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The Dalradian rocks of the northern Grampian Highlands of Scotland

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ABSTRACT

The northern Grampian Highlands are dominated by the outcrop of the Grampian Group, together with infolds and structural outliers of Appin Group strata and inliers of pre-Dalradian 'basement', consisting of Badenoch Group metasedimentary rocks. The south-eastern limit of this mountainous region corresponds with the regionally continuous Grampian Group-Appin Group boundary, which in the south is marked by a high-strain zone corresponding to the Boundary Slide of some authors. The more arbitrary southern boundary runs north-west from Blair Atholl along the A9 road and then westwards to Fort William.

The Neoproterozoic-age Grampian Group siliciclastic succession accumulated during several transgressive and regressive cycles in multiphase ensialic rift basins. The Badenoch Group constitutes the crystalline floor to those basins and had experienced amphibolite-facies metamorphism, migmatization, gneissification and deformation between *c.* 840 and 800 Ma, prior to deposition of the Dalradian strata. In contrast, evidence for only 470–450 Ma Caledonian orogenic events is found at higher structural levels in the Grampian and Appin group successions. Locating and understanding the nature of the contact between the basement gneisses and the Dalradian cover sequence has long been a major challenge of Highland geology. Recent research has argued that not only is a rift-basin architecture evident from the patterns of Neoproterozoic stratigraphy, but also that it played a significant role in influencing the geometry of the superimposed Caledonian deformation, with the basin infill buttressed against its margins or intrabasinal 'highs'.

The GCR sites in this region preserve important evidence of cover-basement relationships, patterns of punctuated deposition, and onlapping sequences. The effects of both pre-Caledonian and Caledonian deformation and metamorphic events are also well represented. Despite the deformation and metamorphism, spectacular sedimentary structures are visible at several of the GCR sites and there is evidence of the earliest recorded glacigenic sediments in the Neoproterozoic rocks of the British Isles.

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1. Introduction (A.G. Leslie)

The northern Grampian Highlands are dominated by a widespread and thick succession of Neoproterozoic siliciclastic deposits referred to as the Grampian Group (Fig. 1). Most interpretations of the regional geological relationships have suggested that the strata were deposited upon an orogenic unconformity, now largely obscured by a zone of ductile shearing at or near the base of the group (Piasecki and van Breemen, 1979b, 1983; Piasecki, 1980; Piasecki and Temperley, 1988a and references therein). These interpretations were based upon structural and metamorphic contrasts recognized between rocks referred to an older 'Moine-like' crystalline basement of probable Grenvillian age and termed the 'Central Highland Division', and a cover sequence referred to as the 'Grampian Division' or Grampian Group. The basement rocks apparently underwent amphibolite-facies migmatization, gneissification and deformation prior to deposition of the cover sequence. While lithologically similar to the Moine Supergroup of the Northern Highlands, and formerly termed the 'Younger Moine', the Grampian Group was included within the Dalradian Supergroup by Harris et al. (1978) on the basis of the apparent stratigraphical, structural and metamorphic continuity south-east of the Great Glen Fault in the Grampian Terrane (Harris et al., 1994; Stephenson and Gould, 1995; Strachan et al., 2002). Locating and understanding the nature of the contact between the rocks of the Northern Highlands and Grampian terranes has long been a major challenge of Highland geology.

An alternative model viewed the rocks of the northern Grampian Highlands as part of a single stratigraphical succession in which a regional metamorphic front separates the supposed basement and cover sequences (Lindsay et al., 1989). Such a model was not however supported by more-recent radiometric studies that confirmed the existence of Neoproterozoic tectonothermal events (*c.* 840–800 Ma) in parts of the northern Grampian Highlands (Noble et al., 1996; Highton et al., 1999), even though only Caledonian orogenic events (470–450 Ma) are known at higher levels in the Dalradian succession. Such a paradox, whereby comparable studies recognized discrete tectonothermal events in different parts of an apparently continuous stratigraphical succession, but were unable to separate or define the limits of these events, continues to be one of the key problems in Highland geology.

A lithostratigraphical framework has been erected for the Grampian Group in the western and south-western parts of the northern Grampian Highlands, despite the problems of correlation across major structures, polymetamorphism and the absence of biostratigraphical control (Glover and Winchester, 1989; Glover et al., 1995; Key et al., 1997). Those authors described an evolving depositional basin in which marine and locally terrestrial deposition occurred within multiphase ensialic rift basins, during several transgressive and regressive cycles (Glover et al., 1995; Glover and McKie, 1996). Smith et al. (1999) extended the lithostratigraphical approach and integrated detailed mapping with geophysical modelling to define a series of basin-bounding structures in the northern Grampian Highlands (Fig. 2). Current research continues to refine and improve the understanding of this depositional framework (Banks and Winchester, 2004; Banks, 2005; Banks et al., 2007).

The Grampian Group sediments were deposited in NE- to SW-trending marine basins formed during a major phase of Neoproterozoic rifting. These basins extended rapidly and accumulated up to 5 km of turbiditic deposits, possibly within 20–30 Ma (Ryan and Soper, 2001). Later thermal subsidence is suggested by the regional development of shallow marine-shelf environments and could have occupied a similar length of time. The margins to these basins are characterized by lateral facies and thickness changes, stratigraphical omission and onlap relationships of both Grampian and Appin group strata onto a basement of predominantly gneissose rocks that records the older, pre-Caledonian tectonothermal history. Stratigraphical relationships are summarized in Fig. 3, which is based largely upon Smith et al. (1999).

Smith et al. (1999) and Robertson and Smith (1999) argued that the basin architecture thus determined is not only reflected in the patterns of Neoproterozoic sedimentation, as would be expected, but also played a significant role in predetermining the geometry of the superimposed orogenic deformation in the northern Grampian Highlands. For example, the Geal-charn–Ossian Steep Belt has been re-interpreted by those authors to reflect buttressing of basin infill against the architecture of the basin margins or any intrabasinal 'highs'. Such analysis of preserved 'cover-basement' relationships led Smith et al. (1999) to propose that a significant stratigraphical and sedimentological break does indeed exist at the base of Grampian Group, much in the manner originally suggested