cleavage. In some specimens a later cleavage, defined by muscovite laths, lies markedly discordant to the earlier fabrics. This S3 cleavage can relate to open to close minor folds. Generally all three cleavages dip more steeply than bedding. Garnets, where present, contain inclusion trails of the S1 cleavage and apparently pre-date the S2 cleavage. In the more-slaty units, by Bridge of Brown, minor F4 kink folds are also sparsely developed. Recorded F4 axes plunge gently east and south-west.

Peak metamorphic conditions were attained during the D2 deformation, and in this area they reached temperatures of 620 to 650°C and pressures of 8 to 8.5 kbar (Beddoe-Stephens, 1990). These conditions lie close to the upper limits of the lower amphibolite facies.

8.3 Interpretation

The Grampian Group rocks represent shallow-marine shelf-sands and subsidiary silts with material being repeatedly reworked. The presence of cross-bedding and slump structures attests to the presence of strong currents and at least locally, relatively rapid deposition. The transition to Appin Group rocks is marked by the incoming of more-intermixed psammite and semipelite and calcareous lithologies that make up the Lochaber Subgroup. It signifies basin shallowing and regression in this area with some possible emergent areas, although in the Northern Grampian Highlands, Banks (2005) has suggested that the semipelitic and pelitic elements represented more-distal deposition during a moderate transgression. The quartzitic units are interpreted as a product of reworking of the underlying succession, rather than input of additional sand material. The Fireach Beag Kyanite Gneiss, which forms a marker unit, represents aluminous mud and silt, possibly representing input of tropically weathered material derived from the nearby source area.

Elsewhere in the Dalradian succession, block uplift appears to have created local unconformities in the Lochaber Subgroup succession, and in extreme cases the entire subgroup is absent (see Treagus et al., 2013). Although the presence of gaps in the succession at Bridge of Brown cannot be ruled out, there is no evidence for significant gaps in the lithostratigraphy. The Fodderletter Calcareous Flag Formation occupies a similar position in the stratigraphy to the Leven Schist Formation of Glen Spean and Appin and the Baddoch Burn Striped Pelite of Glen Shee. It presages the incoming of the Ballachulish Subgroup, indicative of a more-widespread transgression that covered most of the upstanding blocks (Banks, 2005).

The Grampian–Appin group boundary throughout much of Perthshire is marked by a zone of very highly attenuated Appin and Argyll group rocks that form a major NNW-verging D2 shear-zone, termed the 'Boundary Slide' (see the *Allt Druidhe*, *Strath Fionan*, *Gilbert's Bridge* and *Glen Ey Gorge* GCR site reports). In those areas, the position of the slide might also reflect an original unconformity or a basement lineament. The tectonics of the North-east Grampian Highlands are somewhat different and shear-zones are found within several parts of the Grampian, Appin and Argyll group succession, mostly reflecting thrusting to the north-west during the major Grampian D2 event. Although the Grampian–Appin group boundary does represent a major lithological competence contrast, it is not coincident with a single, laterally continuous major shear-zone and in many places, particularly towards the north coast, there is no shearing or dislocation at all. At Bridge of Brown, although there is evidence of increased strain and even localized shearing in the Lochaber Subgroup rocks, no specific Boundary Slide-type structure is present.

8.4 Conclusions

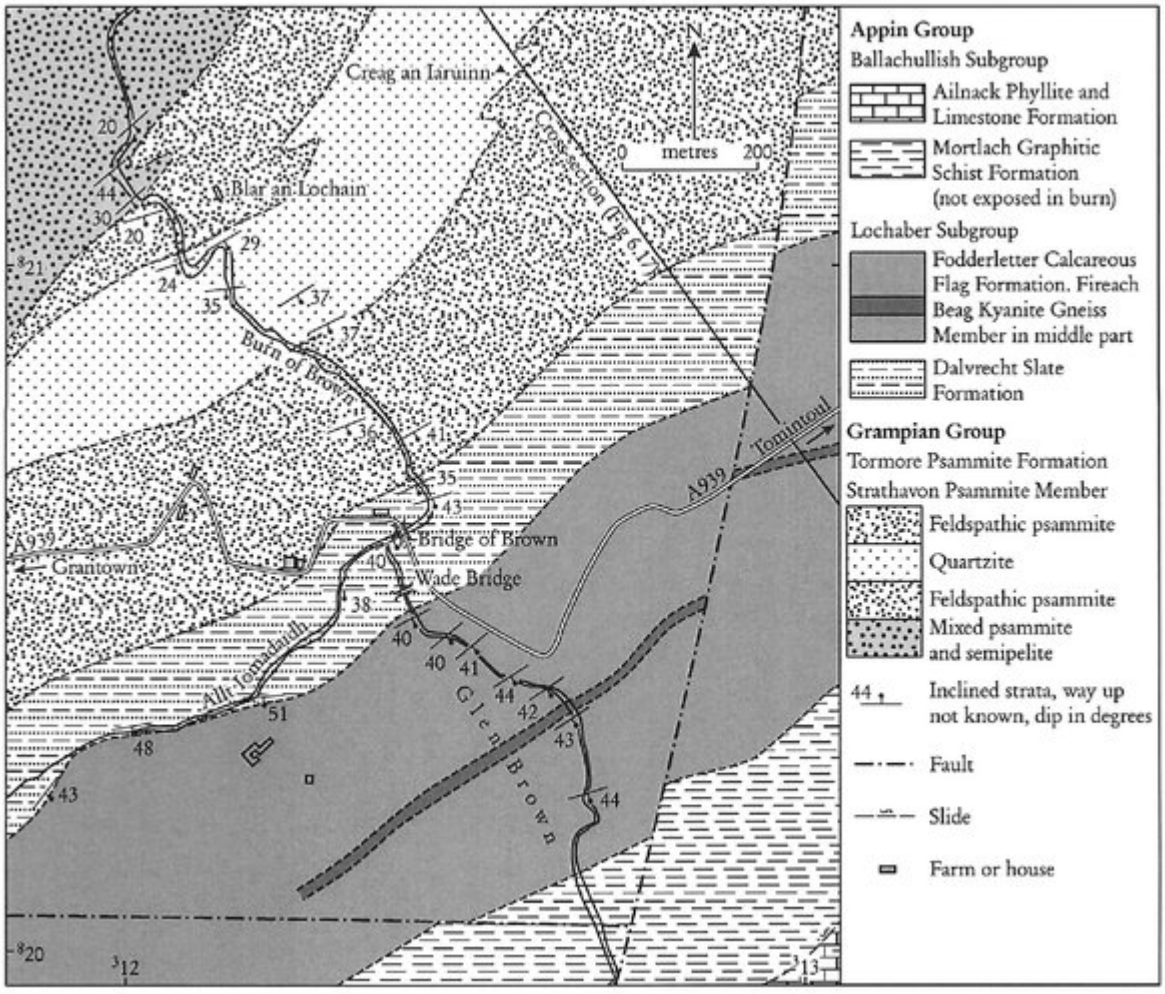
The Bridge of Brown GCR site demonstrates the transitional nature of the contact between Grampian Group and Appin Group strata in the North-east Grampian Highlands. Here, there is no major shear-zone or dislocation at this junction, in marked contrast to the situation in Perthshire, where the Boundary Slide is recognized.

Structurally the rocks are relatively simple in that the succession dips moderately to the south-east and the beds become younger in that direction. The Grampian Group rocks are psammites and subsidiary semipelites that show cross-bedding

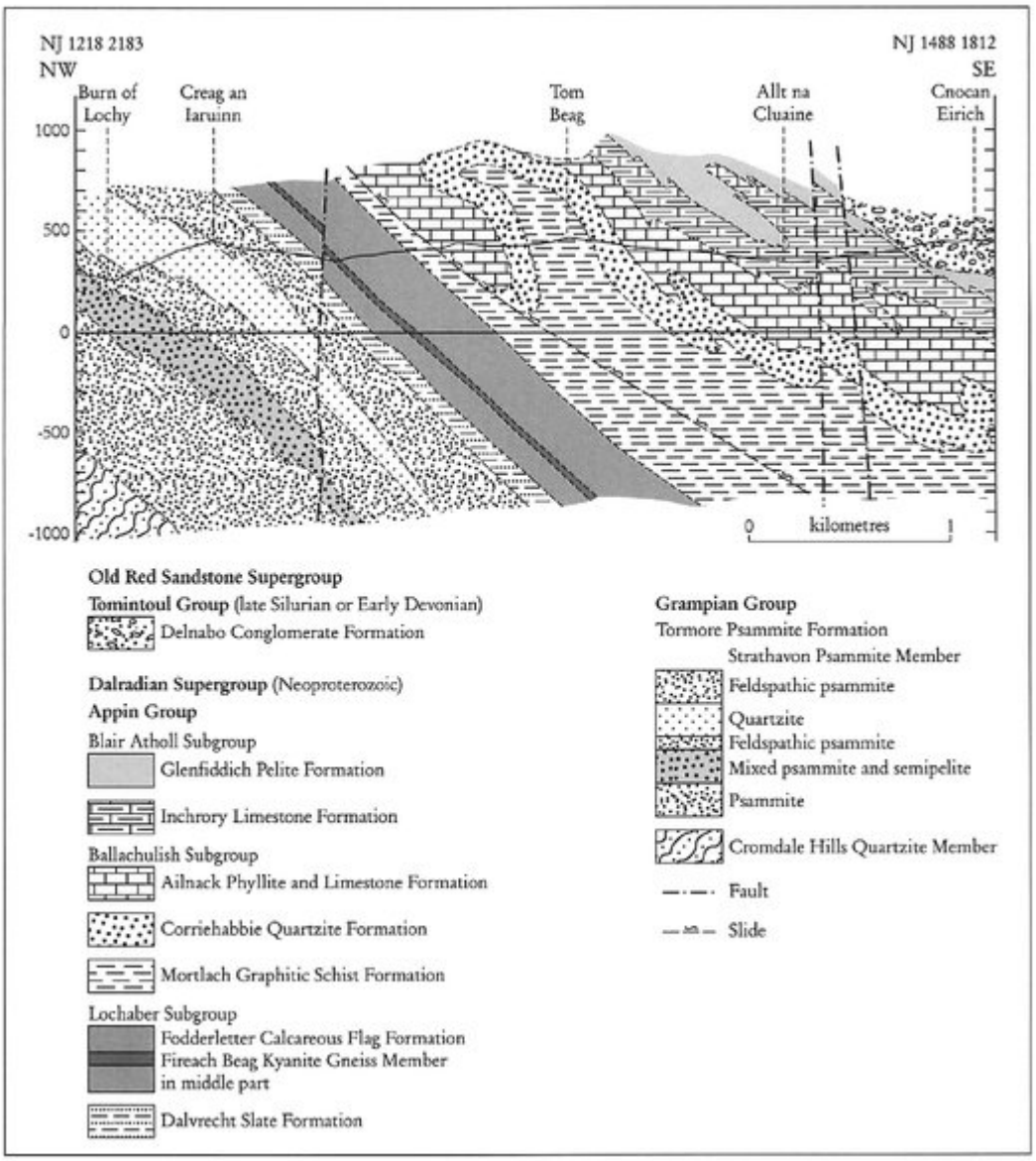
and slump structures indicative of shallow-marine shelf deposition. Where lithologies are mixed, two sets of folds and related cleavages are developed. They pass upwards into thinly interbedded psammites and semipelites with thin quartzites that mark the lowest beds of the Lochaber Subgroup. These beds are attenuated and show evidence of three cleavages and increased strain. They are succeeded upwards by calcareous semipelites and micaceous psammites with abundant bands and lenses of calcsilicate rock, minor graphitic pelite and some thin quartzite beds. These lithologies show very little internal structural complication but they do contain a prominent massive gneissose kyanite-muscovite-biotite-garnet semipelite unit that can be recognized as a marker bed in several parts of the North-east Grampian Highlands.

This site is complementary to the *Bridge of Avon* GCR site, which effectively extends the cross-section to the south-east. It also provides an important reference site between the complex geometry of the Boundary Slide in Perthshire and the enhanced stratigraphical sequence of the Banffshire Coast.

References



(Figure 6.16) Map of the area around Bridge of Brown, based upon BGS 1:10 000 Sheet NJ12SW (1991). The line of part of the cross-section in (Figure 6.17) is indicated.



(Figure 6.17) North-west–south-east cross-section across the area surrounding the Bridge of Brown and Bridge of Avon GCR sites. The line of section intersects (Figure 6.16) and passes to the south-west of (Figure 6.18).