Towie Wood

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Potential GCR site

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Introduction

One of the most distinctive aspects of the 'Younger Basic' intrusions is the local occurrence of a marginal facies of cordierite norites rich in xenolithic material derived from the Dalradian country rock. These are known from both the Insch and Huntly intrusions, but reach their maximum development in the Haddo House–Arnage intrusion (Read, 1923, 1935; Read and Farquhar, 1952; Gribble, 1968), notably in the classic, but poorly exposed, areas of Craigmuir Wood and Wood of Schivas, in the Ythan Valley. Here the least modified component of the 'Younger Basic' intrusions is quartz-norite, although olivine-norite occurs locally.

The xenolithic complexes comprise abundant small fragments of hornfels in a matrix of igneous aspect texturally, but with a distinctive mineralogy involving various proportions of plagioclase, cordierite, biotite, orthopyroxene and quartz, sometimes accompanied by garnet and alkali feldspar. These rocks are generally referred to as cordierite norites although some of them are quartz-rich and would be more accurately described as tonalites. The xenoliths represent a wide range of compositions, but fall into two principal categories, namely silica-deficient, aluminous types and silica-rich types. These are believed to represent argillaceous and quartz-rich Dalradian metasedimentary rocks, respectively. Local concentrations of calc-silicate hornfels xenoliths (e.g. from Craigmuir Wood, near Haddo House) were presumably derived from calcareous layers in the Dalradian (Read, 1935). The cordierite norites and associated xenoliths have generally been taken to represent some form of interaction between 'Younger Basic' magmas and the adjacent country rock, especially in the roof region of the original intrusions, but there has been considerable disagreement about the precise nature of this interaction.

Description

The Towie Wood site lies towards the northern extremity of the eastern or Arnage area of the Haddo House–Arnage intrusion (Figure 3.17). Most of the exposures are found on, or close to, the former railway line and in the adjacent Ebrie Burn. At Towie Wood, the old railway cutting provides exposures of quartz-norite, while a small, but compact and well-exposed area of xenolithic material occurs just to the south, on the eastern side of the railway trackbed, where it forms a distinct knoll (Munro and Leslie, 1987).

The quartz-norite, which is essentially homogenous and xenolith-free, consists of plagioclase ($An_{60–50}$), orthopyroxene ($En_{68–55}$), clinopyroxene, hornblende, biotite and quartz. It is of medium- to coarse-grain size, with conspicuous biotite crystals (Munro and Leslie, 1987).

The xenolithic complex has an igneous-textured matrix of rather variable grain size and modal proportions, in which the principal minerals are plagioclase, cordierite, biotite, orthopyroxene, garnet and quartz. This cordierite norite is intimately associated with xenolithic material, although the relationship between the two components is by no means constant. Locally the xenoliths are dominant, and appear to represent relatively undisturbed country rock invaded by veins and stringers of norite. This arrangement was taken by Read (1923) to indicate proximity to the roof of the intrusion. Elsewhere, xenoliths and matrix are approximately equal in abundance, with an apparently chaotic mixture of xenolith types in random orientation. This type of assemblage grades into more homogeneous cordierite norites, with fewer relict xenoliths.

Two principal types of xenolith are present. One type is quartz-rich, presumably representing more psammitic Dalradian material. These tend to be angular in shape, and show all size gradations from centimetres to tens of centimetres across; some display relict bedding structures. In thin section they are seen to be plagio-clase-quartz-biotite hornfelses, with sporadic garnet, cordierite or orthopyroxene. The other type comprises compact, homogeneous blue-grey hornfelses derived from pelitic Dalradian metasediments. They tend to be smaller (generally less than 5 cm across) and more rounded than the siliceous xenoliths. Mineralogically, they are silica deficient, consisting of variable proportions of cordierite, plagioclase, spine!, sillimanite and garnet, accompanied by corundum, orthopyroxene or biotite. Some of the argillaceous xenoliths are composed entirely of cordierite. In addition to the xenoliths and cordierite norite matrix, quartz-rich veins and stringers are quite widespread.

Interpretation

Although there has been broad agreement that the cordierite norites and associated xenolithic assemblages are genetically related, and were developed as part of the 'Younger Basic' magmatic event, various explanations of their precise relationship and significance have been presented.

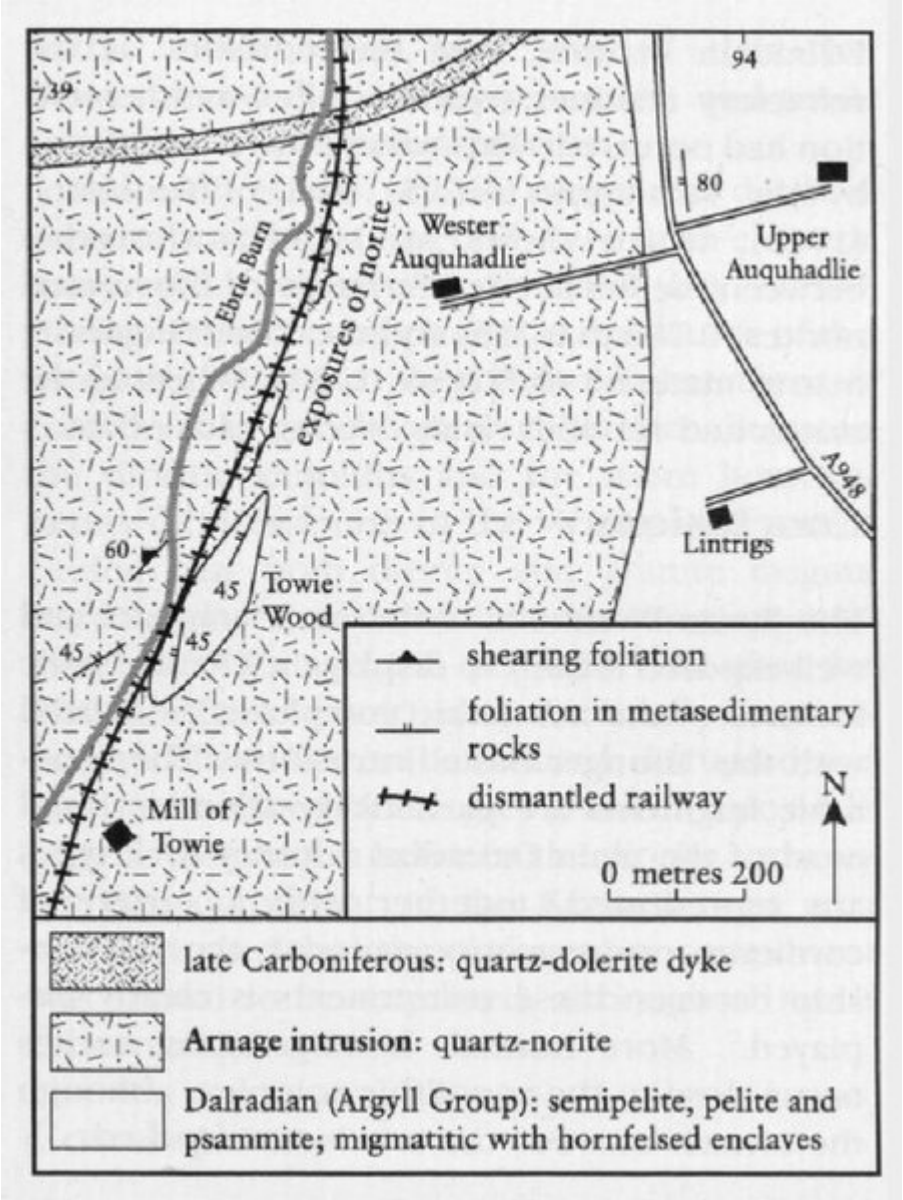
Read (1923) considered the cordierite norites to represent basic magma which had been contaminated by assimilation of country rock. He suggested that Si, Ca, Na and K had been selectively extracted from Dalradian pelites by the magma, leaving a residue of silica-deficient, alu-minous xenoliths. He also regarded the more homogeneous quartz-norites of the Haddo House–Arnage area, as mildly contaminated intermediates between the cordierite norites and the olivine-gabbros more typical of the 'Younger Basic' activity in general. Read subsequently re-interpreted these xenolithic rocks as parts of an older migmatite complex implying that the associated 'Younger Basic' norites were not actively involved in their formation (Read and Farquhar, 1952). However, he continued to invoke large-scale regional contamination of 'Younger Basic' magma with Dalradian pelitic material to explain the apparently anomalous hypersthene-gabbro unit (now interpreted as Middle Zone cumulates) in the Insch intrusion (Read *et al.,* 1965), and appeared to accept a contamination origin for xenolithic cordierite norites occurring locally at the margin of this intrusion.

Gribble (1968) re-investigated the xenolithic complexes at Haddo House–Arnage, and concluded that the 'Younger Basic' intrusions had played a vital part in their formation by raising temperatures in the adjacent country rocks, so that they began to melt. The cordierite norites were believed to represent partial melts of the Dalradian material, and the xenoliths as the refractory residues (restites) after melt extraction had occurred. This conclusion is supported by the strontium isotope data of Pankhurst (1969), which shows no significant overlap between the initial $^{86}Sr/^{87}Sr$ ratios for the normal norites (0.706 to 0.715) and the cordierite norite matrix material (0.720 to 0.731), whereas the matrix and xenolith ratios overlap each other.

Conclusions

The Towie Wood site is the most compact and well-exposed locality to display the characteristic features of the xenolithic complexes associated with the 'Younger Basic' intrusions. The xenolithic fragments are particularly abundant, and most of the main Dalradian country rock types are represented, together with a variety of cordierite norite matrix material; the relationship between these components is clearly displayed. More normal, homogeneous norites occur close to the xenolithic complex, although the contact between the two is not exposed.

References



(Figure 3.17) Map of the area around the Towie Wood GCR site, Arnage-Haddo intrusion, from BGS 1:10 000 Sheet NJ93NW (1986) by W Ashcroft and M. Munro, Aberdeen University