Llangynog

[SN 330 145]

Potential GCR site

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Introduction

This structural inlier, in the vicinity of Llangynog, Carmarthenshire, comprises one of three important Precambrian sites in Wales lying to the south-east of the Menai Strait Fault System (Figure 6.1). Together with the Llyn Padarn and the St David's Peninsula GCR sites, described in Chapter 6, it provides critical evidence for the nature of the Precambrian basement beneath the Welsh Basin region. The site is of further significance, however, in representing one of the most south-westerly outcrops of the Wrekin Terrane (Figure 1.1). As will be discussed below, its rocks have affinities with the Uriconian Group of Shropshire and are dissimilar to the Pebidian Supergroup of south-west Wales, even though the latter are in closer proximity. A terrane boundary is inferred to separate the two, as shown in (Figure 6.1).

The sequence exposed (Figure 5.22) is 1100 m thick and consists of rhyolitic and basaltic lavas, rhyolitic pumiceous and shardic ash-flow tuffs, basaltic autobreccias and uncommon hyaloclastites. These rocks are associated with intrusions of basic and, rarely, intermediate composition.

The earliest geological descriptions of the Llangynog area were by Murchison (1839), based on the rhyolitic rocks of the Capel Bethesda and Castell Cogan areas. The area was first investigated in any detail by the Geological Survey during their geological mapping of the district around Carmarthen. Cantrill and Thomas (1906) presented a full account of the Llangynog area, which was the basis for the subsequent memoir description compiled by Strahan *et al.* (1909). In these accounts the volcanic rocks were assigned an Ordovician age.

Identification of Tremadoc-age strata in the Llangynog area (Cope *et al.,* 1978) led to a renewed interest in the geology of this region, and brought into question the supposedly Arenig age of the volcanic rocks (Arenig being younger than Tremadoc), which actually underlie the Tremadocian strata. In particular, this study led to the conclusion that the rhyolites of the Castell Cogan area are of pre Tremadoc age. Most significant of all, however, was the discovery of an Ediacaran fauna in associated strata (see the Coed Cochion GCR site report, Chapter 8), which confirmed a Precambrian age for at least some of the rocks of the Llangynog Inlier (Cope, 1977). The discovery has also established this site as one of international geological importance.

Later studies by Cope and Bevins (1993) confirmed that the Ediacaran fauna was preserved in volcaniclastic strata, and, as discussed in the introduction to this chapter, the rhyolites, basalts and related rocks are by association assumed to be late Precambrian. Cope and Bevins (1993) reviewed in detail the volcanic rocks of the Llangynog Inlier and established a new stratigraphical succession. This revised stratigraphical nomenclature is used in the description below.

Bevins *et al.* (1995) presented geochemical data for the basic, (rare) intermediate and silicic rocks from the Coomb Volcanic Formation. They concluded that the various rock types are petrogenetically related, most probably by low-pressure fractional crystallization dominated by plagioclase feldspar and possibly amphibole. In particular, the Precambrian volcanic rocks of the Llangynog Inlier constitute a bimodal magmatic suite with marked petrological and geochemical similarities to the Uriconian Group, exposed farther north in Shropshire. On multi-element normalized diagrams, the basalts exhibit slight depletions of Ta and Nb and slight enrichments of Th and Ce indicative of active continental margin tectonic settings, but the Nb/Y diagram also indicates a strong within-plate chemical component. There are, however, certain geochemical differences to the Pebidian volcanic rocks exposed in the St David's Peninsula GCR site, which in fact are more similar to the volcanic rocks of presumed Precambrian age recovered from the Bryn-teg borehole in the Harlech Dome region of North Wales (see Chapter 6). The chemistry therefore supports the model discussed above, featuring a major intervening crustal boundary separating the Cymru and Wrekin terranes (Figure 1.1).

The western boundary of the Precambrian outcrop is fault-defined, with Llanvirn rocks lying to the west (Strahan *et al.,* 1909). To the south and east the Precambrian rocks are overlain unconformably either by early Cambrian rocks (Cope and Rushton, 1992) or by Old Red Sandstone (Cope, 1980).

Description

The various Precambrian volcanic and volcaniclastic rocks of the Llangynog Inlier are exposed chiefly in the unnamed river valley and adjacent crags to the south of Llangynog village (Figure 5.22). Cope and Bevins (1993) coined the term Coomb Volcanic Formation for these rocks, recognizing two members, a lower Castell Cogan Rhyolite Member and an upper Coed Cochion Volcaniclastic Member.

The Castell Cogan Rhyolite Member, up to 400 m thick and younging to the north, chiefly comprises rhyolitic lavas, seen for example on the high ground of CasteII Cogan [SN 3277 1394] and also on the crags of Allt yr Hendre [SN 3317 1417]. More remotely, rhyolitic rocks are also exposed in the vicinity of Capel Bethesda (around [SN 363 157]) and to the east of Waun-das [SN 3553 1509], respectively lying to the north-east and south of (Figure 5.22). The rhyolites show extensive silicification, dominated by mosaics of coarse-grained quartz, and are commonly cut by thin quartz veinlets. They do, however, preserve evidence of primary flow-banding, seen for example in forestry track exposures on Gallt y Minde, about 300 m west of Castell Cogan. The rhyolites are typically sparsely porphyritic, with feldspar phenocrysts up to 2 mm in length, although these are commonly replaced by white mica. The only other primary phase present is zircon.

Conglomerates, which crop out in the vicinity of Capel Bethesda, considered by Cope and Bevins (1993) to belong to the Castell Cogan Member, contain rounded cobbles and boulders of rhyolite up to 0.6 m in diameter. Other conglomerates, exposed farther south on the slopes of Allt y Coomb, to the south-east of old Tre-hyrn Farm (Figure 5.22), are correlated with the Coed Cochion Member.

The fossil-bearing Coed Cochion Member consists predominantly of volcaniclastic rocks, associated with rare basaltic lavas, rhyolitic ash-flow tuffs and an horizon of rhyolitic lava and associated conglomerates. The volcaniclastic rocks, which dip to the north at around 50°, are well exposed around the derelict house at [SN 3332 1467] and at the disused quarry at Coed Cochion [SN 3335 1465]. Sedimentary structures present include cross-lamination, climbing ripple lamination and sporadic flaser bedding; finely laminated and normally graded beds also occur. It is within these volcaniclastic beds that the Ediacaran fauna (Cope, 1977) occurs (see the Coed Cochion GCR site report, Chapter 8). The ash-flow tuffs display classic shardic textures (Figure 5.23) and contain clasts of welded ash-flow tuff with streaked out pumices (parataxitic texture) similar to inclusions in tuffs from the St David's Peninsula GCR site. Within the succession at least five thin basalt lava sheets have been identified, cropping out in the valley sides both to the north and south of Coed Cochion.

Basaltic lavas are sparsely porphyritic, with plagioclase phenocrysts up to 4 mm in length. These are set in a groundmass of recrystallized glass (now chlorite), accompanied by chloritic pseudomorphs after primary mafic minerals (most probably olivine and clinopyroxene), and Fe-Ti oxide minerals. The lavas show evidence of quench textures, including skeletal crystal forms, in particular 'swallow-tail' and 'belt-buckle' textures (Figure 5.24). A basalt flow exposed some 140 m to the north of Coed Cochion shows a brecciated margin in contact with adjacent sedimentary rocks. The breccia is composed entirely of former glassy basalt fragments and was originally a hyaloclastite.

The rhyolitic tuffs comprise crystals, chiefly angular quartz and plagioclase, and lithic clasts up to 3 mm in diameter. Other fragments typically include rhyolitic lava and rarer basalt, together with pumice fragments (again up to 3 mm) ubiquitously replaced by sericite and/or chlorite and showing no signs of flattening. Also present are glass shards, now replaced by fine-grained aggregates of quartz and feldspar.

Volcaniclastic siltstones are best exposed along the northern section of Allt y Coomb and on the lower slopes of Allt Tre-hyrn (Figure 5.22). Coarser-grained siltstone beds contain chiefly angular, fractured plagioclase crystals, angular quartz chips, chloritic pseudomorphs after mafic minerals, rarer white micas and scattered aggregates of celadonite. In places, rare basaltic lithic lapilli are present, and one bed has a preponderance of recrystallized glass shards.

Heterolithic conglomerates, exposed to the south-east of old Tre-hyrn Farm, contain a variety of angular to sub-rounded clasts, up to 3 cm in diameter, chiefly rhyolitic lava in character, but also including volcaniclastic sandstone, basaltic lava, and various types of rhyolitic tuff.

A number of basic intrusions are present in the site area, the largest occurring on the east-facing lower slopes of Allt Tre-hyrn and best exposed in a small quarry in the vicinity of old Tre-hyrn Farm at [SN 3312 1445]. Primary textures are typically ophitic to sub-ophitic and well preserved, although primary minerals are almost entirely altered. Original Ca-plagioclase feldspar is ubiquitously replaced by albite, and primary mafic minerals are mostly replaced by chlorite (clinopyroxene is sporadically preserved). Prehnite and pumpellyite are present in minor amounts, reflecting alteration of original plagioclase feldspar and also groundmass; these minerals indicate low-grade metamorphism that is typical of the Lower Palaeozoic rocks across the Welsh Basin region (Bevins and Rowbotham, 1983). A single dacite intrusive sheet is present in the upper slopes of Allt Tre-hyrn. It is holocrystalline, with microporphyritic albitized plagioclase feldspar crystals and calcite pseudomorphs after amphibole, contained in a fine-grained feldspar-quartz dominated groundmass.

Interpretation

Geochemical studies, discussed in the introduction to this chapter, suggest that the Coomb Volcanic Formation has attributes of active continental margin magmatism, though with a superimposed within-plate component. Eruptions occurring within a fault-controlled ensialic marginal basin in a late Precambrian Avalonian volcanic arc (Figure 1.4) would probably have produced such a sequence.

Early volcanic activity in the Llangynog area was dominated by silicic magmatism, now represented by flow-banded rhyolites of the Castell Cogan Rhyolite Member that pass upwards into coarse, monolithic breccias. Such a progression suggests that the rhyolites were of extrusive origin, and most probably were subaqueously emplaced in the form of thick flows or domes. Reworking of the brecciated carapaces of these flows or domes probably provided the debris for the heterolithic conglomerates. Sporadic explosive eruptions are represented by the thinner pumiceous and shardic ash-flow tuffs.

Later activity was characterized by both acid and basic magmatism in the Coed Cochion Member. Basaltic lavas show quench textures, suggestive of subaqueous emplacement, as does the presence of hyaloclastite deposits, although no pillow structures have been recorded. Breccias composed almost entirely of basalt lava fragments are thought to have been derived from the reworking of lava flow tops, which with further reworking led to the development of volcaniclastic siltstones and fine-grained sandstones. Evidence provided by sedimentary structures suggests that these volcaniclastic siltstones, together with their medusoid fossil faunas at Coed Cochion (Chapter 8), originated in shallow water to intertidal environments. A model of ephemeral volcanic islands undergoing continuous erosion and reworking has been put forward by Cope and Bevins (1993).

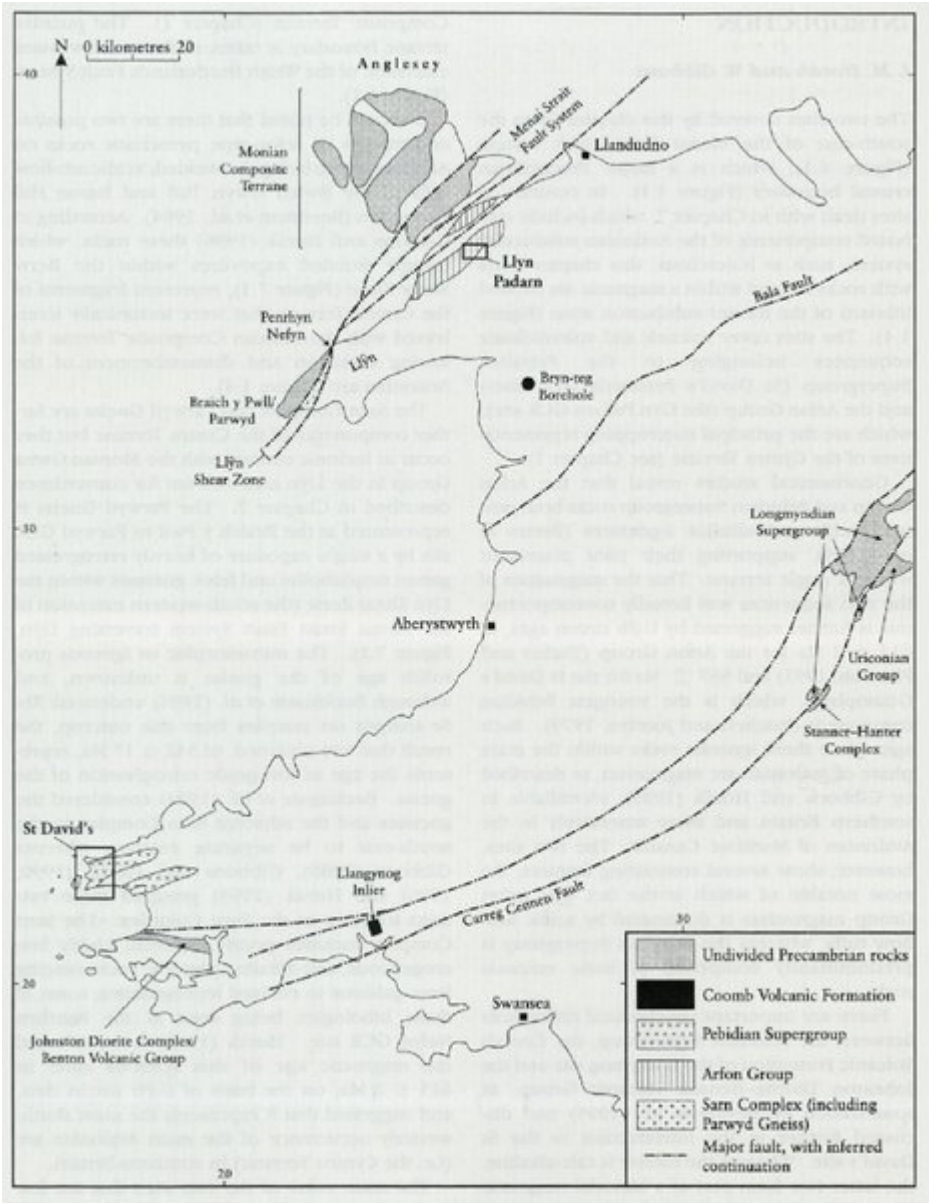
Conclusions

Within the Llangynog Inlier it is possible to examine Precambrian volcanic rocks ranging from acid through rare intermediate to basic types. In chemical composition these rocks are markedly similar to the Uriconian Group, described for example at the Wrekin GCR site, which are thus considered to be close age-equivalents. Some volcanic rocks of the Castell Cogan Rhyolite Member are associated with unusual types of breccias, in keeping with an origin as rhyolitic or basaltic lava flows or domes emplaced in shallow waters. Explosive eruptions also took place, generating the ash-flow tuffs, and it is probable that all of this activity occurred in a continental margin setting, along the axis of a volcanic arc that was undergoing rifting. Erosion of these lavas produced abundant debris, which accumulated to form the thick volcaniclastic deposits of the Coed Cochion Member. Volcanism had not yet ceased, however, as the intercalated basalt flows testify. Shallow-water environments persisted throughout deposition of the volcaniclastic strata, and at times the medusoid Ediacaran faunas of Coed Cochion flourished and were preserved as fossils within the sedimentary layers.

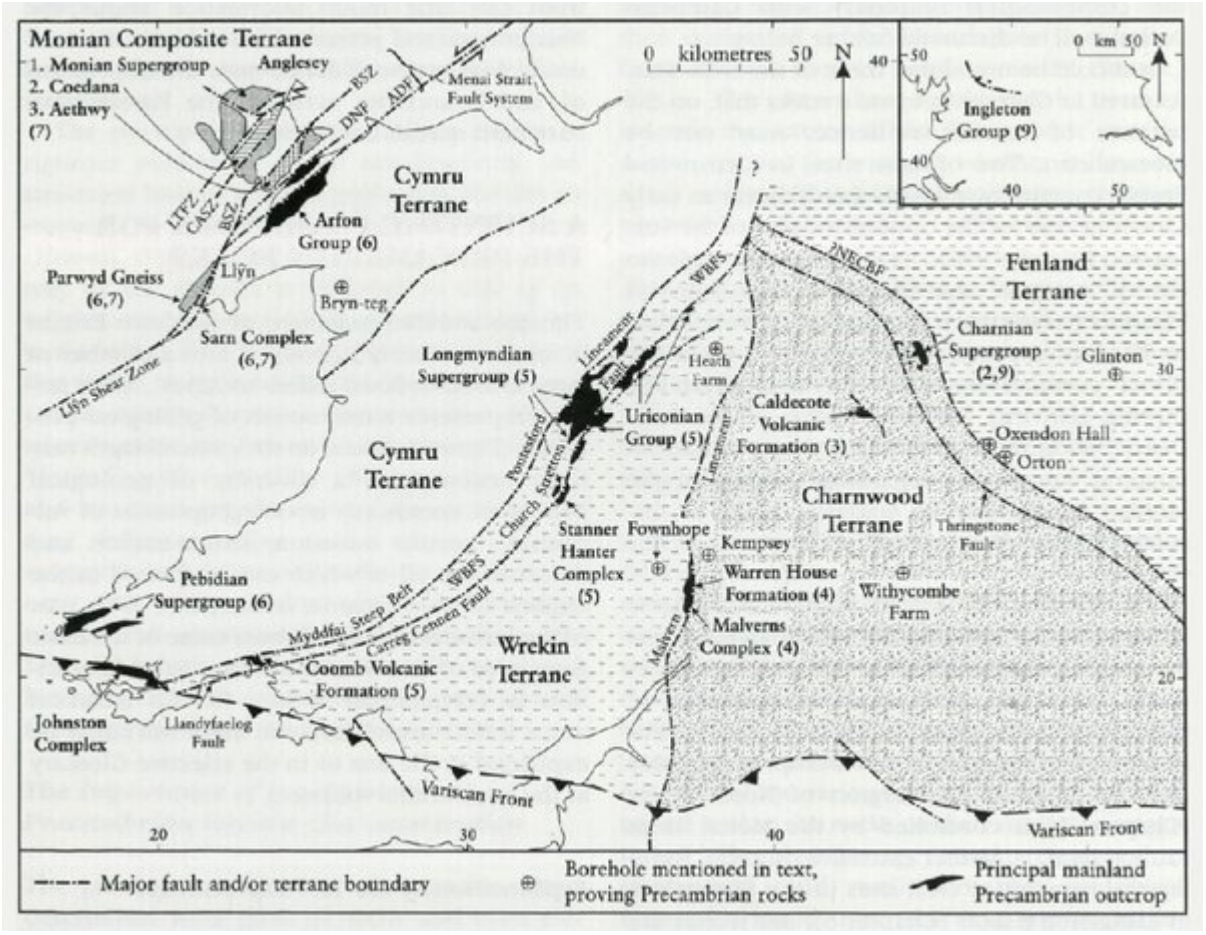
Along with evidence from geological sites in the St David's and Llyn Padarn areas of western and northern Wales respectively, reviewed in Chapter 6, the Llangynog sequences provide an insight into the likely nature of the low-grade

metamorphic basement underlying much of the Welsh Basin region.

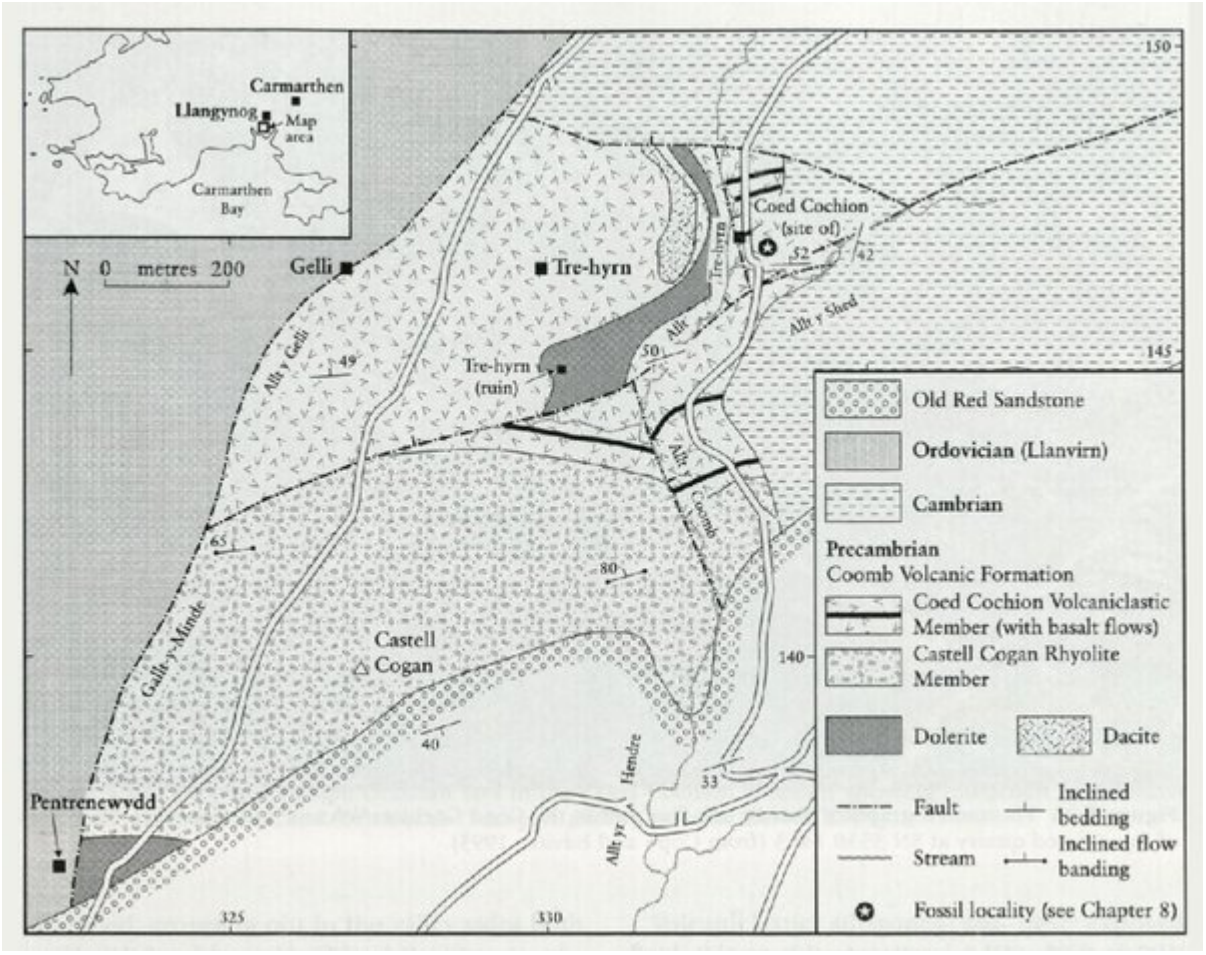
References



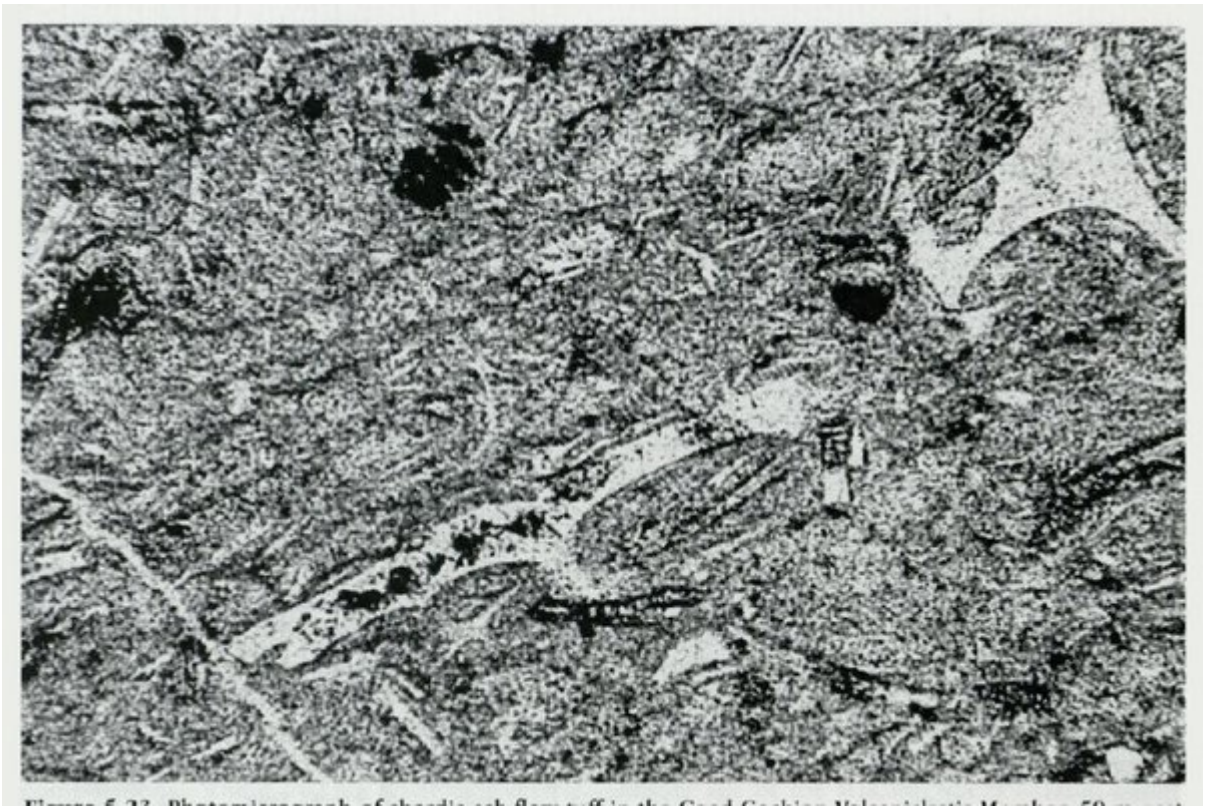
(Figure 6.1) Geological map showing the relationship of the St David's and Llyn Padarn sites to other Precambrian outcrops.



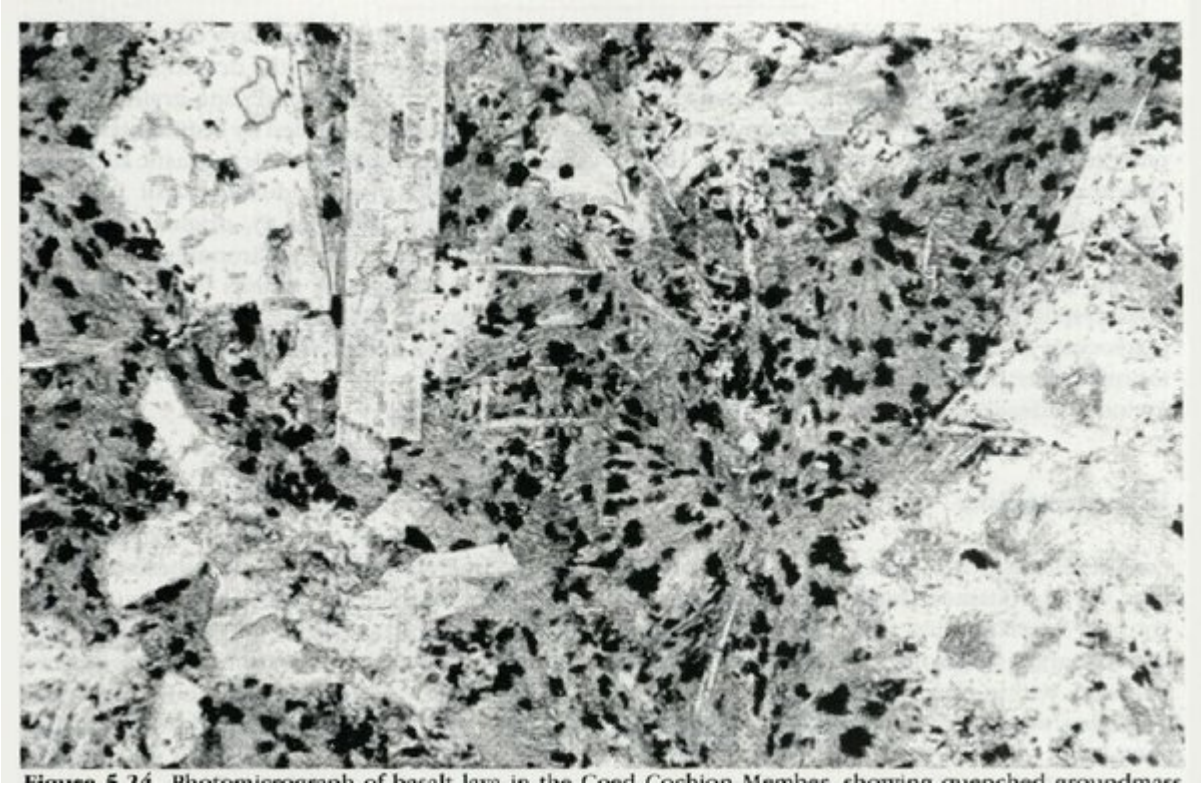
(Figure 1.1) Sketch map showing the distribution of Precambrian outcrop, and boreholes proving Precambrian rocks, in southern Britain. Note that the outcrops are labelled with the names of the principal geological units, followed by numbers (in brackets) of the chapters for the relevant GCR sites. Terrane boundaries are slightly modified after British Geological Survey (1996); Myddfai Steep Belt after Woodcock (1984a); Monian Composite Terrane after Gibbons and Horák (1990). Key: ADF, Aber-Dinlle Fault; BSZ, Berw Shear Zone; CASZ, Central Anglesey Shear Zone; DNF, Dinorwic Fault; LTFZ, Llyn Traffwll Fault Zone; ?NECBF, postulated NE Charnwood Boundary Fault. The boundary of the Midlands Microcraton basement domain is outlined by the NECBF and Pontesford-Myddfai lineament systems; WBFS, Welsh Borderland Fault System.



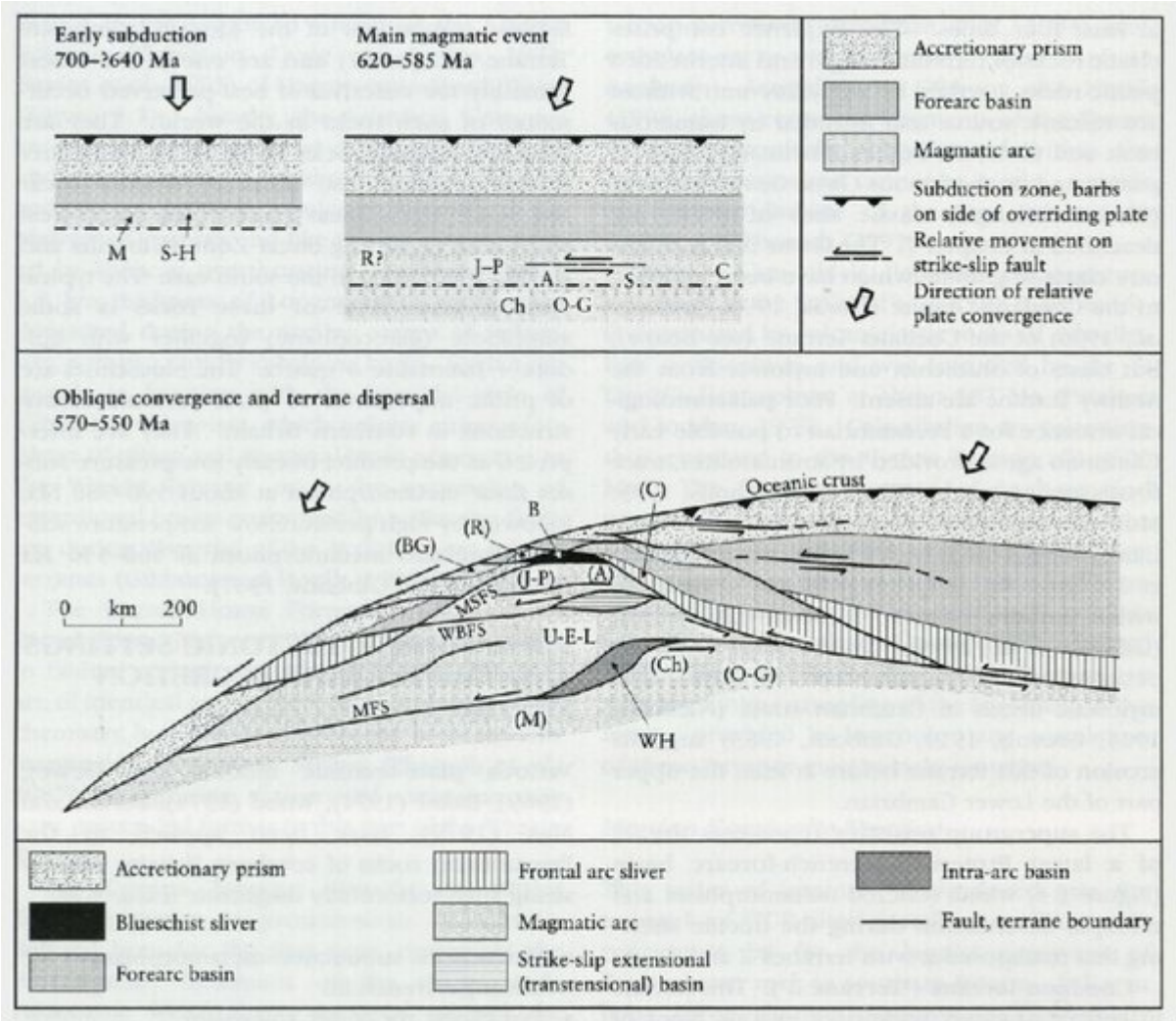
(Figure 5.22) Geological map of the Llangynog inlier, including the Coed Cochion palaeontological site. This diagram is reproduced with the permission of the Geological Magazine, Cambridge University Press (modified from Cope and Bevins, 1983).



(Figure 5.23) Photomicrograph of shardic ash-flow tuff in the Coed Cochion Volcaniclastic Member, 50 m cast of the disused quarry at [SN 3338 1463] (from Cope and Bevins, 1993).



(Figure 5.24) Photomicrograph of basalt lava in the Coed Cochion Member, showing quenched groundmass with skeletal, spherulitic and belt-buckle' feldspars (from Cope and Bevins, 1993).



(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.