Gwalchmai

[SH 379 766]–[SH 381 773]

Potential GCR site

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Introduction

This site lies on the western margin of the granite outcrop and has been proposed for the GCR because it illustrates particularly well the textural range of the Coedana Granite, here consisting of porphyritic, non-porphyritic and aplitic facies. The central part of the site (Figure 7.6) falls within the actively working Gwalchmai Quarry, suggesting the possibility of continuing good exposure.

The Coedana Granite constitutes one of the three units of the Coedana Complex (Bassett *et al.,* 1986). Its outcrop trends NE–SW, although exposure is poor in its north-eastern and southwestern extremities. To the south-east the granite is bounded by low-grade hornfels and rocks of the Central Anglesey Shear Zone, which may in part have a granite protolith (Horák, 1993). On the north-western side it is flanked by the Central Anglesey Gneisses and a minor outcrop of hornfels. In all instances the contact with the gneisses is faulted or unexposed.

Greenly (1919) provided the first detailed study of the granite, identifying facies variations and the presence of two fabrics, referred to as the *old foliation* and *mylonitization.* Although he initially considered the granite to intrude the metasedimentary rocks of the Monian Supergroup, he later reconsidered this and incorporated the Coedana Granite with the gneisses into the *ancient floor* (Greenly, 1919). Shackleton (1954, 1956) introduced a new model, re-interpreting the granite as the ultimate product of anatexis of the Monian Supergroup whereby the schists and gneisses represented intermediary stages of metamorphism. On the basis of later studies on the Monian rocks of Ll■n, Baker (1969) and Gibbons (1983) demonstrated that Shackleton's 'prograde metamorphic transition' model was not valid. Gibbons' (1990) terrane tectonic analysis of Monian geology once again grouped the Coedana Granite and its hornfels with the Central Anglesey Gneisses to form the Coedana Complex (Bassett *et al. ,* 1986).

The Coedana Granite has been subject to more isotopic age dating than any other Monian unit. The earliest attempts to date the Coedana Granite produced a Rb-Sr whole-rock age of 581 ± 14 Ma and K-Ar and Rb-Sr muscovite age of 576 ± 13 Ma respectively (Fitch *et al. ,* 1964, 1969; Moorbath and Shackleton, 1966). The low initial $^{87}Sr/^{86}Sr$ ratio of 0.7017 ± 0.0015 obtained by Moorbath and Shackleton (1966) was taken as indicating a mantle derivation for the granite, although this contradicted Shackleton's prograde metamorphic theory for its origin. More recently, Beckinsale and Thorpe (1979) published a whole-rock Rb-Sr age of 604 ± 4 Ma, using samples from Gwalchmai Quarry, and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7086 ± 9, which was interpreted as representing contamination of a mantle-derived melt, either by crustal material or by melting of a crustal protolith. A suggestion was also made that the granite could have been derived from melting of Monian paragneisses, such as those described from Holland Arms, southern Anglesey, by Beckinsale and Thorpe (1979).

The publication of a U-Pb zircon age of 614 ± 4 Ma (Tucker and Pharaoh, 1991) has constrained precisely the age of crystallization of the Coedana Granite. Furthermore, the upper intercept of the U-Pb discordia provided an age of 1443 ± 34 Ma, consistent with the 1350–1430 Ma NdT(DM) model age of Davies *et al.* (1985).

In contrast to the amount of isotopic work carried out on the granite, only a single whole-rock geochemical analysis has been published (Thorpe, 1982), although representative data were presented by Horák (1993). These geochemical analyses must be interpreted with caution in view of the pervasive ductile deformation present within the Coedana Granite, which is largely a protomylonite or a mylonite. It was found that the granite had an evolved composition (all samples with > 70 wt % SiO_2 and many > 74 wt % SiO_2), and an arc-related signature. The geochemical and isotopic data indicate that the Coedana Granite has an intrinsically Avalonian' signature, suggesting that it represents an outboard, fault-bounded sliver of the Avalonian subduction system.

Description

The site demonstrates a number of facies of granite. Porphyritic granite is medium-grained, less commonly coarse-grained, with a greenish pink colour. Typical exposures of this facies are seen on the ridge east of Clegir Mawr [SH 388 772], where the large alkali-feldspar phenocrysts appear pale pink. Many exposures show evidence that the granite has experienced ductile deformation, the result being most clearly displayed by deformed quartz crystal aggregates, which exhibit a crudely developed rodding fabric. Cut blocks (Figure 7.7) and thin sections show the extent of brittle deformation represented by fracturing of feldspars, chlorite-filled fractures and local brecciation textures.

Thin sections show that the primary morphology of quartz crystals has been modified or destroyed, biotite crystals are altered to chlorite and realigned to form impersistent foliae, and feldspars show limited recrystallization (although brittle deformation is the dominant process). Garnet pseudomorphs from this locality, although possibly xenocrysts from the gneiss-es, are more likely to be igneous in origin as they do not preserve evidence of inclusions and have euhedral form (Horák, 1993). The contact relationships between the porphyritic and non-porphyritic facies are not well defined, which is in part due to deformation and weathering that has obscured original textures.

Non porphyritic granite is the most abundant facies within the Coedana Granite. Its mineralogy varies from that of a relatively mafic, biotite-rich rock, which more closely resembles the porphyritic facies, to a more leucocratic variety. The facies weathers white to pale green, with broken surfaces showing mica, dominantly biotite, defining a foliation of variable intensity. More extensively deformed samples are commonly deeply altered and cut by chlorite veins, thus preserving little evidence of primary igneous texture.

Aplite is the least abundant facies within the Coedana Granite and occurs as narrow veins of fine-grained granite up to 1.5 m wide, cutting the other granite varieties, for example in the locality just north of the A5 [SH 378 766]. The aplite is pale pink to cream in colour, has a fine-grained saccharoidal texture, and contains small muscovite laths. Deformation of this facies is not obvious in hand specimen, but thin sections show that quartz is extensively recrystallized. Accessory minerals are scarce, but pseudomorphs, after possible garnet, have been recorded. This is substantiated by a thin section of aplite from an exposure south-east of Coedana Chapel (several kilometres north-east of this site and the type locality for the Coedana Granite), which shows abundant euhedral to subhedral garnet. This exposure was mapped by Greenly (1919), but unfortunately no longer exists, so the composition of the garnet in the aplite remains unanalysed.

Interpretation

The Coedana Granite represents the most extensive outcrop of plutonic igneous rock within the Monian Composite Terrane and this site is highly representative in that it demonstrates the occurrence of three out of the four granite facies that have been recognized. The site also allows observation of deformation textures, both at outcrop scale and within large blocks with weathered surfaces within the quarry.

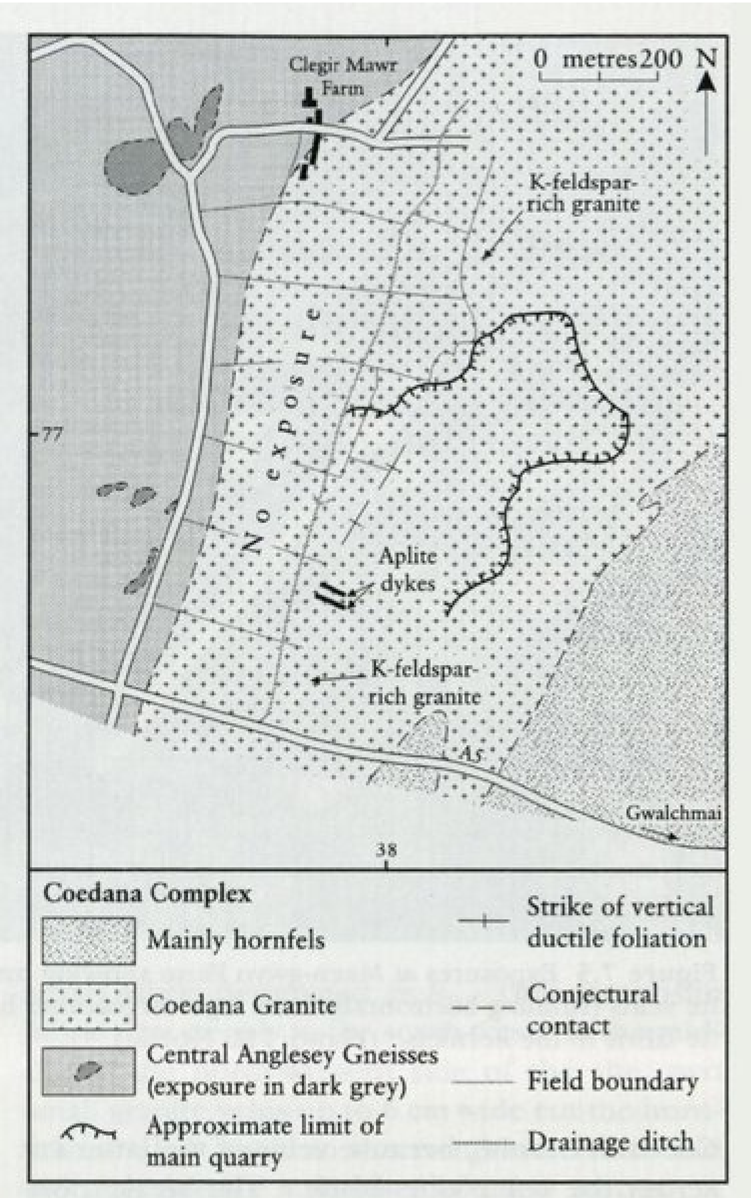
Geochemical data indicate that the granite has an evolved composition and can be classified as being dominantly a monzogranite that arose within a volcanic arc tectonic setting. Mineralogical and isotopic data further suggest that the granite has an important inherited crustal component, with a calculated average crustal residency age of 1350–1430 Ma. This value is not significantly different to that determined for other Precambrian plutonic rocks of southern Britain. It precludes the granite being derived solely from the Central Anglesey Gneisses, one of the other components of the Coedana Complex, but does not rule out these gneisses being contaminants, or having a minor role as one of several protoliths supplying the melts that formed the granite. The geochemical signature, and the precise resolution of its magmatic age, have together enabled Gibbons and Horák (1996) to categorize the granite as belonging to Avalonian Event 2, which is the main arc-magmatic phase (Figure 1.4).

The presence of the Central Anglesey Shear Zone on the south-eastern side of the Coedana Granite is a reflection of the complex tectono-thermal history that the Coedana Complex has experienced, compared to the history of contemporary plutons elsewhere in southern Britain. Horák (1993) interpreted the Coedana Complex and granite as a sliver of the main Avalonian arc that has been dissected from its original position by transcurrent faults. Kinematic indicators in the shear zone that provide evidence for sinistral movement, show that the Coedana Granite could have originated some unknown distance to the north-east of its present location.

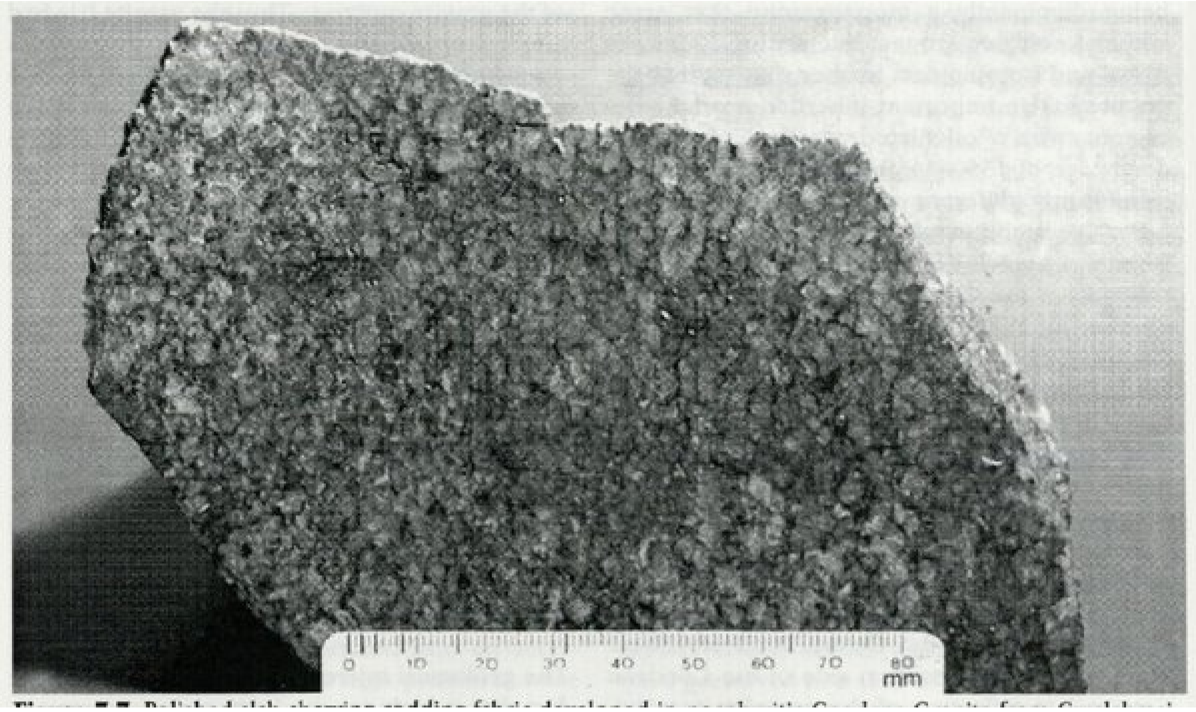
Conclusions

The Gwalchmai site contains good exposures of the Coedana Granite, which in terms of its chemistry is a typical calc-alkaline volcanic arc granite generated in the late Precambrian Avalonian subduction system (Figure 1.4). The main lithologies demonstrated at the site are the porphyritic, non-porphyritic and aplite facies of the granite. These original textures were largely overprinted and obscured by a later deformation that has resulted in the development of an impersistent rodding fabric and foliation, accompanied by extensive recrystallization of the granite. The stress regime causing this may in large part have been transmitted from movements occurring along a major ductile fault zone, the Central Anglesey Shear Zone, on the south-eastern side of the granite outcrop. Thus the granite has had a more complex history than its contemporaries elsewhere in southern Britain. Interpretations of the shear zone suggest that after intrusion, the granite was transported from its position in the main Avalonian arc and moved over some unknown distance to the south-west along the Avalonian subduction complex. This tectonic setting is comparable to that observed today in the San Francisco Bay area, where transcurrent movement along the San Andreas Fault is currently transporting the Salinian Block (a sliver of arc granite) northwards.

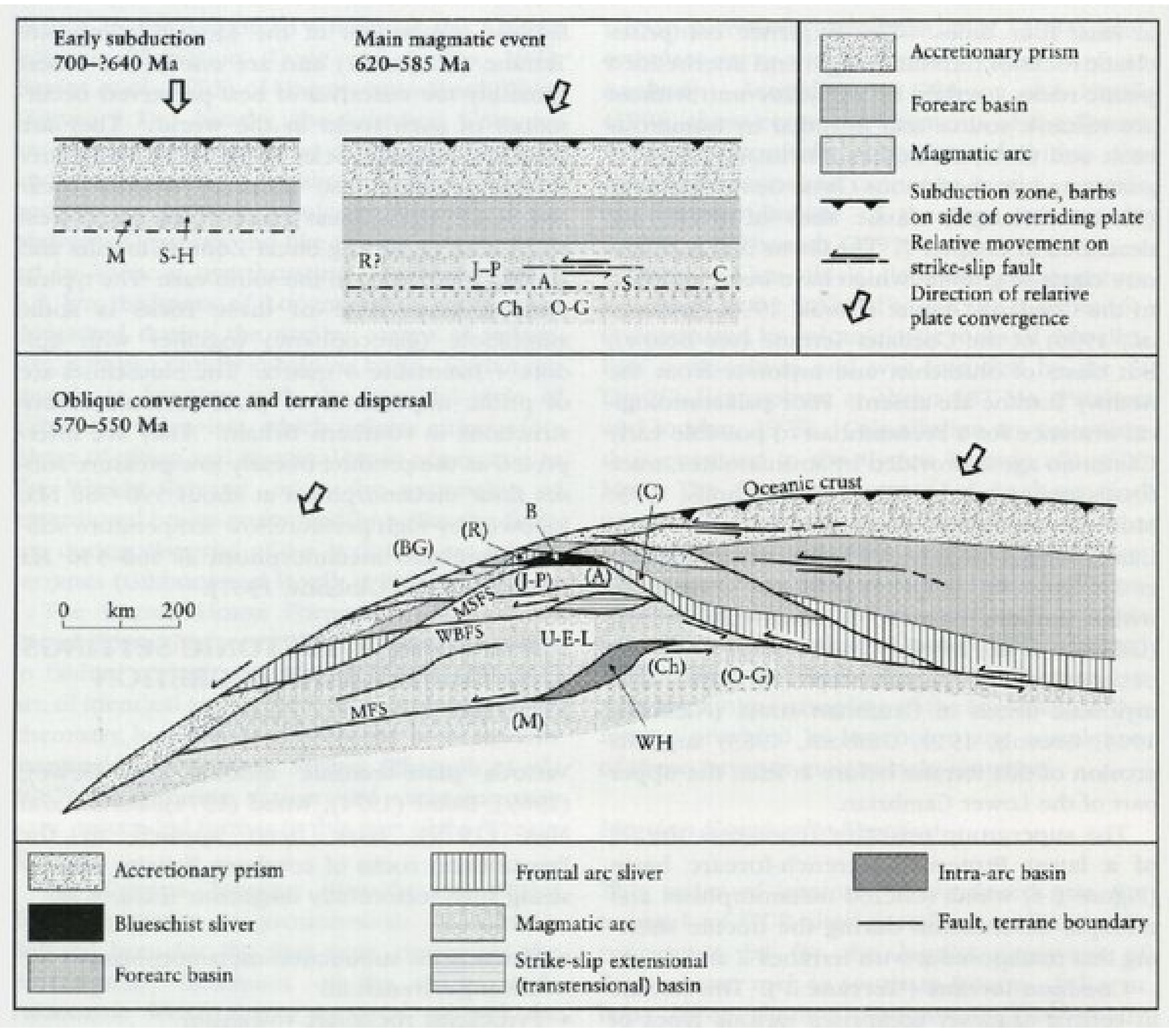
[References](#)



(Figure 7.6) Geological map of the Gwalchmai site.



(Figure 7.7) Polished slab showing rodding fabric developed in porphyritic Coedana Granite from Gwalchmai. (Photo: J.M. Horák.)



(Figure 1.4) Model for the late Precambrian evolution of the Avalonian subduction system: episodic Precambrian magmatism (top two cartoons) followed by the dispersal of terranes by transcurrent faulting along the plate margin as *convergence became increasingly oblique during the latest Precambrian (modified from Gibbons and Horik, 1996). Note that the presence of the Monian Composite Terrane within this system cannot be proved until Arenig time. A = Arfon Group; B = Anglesey blueschists; BG = Bwlch Gwyn Tuff and related strata (Anglesey); C = Coedana Complex; Ch = Charnian Supergroup; J-P = Johnston Plutonic Complex and Pebidian Supergroup; M = Malverns Complex; MFS = Malverns lineament or fault system; MSFS = Menai Strait fault system; O-G = volcanics in Orton and Glinton boreholes; R = Rosslare Complex; S = Sam Complex; S-H = Stanner-Hanter Complex; U-E-L = Uriconian Group, Ercall Granophyre, Longmyndian Supergroup; WBFS = Welsh Borderland fault system; WH = Warren House Formation. The same letters in brackets (lower cartoon) refer to the relative positions of those volcanic belts that were by then extinct.*