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The Dalradian rocks of the north-east Grampian Highlands of Scotland

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ABSTRACT

The north-east Grampian Highlands, as described here, are bounded to the north-west by the Grampian Group outcrop of the northern Grampian Highlands and to the south by the Southern Highland Group outcrop in the Highland Border region. The Dalradian succession therefore encompasses the whole of the Appin and Argyll groups, but also includes an extensive outlier of Southern Highland Group strata in the north of the region. The succession includes shallow-marine sequences, glacigenic deposits at two stratigraphical levels, the earliest evidence for volcanism in the Dalradian, a later major development of basaltic and picritic sub-marine lavas, and thick turbiditic sequences.

In the south, the Grampian–Appin group boundary is a high-strain zone, with no obvious dislocation or stratigraphical excision, which was formerly termed the Boundary Slide. Shear-zones at higher structural levels are associated with pre-tectonic granites, such as the Ben Vuirich Granite, which have been dated at *c.* 600 Ma and hence place limits on the timing of sedimentation, deformation and metamorphism. The region is divided from north to south by a major zone of shearing and dislocation with associated igneous intrusions, termed the Portsoy Lineament. To the west of the lineament, the stratigraphy is more-or-less continuous along strike with that of the central Grampian Highlands. D1, D2 and D3 structures extend from the Tummel Steep Belt north-eastwards throughout this area. The stratigraphical succession is broadly continuous across the Portsoy Lineament but to the east, in the Buchan Block, correlations are more tenuous and do not extend below subgroup level. High-grade migmatitic paragneisses were once interpreted as pre-Dalradian basement but they are now assigned to the Crinan Subgroup, within the Dalradian succession. Within the Buchan Block the outcrop pattern is controlled by two broad, open, post-metamorphic folds, the Turriff Syncline and the Buchan Anticline.

The Buchan Block is the international type area for the high-temperature/low-pressure Buchan-type regional metamorphism. To the south and west, this passes into higher pressure Barrovian-type metamorphism. South of Deeside, metamorphic conditions reached 820 °C and over 8 kbar, well into granulite facies and the highest recorded in the Grampian Terrane. The detailed relationship between the high heat-flow and the emplacement of large bodies of basic and silicic magma is a matter of ongoing research. Plutons of the north-east Grampian Basic Suite, emplaced at *c.* 474–470 Ma, during or shortly after the peak of metamorphism and the D3 deformation, provide key evidence for the timing of the Grampian orogenic event.

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1. Introduction (D. Stephenson, J.R. Mendum and D.J. Fettes)

The north-east Grampian Highlands are defined here largely by two geological boundaries (Fig. 1). To the north-west, the boundary with the northern Grampian Highlands is taken at the Grampian–Appin group junction, which to the south of the Cairngorm Pluton is marked by the Boundary Slide or the Loch Tay Fault; farther north, a rapid stratigraphical transition is present, albeit with some local shearing. To the south, the boundary with the Highland Border region is taken at the top of the Loch Tay Limestone Formation between Pitlochry and the Mount Battock Pluton, and then along the projected continuation of the Argyll–Southern Highland group junction on Deeside, east to Aberdeen. The short south-western boundary with the central Grampian Highlands is the valley of the rivers Garry and Tummel, as followed by the railway and A9 road, between Pitlochry and Blair Atholl.

The region is divided into three distinct geological areas by two of the major lineaments of the Grampian Highlands (see Stephenson et al., 2013). The east–west Deeside Lineament, to the north of the River Dee, is marked by a line of large granitic plutons with only narrow intervening outcrops of Dalradian strata. The Dalradian succession is generally coherent across this essentially late-Caledonian lineament, although some facies changes have been recognized and many of the formation names change. Hence it is a useful boundary for descriptive purposes, at least in upper Deeside. The north–south Portsoy–Duchray Hill Lineament is an older structure that was active during Dalradian sedimentation and was a locus for basic magmatism and major tectonic dislocation during the Caledonian Orogeny (Fettes et al., 1986a; Goodman, 1994). It forms a fundamental stratigraphical and structural boundary stretching from the north coast at Portsoy to Glen Muick on south Deeside. To the south-west of the Lochnagar Pluton, it is less well defined but marks changes in stratigraphy that were recognized by Barrow (1912). It is coincident with the later, brittle Glen Doll Fault for some distance but turns towards the south-west, along strike, and peters out beyond Duchray Hill in Glen Shee.

To the west of the Portsoy–Duchray Hill Lineament, Dalradian successions and structures can be traced into those of the northern and central Grampian Highlands with little difficulty. A generally eastward-younging stratigraphical succession does seem to continue, albeit with some attenuation and disruption, across the lineament and elements of the structural history are common to both sides. However, to the east of the lineament only tentative stratigraphical and structural correlations can be made with higher parts of the Dalradian succession elsewhere and this area seems to have had, to some extent, a distinctly different sedimentological, structural and metamorphic history. It is commonly referred to as the 'Buchan Block' and has been regarded by several authors as a tectonically juxtaposed separate subterrane. Regional gravity and magnetic anomalies, which show steep gradients coincident with the Portsoy–Duchray Hill Lineament, suggest that there are fundamental differences in the sub-Dalradian basement (Trewin and Rollin, 2002). The southern margin of the Buchan Block is difficult to define either geologically or geophysically. It extends southwards at least to the Deeside Lineament, where the geophysical anomalies are subsumed by the plethora of large granitic plutons. To the south of Deeside the lithologies and structures gradually merge with those of the Highland Border region.

Early interpretations divided the succession in the Buchan Block into a 'Banff division', restricted to a 'Banff Nappe', separated by a slide from an underlying, more-typical Dalradian sequence, termed the 'Keith division' (Read, 1923, 1955; Read and Farquhar, 1956). Although some authors have also suggested that parts of the area are allochthonous (Sturt et al., 1977; Ramsay and Sturt, 1979), most current interpretations have attempted to correlate the stratigraphical succession in broad terms (i.e. at subgroup level) with Argyll and Southern Highland group successions farther to the south-west (Harris and Pitcher, 1975; Ashworth, 1975; Harte, 1979; Treagus and Roberts, 1981; Ashcroft et al., 1984; Fettes et al., 1991; Harris et al., 1994; Stephenson and Gould, 1995).

Several other lineaments and dislocations in the north-east Grampian Highlands have been recognized as being of more than just local significance. Some have contributed significantly to debates over the timing of Caledonian and earlier deformation, and their associated intrusions have provided material for precise radiometric age determinations that now define magmatic events both at 600 and 470 Ma.

1.1. Stratigraphy

1.1.1. Pitlochry–Blair Atholl area to Deeside

In this area, most of the Appin and Argyll group successions can be correlated precisely with that of the adjoining central Grampian