Cruachan Reservoir

[NN 077 285]

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Introduction

To the north of the Cruachan hydroelectric power station, outcrops along the Pass of Brander and on the SE flanks of Ben Cruachan provide a traverse through the metasedimentary envelope and marginal facies of the Etive pluton. This large elliptical pluton comprises four discrete intrusive phases; in order of emplacement these are the Quarry intrusion, the Cruachan facies, the Meall Odhar facies and the central, Starav facies (Figure 8.15) (see the Bonawe to Cadderlie Burn GCR site report). The envelope and complex contact relationships along this southern margin of the pluton, first described by Kynaston and Hill (1908), are well displayed within this GCR site. The outer margin comprises rocks of the Cruachan and Meall Odhar facies, similar to those documented within the Bonawe to Cadderlie Burn site. The inner, Starav facies, which is well displayed at the Bonawe to Cadderlie Burn site, is not represented at the Cruachan Reservoir site. Here also, an apparently down-faulted block of andesitic lavas, the Beinn a' Bhuridh screen, separates an arcuate satellite body, the Quarry intrusion, from the main body of the pluton. Within the Quarry intrusion, assimilation of calcareous metasedimentary rock xenoliths has produced some unusual hybrid rocks (Nockolds, 1934).

The Cruachan Reservoir GCR site encompasses the Cruachan pump storage system, part of the Loch Awe hydroelectric scheme (Figure 8.18) and (Figure 8.19). Excavations for the dam construction and the modification of water courses reveal details of the contact relationships between the Etive pluton and its envelope. Detailed geological information was also obtained during the construction of underground tunnels, aqueducts and the power station (Knill, 1972).

Description

Margin and envelope

Much of the pluton envelope within the GCR site comprises metasedimentary rocks of the Ardrishaig Phyllite (Argyll Group, Dalradian Supergroup). These comprise finely interlayered black or purple chloride phyllites and calc-silicate rocks, with thicker bands of impure metalimestone and calcareous quartzite. Close to the contact with the Quarry intrusion, the phyllites become hard splintery hornfelses, in which the regional deformational fabrics are poorly preserved. Biotite, as small porphyroblasts or aggregates, is the most common thermal aureole mineral, with rare cordierite spots. Within 200 m of the intrusion the calcareous rocks contain a contact metamorphic assemblage of pale-green diopsidic pyroxene, garnet, epidote and amphibole.

Quarry intrusion

This arcuate satellite intrusion consists of diorite and quartz-diorite variants. Both are represented within the GCR site (Figure 8.18). Only the quartz-diorite is in contact with the metasedimentary rocks of the envelope. The contact is discordant to the foliation in the host Ardrishaig Phyllite and has a steep outward dip, which is seen in the Allt Cruachan. Here, the quartz-diorite at the intrusion margin is fine grained but elsewhere, (for example at [NN 0775 2813]) and in the access road to the dam, it is commonly medium to coarse grained. It comprises phenocrysts of plagioclase, up to 1.5 cm long, and brown amphibole with interstitial quartz and K-feldspar. Country rock xenoliths in varying stages of assimilation are common, often enclosed by a heterogeneous quartz-rich hybrid granodiorite [NN 0819 2804].

The diorite is finer grained than the quartz-diorite, with pyroxene phenocrysts, up to 8 mm long, as the predominant mafic mineral. A green amphibole occurs both as small phenocrysts and as aggregates, with biotite, after pyroxene. The contact between the two dioritic variants is transitional, for example along the shore of the reservoir [NN 0785 2030]. A margin-parallel pre-full crystallization fabric is present throughout the intrusion, but is most conspicuous in the

coarser-grained rocks.

Beinn a' Bhuridh screen

The augite-hornblende andesites of the Beinn a' Bhuridh screen form the conspicuous crag at [NN 0775 2868], and crop out on the access track at [NN 0785 2870] and on the shore of the reservoir (Figure 8.18). A steeply dipping outer contact with the Quarry intrusion is exposed close to the tunnel entrance, west of the reservoir [NN 0783 2865], and in the slopes above. The inner contact with marginal rocks of the main pluton (Cruachan facies) is not found within the site, and can only be inferred from elsewhere (cf. Anderson, 1937). However, the lavas are clearly hornfelsed and are commonly altered from dark-grey to a greenish colour. In outcrops to the west of the reservoir the lavas are commonly vesicular, the voids being infilled with quartz and/or chlorite. Here, fragments and small blocks of 'quartzite', up to 10 cm across, are also present.

Cruachan facies

Rocks of the Cruachan facies, which comprise the outer part of the main Etive pluton, form the outcrops close to the northern tall race entrance [NN 0827 2946], on the NE-facing slope of Meall Cuanail [NN 0775 2953], and in the burn emanating from Coire Dearg [NN 0768 2972]. Rocks of this facies cross-cut and vein rocks of the Quarry intrusion. The Cruachan facies comprises coarse-grained, pale pink-grey hornblende-biotite monzodioritic to granodioritic rocks, and is similar to the inner variant described from the Bonawe to Cadderlie Burn GCR site. Large crystals of biotite and small phenocrysts of green hornblende are the predominant mafic minerals in these rocks. The amphibole also occurs in mafic aggregates, up to 1 cm in diameter, with biotite, opaque minerals and rare pyroxene. Titanite is conspicuous as small deep-pink crystals. A pre-full crystallization fabric is ubiquitous, but is most intense at the pluton margin.

Within the tail race tunnel of the hydroelectric scheme, the monzodiorites of the Cruachan facies are cross-cut by veins of K-feldspar megacrystic hornblende-biotite granodiorite. This lithology may be a correlative of the marginal variant seen within the Bonawe to Cadderlie Burn GCR site. The mafic content of these rocks is variable, although mostly less than 15%. Biotite is predominant, while amphibole commonly occurs within small, 1–2 mm, mafic microgranular aggregates with titanite, magnetite and biotite.

Meall Odhar facies

This facies forms the twin summits of Ben Cruachan (Figure 8.19) and slab-like outcrops along the S-trending ridge from Meal! Cuanail [NN 072 288], where it imparts a characteristic pink colour to the ground. The facies comprises a fine- to medium-grained, equigranular, K-feldspar-phyric monzogranite. K-feldspar megacrysts, up to 1.5 cm long, vary from white to pale-pink where rocks are fresh, to deep-red in areas of alteration. Contacts with either the Cruachan facies or Quarry intrusion are not seen, although both are cut by thin sheets, or more commonly anastomosing veins, of this granite. In exposures on the flanks of Meall Cuanail, the granite contains' large xenoliths of andesitic lava, similar to those of the Beinn a' Bhuridh screen, and of fine-grained acid (?rhyolitic) lava (Anderson, 1937).

Minor intrusions

The synplutonic intrusions of the Etive dyke-swarm consists mostly of steeply inclined NE-trending dykes, with a few shallow-dipping sheets (Figure 8.18). Branching and side-stepping along joint structures is a characteristic of many of these intrusions. The highest concentration of intrusions occurs in the country rocks and the swarm density decreases towards the centre of the pluton. Three distinct sub-suites are recognized as follows.

1. Porphyritic andesites.
2. Microdiorite, porphyritic micromonzodiorite/microgranodiorite (formerly 'porphy-rites') and rare spessartite.
3. Porphyritic microgranite (formerly 'quartz-porphyry') and aplitic microgranite (formerly 'felsite').

Members of sub-suite (a) occur only within the country rocks. These are dark grey-green, fine grained to aphanitic, and have been partially recrystallized by contact metamorphism. The more abundant microdiorite and microgranodioritic

Intrusions of sub-suite (b) may reach 15 and 35 m-thick respectively, but are mostly less than 6 m. The more basic intrusions are dark-green rocks, with phenocrysts of green or brown amphibole; the latter is commonly in association with augite, and plagioclase. The microgranodioritic rocks are a grey-buff colour, and are characterized by large oscillatory zoned crystals of plagioclase, 0.5–2 cm long. Plagioclase is the most abundant phenocryst in these rocks, with biotite predominant over amphibole. Within-dyke textural and compositional variations are common, often manifest as feldspathic net-veining.

On the basis of intrusive relationships the dyke swarm is further divisible into those that:

1. pre-date the Quarry intrusion;
2. are cut by the Cruachan facies or veins of monzodiorite/granodiorite;
3. cross-cut the Cruachan facies but are cut by the Meall Odhar facies or veins of similar age;
4. post-date all the main facies of the Etive pluton within the site.

Intrusions of sub-suite (c) consistently postdate all rocks of the pluton and the dykes of intermediate composition. A good example of this relationship is seen in the access road to the dam [NN 0828 2735]. All members of the Etive dyke-swarm are cut by ESE-trending quartz-dolerite and camptonite dykes of late Carboniferous to Permian age.

Interpretation

The origin of the Beinn a' Bhuridh screen is equivocal, although $^{87}Sr/^{86}Sr$ isotope values lie within the range of the Lorn Plateau lavas. However, contact metamorphic alteration is extensive, as seen by a $\delta^{18}O$ value of 6.3 (Frost and O'Nions, 1985), thus negating any meaningful comparison with other plutonic rocks or with Siluro-Devonian lavas. The arcuate form of the screen is compatible with Anderson's (1937) interpretation as a drop-down block within a ring fracture. There is no evidence for post-pluton emplacement ring fracturing within the GCR site, although elsewhere Anderson (1937) describes fault crush along the contact of the Quarry intrusion. Similarly, the shape of the satellitic Quarry intrusion suggests the exploitation of a pre-existing fracture system as a magma conduit.

Anderson (1937), following Nockolds (1934), attributed the turbid patches that disrupt oscillatory zoning in plagioclase crystals in the Quarry intrusion to contact metamorphism. However, this 'patchy zoning' is common in the Cruachan facies rocks, and is a feature of many plutons worldwide (cf. Vance, 1965). The origin of this texture is attributable to feldspar dissolution as a consequence of crystal-melt disequilibria during such processes as magma mixing (Wark and Watson, 1993). A pre-full crystallization texture is present in both the Quarry intrusion and the Cruachan facies. The absence of plastic strain fabrics and evidence of high temperature recrystallization, e.g. biotite overgrowth, argues against the dioritic Quarry intrusion being fully crystalline prior to pluton emplacement.

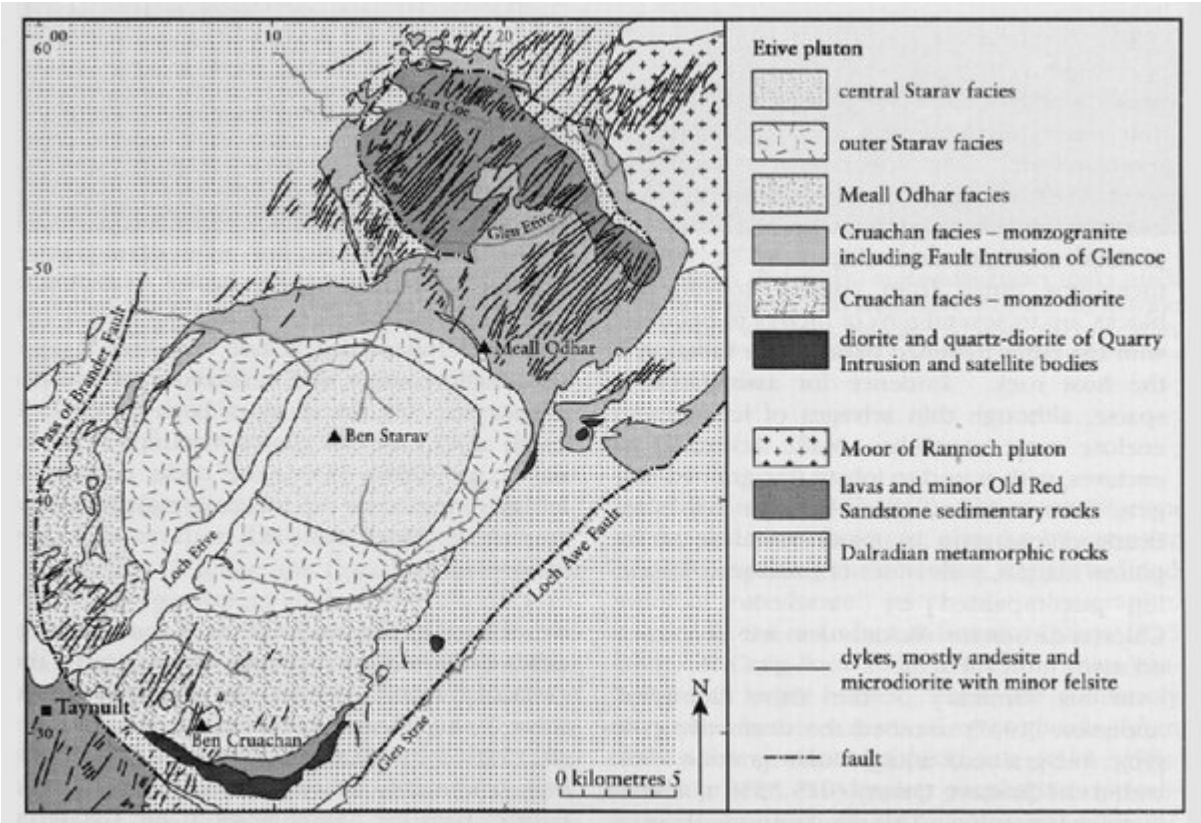
The multistage and multiple pulse emplacement history for the Etive pluton, described in the Bonawe to Cadderlie Burn GCR site report, is confirmed here. Both the Cruachan facies and the Quarry intrusion are cut by a large flat lying intrusion of the Meall Odhar facies at the highest preserved level within the pluton. Some members of the synplutonic dyke-swarm post-date all plutonic rocks within the GCR site. This points to the continued availability of Cruachan facies-type magmas after emplacement of Meall Odhar facies intrusions. This is demonstrated by the complex intrusive history of the Etive dyke-swarm, in which clearly defined sub-suites represent tapping of successive magma pulses during pluton emplacement. Cross-cutting relationships do not necessarily follow compositional maturity (i.e. acid cutting basic), but are time dependent, i.e. an acid intrusion of an earlier sub-suite will be cut by a basic component of a later sub-suite. The exception lies with the quartz-phyric and aplitic microgranites. These compositionally distinct intrusions post-date all basic to intermediate members of the swarm, and are likely to be penecontemporaneous with the Starav facies (not represented within this GCR site).

Conclusions

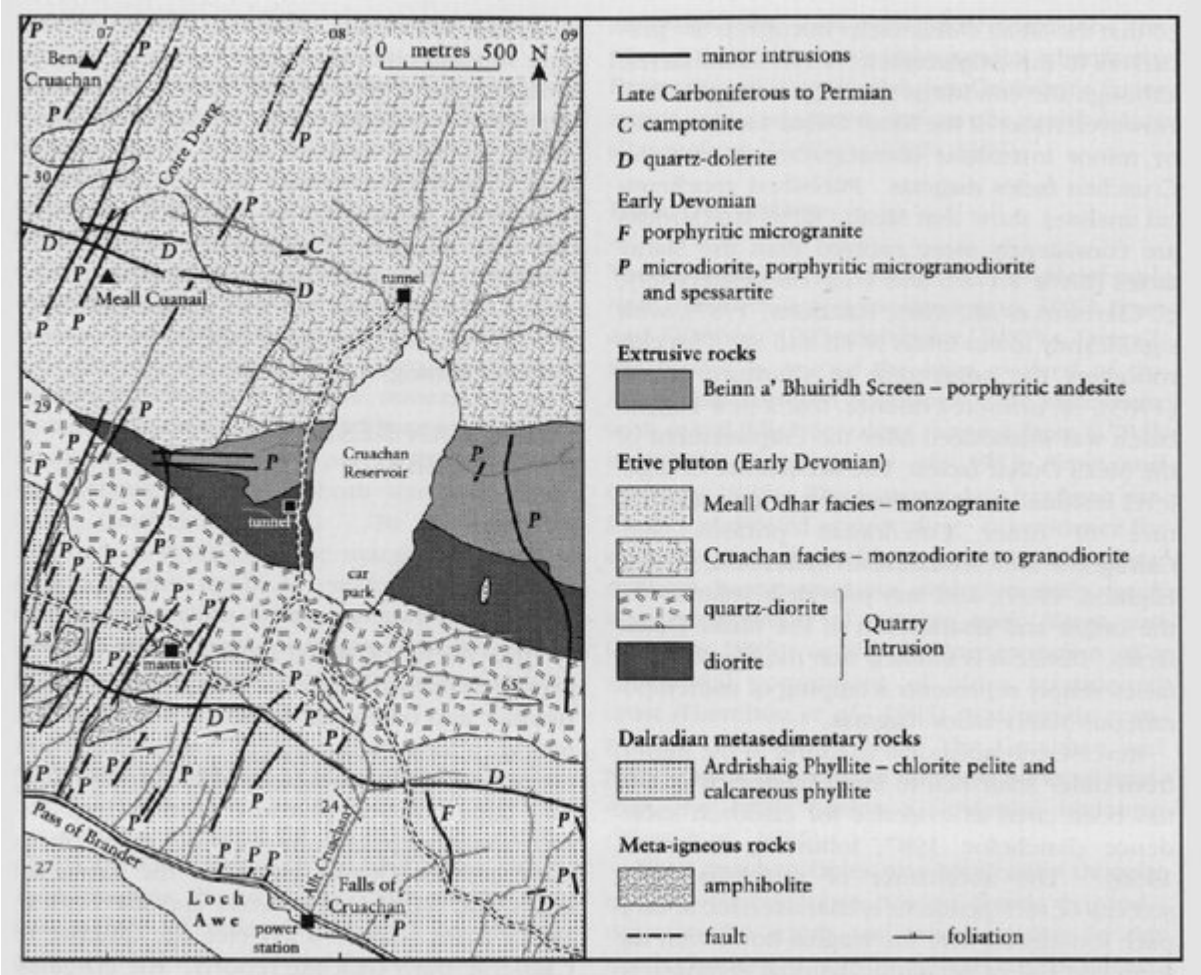
The Cruachan Reservoir GCR site is of national importance as a representative of the Etive pluton, in particular the satellitic Quarry intrusion, which is separated from the main pluton by a screen of andesitic lavas. The pluton is of major

importance for its contribution to the understanding of multiple pulse emplacement mechanisms in the Caledonian plutonic suites. Of particular interest here are the numerous sub-suites of minor intrusions. Their emplacement relationships to facies within the Etive pluton, provide an unrivalled example of near-contemporaneous dyke intrusion into large bodies of magma that were still cooling. The high-level emplacement of the pluton is indicated by the presence of down-faulted volcanic rocks bound by a ring fracture. The arcuate form of the Quarry intrusion suggests exploitation of this fracture by the dioritic precursor magmas. Subsequent emplacement of the main body of the Etive pluton induced widespread baking and alteration of rocks within the envelope. Evidence for recrystallization of rocks within the satellite Quarry intrusion is, however, equivocal.

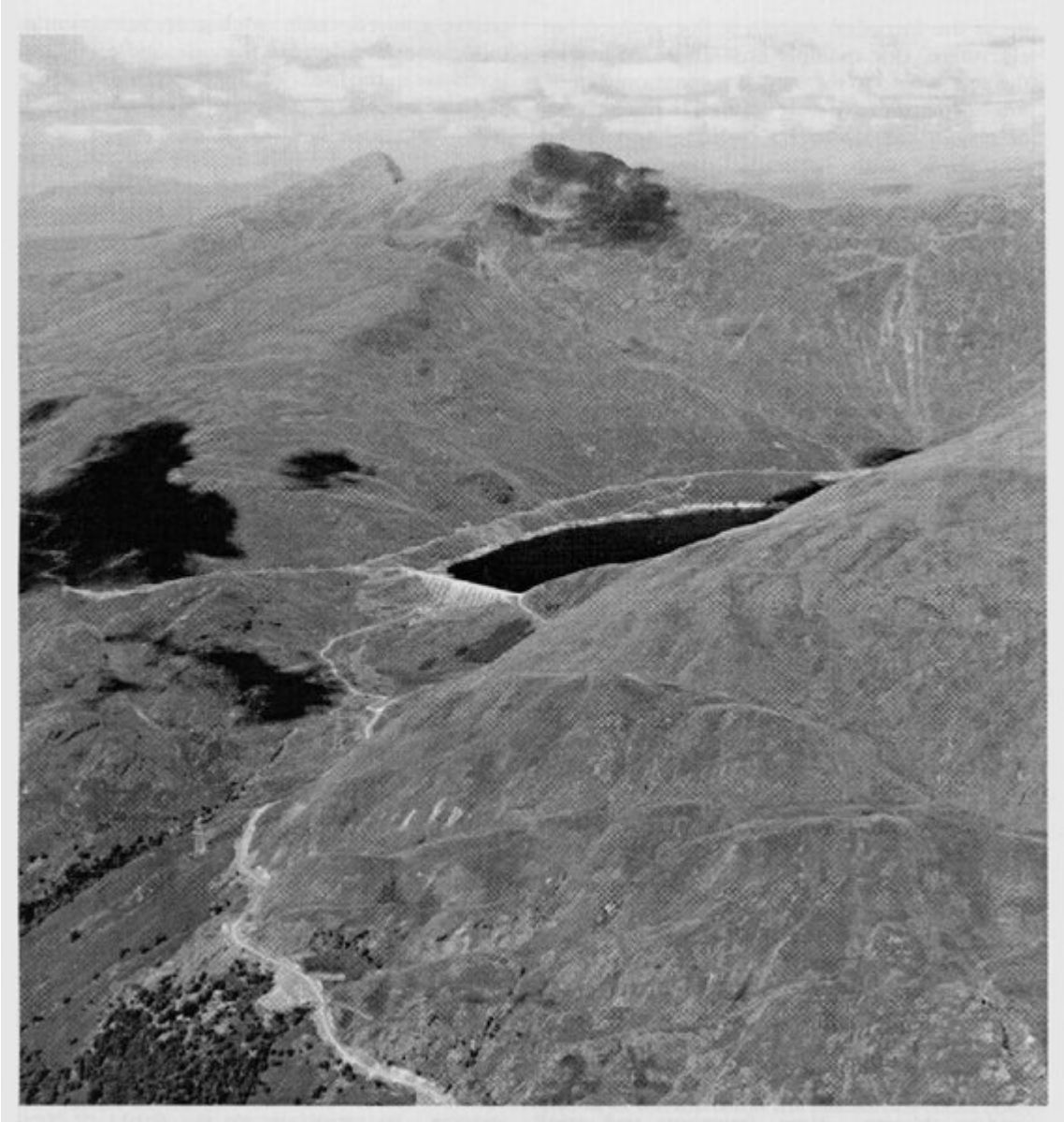
References



(Figure 8.15) Map of the Etive and Glencoe complexes, after Anderson (1937) and Batchelor (1987).



(Figure 8.18) Map of the area around the Cruachan Reservoir GCR site, Etive pluton, adapted from BGS 1:50 000 Sheet 45E.



(Figure 8.19) Aerial view of the Cruachan Reservoir GCR site, Etive pluton, looking WNW to Ben Cruachan. (Photo: BGS no. D 2571.)