Coed Llyn y Garnedd

[SH 650 420]

Introduction

Forest roads that were extended in the late 1990s on the wooded hillside at Coed Llyn y Garnedd (Figure 5.45) provide an almost continuous section through sedimentary, volcanic and intrusive rocks of Tremadoc through to Caradoc age. Mineralization exposed in the roadside cuttings falls into four distinct categories and the section offers some valuable age-constraining relationships when examined in conjunction with the Ffestiniog Granite Quarry, Manod Quarry and Afon Stwlan GCR sites. Two generations of veining, the 'Regional veins' (Fitches, 1987), and the Ffestiniog–Porthmadog Belt quartz-sulphide veins, are pre-tectonic with respect to Acadian deformation, while apparently syntectonic veins of the 'Alpine-type' suite occur locally. The fourth generation of veining is post-tectonic, consisting of coarsely crystalline marcasite associated with quartz, an assemblage which occurs regionally across North Wales.

Description

The track section described here commences from the B4410 Garreg–Maentwrog road at a forest car-park, and passes up through Tremadoc-age sedimentary rocks (intruded by a dyke-like body of microgranite) into Arenig–Llanvim sandstones and mudstones, including, at the top, laharic flow-breccias, and finally rocks of the Moelwyn Volcanic Formation of Caradoc age. The section is described in an anticlockwise manner.

In the first kilometre from the car-park, the geology comprises sandstones and siltstones of the Dol-cyn-afon Formation of Tremadoc age, intruded at one point by a wall-like body of microgranite, related genetically to and probably part of the Tan y Grisiau Microgranite. The sedimentary rocks reveal thermal spotting to a considerable distance from the microgranite outcrop, indicating that the intrusion is of much wider extent at depth than its surface exposure suggests. The microgranite varies in colour from mottled grey to pink, and is cut by two types of veins. Firstly there are quartz veins with pyrite and sphalerite, belonging to the Ffestiniog–Porthmadog belt group, as exposed at the Afon Stwlan GCR site. Secondly, there are vuggy veins carrying quartz, chlorite, pink albite and rare anatase, belonging to the 'Alpine-type' group. Both types of veins are thin and irregular, but they usefully demonstrate their age relationship with the microgranite.

Further along the track, a prominent outcrop on its eastern side is dominated by a massive, NW–SE-striking steeply dipping quartz vein hosted by spotted grey siltstones belonging to the Dol-cyn-afon Formation. The surface of the vein has been smoothed by glacial action but broken debris occurs immediately to its south. Much of this consists of siltstone clasts and quartz, derived from the vein margins, and where the quartz-clast interface has ruptured, a crystalline vug-lining assemblage has developed which consists of further quartz, pink to white albite and deep sapphire-blue tabular anatase. Many of the anatase crystals, which reach 1–2 mm, have been broken and healed, giving them a slightly curved appearance. The massive quartz vein is thought to belong to the 'Regional veins' noted in the 'Introduction', whilst the anatase-bearing vug-filling mineralization, belonging to the 'Alpine-type' suite, is thought to represent localized extensional fracturing along the interface between the massive quartz and sedimentary rock clasts during Acadian deformation.

The track climbs for a few hundred metres, passes two minor turn-offs on the right and then turns sharply back left. Here, lying unconformably above the Dol-cyn-afon Formation is the Garth Grit, belonging to the Allt Liryd Formation. The grit is a coarse, quartzose sandstone of Arenig age, which contains numerous milky quartz veins. Along the descending track section from this locality, grey, spotted mudstones belonging to the main part of the Allt Ll■d Formation are particularly intensely veined. One set of veins (set 1), belonging to the Ffestiniog–Porthmadog belt suite, consists of milky quartz with sphalerite and occasional pyrite and chalcopyrite. These veins form two well-defined subsets (sets la and lb) at this locality: firstly, there are numerous, low-angle 2–3 cm-wide veins, dipping NNW at 25°–30° with the bedding; and secondly there are steep to vertical link-veins, generally striking in a northeast-to south-west to ENE–WSW direction. The

other set of veins (set 2) strikes ENE–WSW to east-west and slightly displaces the quartz-sphalerite veins where it cuts them. The set 2 veins consist of open fracture-linings of cockscomb marcasite, now rather weathered, accompanied by clear to greyish stumpy quartz crystals. Pyritic haloes up to 0.3 m in width have formed in the wall-rock adjacent to the set 2 veins.

The track climbs slightly and reaches a T-junction. To the right, a short distance on, a small roadside quarry has been worked in thick scree derived from Nant Ffrancon Subgroup rocks, and has exposed the underlying glacially smoothed bedrock. A short distance up the exposure, there crops out an irregular, strongly jointed quartz vein belonging to the 'Regional veins', and blocks lying beneath reveal small extensional fractures at its margins, forming vugs containing green crystalline rosettes of chlorite up to about 2 mm and hair-like crystals of rutile, this belonging to the 'Alpine-type' suite.

Leftwards from the T-junction, the track steadily descends back towards the road. Along its western side there are numerous exposures of mudstones belonging to the Nant Ffrancon Subgroup with strong developments of veining in places, especially those belonging to the 'Regional veins'. These occur in locally dense arrays of flat-lying quartz veins separated by a few centimetres of strata. The veins are typically 3–30 cm in thickness and are buckled and weakly boudinaged in places; cleavage in the mudstone between the veins has been strongly disturbed in places (Figure 5.46). Thinner steeply inclined veins join the flat-lying veins in places and are occasionally seen to extend above the vein arrays only to pinch out after a few tens of centimetres. Broken vein sections reveal intra-vein partings deformed into strongly stylolitic surfaces marked by chlorite. The other veining along this section belongs to the Ffestiniog–Porthmadog suite and consists of narrow (2–3 cm) quartz-sphalerite-chalcopyrite-pyrite veins which are almost concordant with bedding, dipping into the hillside at 20°–30°. Well-exposed intersections with the 'Regional veins' are hard to find today: in 1997, when the exposures were fresher and less vegetated, it was noted that the Ffestiniog–Porthmadog belt veins were very occasionally seen to cut the 'Regional veins' without displacing them.

Interpretation

This section has demonstrated the age relationships of the various types of mineralization and the sedimentary rocks and a major intrusion within the Ffestiniog–Porthmadog slate-belt, and complements other GCR sites in the area, where their detailed mineralogy is displayed to better effect. It reveals the important time sequence of intrusion and mineralization which is as follows:

1. Post-burial development of the 'Regional veins' of predominantly flat-lying quartz vein-arrays;
2. Intrusion of the Tan y Grisiau Microgranite into strata of Lower Ordovician age;
3. Fracturing and emplacement of the Ffestiniog–Porthmadog belt quartz-sulphide veins;
4. Acadian deformation and local extensional fracturing; formation of 'Alpine-type' veins; and
5. Emplacement of regional crustiform quartz-marcasite-dominated veins.

The 'Regional veins', recorded across the Welsh Basin from all stratigraphical levels from Cambrian up to Silurian and in all lithotypes, are considered to be products of hydraulic jacking by overpressurized pore-fluids during burial-related metamorphism (Fitches, 1987), and as they formed during progressive burial of the various lithologies of various ages, they are clearly diachronous. However, the burial depth at which they started to form is uncertain. The hydraulic jacking mechanism, explained by Fitches (1987), involved porewaters migrating upwards through the sedimentary pile and regularly getting trapped beneath layers of argillite whose permeability had been reduced by compaction and diagenesis. High fluid pressures in such instances would have led to failure along the lines of weakness represented by bedding surfaces, resulting in bedding-parallel cavities opening up with minerals being deposited on cavity surfaces. The veins at a steep angle to bedding formed due either to hydraulic fracturing of cavity ceilings or, possibly, where the strata were slightly inclined, with assistance from extra horizontal tensile stresses due to downslope extension. By these processes, a stack of bedding-parallel veins, linked by steeper veins, would propagate upwards through the sedimentary pile, and would continue to form while there was sufficient availability of fluids. The hydrothermal systems involved seem to have been rather localized in extent, in the order, perhaps, of just hundreds of metres, and the fluids would probably have been a mixture of buried seawater and water released via dehydration reactions during diagenesis. The limited extent

and lack of circulation of the fluids is the likely explanation for the veins being: (a) dominated by quartz; and (b) having accessory minerals that reflect host-rock composition.

The pre-Acadian Ffestiniog–Porthmadog belt mineralization has been discussed in detail elsewhere in this chapter (see the Afon Stwlan GCR site report). That the veins cut both the 'Regional veins' and the Tan y Grisiau Microgranite, yet are themselves deformed, as seen at Afon Stwlan, constrains their age to a point between the Caradoc, when the microgranite was intruded, and the early Devonian. In the immediate vicinity, the only other identifiedmetallogenic episode during the above time-frame was the Snowdon Caldera Cu-Zn-Fe-Pb-As mineralization, seen for example at the Lliwedd Mine GCR site. Snowdon is less than 10 km away from this site, and it is possible that these quartz-sulphide veins represent a distal facies to the caldera mineralization, which, it is already known, extended beyond the caldera margin, as seen at the Llanberis Mine GCR site.

The 'Alpine-type' veins are only weakly represented at this site. However, one interesting feature is well-demonstrated here in that they can develop along the margins of existing 'Regional veins', a feature also well known in the Alps where they have been worked for specimens for centuries. Under high-strain situations, the strong rheology-contrast across the often irregular interface between the margin of a favourably orientated massive quartz vein and its wall-rocks can become a locus for shear movements and consequent localized extensional fracturing, creating small cavities that any available fluids would enter, depressurize and deposit minerals on the cavity sides. In such a scenario, the sources for the fluids would be extremely localized, as would be the elements dissolved in them. Widespread circulation of fluids is less favoured in high-strain situations.

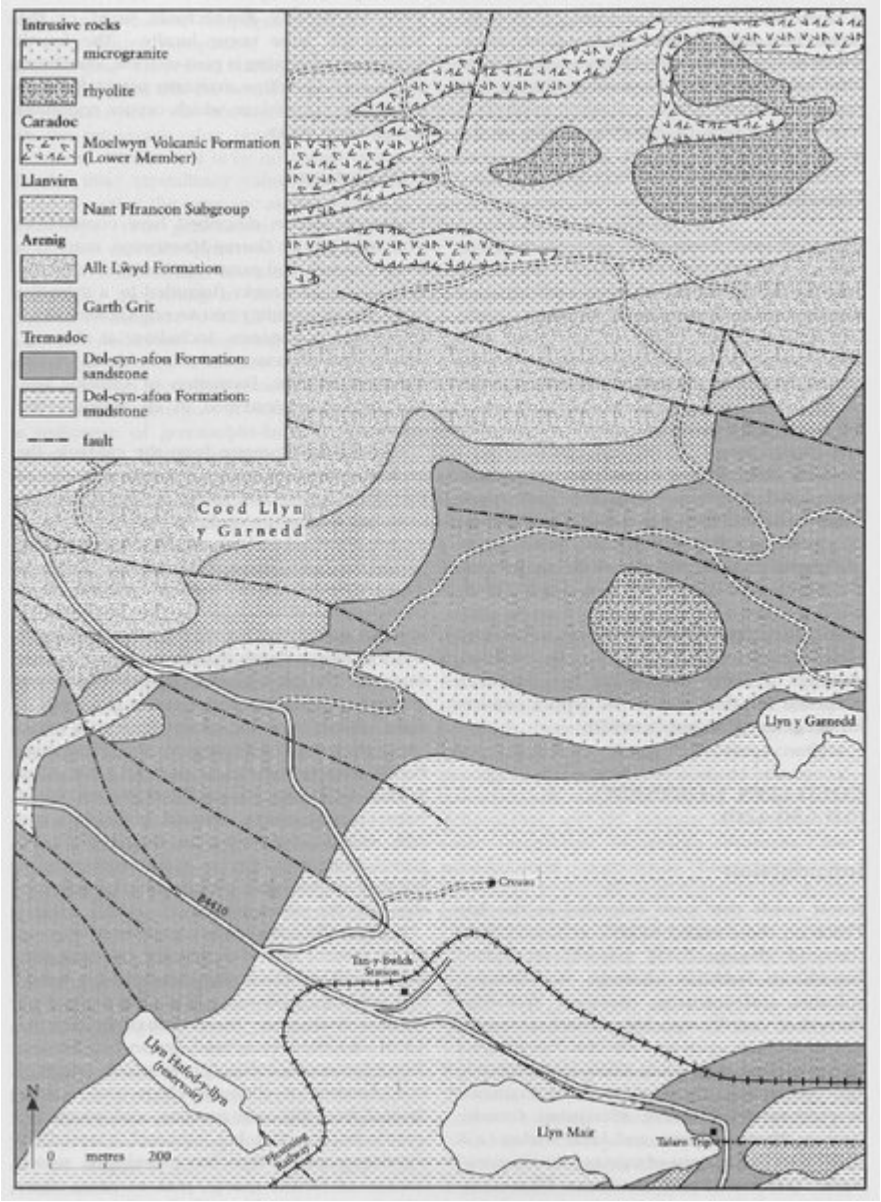
The quartz-marcasite veining is representative of a regional group of post-Acadian crustiform veins which is developed throughout the Welsh Caledonides. Closely similar veins are common in the Dolgellau Gold-belt, where they cut, but rarely displace, the gold-belt veins (Mason *et al.,* 1999). Within the Snowdon Caldera and environs, crustiform-banded calcite-marcasite-dominated mineralization is widespread in small amounts (Bevins and Mason, 1998) and is Assemblage 4 of Reedman *et al.* (1985). To the north-east of the Snowdon Caldera, such mineralization is more intensively developed within the Llanrwst mining district, where it was extensively worked for lead and zinc (Haggerty, 1995), while to the south of Snowdonia, the late (A2) assemblages of the Central Wales Orefield (Mason, 1994, 1997) frequently exhibit mineralogical and textural features which suggest that they may also be assigned, at least in part, to this regional suite of veins.

The regional, post-Acadian crustiform fissure-fill veins are expressions of periodic regional crustal extension and hydrothermal fluid-flow at various times from Upper Palaeozoic times onwards. Such tectonic regimes and associated hydrothermal activity were a feature of the Welsh Caledonides in pre- and particularly post-Variscan times, when the area was surrounded by a series of subsiding basins from which connate brines were driven, either into uplifted Lower Palaeozoic rocks or into Carboniferous carbonate-dominated sequences, as in the North-east Wales Orefield. If anything, the information that can be gained by studying their extent, in terms of size and distribution, may serve to indicate crudely the intensity of regional extension in any given area.

Conclusions

Roadside exposures in Coed Llyn y Garnedd, exposing strata of Tremadoc to Caradoc age, reveal structural evidence which provides age constraints for the various suites of mineral veins occurring within the Ffestiniog–Porthmadog belt, an area of considerable geological controversy, particularly in relation to its structural evolution.

References



(Figure 5.45) Map of the Coed Llyn y Garnedd GCR site. After British Geological Survey 1:50 000 Sheet 119, Snowdon (1997).

(Figure 5.46) Arrays of flat-lying regional pre-tectonic quartz veins hosted by mudstones of the Nant Ffrancon Subgroup. Note disturbance of the cleavage of the mudstone adjacent to the veins. (Photo: J.S. Mason.)