FFESTINIOG GRANITE QUARRY

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Introduction

Within the Ordovician (Caradoc) cycle of volcanism in Snowdonia there are only a small number of subvolcanic intrusions that are not spatially related to the main eruptive centres. Among the largest are the granite plutons of Tan y Grisiau and Mynydd Mawr, which lie several kilometres outside the main zone of Caradoc caldera structures, intrusions and related extrusions as defined by Howells *et al .* (1991). They were emplaced mainly into Lower Ordovician (Tremadoc) or Cambrian (Merioneth) sandstones and siltstones. Sections in the Ffestiniog Granite Quarry provide a rare example of the contact relationships and autometasomatic effects that occurred in the granite roof during volatile streaming and crystallization. The area was originally described by Jennings and Williams (1891) and later revised by Bromley (1963), whose maps and descriptions are incorporated into the recent resurvey (Howells and Smith, 1997).

The Tan y Grisiau Granite has an outcrop area of *c.* 4 km² and is intruded into sandstones and siltstones of the Dol-cyn-afon Formation (Figure 6.56). The outcrop pattern is that of a truncated ellipsoid but the extent of the hornfels and aureole and associated geophysical anomalies show a much larger body at depth (Howells and Smith, 1997). The gravity and magnetic data have been interpreted to reflect a steep-sided, sub-vertical body, elongated some 10 km to the NE and 5 km to the SW of the main exposures with a NNW-dipping roof (Cornwell *et al*., 1980; Campbell *et al*., 1985). The roof zone of the granite is best exposed in a small quarry, now largely infilled, situated along the north-eastern margin of the granite outcrop.

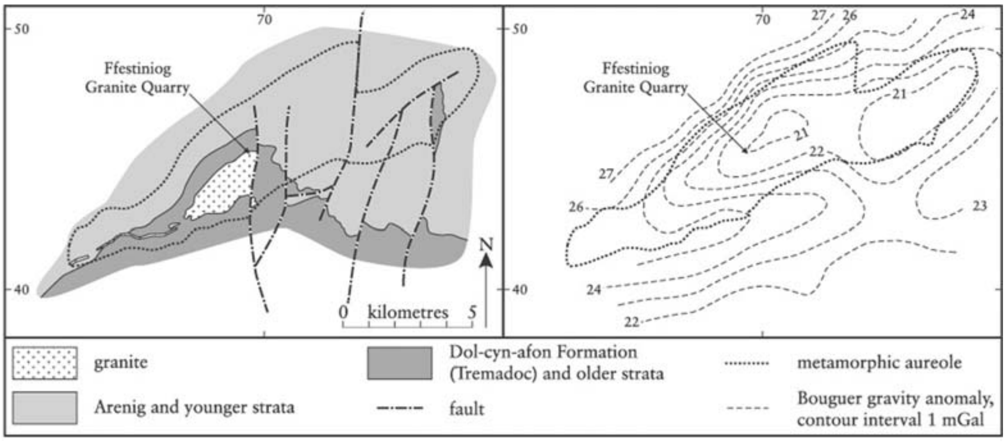

Figure 6.56: Map of the Ffestiniog area showing the surface outcrop and limit of metamorphic aureole of the Tan y Grisiau Granite and the associated Bouguer gravity anomaly.

Description

The Ffestiniog Granite Quarry GCR site exposes the upper contact of the Tan y Grisiau Granite, here dipping 40° to the NW. The contact is clearly discordant (Figure 6.57) and separates Tremadoc siltstones and mudstones in the upper part of the quarry face from a distinctive roof facies of the granite.

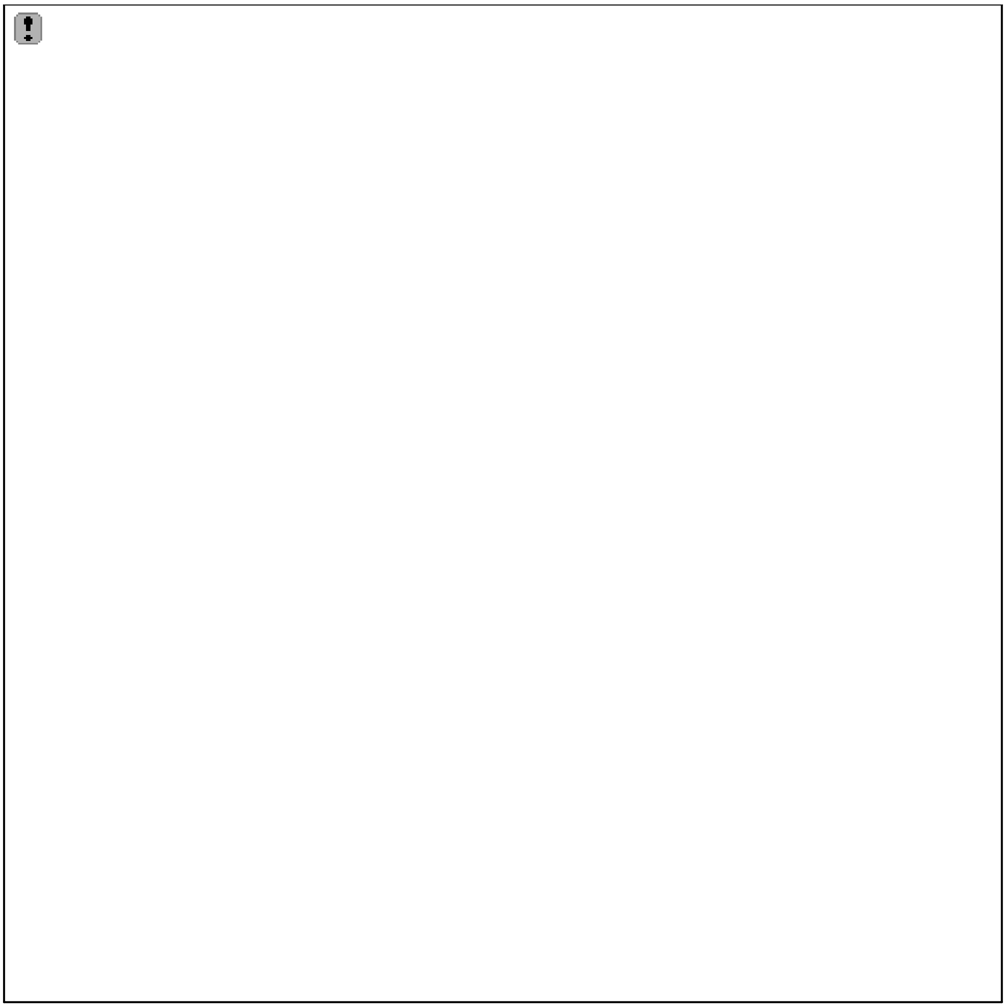

Figure 6.57: The roof zone of the Tan y Grisiau granite intrusion, Ffestiniog Granite Quarry. (Photo: reproduced from Roberts, 1979.)

In the lower quarry face (now largely obscured) the granite is a grey-green, homogeneous, fine-grained equigranular mosaic of plagioclase (albite–oligoclase), perthite and quartz with dark clots (0.5–1.0 cm in diameter) of chlorite after biotite. Common accessories include magnetite, zircon and allanite with traces of titanite, monazite, fluorite and epidote. In thin section, granophyric intergrowths of quartz and alkali feldspar are common and feldspars are altered to sericite. Bromley (1963) also recorded the presence of the blue-green amphibole ferrohastingsite. Towards the contact the granite becomes finer grained and vesicular, perthite is altered to muscovite, and plagioclase to aggregates of albite, quartz and calcite. This zone, heavily veined with graphic pegmatites and granite apophyses, contains rounded metasomatized xenoliths with whitish reaction rims (Bromley, 1964). Mineral assemblages in the marginal zone include biotite, almandine garnet and cordierite. Cavities, vugs and irregular thin pipes within this zone, and well exposed in a small quarry to the west of, and below, the main quarry (Roberts, 1979), contain allanite, pyrophyllite, quartz and traces of molybdenite.

The overlying country rocks belong to the Upper Sandstone Member of the Dol-cyn-afon Formation and comprise well-bedded medium- to fine-grained sandstones and siltstones. Immediately adjacent to the granite these strata are a very fine-grained, flinty, yellow-grey, unfoliated hornfels with irregular planar light and dark banding. In thin section a granoblastic texture of quartz with decussate muscovite is dotted with irregular dark blebs of chlorite and magnetite. Rare euhedral laths of sericite and chlorite may represent pseudomorphs after andalusite. Thin veins of albitic feldspar, often following early joints, and associated with enhanced levels of sericitic alteration in the adjacent wall rocks, are interpreted as former pathways for escaping volatiles.

At 10–15 m from the contact, the above rocks pass gradationally up into coarser grained, foliated, spotted hornfelses comprising the assemblage albite-epidote-chlorite-sericite-quartz. The spots, between 1 to 10 mm in diameter, consist of radial or concentric aggregates of sericite, quartz and penninitic chlorite with inclusions of fine-grained magnetite. A thin rim of leucoxene and microcrystalline chlorite often mantles the spots. Where the spots are weakly altered or deformed they are identifiable as pseudomorphs after porphyroblastic andalusite and less commonly cordierite. The presence of relict andalusite, cordierite and minor amounts of biotite and hornblende indicate original hornblende hornfels facies rocks subsequently retrogressed to the albite-epidote hornfels facies.

Interpretation

Compositionally, the Tan y Grisiau Granite has a rhyolitic to rhyodacitic trace element signature and Howells *et al*. (1991) noted a close comparison with the main phases of rhyolite dome emplacement in the Lower Rhyolitic Tuff Formation caldera. The granite appears to have been emplaced by stoping and contains a prominent marginal zone choked in places with partially digested xenoliths associated with pegmatite and tourmalinized breccias, and cut by veins of micrographic aplite and granophyre. Deformation within much of the granite is weak to non-existent and the lack of a penetrative foliation or mineral lineation supports a passive emplacement model. Locally, however, discrete narrow (1–2 m wide) zones of intense strain have been recorded (Smith, 1988). These zones, often associated with sheared dolerite dykes, are characterized by an intense foliation, a marked reduction in grain size and mylonitic fabrics; they indicate that the granite was deformed during the Caledonian Orogeny. Deformation is more clearly expressed in the overlying aureole rocks which are characterized by the development of thermal spots in sedimentary rocks up to 1 km stratigraphically above the granite roof. The spots, composed mainly of radial aggregates of sericite, quartz and chlorite, make excellent strain markers and have been studied by a number of workers (Bromley, 1963; Coward and Siddans, 1979; Smith, 1988; see review by Scott, 1992).

The extensive hornfels aureole and associated geophysical anomalies clearly show that the outcrop in the Tan y Grisiau area represents only a small part (less than 10%) of a large granite body (Figure 6.56). Subsurface, the granite has a sheet-like form, elongated NE–SW, with a NW-dipping roof. During emplacement and crystallization, streaming of silica-rich volatiles altered the original magmatic assemblage, producing a distinctive vesicular mineralized facies within the roof zone and retrogression of the surrounding hornfels. This autometasomatism is expressed elsewhere along the north-western margin of the granite with enhanced radiogenic values in areas of allanite mineralization and cavity development associated with tourmalinized breccias (Bromley, 1969).

The timing of emplacement of the Tan y Grisiau Granite has long been the subject of debate. On the basis of petrography, mineralization and deformation within the aureole, it has been assigned either to the Caradoc or to a late stage in the Caledonian Orogeny (see Bromley, 1969 for review). To the SW of the main outcrop, granophyric apophyses and sheets intrude Arenig strata, and transgress the mid-Caradoc unconformity (Smith *et al*., 1995) and the disrupted strata within the Rhyd mélange (Bromley, 1969; Smith, 1988; Howells and Smith, 1997). The extent of the hornfels (thermal spotting) aureole (Bromley, 1963, 1969) further indicates that rocks up to Costonian–Harnagian in age (the Moelwyn Volcanic Formation) are affected whereas younger rocks are not. Thus, the granite is stratigraphically constrained to the Caradoc. This, together with its geochemical correlations with the Lower Rhyolitic Tuff Formation, suggests that it is a subvolcanic intrusion associated with the 2nd Eruptive Cycle of caldera volcanism in North Wales (see the Snowdon Massif GCR site report).

Magnetic studies by Piper *et al*. (1995) indicate that the tilt-adjusted remnance directions are pre-Silurian and that magnetization occurred after deformation in late Ordovician times. K-Ar isotopic determinations by Thomas *et al*. (1966) suggest an age of *c*. 408 Ma, and recent Rb-Sr determinations by Evans (1990) provide an age of 384 ± 10 Ma. In common with many other younger Caledonian granites in North Wales these are considered to be reset ages affected by low-grade metamorphism and deuteric alteration during the Acadian Event (Evans, 1991). The emplacement age is probably concordant with the Mynydd Mawr Granite (438 ± 4 Ma) and the Bwlch y Cwyion hornfels (454 ± 20 Ma) which are the only two North Wales granites currently known to have escaped isotopic resetting (Evans, 1991).

The granite is broadly parallel to the main Caradoc volcanic rift structure in northern Snowdonia (Howells *et al*., 1991), and is on the northern margin of the Harlech Dome, so it may well have been focused along a pre-existing basement fracture (Smith, 1988).

Conclusions

The Tan y Grisiau Granite represents a large, elongate, subvolcanic intrusion within the Ordovician (Caradoc) marginal basin of Wales. The Ffestiniog Granite Quarry GCR site provides excellent exposures of the granite as well as preserving an important section through its heavily veined and mineralized roof zone and into the overlying hornfelsed sedimentary rocks.

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