Penrhyn Nefyn

[SH 290 408], [SH 293 409], [SH 296 413]

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Introduction

This site is a foreshore section that preserves an important contact between the two main units together compriseing the oldest rocks in mainland North Wales: the Gwna Group (Monian Supergroup) and the Sarn Complex. An intervening narrow schist belt represents the contact zone itself. Penrhyn Nefyn was selected as a GCR site because it is the only place where one can walk across a foreshore exposure northwestwards from the Sarn Complex into schists and on to the Gwna Group (Figure 7.22). Because of this, the site has figured as a key exposure in the published works of Matley (1928), Shackleton (1956), Baker (1969), Barber and Max (1979) and Gibbons (1981, 1983). Arguments over this site have epitomized the nature of the controversies that have surrounded the interpretation of the basement to northwest Wales, with disagreements focusing on the relative and absolute stratigraphical ages and on structural interpretation. The site occupies a pivotal position within the Menai Strait Fault System. It has been particularly instructive in illustrating the importance of recognizing ductile shear-zone rocks, their critical role in the interpretation of basement tectonics and their current importance to the 'terrane concept' of British Precambrian geology discussed in Chapter 1. The site is of additional interest because it is the only place on the mainland of Wales where blue amphibole-bearing schist has been discovered (Gibbons, 1981).

Description

The exposures at Penrhyn Nefyn occupy the width of the beach and are capped above high water mark by a thick mantle of sandy glaciofluvial deposits. The most westerly exposures are the least deformed and belong to Gwna Group basalts, revealing primary igneous textures such as jaspery basaltic breccias and lavas with flattened pillow structures. Locally, the lavas are cut by narrow shear zones within which the basaltic parent is transformed into low-grade mylonitic greenschist — the basic schists of (Figure 7.22) (Gibbons, 1981).

Such low-grade sheared equivalents of the Gwna basalts become dominant southwards, around the headland of Penrhyn Nefyn, as one moves into the schist belt referred to by previous authors as the 'Penmynydd Zone of Metamorphism' (e.g. Greenly, 1919). The majority of these greenschists are lithologically monotonous, although locally areas of massive green lavas have escaped much of the deformation. Under the microscope, these metabasic rocks reveal a greenschist facies mineral assemblage of: epidote, chlorite, actinolite, and albite.

The degree of recrystallization increases towards the south, and 60 m along the foreshore from the headland, on its east side, these basic schists are interleaved with fine-grained, semi-pelitic, mylonitic mica-schists (Figure 7.23). At this point the basic schists locally show the overprint of blue amphibole over the greenschist facies assemblage — an unusual and interesting occurrence of the greenschist–blueschist transition within a shear zone. The glaucophanic amphibole within these specimens typically coexists with and partially replaces actinolite crystals, in much the same way as seen in the classic Anglesey blueschists exposed 20–30 km farther along strike at the Marquis of Anglesey's Column GCR site, south-east Anglesey (Gibbons, 1981; Horák and Gibbons, 1986). The slices of mica schist interleaved with the Gwna metabasites are up to 8 m wide and display intrafolial folds, a steep NW-dipping foliation, a gently SW-plunging mineral lineation, and late kinking and cata-clasis. Under the microscope these are fine-grained phengite, albite, quartz schists.

The interdigitated micaceous and metabasic schists occur for some 50 m across the foreshore, beyond which, to the south, they are in abrupt tectonic contact with sheared and altered tonalite belonging to the Sarn Complex. The contact can be difficult to locate because of the intense greenschist-facies shearing that has affected all rocks, reducing them to fine-grained schists. These exposures preserve a classic transition from a coarse plutonic protolith (Figure 7.24) northward into a low-grade mylonite produced by a combination of ductile and brittle processes (Gibbons, 1980). Initially, ductile deformation processes are seen to have been completely subordinate to brittle fracturing. Closer to the mica-schist contact, however, ductile flow and recrystallization become more pervasive. Finally, there are several excellent examples of late fault brecciation, indicating continued reactivation of the Penrhyn Nefyn shear zone at higher crustal levels.

Interpretation

Matley (1928) was the first to map this section, and described a 'granitoid gneiss' faulted against 'Penmynydd schists', which graded from greenschists to recognizable pillow lavas towards the west. The schists were therefore considered to be the metamorphosed equivalents of the lavas, which belonged to the Gwna Group. Shackleton (1956) ambiguously referred to Matley's granitoid gneiss as both a crushed tonalite and as a gneiss. He went on to interpret this lithology as both progradational from, and locally intrusive into, the adjacent schists, and thus deduced it to be younger than the schists and Gwna Group. This conformed to his concept of a narrow prograde metamorphic transition between the lower- and higher-grade metamorphic rocks on Anglesey and Ll■n. This idea was later superseded by the recognition that many such contacts are shear zones within which there is metamorphic convergence between tectonically juxtaposed higher- and lower-grade rocks.

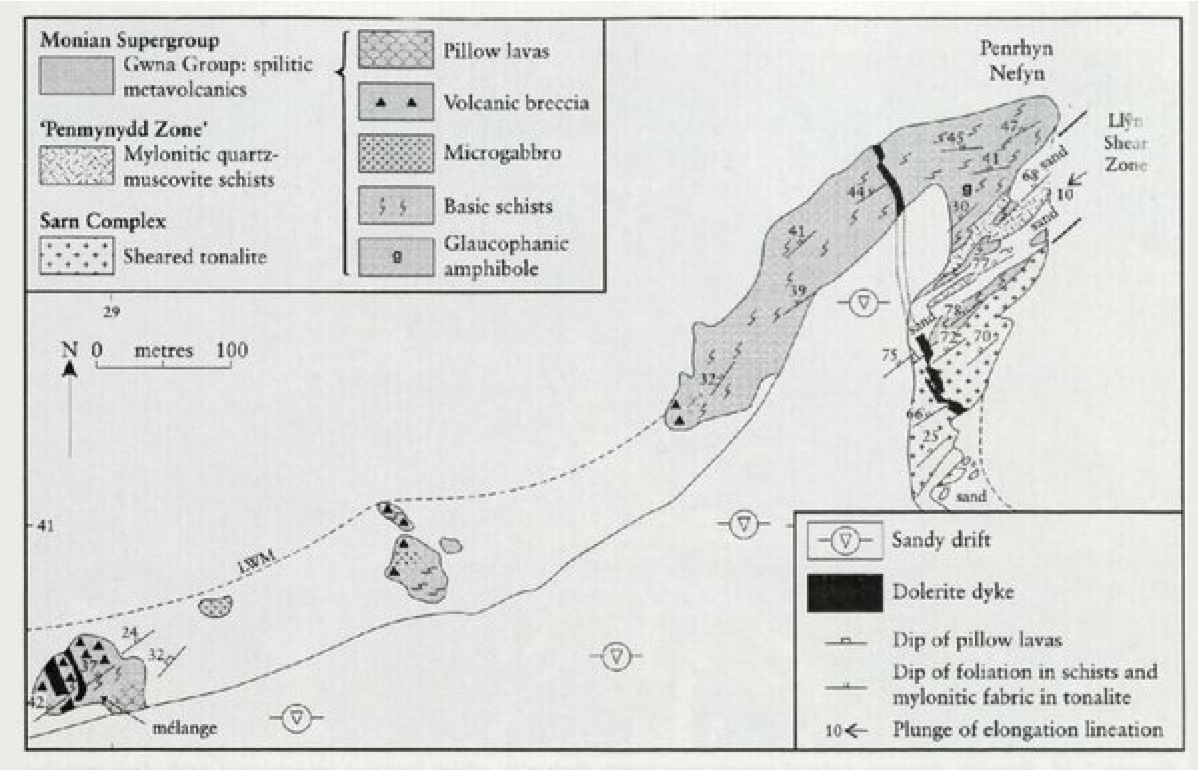
Baker (1969) was the first to dispute the 'prograde transition hypothesis' by pointing out that, as Shackleton (1956) had himself described, the gneiss was in fact a plutonic igneous rock and therefore irrelevant to any ideas on schist–gneiss transitions. Despite this, a later description by Barber and Max (1979) resurrected the term 'gneiss' to describe the rocks, but recognized the tectonic transition from these rocks into mylonitic schists. A major point of disagreement with all previous (and later) authors, however, was in the interpretation of the Gwna Group metabasalts and mica schists as slightly foliated laminated tuffs and spilitic lavas. This latter description of the Gwna lithologies conformed to their interpretation of the Gwna Group as being younger than, and therefore unaffected by, the schist zones of Anglesey and Ll■n. Finally, Gibbons (1980, 1981, 1983) produced a detailed map and petrographical study of the section and showed it to represent one sector of the Ll■n Shear Zone, in which a Sarn Complex tonalite was sheared against low-grade Gwna metasediments and metabasalts. Based on findings such as those at Penrhyn Nefyn, Gibbons went on (1987) to emphasize the importance of shear zones to the basement geology of southern Britain and applied the suspect terrane concept (Chapter 1). This concept recognizes the importance of strike-slip faulting within active plate margins and argues that the Sarn Complex and Gwna Group belong to two quite different subduction-related terranes — the Cymru and Monian Composite terranes respectively (Figure 1.1). These terranes were originally separated by some unknown (and possibly very great) distance and were subsequently juxtaposed during late Precambrian or early Cambrian movements along the Ll■n Shear Zone (Figure 1.4).

The remarkably conflicting accounts and interpretations of the geologically complex Penrhyn Nefyn foreshore section may be explained by a combination of: poor exposure at critical contacts, a generally very fine-grain size in hand specimens, confusion over the meaning of the term 'gneiss', a failure to recognize shear zone textures and the tendency towards metamorphic convergence and lithological similarity within such zones, and in some cases a preference to fit the interpretation of field relation ships to preconceived models.

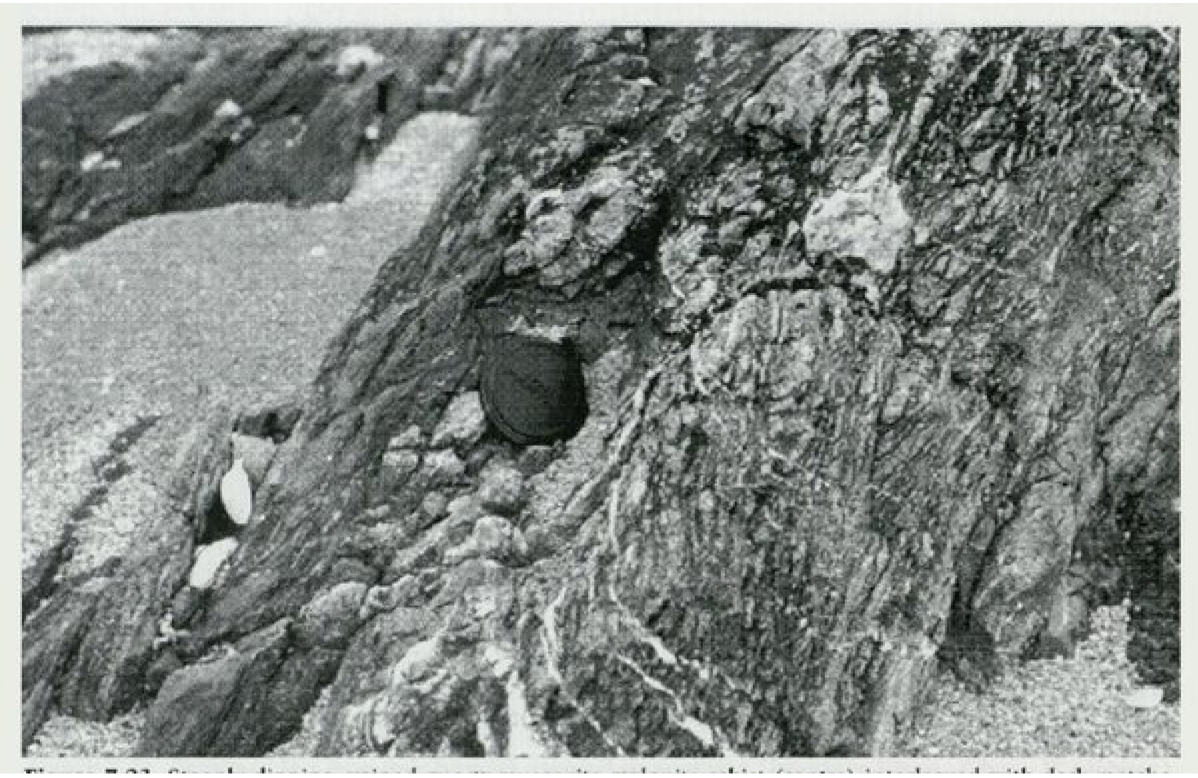
Conclusions

The Penrhyn Nefyn foreshore offers one of the very few, easily accessible exposures of metamorphic rocks on the mainland of North Wales. Fortuitously, these rocks show what is the only well-exposed example of a terrane boundary, revealed as a structural transition from the Sarn Complex to the Gwna Group: the two main components of the basement geology in this area. Given the complexities and difficulties in understanding the significance of these exposures, they have been the subject of several remarkably different interpretations. As such this site is of especial historical interest, illustrating how a combination of difficult geology, preconceived ideas, insufficient data and a limited understanding of key concepts (such as shear-zone geology) can breed a plethora of conflicting interpretations. The site is one of the few places in mainland Wales where Precambrian rocks can be easily visited, and the only place on the mainland where blue amphibole-bearing metamorphic rocks have been recorded.

[References](#)

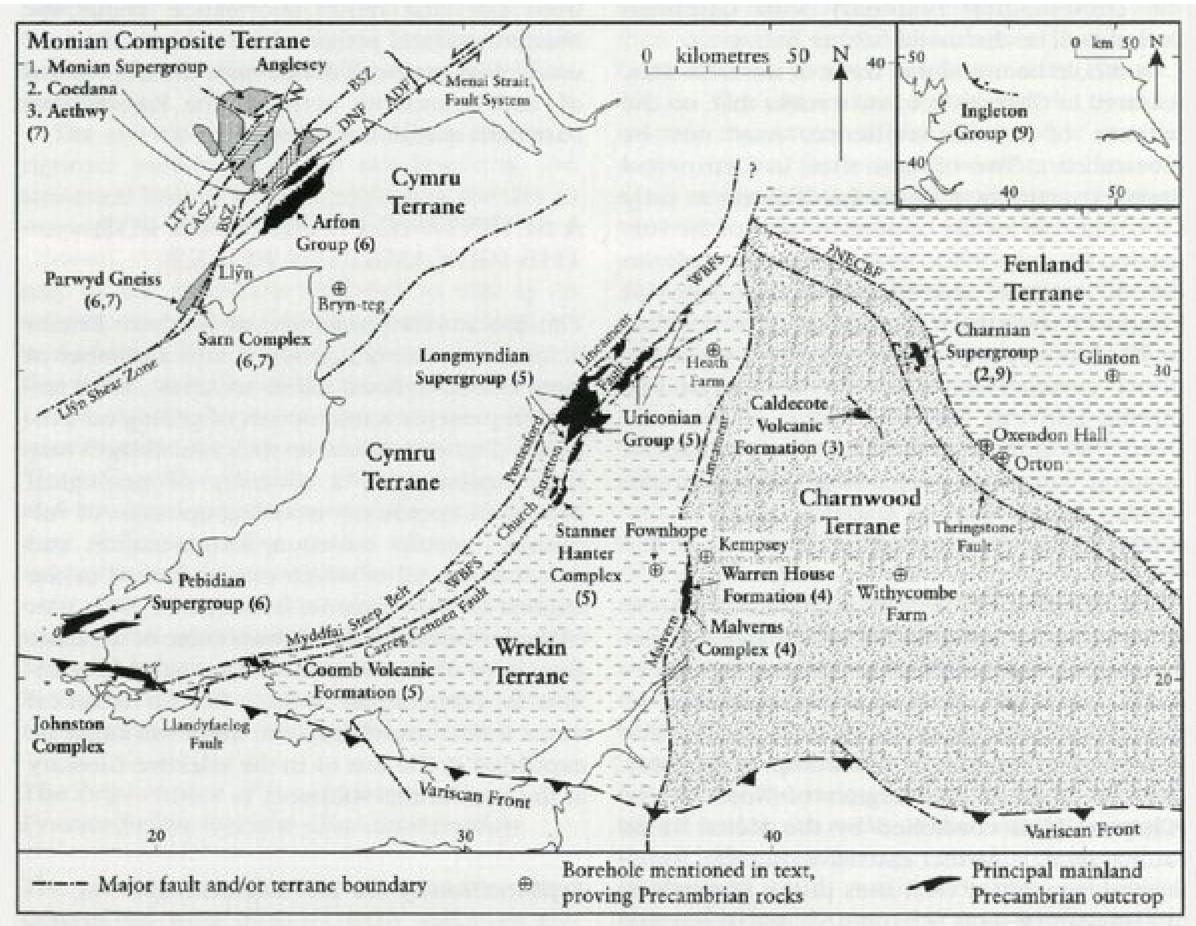


(Figure 7.22) Geological map of Penrhyn Nefyn.

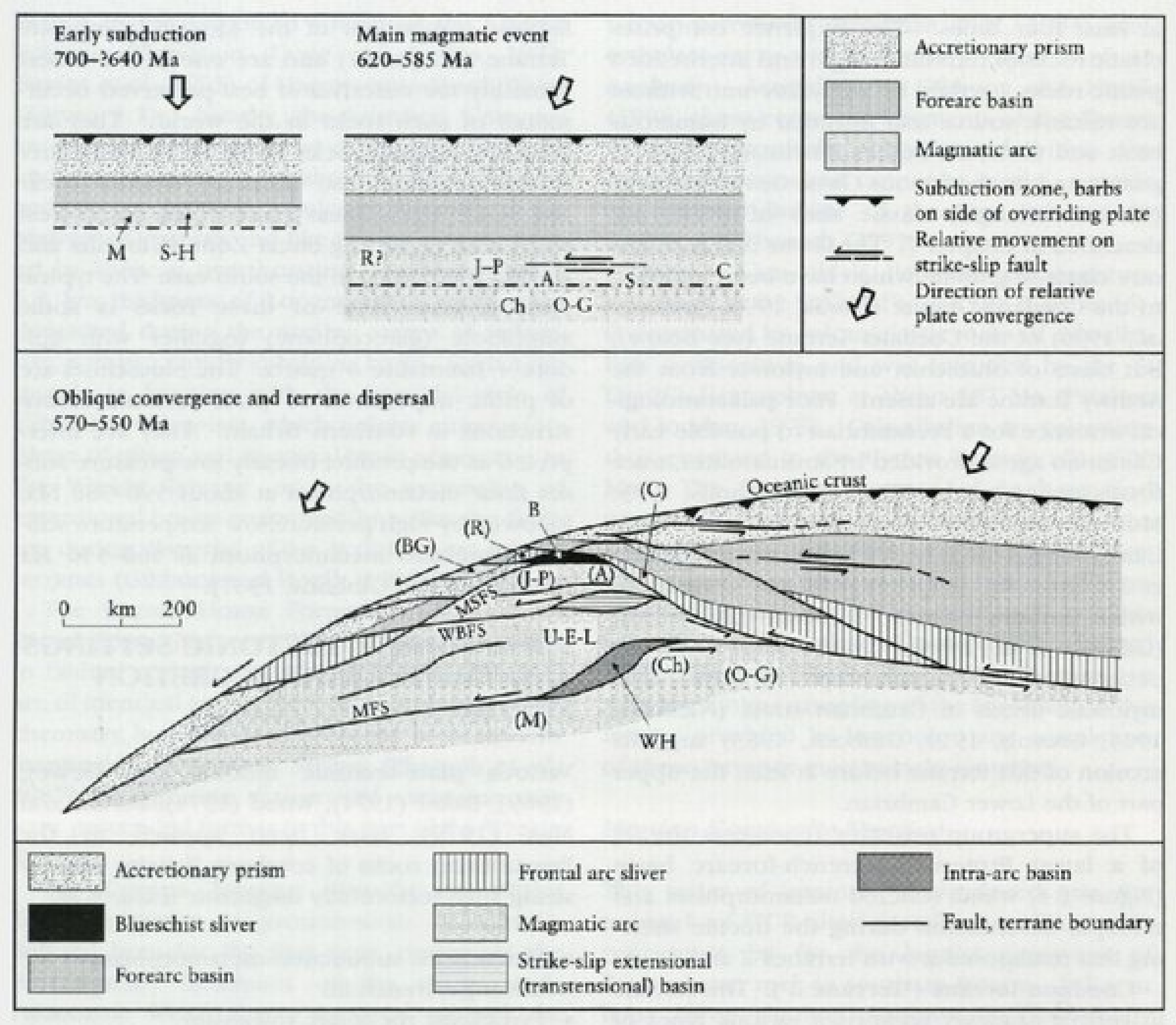


(Figure 7.23) Steeply dipping, veined quartz-muscovite mylonite schist (centre) interleaved with dark metaba-site derived from Gwna Group basalts (left). (Photo: W. Gibbons.)

(Figure 7.24) Remnants of coarse-grained plutonic igneous texture in sheared Sarn Complex tonalite on foreshore at Penrhyn Nefyn. (Photo: W. Gibbons.)



(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 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.