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# Garron Point to Slug Head

[NO 893 877]–[NO 886 873]

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## Introduction

Mafic lavas, mafic and ultramafic intrusions and associated sedimentary rocks of the Highland Border Complex (HBC) are well exposed and readily accessible along the rugged, indented coastline between Slug Head and Garron Point, about 1 km NE of Stonehaven. At this site, the HBC crops out over about 1 km of strike, with an outcrop width of about 200 m, forming the most easterly and best exposed single occurrence of HBC rocks in Scotland. The complex is reverse-faulted against metagreywackes, grits and pelites of the Dalradian Southern Highland Group and is overlain unconformably by Old Red Sandstone facies, terrigenous clastic sediments of the Cowie Formation (Stonehaven Group), which are of Wenlock (Silurian) age.

The HBC rocks at Stonehaven were assigned a possible Arenig age on the first Geological Survey maps of the area (Sheet 67, Stonehaven), but Campbell (1911, 1913) provided the first detailed accounts of the rocks and described palaeontological evidence for their being Late Cambrian in age. The palaeontological evidence for the age of the rocks was based largely on brachiopod fragments found in the black shales intercalated with the lavas in Craigeven Bay. Although the faunal assemblages suggested a Late Cambrian age, Peach and others in the Geological Survey and Anderson (1947) considered the rocks to be Arenig or Caradocian in age, based on comparison with similar faunal assemblages in the Southern Uplands and the Stinchar Limestone of the Girvan district. Doubt was cast on the acceptability of the fossils from Craigeven Bay when Bulman and Rowell concluded that the identification of a comparable fauna from Aberfoyle was unreliable (Institute of Geological Sciences, 1963). However, more recent palaeontological work by Curry and colleagues (Curry *et al.*, 1982; Curry *et al.*, 1984; Ingham *et al.*, 1985) has restored an Ordovician age for at least part of the HBC elsewhere.

Campbell (1913), in collaboration with Peach and others of the Geological Survey, identified the contact between the HBC and the Dalradian rocks as the Highland Boundary Fault, which previously had been placed at the boundary between the HBC rocks and the overlying Old Red Sandstone facies Silurian rocks. They recognized that the Silurian sedimentary rocks are unconformable on the HBC, despite local modification of the unconformity by faulting.

The petrogenesis of the pillow lavas and associated igneous rocks has been studied by Bloxam (1982).

## Description

The Highland Border Complex is dominated largely by meta-igneous rocks at Stonehaven. Although metamorphosed to lower greenschist facies, extensively sheared and even phyllitic in places, spilitized mafic pillow lavas are generally well preserved (Campbell, 1913; Gillen and Trewin, 1987, plate 17) and clearly show the way-up, younging to the north. The rocks within the complex dip very steeply to the north and the pillow lavas become more intensely sheared and boudinaged northwards towards the tectonic contact with the Dalradian at the Highland Boundary Fault. The geological relationships are summarized in (Figure 2.18) and illustrated in (Figure 2.19).

The vesicular character of the pillow lavas is still recognizable and variolitic textures are commonly developed. Relict basaltic textures are preserved in places, although the development of epidote aggregates destroys most of the original igneous textures; fresh colourless calcic augite is occasionally preserved. Geochemical evidence from the pillow lavas suggests oceanic tholeiite affinities (Bloxam, 1982). Small, irregular doleritic and gabbroic intrusions in the pillow lavas are common on Garron Point.

A distinctive, orange-coloured, dolomitized and silicified serpentinite occurs along the Highland Boundary Fault and associated splays at Garron Point and is the most northerly unit of the HBC at Stonehaven. The serpentinite is well-seen in Craigeven Bay and over the headland on to Garron Point and is up to 15 m thick. The conspicuous colouration is imparted by iron in the dolomite. The serpentinite also contains nodular inclusions of serpentinitized gabbro. Bloxam (1982) records that the inclusions are difficult to distinguish from the serpentinite itself, being much more highly altered than the mafic intrusions outside of the serpentinite. The feldspars are now albite and the mafic minerals are largely replaced by hornblende, chlorite and serpentine.

Associated with the lavas and mafic intrusions are red and black cherts, including parallel-laminated black cherts with abundant pyrite, and siliceous siltstones and mudstones (Campbell, 1913; Henderson and Robertson, 1982). These occur as intercalations between flows or as lenticular masses, possibly filling the space between adjacent pillows. It is from these rocks that the faunal assemblage, dominated by brachiopods, was recovered. Grading indicates younging to the north, consistent with the younging indicated by the pillow lavas.

## Interpretation

The lithological assemblage comprising the Highland Border Complex between Slug Head and Garron Point represents fragments of oceanic crust formed during the early Ordovician and tectonically emplaced against the Dalradian. The oceanic volcanotectonic setting for the rocks is clear from the lithological assemblage at Stonehaven. Although some of the mudstones and siltstones represent terrigenous material brought in by distal turbidites, most of the cherts were considered to be pelagic (Henderson and Robertson, 1982).

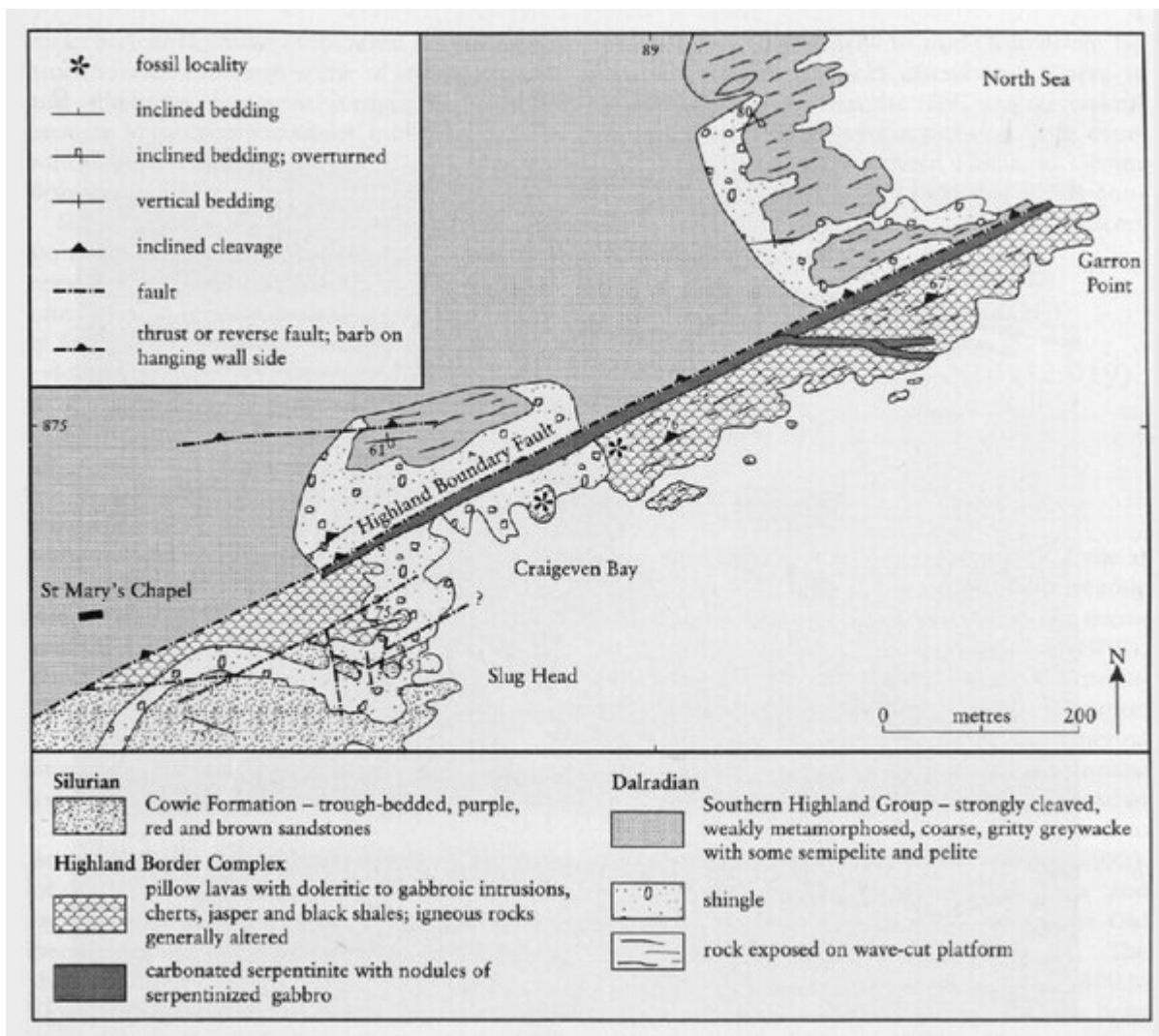
Bloxam (1982) suggested that the mafic inclusions in the serpentinite could be disrupted remnants of sheets intruded into the serpentinite or could have been incorporated tectonically from adjacent rocks. On the petrographical evidence, it appears that both the ultramafic protolith to the serpentinite and the mafic intrusions were serpentinitized after the intrusion and albitization of the metamorphic rocks. By analogy with Ballantrae and similar rocks in California, Bloxam (1982) considered that the ultramafic protolith was probably emplaced as 'a low temperature 'mush' and/or solid tectonic slices caught up in the Highland Border 'melange'. Henderson and Robertson (1982) considered that the whole of the HBC was emplaced tectonically.

The radiometric age of the HBC at Stonehaven remains undetermined. The faunal assemblages elsewhere in the HBC have Laurentian affinities and range in age from Arenig to possibly Llandeilo. However, the age of the HBC at Stonehaven is poorly constrained by the palaeontology and an Ordovician age has been assigned largely by analogy with the age derived from the faunal assemblage in the Dounans Limestone of the Highland Border Complex at Aberfoyle (e.g. Curry *et al.*, 1982; Ingham *et al.*, 1985).

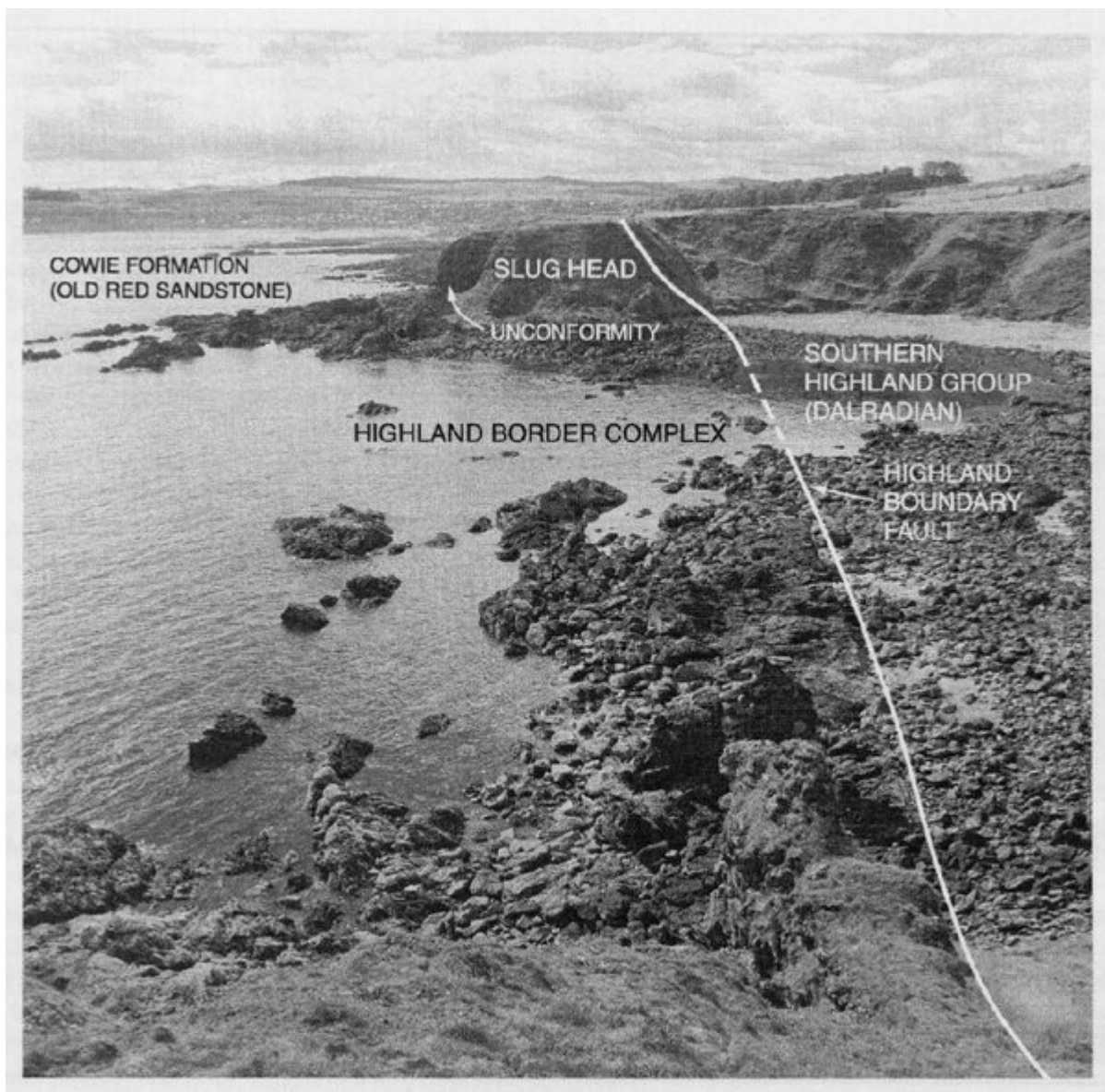
## Conclusions

The Stonehaven section provides one of the most extensive outcrops of igneous rocks in the Highland Border Complex, an understanding of which is an essential part of any tectonic interpretation of the Scottish sector of the Caledonian Orogen. This enigmatic assemblage represents remnants of ocean crust, consisting chiefly of metamorphosed tholeiitic pillow lavas with intercalated cherts, siltstones and mudstones. The complex also contains subordinate gabbroic and doleritic intrusions. Associated spatially with these rocks is a carbonated and silicified serpentinite with nodules of serpentinitized gabbroic rocks; serpentinitization occurred after the intrusion of the gabbros. The age of the HBC at Stonehaven is not determined, but is likely to be early- to mid-Ordovician, by analogy with HBC rocks elsewhere. There is general agreement that the HBC was tectonically emplaced into its current position. It is overthrust by Dalradian Southern Highland Group rocks to the north and is overlain unconformably to the SW by Old Red Sandstone facies rocks of Wenlock (Silurian) age.

## References



(Figure 2.18) Map of the Garron Point to Slug Head area, Stonehaven. Based on BGS 1:10 000 Sheet NO88NE (1996).



(Figure 2.19) The Highland Border Complex at Slug Head and Garron Point looking SW towards Stonehaven. (Photo: C.W. Thomas.)