Bin Quarry

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Introduction

Although the 'Younger Basic' igneous bodies are generally interpreted as layered intrusions, because of their large-scale compositional variations, they rarely display convincing small-scale layered structures. However, the Bin Quarry, which is located near the western margin of the Huntly-Knock intrusion (Figure 3.6), is exceptional in this respect, and exposes a sequence of spectacularly layered cumulates.

The Bin Quarry rocks are broadly troctolitic (plagioclase-olivine cumulates) to gabbroic (pla-gioclase-olivine-augite cumulates) .in composition, but there are considerable modal variations from layer to layer (generally on a scale of centimetres or tens of centimetres), producing mafic (olivine-rich) and felsic (plagioclase-rich) lithologies locally. These layered rocks have moderately steep dips towards the west, but since they are believed to represent the lower part (LZ) of the Huntly-Knock cumulate sequence, which generally 'youngs' from west to east in this area, (Munro 1984), they must have been overturned tectonically in the vicinity of the Bin Quarry. This view is supported by the evidence of small-scale 'sedimentologicar features such as graded bedding which are clearly displayed in the quarry (Shackleton, 1948), and by progressive variations in the mineral compositions in this part of the Huntly intrusion.

Description

The main face of the quarry is 130 m in length, and exposes an apparently continuous succession of layered cumulates dipping at angles between 40° and 60° (averaging 50°) towards the WNW; the exposed stratigraphical thickness is therefore approximately 100 m. The layering is exceptionally well-developed and is generally very regular (Figure 3.7), (Figure 3.8). It consists of small-scale (centimetres to tens of centimetres) lithological variations from peridotite (olivine cumulate) to troctolite (plagioclase-olivine cumulate) and olivine-gabbro (plagioclase-augite-olivine cumulate), with considerable variations in grain size and texture as well. The olivine cumulate layers are best observed towards the western end of the main face (Figure 3.7) where they occur as thin (2–25 cm) units of dark, highly serpentinized peridotite, with scattered poikilitic crystals of pyroxene. Some of these layers display obvious grading into the adjacent troctolites. This graded bedding is consistent in direction and provides clear evidence that the stratigraphical succession youngs from west to east (Shackleton, 1948).

Although most of the layering is regular, examples of laterally impersistent, wispy layering and local cross-bedding are found, notably in the large loose blocks at the foot of the main face towards the western end of the quarry. These have probably fallen from the exceptionally well-layered material which can be seen near the top of the face in this area. There is considerable variation in grain size between layers, and there are also lenses of very coarse-grained pegmatitic gabbro which are associated with significant sulphide mineralization (Fletcher, 1989; Gunn and Shaw, 1992). Two areas of gossan seen in the main quarry face (Figure 3.6) mark the location of irregular pegmatitic pyroxenite sheets. The troctolites and gabbros are well jointed, with the principal joint surfaces dipping at moderate angles (20–25°) towards the east. They are mostly well spaced, but are closer together (and slightly steeper) in the central part of the main quarry face.

The troctolitic and gabbroic cumulates are distinctively speckled black and white rocks, with variable proportions of cumulus plagioclase to cumulus olivine, and typically displaying a preferred orientation of the tabular plagioclase crystals parallel to the lithological layering (a feature normally referred to as 'igneous lamination'). The olivines sometimes display corona structures consisting of granular orthopyroxene and fibrous amphibole and presumably of metamorphic origin. Serpentinization of the olivines has resulted in the development of distinctive expansion cracks, radiating from the altered olivines out into the surrounding feldspars. The troctolites usually contain scattered crystals of intercumulus augite, and they are interlayered with more obviously gabbroic cumulates, in which the augite is of cumulus habit. Orthopyroxene is not present as a primary mineral (either cumulus or intercumulus) in these rocks. Cumulus mineral compositions in the troctolites and gabbros have been determined as follows: plagioclase (An_{74}), olivine (Fo_{80}) and augite ($Ca_{48}Mg_{44}Fe_{8}$) (Munro, 1984). There is also evidence of a slight but progressive change in olivine composition from west to east within the quarry (Fo_{81} to Fo_{78}), and this fits well with the graded layering structures in indicating eastward 'younging' of the succession despite the westward dips.

Thin sheets of pegmatitic gabbro, consisting of quartz, feldspar and biotite, occur in the eastern part of the main face. They are generally sub-horizontal in attitude, but have some steeper offshoots. They appear to have caused extensive amphibolitization of the mafic minerals in the immediately adjacent cumulates. Some vein-like areas of alteration contain radiating needles of xonotlite and botryoidal prehnite (Gillen, 1987).

Interpretation

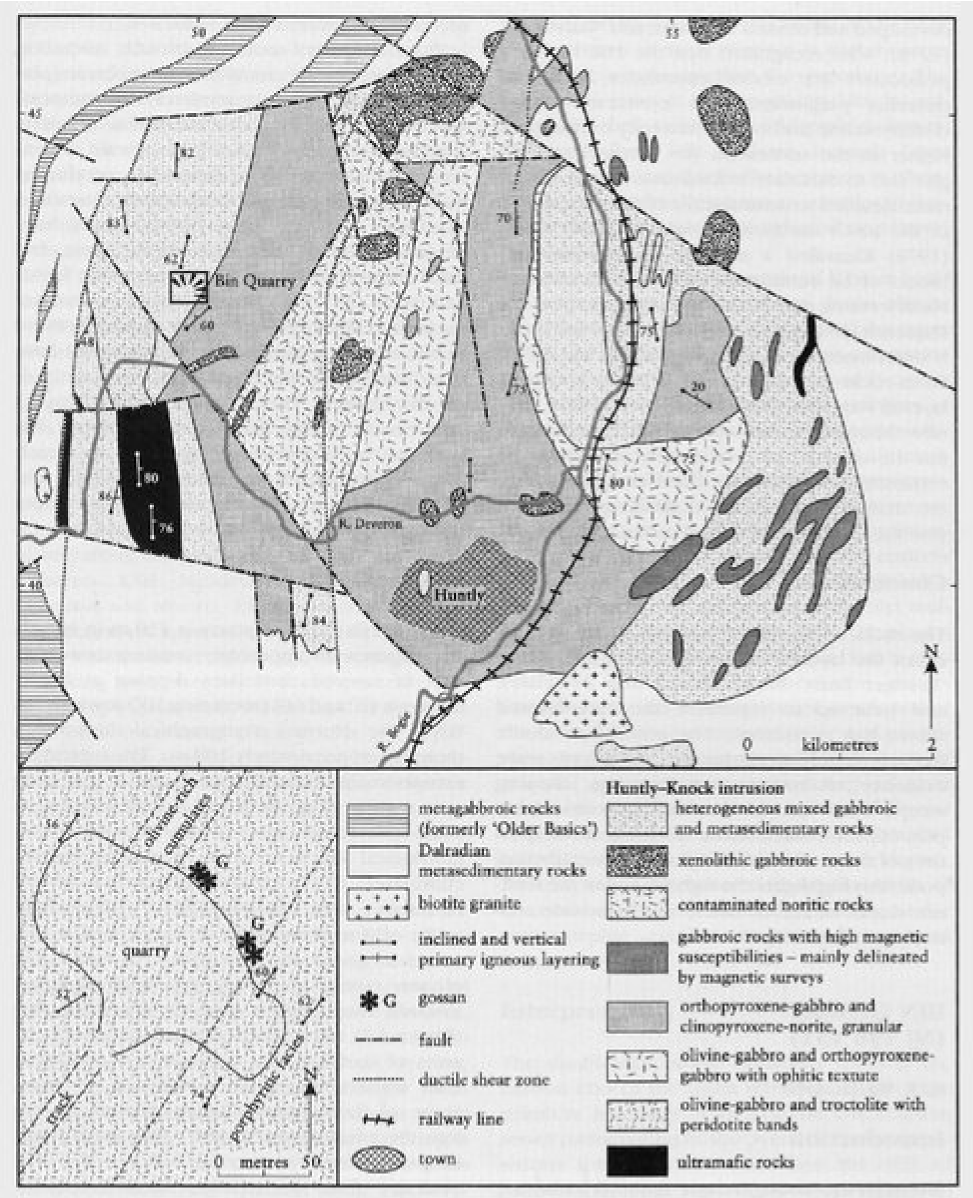
The recognition that the Bin Quarry provides a classic example of cumulate rocks formed at a relatively early stage of gabbroic magma crystallization is based on a combination of lithological features. These include: a) the small-scale layering itself, which is predominantly the result of frequent changes in the cumulus mineral assemblage, but also involves textural features, such as the development of well-laminated plagioclase-rich layers; b) the occurrence of distinctive textures comprising both cumulus and intercumu-lus components; c) the cumulus mineral compositions (relatively magnesian olivine and augite, relatively calcic plagioclase) and their slight but systematic variation with stratigraphical position. The recognition of specifically sedimentational aspects (especially graded bedding, and its use as a 'way-up' criterion) was first applied to the 'Younger Basics' by Shackleton (1948), as the results of observations at the Bin Quarry, and this approach has been substantiated by most other studies in the area (e.g. Stewart and Johnson, 1960; Read, 1961).

In general terms, the predominantly troc-tolitic cumulates of the Huntly–Knock area are regarded as equivalent to Lower Zone rocks at Belhelvie and Insch, but from higher levels than LZa (as seen at the Hill of Barra GCR site in the Insch mass, or on the western edge of the Belhelvie mass). They are therefore referred to LZb/LZc, since they contain cumulus plagioclase and augite (Wadsworth, 1982; Munro, 1984; Fletcher, 1989). However, there is now considerable evidence that the lower part (11) of the Huntly–Knock succession is not identical to the Insch and Belhelvie equivalents. For example, there is no evidence of a distinct ultramafic (LZa) unit in the Huntly–Knock mass, although olivine-rich cumulate layers occur locally, as in the Bin Quarry sequence. Shallow drilling of the poorly exposed western margin (Munro, 1984) suggests that troctolitic and gabbroic rocks persist from the quarry area as far as the contact with Dalradian country rocks. In addition, there is the scarcity of orthopyroxene in the Huntly–Knock LZ cumulates, and the compositions of the co-existing cumulus minerals (olivine, plagioclase and augite) show small but significant differences between Huntly–Knock and Belhelvie–Insch (Munro, 1984; Wadsworth, 1991). These features lend support to the view that the regionally available 'Younger Basic' gabbro magma underwent progressive fractional crystallization in at least two separate magma chambers (or distinct compartments of a single complex chamber) with resultant slight differences in the respective crystallization sequences, as advocated by Weedon (1970), Ashcroft and Munro (1978) and Munro (1984). This is in contrast to the proposal by Wadsworth (1970, 1982) that the 'Younger Basics' represent a single-layered intrusion, subsequently disrupted by tectonic events.

Conclusions

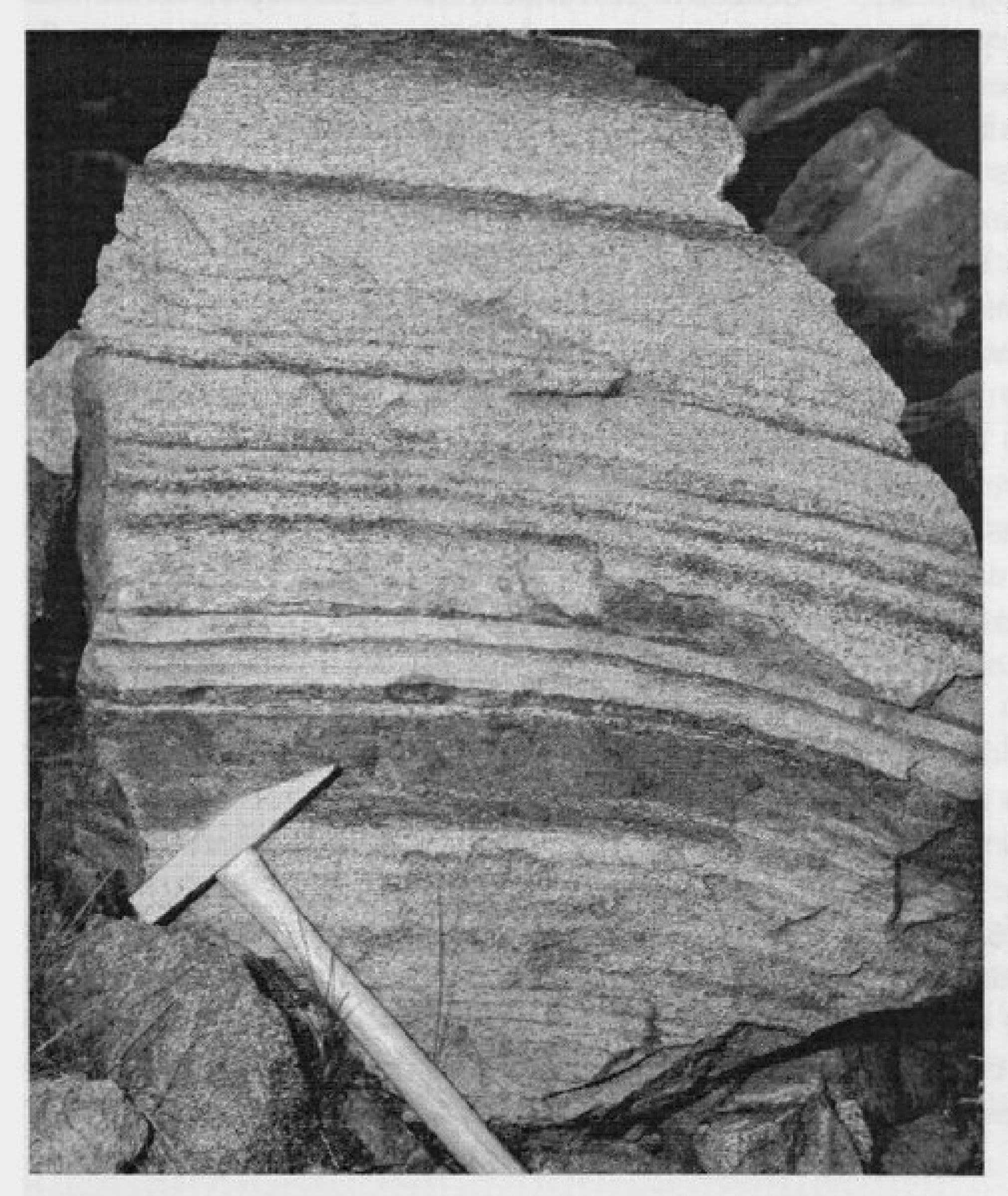
The troctolitic and gabbroic cumulates of the Bin Quarry GCR site, with their magnesian olivines and pyroxenes, and calcic feldspars, are excellent examples of a relatively early stage of fractionation in the Lower Zone (LZb/LZc) of the 'Younger Basic' layered sequence, although they are not quite as primitive as the ultramafic (LZa) cumulates at the Hill of Barra GCR site. Various features of the rocks are of particular significance in the context of the 'Younger Basic' intrusions. Most prominent is the small-scale layering, with its associated 'sedimentary' structures, providing convincing evidence of gravity accumulation of crystals. The steep dips indicate post-depositional tectonic disturbance, and the graded (olivine-rich to plagioclase-rich) layers show that the sequence has been overturned, at least in the quarry area.

References



(Figure 3.6) Map of the southern part of the Huntly–Knock intrusion, from BGS 1:50 000 Sheet 86W (in press), with details of the Bin Quarry GCR site, from Gunn and Shaw (1992).

(Figure 3.7) Layered olivine-gabbro cumulates of the Huntly intrusion Lower Zone in the Bin Quarry. Layering dips at 50° to the NW but modal layering, 'sedimentary' structures and variations in mineral composition show that the sequence 'youngs' to the SE and hence is inverted. (Photo: BGS no. D4122.)



(Figure 3.8) Block of layered olivine-gabbro cumulate of the Huntly intrusion Lower Zone in the Bin Quarry. The layering, which is inverted in this photograph, reflects both modal and mineral compositional variation, ranging from peridotite, through mafic gabbro and troctolite to anorthosite. (Photo: BGS no. D4121.)