BECKFOOT QUARRY

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OS Grid Reference: NY164003

Introduction

Beckfoot Quarry is located in the central part of the Eskdale pluton, the westernmost exposed portion of the largely concealed Lake District batholith. The pluton consists of two major components: a well-exposed northern granite and a generally poorly exposed southern granodiorite. The geology and petrography of the Eskdale pluton has been described by Dwerryhouse (1909), Simpson (1934), Trotter *et al.* (1937), Firman (1978b), Ansari (1983), Young (1985), Young *et al*. (1988) and Millward *et al*. (in press). The geochemistry of the granites has been discussed by Ansari (1983) and O'Brien *et al*. (1985). Within the northern part of the pluton three main facies of granitic rocks may be distinguished: medium-grained aphyric muscovite granite (the so-called ‘normal' granite of several authors); a series of microgranites that vary from aphyric to markedly porphyritic and megacrystic; and a local development of a coarse- to very coarse-grained granite. The distribution of these facies is shown on recent Geological Survey maps of the area (1:25 000 special sheet, 1991; 1:50 000 Sheet 38, 1996).

Previously held views that the Eskdale pluton is a late Caledonian intrusion, similar in age to the granites of Shap and Skiddaw, were dispelled by the Rb-Sr age of 429 ± 4 Ma (Rundle, 1979) and the discovery of cleavage within the Eskdale granite (Allen, 1987). More recently, Hughes *et al*. (1996) have published a U-Pb age of 452 ± 4 Ma, which confirms the late Ordovician age of this subvolcanic intrusion.

The Beckfoot Quarry GCR site (Figure 4.35) is the only site selected for the GCR within the granite of the Eskdale pluton; the contrasting granodiorite that comprises the southern portion of the Eskdale pluton is described in the Waberthwaite Quarry GCR site report (see below). Good examples of the ‘normal' granite and its relationships with the microgranite facies are exposed (Figure 4.35). Beckfoot Quarry was chosen for sample collection for U-Pb dating on zircon because the granite there is xenolith free and largely unaffected by vein mineralization (Hughes *et al*., 1996). Therefore, it is a key site in understanding the magmatic history of the Lake District.

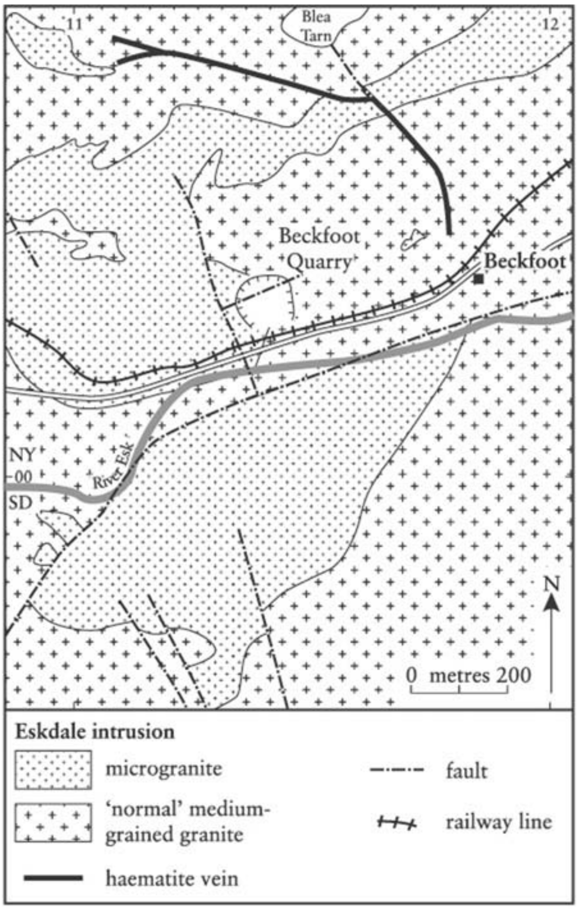

Figure 4.35: Map of the area around Beckfoot Quarry.

Description

Beckfoot Quarry is an abandoned quarry within the medium-grained 'normal' granite and microgranite facies of the Eskdale pluton (Figure4.35). Microgranites are common within the granite, especially in the NE part of the intrusion. The commonly complex field relationship of the microgranites with the 'normal' granite has been described byYoung (1985).

Medium-grained 'normal' granite forms much of the eastern face of the quarry. This rock is typically a pale-pink equigranular granite composed of perthitic feldspar, sodic plagioclase and quartz with some muscovite and biotite. Accessory minerals are generally scarce but zircon is common in altered biotite. Tourmaline is found locally as clusters of radiating black crystals coating joint surfaces (Jones, 1915). Much of the central and western parts of the quarry expose a variety of microgranite lithologies. These are mineralogically identical to the granite, but commonly exhibit various textures even within a single small exposure. Aphyric and porphyritic variants occur, the latter with abundant quartz or feldspar phenocrysts, commonly in clustered aggregates. The relationship of the microgranite to the granite within the quarry is not clear, though in the immediate neighbourhood of the quarry the microgranites appear to lie beneath the granite.

Both the granite and microgranite are cut by a roughly WSW–ENE vein composed of microgranite fragments cemented by quartz and pale- fawn dolomite. Some haematite staining occurs locally on joint surfaces within the microgranite.

Interpretation

The identical mineralogical composition of the 'normal' granite and associated microgranites within the Eskdale pluton are consistent with a co-magmatic origin. Moreover, the complex and often intricate relationships between these facies have been cited as the result of partial mixing of two or more pulses of the same, or extremely similar, magma in a partially crystallized or plastic state (Young *et al.*, 1988). Clusters of quartz and feldspar phenocrysts within the microgranites have been interpreted as partially absorbed xenoliths of coarsely crystallized granite (Millward *et al.*, in press).

Mapping suggests that the Eskdale granite exposed in the central and upper parts of Eskdale lies within a few hundred metres of the roof of the intrusion. Outcrops of hornfelsed Borrowdale Volcanic Group rocks overlie granite NE of Blea Tarn (168 012) and NE of Boot (181 014; 185 016).

Ansari (1983) and O'Brien *et al.* (1985) noted the differences in geochemistry between the granite and granodiorite in the Eskdale pluton. Analytical data for the lithologies emphasize the more evolved nature of the former and show a compositional hiatus between them. Ansari (1983) concluded on this basis that there is no genetic relationship between the granite and granodiorite, and that they are effectively separate intrusions. However, O'Brien *et al.* (1985) suggested that the granodiorite and granite are petrogenetically linked by crystal–liquid fractionation of a common parental magma intermediate in composition to the granite and granodiorite. This is supported by similar initial $^{87}Sr/^{86}Sr$ ratios of 0.7076 ± 0.0005 and 0.7073 ± 0.0007 for the granite and granodiorite, respectively (Rundle, 1979).

Compositional differences are present between the three principal granite lithologies (Millward *et al.*, in press). Early, coarse-grained, predominantly primary textured granites show consistently lower levels of differentiation compared with ‘normal' granite. By contrast, the microgranites, which record a spectrum of two-phase crystallization textures, span or exceed the compositional range of the coarse and normal granites. Crystallization of early magma, represented by the coarse granite, produced residual, more evolved melts that locally infiltrated, invaded and disrupted to varying degrees zones of partly crystallized granite, producing the more chemically variable mixed or hybridized compositions.

An end-Silurian or Devonian age for the granite was inferred for many years and only Green (1917) favoured an Ordovician age. The first radiometric date on the Eskdale granite was a Rb-Sr isochron age of 429 ± 4 Ma (Rundle, 1979), thus clearly establishing an Early Palaeozoic age and a link with the magmatic episode typified by the subduction-related volcanism of the Borrodale Volcanic Group. Allen (1987) noted the presence of cleavage locally within parts of the Eskdale granite though this cleavage is not seen in Beckfoot Quarry. The U-Pb age of 452 ± 4 Ma published by Hughes *et al.* (1996) from zircons obtained from the ‘normal' granite of Beckfoot Quarry confirms the Eskdale pluton as late Ordovician and probably subvolcanic.

Conclusions

The Beckfoot Quarry GCR site contains good examples typical of both the medium-grained (‘normal') and microgranite facies of the Eskdale pluton. The Eskdale granite is the western part of the largely concealed Lake District batholith and has been shown to be a late Ordovician subvolcanic intrusion. The quarry provided the sample from which the late Ordovician U-Pb zircon age of 452 ± 4 Ma was obtained.

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