3 Gilbert’s Bridge, Glen Tilt

[NN 881 699]–[NN 903 719]

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3.1 Introduction

The river section around Gilbert’s Bridge in Glen Tilt, Perthshire is a classic historical GCR site that provides good sections through the tectonized junction between the Grampian and Appin groups of the Dalradian. This junction, between the psammitic Struan Flags to the north-west of Glen Tilt and a pelite, semipelite, metalimestone and quartzite succession to the south-east, was formerly considered to be the Moine–Dalradian boundary. It is currently regarded as part of the Boundary Slide-zone, but its nature is a matter of considerable debate (see 1.2.1 in *Introduction*).

The first geological appraisal of Glen Tilt was made during the historic visit by James Hutton and Sir John Clerk of Eldin in 1785 in search of evidence for the intrusive nature of granite (see the *Forest Lodge* GCR site report in the *Caledonian Igneous rocks of Great Britain* GCR volume; Stephenson *et al*., 1999). A plan of the central part of the glen, drawn by Clerk, clearly shows the orientation of the strata and three concordant sills of ‘porphyry’ immediately downstream from Gilbert’s Bridge (Craig *et al*., 1978).

The results of the primary geological survey were published as 1” Sheet 55 (Blair Atholl, 1902) with an accompanying memoir (Barrow *et al*., 1905). Barrow’s interpretation (Barrow, 1904, figure 9) emphasized the importance of concertina folding and metamorphic recrystallization of part of the Dalradian to form the ‘Moine gneiss’. But it was Bailey (1925) who established that this is the site of a major junction between a very thick succession of Struan Flags and the structurally overlying Dalradian. He described the Dalradian succession, which is separated from the bulk of the Dalradian to the south-east by the Loch Tay Fault, as the ‘Blair Atholl Series of the Banvie Burn Belt’. He indicated a possible slide between the Banvie Burn Belt and the Struan Flags on his map but was unable to confirm its existence due to ‘lack of local evidence’. Its continuation in the Schiehallion area was later established as the Boundary Slide by Bailey and McCallien (1937), who described a fundamental structure, or decollement, separating complex folding in the Dalradian from simpler structures in the Struan Flags below. Pantin (1961), who introduced the simpler term Glen Banvie ‘Series’ for the ‘Blair Atholl Series of the Banvie Burn Belt’, found no evidence for sliding at Gilbert’s Bridge. However, Harris (1963) interpreted the junction to be a thrust slide carrying the Dalradian rocks to the north-west, and Thomas (1965, 1980) concluded that the Boundary Slide is associated with a tectonic schist equivalent to the Beoil Schist of the Schiehallion area (Rast, 1958) (see the *Strath Fionan* GCR site report in Treagus et al., 2013).

The Struan Flags have since been re-allocated to the Grampian Group and the Glen Banvie ‘series’ to the Appin Group, both of the Dalradian Supergroup (Harris *et al*., 1978). Although the junction is recognized as a zone of high strain (Smith, 1980), the amount of excision could be relatively small because a through succession from the Grampian Group into the Appin Group can be demonstrated nearby in the area around Schiehallion (Treagus and King, 1978; Treagus, 1999). The fact that the Ballachulish Subgroup is present on the southern side of Glen Tilt (Smith and Harris, 1976) also makes the tectonic break less important stratigraphically and the Glen Banvie ‘Series’ was correlated tentatively with the Lochaber Subgroup by Smith (1980). It has now been formally designated the Glen Banvie Formation.

3.2 Description

The section in Glen Tilt between Gilbert’s Bridge and Marble Lodge shows a clear and consistent relationship between the Struan Flags, now part of the Glen Spean Subgroup of the Grampian Group, and the younger Dalradian (Figure 6.7). The Grampian Group psammites, which are perfectly exposed in the along-strike river section, have a characteristic

parallel flaggy banding which is largely tectonic; their junction with rocks of the overlying Glen Banvie Formation is strongly attenuated. Most of the attenuation appears to be flattening, although a weak down-dip lineation is evident locally and the axial planes of early (F2) folds have been drawn into parallelism with the main foliation.

Sections across the Boundary Slide are exposed in the River Tilt immediately below Gilbert's Bridge [NN 8812 7005], at the junction of the Tilt with the Allt Fas-charaidh [NN 8832 7035], near its junction with the Allt Mhairc [NN 8902 7118] and at Coille Sron an Duine [NN 8950 7164]. At all of these localities, approaching the Boundary Slide from the Grampian Group, the flagginess of the psammites increases and the banding in them becomes closer spaced and parallel. Coarse white mica is concentrated on the flaggy surfaces. At the slide itself, about 1 m of coarse muscovite-biotite schist has a platy aspect with parallel quartz lenticles. However, similar bands of schist occur within the Glen Banvie Formation above, together with mylonitized metalimestones and strongly deformed quartzites, so that the formation as a whole appears to constitute a high-strain zone. The strong fabric in the rocks near the slide is best appreciated where small quartz pebbles with elongation ratios of 6:1 occur in the quartzites. The elongation lineation is fairly uniform, plunging at about 30° to the south-east.

On the south-east side of Glen Tilt, the Glen Banvie Formation comprises intercalated metalimestones, calcsilicate rocks, schistose pelites and semipelites, psammites and quartzites. A strong foliation has effectively destroyed any sedimentary structures. Alumina-rich calcsilicate rocks with pink microcline are particularly characteristic of the lower part of the formation. Epidote, actinolite and diopside are present locally in these rocks; plagioclase is less common, as is quartz. Downstream from Gilbert's Bridge at [NN 881 698], pale-grey crystalline metalimestones are interbedded with quartz-plagioclase-mica schists. The grey metalimestones contain sparse graphite dust and impure types have tremolite and clinozoisite-epidote or zoisite. Some of the very fine-grained metacarbonate bands are mylonitic. Elsewhere, white metalimestones, up to 2 m thick, are fairly common and several contain calcsilicate minerals. A well-known example of the latter type is the 'Glen Tilt Marble', which was quarried for a short time at [NN 9027 7186]. This decorative marble has pale and darker green blotches of serpentine mineral (antigorite) elongated within the foliation. Antigorite is a common alteration product of tremolite, diopside and forsterite. White mica (?talc) lies in the foliation but pyrite is disseminated within the marble. Dolomitic metalimestones are also present and are composed of up to 90% fibrous tremolite.

In the central part of the Glen Banvie Formation, a quartzite unit, up to 300 m thick, forms a persistent marker (Figure 6.7). Within the quartzite are local feldspathic bands and thin beds of dark pyritic semipelite. Above and below the quartzite are pelites composed of quartz-muscovite-biotite-plagioclase, with or without garnet and kyanite. Some of the pelites are intercalated with fine-grained quartzites on a centimetre scale; others are graphitic and many are retrogressed to chloritic schists. Slightly calcareous pelites contain zoisite, clinozoisite and minor calcite. Near the Sron a' Chro Granite, andalusite porphyoblasts overprint the earlier pelitic assemblages.

The Glen Banvie Formation contains two types of amphibolite that are both considered to have been intrusions; thin sheets of dark-green hornblende schist and larger amphibolitic bodies. The hornblende schists contain up to 75% hornblende, minor plagioclase, quartz, garnet, titanite and iron oxides; the larger bodies additionally contain thin leucocratic bands rich in pinkish sericitized plagioclase, quartz and epidote.

Two sheets of foliated granite are exposed in Glen Tilt about 30 m above the Boundary Slide. They are up to 2 m thick and are roughly concordant with the foliation/banding in the Glen Banvie Formation. The reddish biotite granites show a granoblastic texture of quartz, microcline and albite, and a parallel alignment of sparse biotite laths. Minor secondary muscovite is present and biotite is locally retrogressed to chlorite. At [NN 895 716] by the River Tilt, xenoliths of biotite semipelite (0.15 to 1.2 m long) possess a foliation that is oblique to the one in the granite.

The Glen Banvie Formation has been subjected to three major phases of deformation (Smith, 1980). It typically has a strong flaggy foliation dipping at about 40° to the south-east, which is a composite S1+S2 fabric. Boudinage of the more-competent bands within the main foliation is common and is accompanied by flexing in the less-competent units. Most of the long axes of boudins trend north-east perpendicular to a stretching lineation and both are considered to relate to D2. It is likely that the foliation of the granite sheets is also related to D2, so that the oblique fabric preserved in the xenoliths is probably S1 (c.f. Bradbury *et al*., 1976; Tanner and Leslie, 1994; Tanner, 1996). A poorly developed local crenulation cleavage is assigned to D3. Local brittle deformation, fracturing and kink bands are related to sinistral

movement on the Loch Tay Fault, a branch of which lies about 0.5 km south-east of Gilbert's Bridge (Treagus, 1991).

The peak regional metamorphism is of amphibolite facies, as is indicated by the presence of kyanite-grade assemblages in the pelites. Estimates of pressure and temperature on garnet rims from the Glen Tilt area indicate 9–12 kbar and 550–620° C (Wells and Richardson, 1979). Recrystallization of minerals such as the amphiboles in the hornblende schists (post D2) and later partial retrogression of the rocks is common.

3.3 Interpretation

There are two issues concerning the geology of the central section of Glen Tilt that have generated much debate in the past and are not as yet fully resolved. The first is the stratigraphical affinity of the Glen Banvie Formation and the second is the nature and regional significance of the high-strain zone, the so-called Boundary Slide, that lies between this and the structurally underlying 'Struan Flags'.

The varied lithological assemblage that comprises the Glen Banvie Formation, with its distinctive calcsilicate and metacarbonate rocks, resembles parts of the Appin Group. However, it is difficult to correlate with the Dalradian succession because it lies between the Boundary Slide and the Loch Tay Fault. A calcsilicate-bearing metalimestone, about 3 m thick, downstream from Gilbert's Bridge was formerly correlated with the unit now known as the 'Dark Limestone' of the Blair Atholl Subgroup (Barrow, 1904). Further metalimestone intercalations were considered by Barrow to be folded repetitions of this metalimestone, and in places it was seen to be in contact with the Struan Flags and other rock types such as dark schist and red microcline-rich rock. This was explained as a tightly folded local unconformity of the metalimestone on the Moine rocks (Barrow, 1904). However, Bailey (1925) measured the section downstream from Gilbert's Bridge and concluded that the intercalations are not the Struan Flags or the 'Dark Limestone', but are all part of his 'Blair Atholl Series of the Banvie Burn Belt'. He suggested that the rocks of the Banvie Burn Belt could be equated with his 'Pale Group', i.e. the upper part of what is now the Blair Atholl Subgroup, but he was not certain because of the structural complexity in Glen Tilt. Pantin (1961) made a similar correlation, although the presence of local graphitic bands and a thick quartzite unit are not consistent with this interpretation. A suggestion by Thomas (1965) that the central quartzite unit occupies a synclinal core, and hence a higher stratigraphical level, was refuted by Smith (1980), who found no structural or stratigraphical evidence for this hypothesis.

Although the outcrop of the Glen Banvie Formation is entirely bounded by faults, its position between the Grampian Group psammites and the upper part of the Appin Group, together with its overall lithology, suggests that it could be part of the Lochaber Subgroup (Smith, 1980) e.g. equivalent to the calcareous upper parts of the Leven Schist. It could alternatively represent the Lochaber Subgroup and the lower part of the Ballachulish Subgroup in a condensed sequence (c.f. Treagus, 1999, 2000 in the Schiehallion area).

The importance of the Boundary Slide was stressed by Thomas (1980), who interpreted the presence of a muscovite-rich schist to be a result of the sliding (c.f. the Beoil Schist of the Schiehallion area). According to Thomas, the slide probably developed during the evolution of the primary F1 nappes but was re-activated locally during later deformation. He described it as a dislocation between the Appin Group succession of the Tay Nappe and the Grampian Group rocks beneath, which form a primary south-east- and downward-facing Atholl Nappe. However, Smith (1980) inferred that, because tight to isoclinal F2 folds had their limbs cut out and were sheared locally along their axial planes during D2, the age of the major sliding is D2. The Glen Banvie Formation as a whole is strongly deformed and there are numerous minor slides between the contrasting lithologies, such as the one that Barrow (1904) interpreted as an unconformity. This fact, coupled with the sharp contrast in stratigraphy between the formation and the Dalradian succession to the south-east, led Smith (1980) to the conclusion that the Loch Tay Fault might obscure another major slide forming the south-eastern boundary to the Glen Banvie Formation. He also suggested that the Grampian Group psammites acted as a competent block during deformation and might have influenced the location of the Loch Tay Fault close to the Boundary Slide.

On a regional scale, the age, nature and importance of the Boundary Slide are still debatable issues. Within the northern Grampian Highlands, Appin Group rocks rest on various levels of the Grampian Group (Smith *et al*., 1999, Highton *et al*., 1999), and in the Central Grampian Highlands, large parts of the Appin and Argyll group succession are absent where

high-strain zones are present just above the Grampian Group (Roberts and Treagus, 1979). So it is even possible that the Boundary Slide and/or related structures could conceal orogenic unconformities at various stratigraphical levels, which could eventually help to explain such outstanding problems as the apparently wide age span between older parts of the Grampian Group at *c.* 730 Ma and the top of the Dalradian, which contains an Early Cambrian (*c.* 515 Ma) fauna (e.g. Prave, 1999; Dempster *et al*., 2002; Hutton and Alsop, 2004). See Stephenson et al., 2013a for further discussion.

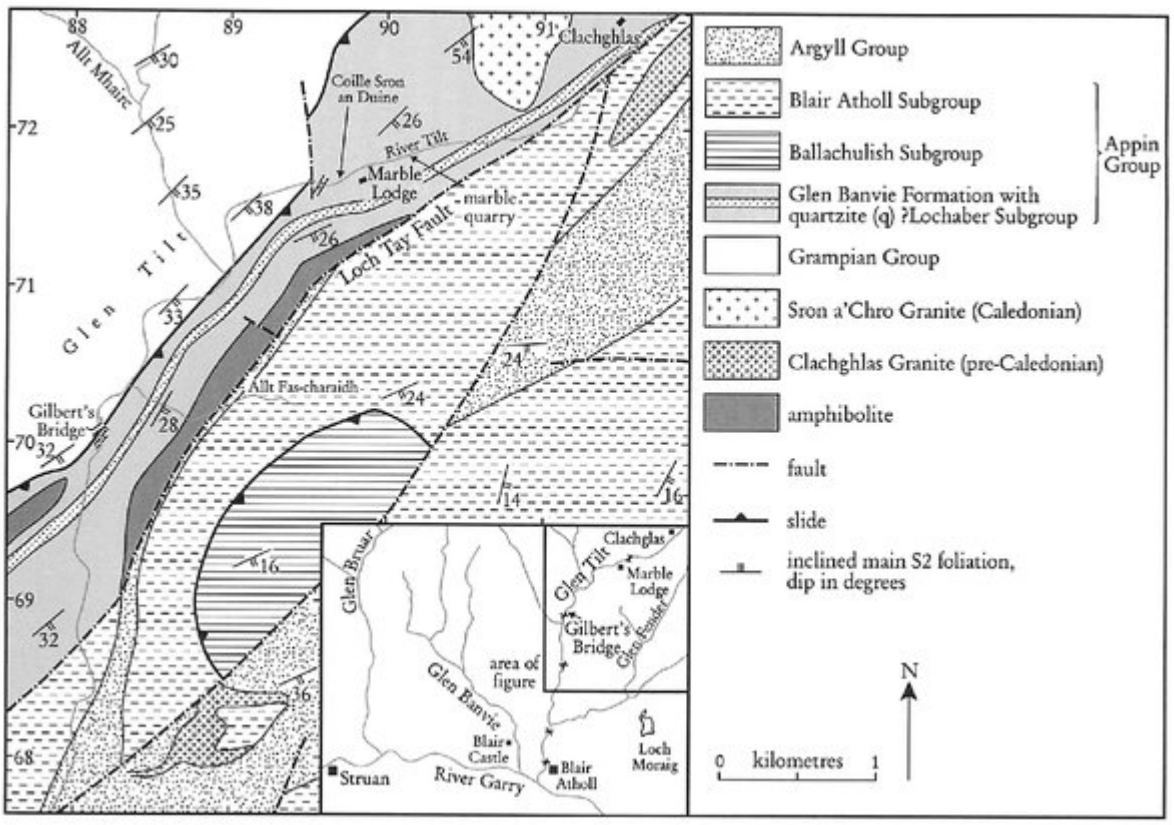
3.4 Conclusions

The River Tilt at Gilbert's Bridge provides a classic section through the junction between the Grampian Group and the Appin Group successions of the Dalradian Supergroup. This junction, usually referred to here as the Boundary Slide, was originally regarded as a major tectonic dislocation or decollement between the highly variable lithologies of the Dalradian to the south-east and the structurally underlying, dominantly psammitic succession to the north-west that was formerly regarded as part of the Moine. Subsequent work has failed to find specific evidence for a major dislocation or for significant excision of strata. However, the junction does occur within highly deformed rocks and the Boundary Slide, at least in this area, is presently interpreted as a high-strain zone related to the D2 phase of deformation.

The problem is compounded in Glen Tilt by uncertainty over the stratigraphical affinities of the strata that lie structurally above the Boundary Slide but separated from the main Dalradian succession to the south-east by the Loch Tay Fault. These lithologically variable strata, termed the Glen Banvie Formation and including some distinctive metacarbonate and calcsilicate rocks, are currently assigned tentatively to part of the Lochaber Subgroup. If this correlation is correct, there could be no significant stratigraphical break here at the Boundary Slide between the Grampian Group and the lower part of the Appin Group.

No matter whether the Boundary Slide is a major dislocation or merely a high-strain zone focused upon the junction between two successions of markedly different competence, it does constitute a major boundary throughout much of the Grampian Highlands. The section at Gilbert's Bridge is one of the best exposed and the conclusions drawn from this GCR site, however tentative, have broader implications for the possible presence or absence of tectonic and/or stratigraphical breaks elsewhere in the Dalradian succession. It is therefore of national importance.

References



(Figure 6.7) Map of the area around the Gilbert's Bridge GCR site, based upon the BGS 1:50 000 Sheet 55E (Pitlochry, 1981).