Chapter 5 Shropshire, Radnor and Llangynog

Introduction

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The Precambrian rocks between Shropshire and Llangynog form a major network of GCR sites disposed in a series of inliers that are bounded by faults and unconformities associated with the major Church Stretton and Pontesford fault systems (Figure 5.1). The inliers vary in size, the largest being that of the Long Mynd massif, and they generally give rise to the impressive hills and fine scenery exemplified by the Wrekin range and the area around Church Stretton (Figure 5.2). Two major groupings of Precambrian rocks crop out within the region.

The older of these is the Uriconian Group, which consists of rhyolitic lavas and associated pyroclastic rocks, with acid and basic intrusions, representing a style of highly explosive, subaerial volcanism. At the Wrekin GCR site, the volcanic rocks are juxtaposed with older schistose and gneissose rocks whose origins are conjectural, but which may in part represent fragments of an earlier Precambrian basement. The Uriconian rocks are overlain by clastic sedimentary sequences of the Longmyndian Supergroup, which represents one of the thickest continuous successions of latest Precambrian sedimentary rocks in southern Britain. These strata record a transition from marine to fluviatile environments and contain, at Ashes Hollow GCR site, several localities displaying fossils impressions (Chapter 8).

The smaller inliers at Old Radnor (Dolyhir and Strinds GCR site) and Llangynog are included here because they have strong lithological affinities with the sedimentary and volcanic sequences of Shropshire. The Stanner–Hanter inlier is unusual, however, in exposing plutonic rock suites. All of these outcrops are representative of rocks comprising the Wrekin Terrane (Figure 1.1), the geological composition of which is discussed in the introductory chapter of this volume.

One of the most important aspects of the well-exposed Shropshire area is its highly complex structural history, in particular the evolution and significance of the major structures that affect Precambrian rocks. These include the Church Stretton and Pontesford fault zones (or 'lineaments') that form part of the Welsh Borderland Fault System (Woodcock and Gibbons, 1988), a long-lived crustal structure that controlled late Precambrian volcanism and sedimentation (Baker, 1973), and may represent a Gondwanan terrane boundary (Figure 1.1). Studies of the Welsh Borderland Fault System (Woodcock 1984b; Woodcock and Gibbons, 1988; Pauley 1991), including the Dolyhir and Strinds GCR site (Woodcock, 1988), have demonstrated the importance of strike-slip displacements periodically during its evolution. Movement along its component faults is thought to have resulted in considerable dismemberment of the Uriconian and Longmyndian sequences (Pauley, 1991). The presence of a locally penetrative cleavage within the Precambrian rocks along the Welsh Borderland Fault System, and its absence from the Cambrian strata, which unconformably overlie them, are generally taken as evidence of a major late Precambrian tectonic event along this important structure. The cleavage that affects the Precambrian rocks strikes NE–NNE, transecting the associated NNE–N fold axes (including the Long Mynd Syncline) in a clockwise sense by angles of up to 22°. This fold-cleavage geometry was considered by Pauley (1991) to have developed during transpressional deformation associated with sinistral displacements along the Welsh Borderland Fault System; he further suggested that the movements were associated with plate tectonic readjustments that terminated Uriconian magmatic activity in late Precambrian to early Cambrian times.

Studies to constrain the age of the cleavage have been carried out on samples collected from various locations, including the Lightspout Hollow GCR site, and are based on the $^{40}Ar/^{39}Ar$ systematics of tectonic micas in deformed Longmyndian mudrocks (BGS, work in progress). The preliminary results suggest that this was probably not a Caledonian event, although it occurred rather later than the end-Avalonian (Cadomian) tectonic dismemberment of terranes that is documented to have occured in the period between 570 and 550 Ma farther west (Gibbons and Hora.lc, 1996). That event included the uplift of blueschists in Anglesey at 560–550 Ma (Dallmeyer and Gibbons, 1987; see also, Chapter 7 of this volume).

The twelve sites of this GCR network, shown in (Figure 5.1), are chosen so as to provide an overview of the stratigraphy and structure of these Precambrian rocks, with particular reference to sedimentological evolution within the lower to middle part of the Longmyndian Supergroup. Each individual site also contains important geological features that are representative of certain stages attained during the evolution of this region from an active volcanic belt to an extensive alluvial plain.

Uriconian Group

The term 'Uriconian' was first applied by Callaway (1886) to the acid, intermediate and basic tuffs and lavas, intruded by granophyre and several dolerite dykes, that crop out at the Wrekin and Lilleshall Hill GCR sites. It was at the former site that Callaway (1879) demonstrated the unconformable nature of the Uriconian and Cambrian, on the basis of derived volcanic pebbles in the overlying Cambrian quartzite. However, it was not until Lapworth (1888) proved the existence of an early Cambrian fauna in the quartzites that a Precambrian age for the Uriconian volcanics along the Church Stretton Fault System was accepted. Even so, correlation of these 'Eastern Uriconian' rocks with the so-called 'Western Uriconian' along the Pontesford–Linley Fault System proved controversial (Callaway, 1882; Blake, 1890; Lapworth and Watts, 1910), and was only established when the structure of the Long Mynd was revealed as a major syncline (James, 1952, 1956). The disparate Uriconian outcrops are now generally considered to lie on opposing limbs of the syn cline, which is cored by sedimentary rocks of the Longmyndian Supergroup. The term 'Uriconian volcanic complex' was used for these rocks by Pauley (1986, 1991); however, although the sequence is as yet undivided it is well stratified and could, eventually, be amenable to further subdivision. The name 'Uriconian Group' (Pharaoh and Gibbons, 1994) is therefore preferred here.

The Uriconian rocks have been widely studied, as summarized in: Pocock *et al.* (1938); Greig *et al.* (1968); Dunning (1975) and Pharaoh and Gibbons (1994), and feature in a number of isotope investigations and plate-tectonic reconstructions of the British Isles (Baker, 1973; Thorpe, 1974; Patchett *et al.,* 1980; Dewey, 1982; Thorpe *et al.,* 1984; Pharaoh *et al.,* 1987b; Piper and Strange, 1989; Tucker and Pharaoh, 1991). The lavas are largely potassic rhyolites and the intrusions include both basic and acidic types, with an important phase of intrusion represented by the Ercall Granophyre. The geochemistry of Uriconian lavas (Pharaoh *et al.,* 1987b) suggests that there is a distinct compositional gap between the more basic (< 53 wt% SiO_2) and intermediate to acid (> 60 wt% SiO_2) compositions, indicating that volcanism was bimodal. Basic rocks show an overall geochemical pattern typical of within-plate basalts, although enrichment in certain rare-earth elements indicates a subduction-related component such as would be found in a volcanic arc environment. Current opinion (Pharaoh and Gibbons, 1994) is that the Uriconian rocks were erupted in a tectonic setting that was transitional between the two, such as a fault-controlled ensialic marginal basin within the Avalonian volcanic arc (Thorpe *et al.,* 1984; (Figure 1.4)).

The eruptive age of the Uriconian Group has been subject to some debate (summarized by Pharaoh and Gibbons, 1994). A maximum age of eruption is given by a Rb-Sr metamorphic age of 667 ± 20 Ma from the Rushton Schists (Thorpe *et al.,* 1984), which are in probable faulted contact with largely unmetamorphosed Uriconian volcanic rocks (Coppack, 1974). More reliable data has come from Patchett *et al.* (1980), who published a Rb-Sr whole rock isochron of 558 ± 16 Ma from acid tuffs within the Eastern Uriconian. This age has been generally confirmed by a U-Pb zircon date from a rhyolite lava near Leaton, in the Wrockwardine inlier (Figure 5.1) which gave an age of 566 ± 2 Ma, considered to be the eruptive age (Tucker and Pharaoh, 1991). That Uriconian magmatism was also diachronous, however, is shown by chemical studies of tuffaceous strata in the Longmyndian Supergroup that constitute the 'Batch Volcanic Beds', summarized in the description of the Long Batch-Jonathan's Hollow GCR site. The upper limit to Uriconian volcanicity is to some extent constrained by the fact that the Lower Cambrian Wrekin Quartzite, which overlies Uriconian intrusive rocks of the Ercall Granophyre at the Wrekin range GCR site, is probably late Tommotian, around 530–534 Ma, in age (Rushton, 1974; Cope and Gibbons, 1987). Radiometric dating of the Ercall Granophyre provides a more accurate estimate for magmatic cessation. The U-Pb zircon age of 560 ± 1 Ma is regarded as that of emplacement (Tucker and Pharaoh, 1991) and it indicates that the Uriconian and much of the Longmyndian arose within a relatively short space of time, between 566 and 560 Ma. The age determination also provides a reliable constraint for deposition of the early Cambrian strata of England.

Longmyndian Supergroup

The Longmyndian Supergroup (Toghill and Schell, 1984) forms a sequence at least 6500 m thick dominated by sedimentary rocks. Its strata are mainly disposed in the Longmynd Syncline (James, 1956), a major eastward-facing isoclinal fold between the Pontesford–Linley and Church Stretton fault zones (Figure 5.1). The Precambrian age of the Longmyndian has long been recognized (Callaway, 1879), and the rocks have received considerable attention for their fine sedimentary sequences and structures, as well as for their enigmatic stratigraphical and structural relationships with the Uriconian Group. Despite this, the broad stratigraphy of the Longmyndian has changed little from the time of Lapworth and Watts (1910) who, based on earlier work by Blake (1890) and Cobbold (1900), divided the sequence into an eastern and western group (named the Stretton and Wentnor 'Series' respectively). These were further subdivided into a number of 'Groups' (the terms 'Series' and 'Group' have now been redesignated as 'Group' and 'Formation' respectively; Dunning, 1975). The succession has been described in considerable detail by Greig *et al.* (1968), who considered that the rocks formed in a range of depositional environments. Modern sedimentological analysis of the Longmyndian Supergroup has been undertaken by Pauley (1986; 1990a,b; 1991), who has recognized basinal, turbiditic, deltaic and fluviatile sequences within the succession, but has retained the existing lithostratigraphical subdivisions of Greig *et al.* (1968).

The relationship between the Uriconian Group and Longmyndian Supergroup is not easily demonstrated owing to a lack of suitable sections, and the faulted nature of the Precambrian outcrop in the Welsh Borderlands. One of the more important sections where a contact is seen is the Lyd Hole GCR site, described below. The abundant volcanic fragments within the Longmyndian have been matched with Uriconian volcanic rocks, indicating that the latter was the source for much of the sediment. Work by James (1952, 1956) firmly established that Uriconian rocks underlie the Longmyndian east and west of the Long Mynd, a relationship that had previously been in dispute (cf. Callaway, 1882; Blake, 1890); more importantly, it confirmed that the main period of volcanism predated Longmyndian sedimentation. The possibility that the waning phase of Uriconian volcanic activity overlapped with Longmyndian sedimentation (Greig *et al.,* 1968) is indicated by the sporadic occurrence of thin volcanic horizons within the Longmyndian succession, the most important of which are the 'Batch Volcanic Beds' (Cobbold, 1900), a group of intermediate felsic tuffs. It suggests that the Longmyndian sediments were derived from erosion of the Uriconian volcanic arc, and that no great time interval separated volcanism and sedimentation.

Perhaps the most important feature of the Longmyndian is its sedimentary evolution, from marine to fluviatile depositional environments, and the implications that follow for reconstructing the tectonic events that may have accompanied the waning phases of Uriconian magmatism. One of the most important sections is at the Ashes Hollow GCR site, where fossil impressions are also well displayed (Chapter 8). It demonstrates a major regressive sequence within the Stretton Group, revealing a transition from deep-water mudstones (Stretton Shale Formation), through progradational turbidites and subaqueous deltaic mudstones and siltstones in the middle and upper parts of the Burway Formation. The top of the Burway Formation is characterized by fluvial environments, represented by the Cardingmill Grit (Pauley, 1990a). Fluviatile, sandstone-dominated facies characterize the later parts of the Stretton Group, with alluvial floodplain environments commencing in the Synalds Formation. In this formation the occurrence of the Batch Volcanic Beds, best seen at The Pike and Long Batch–Jonathan's Hollow GCR sites, represents the youngest record of volcanic activity contemporary with Longmyndian sedimentation. The sandstone component thickens upwards through the Lightspout Formation, reflecting deposition by multiple sheetflood events, but at the Lightspout Hollow GCR site there is evidence for an upwards transition into strata indicative of braidplain deposits.

A marked change in sedimentation occurred at the junction between the Stretton Group and overlying Wentnor Group, as described at the Hawkham Hollows GCR site. The change from alluvial floodplain sedimentation in the Portway Formation, to the deposition of braidplain conglomerates in the Bayston–Oakswood Formation, basal Wentnor Group, is an abrupt one that has been linked to rejuvenation of the source area by movements along the Church Stretton Fault Zone (Pauley, 1990b).

Coomb Volcanic Formation and Johnston Diorite Complex

The Coomb Volcanic Formation, described at the Llangynog site (see (Figure 6.1) for location), is a bimodal suite of basaltic and rhyolitic lavas and associated volcaniclastic rocks (Cope and Bevins, 1993). The volcaniclastic rocks show the features of shallow water to subaerial deposition, and an active continental margin tectonic setting was inferred by Bevins *et al.* (1995) on geochemical grounds.

Although the Coomb Volcanic Formation as yet remains undated, the presence of Ediacaran faunas within associated sedimentary rocks at Coed Cochion (Chapter 8) provides a possible parallel with similar fossils from the Eastern Avalonian, Mistaken Point Formation in Newfoundland. These have a minimum age constraint provided by overlying rhyolitic tuffs dated at 565 ± 3 Ma (Benus, 1988). As a Uriconian rhyolite from Shropshire has yielded a date of 566 ± 2 Ma (see above), and the Coomb Formation and Uriconian are geochemically very similar (Bevins *et al.,* 1995), there seem strong grounds for correlating the two.

Stanner–Hanter Complex

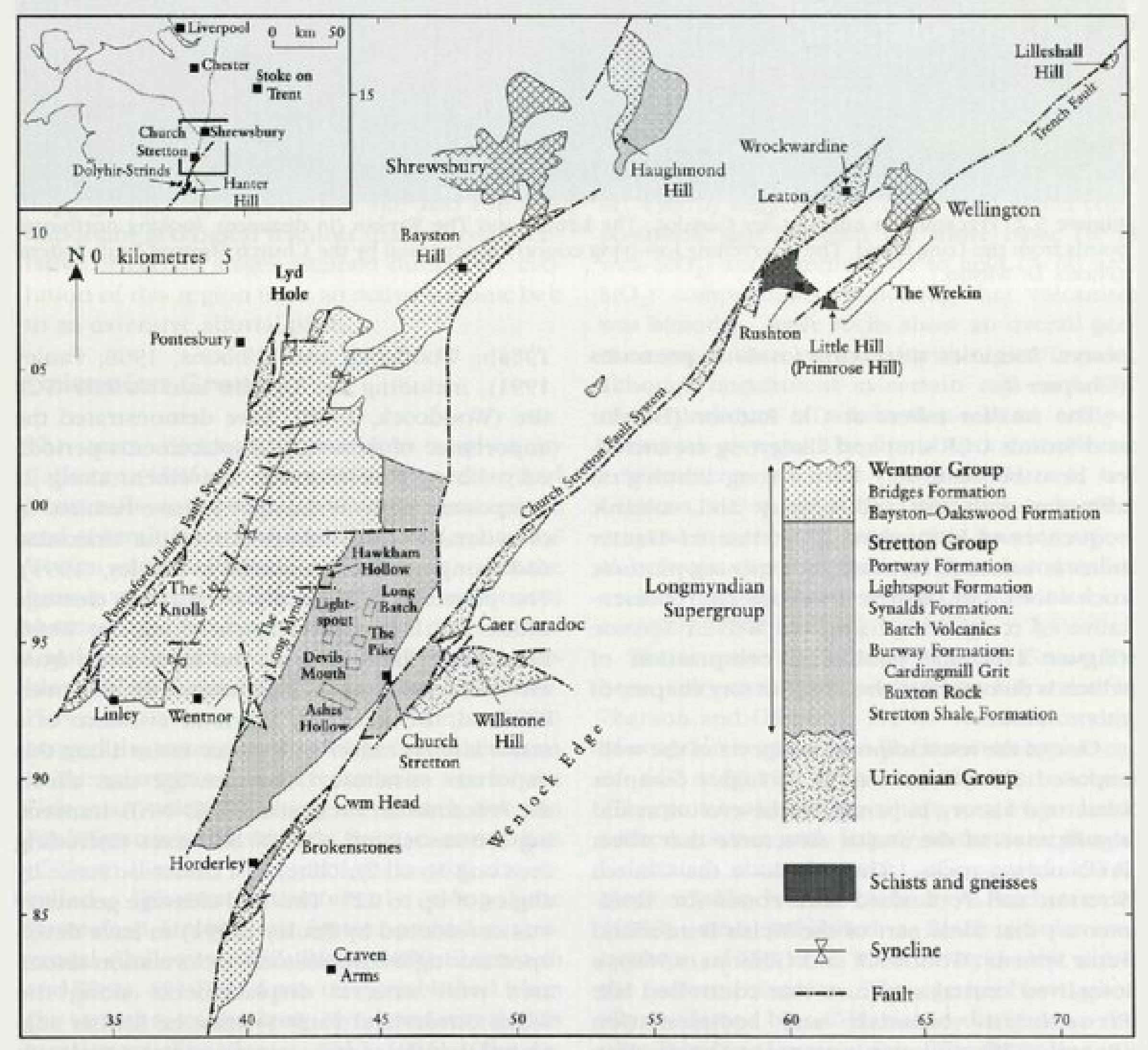
The intrusive rocks of this igneous complex form part of the chain of Precambrian inliers localized along the Church Stretton Fault System (Figure 1.1). At the Hanter Hill GCR site, the gabbros, dolerites and minor granitoids are comparable with lithologies in the Malverns Complex (Chapter 4). The Stanner–Hanter rocks nevertheless appear to be older, with a Rb-Sr isochron age of 702 ± 8 Ma (Patchett *et al.,* 1980).

Another component of the Wrekin Terrane, the Johnston Diorite Complex (Figure 6.1), consists of a heterogeneous, calc-alkaline granodiorite–granite suite comparable to the Malverns Complex and estimated to have been emplaced at about 643 Ma (Patchett and Jocelyn, 1979). Closely associated with it, the Benton Group contains dacitic to rhyolitic tuffs. In a geochemical survey by Bevins *et al.* (1995), the tuffs were shown to plot within or close to the within-plate granite field on Nb-Y vs Zr-TiO_2 diagrams, and are thus comparable to volcanic rocks of the Wrekin Terrane. No GCR sites have been selected for these occurrences.

Metamorphic rocks

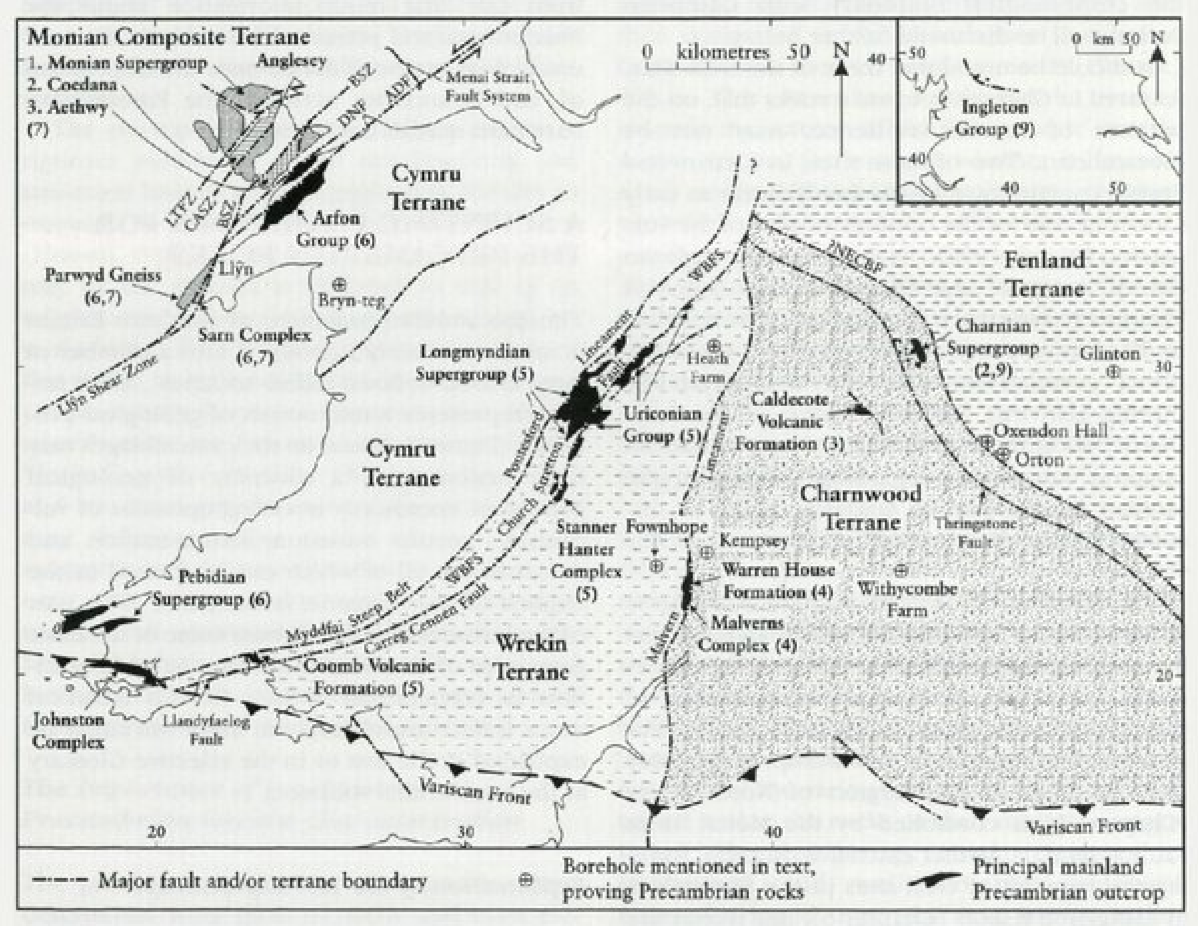
These rocks constitute the Rushton Schist and Primrose Hill Gneiss and Schist (Figure 5.1). The latter are poorly exposed at the Wrekin GCR site, where they are in faulted contact with Uriconian rocks and, in relatively strain-free areas, appear to consist of gneissified granophyre and possible acid tuffs. The Rb-Sr metamorphic age of 667 ± 20 Ma determined for the Rushton Schist (Thorpe *et al.,* 1984) indicates that it was formed at least 100 million years before eruption of the Uriconian Group. The model age, of about 1700 Ma, further suggests that the Rushton Schist could represent basement to the Uriconian Group, with the two units subsequently juxtaposed by faulting.

References

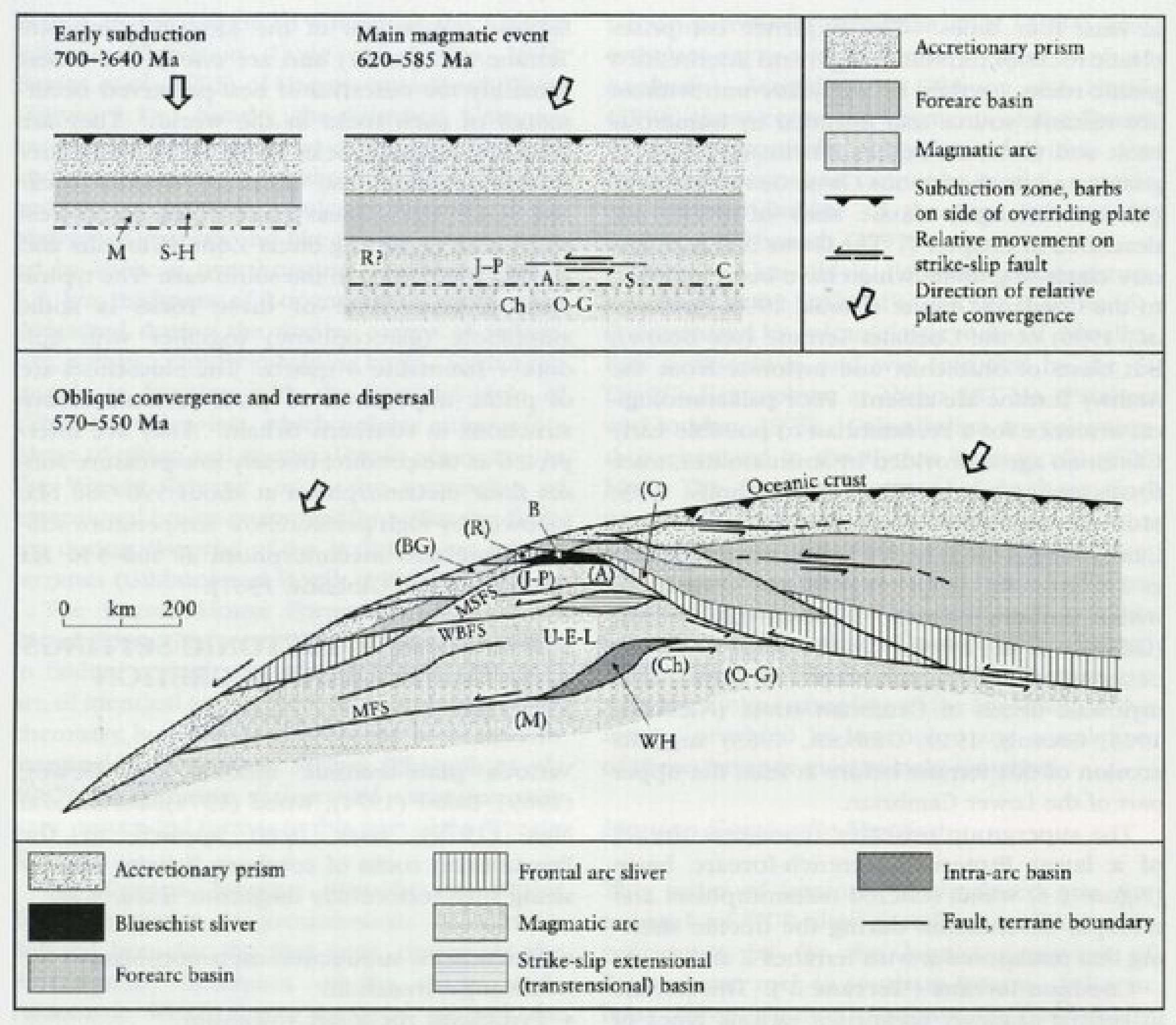


(Figure 5.1) Geological map of the Shropshire Precambrian outcrops (modified from Pauley, 1991), with the GCR sites indicated by bold lettering. The Radnor inliers (Dolyhir and Strinds quarries and Hanter Hill sites) are shown by the inset at top left. The location of the Llangynog site is given in (Figure 6.1).

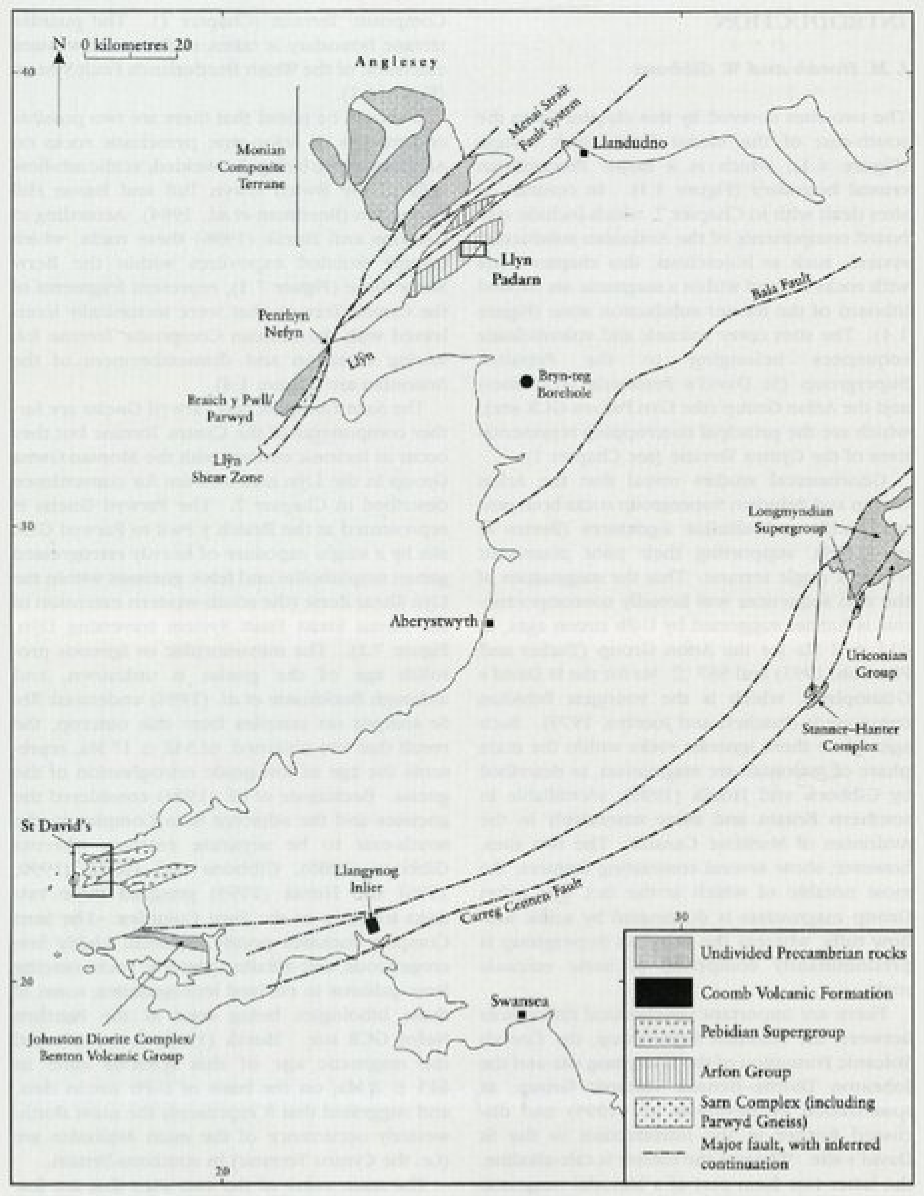
(Figure 5.2) Precambrian hills of Caer Caradoc, The Lawley and The Wrekin (in distance), looking north-eastwards from the Long Mynd. The intervening low-lying country is occupied by the Church Stretton Fault System. (Photo: D. Wilson.)



(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.



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