
St David's Peninsula

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Introduction

This site encompasses part of the rugged coastline and small inland exposures of the St David's Peninsula (Figure 6.2). It provides some of the most extensive sections through Precambrian volcanic rocks and associated intrusions, in particular the St David's Granophyre, to the southeast of the Menai Strait Fault System. In addition to the completeness of the stratigraphical section, this site records the relationships between the overlying Cambrian sedimentary rocks and both the volcanic sequence and the St David's Granophyre.

The volcanic sequence represented is the Pebidian Supergroup of Pharaoh and Gibbons (1994), which comprises basic and acidic lavas, tuffs and minor intrusions. The lavas were originally interpreted as being dominantly andesites, but recent investigations have shown that they are chiefly of basic composition (Bevins *et al.*, 1995).

The St David's site is important for a number of reasons. Stratigraphical relationships in this area were at the centre of one of the greatest controversies in the history of British geology, the debate revolving around the relative ages of the St David's Granophyre and the surrounding rocks. Hicks (1877, 1878) mapped the area in considerable detail and was convinced that the granophyre was of Precambrian age; in contrast, Sir Archibald Geikie, representing the Geological Survey, considered the Pebidian sequence to be Cambrian in age, therefore making the St David's Granophyre a post-Cambrian intrusion. The matter was settled finally by Green (1908), who excavated a trench a short distance to the south of St David's, which clearly demonstrated an unconformable relationship between underlying granophyric rocks and an overlying basal Cambrian conglomerate. Although the trench is now obliterated, a new track-side exposure in the same area provides the critical field evidence today and is described below.

Hicks (1877, 1878) coined the terms 'Dimetian' and 'Pebidian' respectively for the granophyre and the volcanic rocks of the St David's area. Green (1908), however, undertook the first detailed stratigraphical investigation of these rocks, recognizing four divisions within the Pebidian, namely, from bottom to top of the succession: the Penrhiw, Treginnis, Caerbwdy and Ramsey Sound Series. This stratigraphy remained until publication of the 1:25 000 St David's geological map (Institute of Geological Sciences, 1973). This work revised the stratigraphy, adding two 'Groups', namely the Ogofgolchfa Group, at the top of the succession, and the Rhosson Group, lying immediately below the Ogofgolchfa Group. These changes resulted from a reconsideration by Green (in Cox *et al.*, 1930) that Carn Rhosson [SM 728 252] and adjacent crags were not dolerite intrusions but in fact basic lavas and breccias. A similar scheme was adopted for the recent 1:50 000 geological map (British Geological Survey, 1992), although the lower series were grouped together as Lower Pebidian (undivided).

Davies and Bloxam (1990) modified this stratigraphy by: placing the Rhosson Series at the base of the succession; renaming the Treginnis Series the Pen Pedol Series; and including the Penrhiw Series with their Ramsey Sound Series. The ascending order of the stratigraphy was redefined as the Rhosson, Treginnis (Pen Pedol), Ramsey Sound and Caerbwdy series. The British Geological Survey (1992) subsequently made further alterations to this stratigraphy and upgraded the series to group status. The latter stratigraphical sequence has been used in this work and is detailed below:

- Ogofgolchfa Group
- Rhosson Group
- Ramsey Sound Group
- Caerbwdy Group
- Lower Pebidian (undivided Treginnis, Treglemais and Penrhiw groups)

Recent work on the rocks within this site includes isotopic dating of the main intrusion and geochemical studies of both intrusive and extrusive components. Patchett and Jocelyn (1979) published a U-Pb zircon age from the David's

Granophyre of 587 ±25/–14 Ma, proving it to be late Precambrian and providing a minimum age for the Peibidian Supergroup. The study also permitted correlations to be made with other Avalonian rocks both within and outside Britain and in Maritime Canada.

The geochemical investigations into the volcanic rocks and St David's Granophyre revealed the nature of their primary igneous compositions and the effects of element mobility and alteration (Bloxam and Dirk, 1988; Davies and Bloxam, 1990; Bevins *et al.*, 1995). The basic volcanic rocks have a clear calc-alkaline signature, demonstrated by a negatively sloping N-type MORB-normalized trace element pattern with slight Nb and Ta depletion and Th, Ce, P and Sm enrichment (Bevins *et al.*, 1995). Similarly, the Nb-Y tectonic classification diagrams of Pearce *et al.* (1984) show that both rhyolitic tuffs and the St David's Granophyre have a volcanic arc granite affinity (Bloxam and Dirk, 1988; Bevins *et al.*, 1995). The last-named workers discussed comparisons with other Precambrian occurrences and suggested that chemically these rocks are related to the Arfon Group of the Llyn Padarn GCR site, but differ considerably from the Coomb Volcanic Formation at Llangynog.

Description

A selection of some of the more important exposures along St David's Peninsula (Figure 6.2) is described here, with interpretations following in a later, amalgamated section.

St Non's Bay

At St Non's Bay [SM 725 242], the Caerbwdy Group is exposed in contact with basal conglomerates of Cambrian age, the contact being locally overturned. The group largely comprises fine- to coarse-grained silicic tuffs, however, and hence is difficult to distinguish from rocks belonging to the Ramsey Sound Group; indeed it is possible that they are equivalents. The tuffs are composed of varying proportions of crystals and lithic fragments, and in places show a fine-scale layering. Locally, they are thoroughly recrystallized, and were termed 'halleflinta' or 'porcellanite' in the early literature.

Treginnis–Porthtaflod

These localities constitute the chief exposures of the Lower Peibidian sequence. It is shown undifferentiated on the most recently published map (British Geological Survey, 1992), but comprises the Treglemais, Penrhiw and Treginnis groups of the earlier literature. This sequence shows a wide variety of lithologies, although not all are represented in the GCR site areas.

The basic composition of rocks comprising the Treginnis Group is well illustrated, for example, by the exposures near Pen Dal-aderyn (Figure 6.2); [SM 715 233]. They show well-developed columnar jointing in places, such as to the south-west of Porth Henllys [SM 724 233], as well as autobrecciated horizons, seen in the area around Porthtaflod [SM 718 232]. Also, green and purple basaltic tuffs are widespread in the tract of country to the south-west of Treginnis-isaf [SM 724 239]. These tuffs are characterized by abundant, flattened basaltic scoriaceous clasts, accompanied invariably by broken crystals and rare clasts of silicic, shardic tuff. In the coastal section immediately east of Pen Dal-aderyn, basaltic lava and metabasic tuffs overlie a sequence of pink to purple, rhythmically bedded tuffaceous siltstones and mudstones (Figure 6.3). Although silicic rocks are rare in the Treginnis Group, a thin (< 2 m) silicic ash-flow tuff unit, containing prominent rhyolite lithic clasts up to 6 cm, occurs interbedded with metabasic tuffs at Ogof Henllys [SM 725 235].

The Treglemais Group is named for the outcrops at Treglemais [SM 816 281], to the east of the area shown in (Figure 6.2), where it comprises non-welded silicic ash-flow tuffs, composed of broken quartz and feldspar crystals, rhyolitic and (rarer) basaltic lava clasts, fragments of shardic tuff, pumice, and recrystallized glass shards. The Penrhiw Group, at the type locality at Penrhiw Quarry [SM 751 258], comprises a similar but more altered lithological assemblage, and the two groups may be lateral equivalents.

Carn ar Wig and Porthlysgi Bay

These localities provide exposures of the Ramsey Sound Group, made up of silicic pyroclastic rocks. Extensive recrystallization has unfortunately destroyed many of the original textures. However, sufficient details remain to suggest that these rocks were composed originally of varying proportions of crystals, lithic fragments, pumice and shards. Locally, as at Carn ar Wig [SM 719 239], eutaxitic textures are preserved. At Porthlysgi Bay [SM 730 236], tuffs of the Ramsey Sound Group are intensely sericitized and many primary textures have been obliterated. In some cases, however, the presence of pumice, shards, lithic fragments and broken crystals can be determined; original eutaxitic fabrics can also be discerned.

Rhosson and environs

This large area contains a number of localities exposing the Rhosson Group. According to the British Geological Survey map (1992), this comprises andesitic and trachytic tuffs and lavas. Petrological and geochemical analyses (Davies and Bloxam, 1990; Bevins *et al.*, 1995) suggest, however, that the rocks are of basaltic affinity, and that the various tuffs are autobrecciated lavas and scoriaceous debris.

The Rhosson Group is best exposed on Carn Rhosson [SM 7275 2513]. The lavas are commonly vesicular, and carry phenocrysts of olivine and plagioclase, although both these minerals are altered; fresh clinopyroxene is, however, present in some samples. Almost all samples show the presence of epidote, some lavas being pervasively epidotized, for example in the vicinity of orphy Croeswdig [SM 738 263] and Carn Poeth [SM 732 257]. Near to Maen Bachau [SM 732 257], the lavas are silicified; the presence of abundant olivine pseudomorphs, however, points to their original basic composition. Some lavas show evidence of autobrecciated horizons, whereas other breccias appear to be accumulations of scoriaceous material, commonly containing angular quartz crystals and in one case, 150 m to the south-east of old Rhosson Chapel [SM 729 251], a clast of silicic welded ash-flow tuff.

Ogofgolchfa

This locality [SM 7303 2643] contains exposures representative of the Ogofgolchfa Group, and its marked unconformity with a basal conglomerate belonging to the Caerfai Group, of lowermost Cambrian age. The Ogofgolchfa Group comprises green, chloritic tuffaceous rocks and purple slates, the latter showing extreme stretching of lithic fragments. A thin basic sheet intrudes these rocks. This section is important as it clearly demonstrates that the Peibidian Supergroup is of Precambrian age.

Porthlysgi Bay and Porth Clais

These localities contain some of the most informative exposures of the St David's Granophyre. On the eastern side of Porthlysgi Bay [SM 732 236], the granophyre is seen in fault contact with the Peibidian Supergroup. The granophyre becomes finer grained towards its margin, but is typically medium-grained and highly leucocratic. In thin section it shows a simple assemblage dominated by quartz and plagioclase, with classic granophyric textures locally showing an almost graphic form. Alkali feldspar is restricted to groundmass crystals, whereas both plagioclase and quartz form phenocrysts. This assemblage is variably hydrated, with plagioclase alteration ranging from clouding to extensive replacement by sericite. Ferromagnesian minerals are restricted to biotite, but this is totally replaced by chlorite. Both epidote and clinozoisite are present, although not noticeably pseudomorphing primary phases. Bloxam and Dirk (1988) have classified this intrusion as a trondhjemite on the basis of its low content of alkali feldspar and ferromagnesian minerals.

To the north-west of Porth Clais [SM 742 238] lies the famous site where Green (1908) dug a trench to demonstrate the unconformable relationship between the St David's Granophyre and the overlying Cambrian succession. As the trench no longer permits the observation of this key piece of stratigraphical evidence, a new exposure, approximately 40 m to the southwest, was created in 1997. The exposure (Figure 6.4) lies on the edge of a small farm track [SM 7388 2430]. It shows the unconformity dipping at 75° to the north-west, separating highly weathered, locally iron-stained granophyre, cut by minor faults, from overlying Cambrian conglomerates of the Caerfai Group. The conglomerates contain rounded pebbles and sporadic cobbles chiefly of colourless to liver-coloured quartz.

Interpretation

Geochemical studies of the igneous rocks from the St David's site, discussed in the introduction to this chapter, show that they can all be interpreted as the products of subduction zone magmatism (Bloxam and Dirk, 1988; Bevins *et al.*, 1995). The compositional range of these rocks is typical of many volcanic arc sequences and is particularly emphasized within the Lower Pebidian, which includes basaltic lava and tuff sequences, the latter with interbedded silicic pyroclastic rocks. In the Ramsey Sound Group, these latter silicic rocks are dominant, their content of broken crystals, lithic fragments, pumice and shards leading to the conclusion that they were originally ash-flow tuffs. Original eutaxitic fabrics, characteristic of welded ash-flow tuffs, can also be discerned.

The Rhosson Group was interpreted in an earlier survey to comprise andesitic and trachytic tuffs and lavas. Petrological and geochemical analyses (Davies and Bloxam, 1990; Bevins *et al.*, 1995) suggest, however, that together with the overlying Ogofgolcha Group it marks a reversion to basaltic volcanism, the various tuffs being interpreted as autobrecciated lavas and scoriaceous debris related to lava effusion. The occurrence of silicic welded tuff clasts demonstrates further that acidic volcanic activity predated the eruption of these basic lavas.

Bevins *et al.* (1995) have contrasted the chemistry of the volcanic rocks from the St David's Peninsula site with those of the Coomb Volcanic Formation and Johnston Complex–Benton Volcanic Group, which lie to the south and are of 'Uriconian' affinity. Such studies have furnished important evidence for the existence of separate Precambrian terranes in the local basement, as discussed in the introduction to this chapter.

Although the Pebidian Supergroup has been widely correlated with other Precambrian volcanic successions in southern Britain, the geochemical characterization of the Pebidian Supergroup and St David's Granophyre now allow more valid correlations to be made. The U-Pb zircon age date (within error) allows these intrusive and extrusive rocks to be placed within Avalonian Event 2, at 630–600 Ma, which has been interpreted by Gibbons and Horák (1996) as the main phase of Avalonian magmatism. The Pebidian Supergroup and associated intrusives can therefore be categorized in terms of the Avalonian crustal evolution of southern Britain. They can also be more broadly correlated with components of the Avalonian basement in eastern Canada, and thus provide evidence of the extent and nature of magmatism in this complex, multiple-arc system. In addition, these rocks, together with those of the Arfon Group at the Llyn Padarn GCR site, provide insight into the likely nature of the pre-Palaeozoic basement below much of the Welsh Basin.

The Precambrian igneous sequences of the St David's Peninsula also provide evidence for a discordant, unconformable contact with overlying Cambrian strata.

Conclusions

The Pebidian Supergroup exposures at this site-exemplify the diversity of rock types formed within a late Precambrian volcanic arc. They are volcanic rocks such as basaltic lavas and tuffs, which are in places interleaved with ash-flow tuffs derived from a contemporary, more silica-rich and explosive style of volcanism. The final stage of magmatism involved the intrusion of granophyre, as is also seen in the Precambrian suites of Charnwood Forest (Chapter 2) and the Uriconian Group of The Wrekin (Chapter 4). These rocks contribute much evidence about the nature, evolution and extent of Precambrian Avalonian arc magmatism in southern Britain and its correlation with the well-documented events of similar age in eastern Canada. Regionally the St David's Peninsula occurrences are significant in that they represent parts of the 'basement' that lies unconformably beneath Palaeozoic sedimentary rocks of the Welsh Basin.

[References](#)



(Figure 6.3) Well-bedded, possible airfall tuffs overlain by basalt lava; Treginnis Group east of Pen Dal-aderyn, St David's Peninsula, Pembrokeshire. (Photo: J.C.W. Cope.)



(Figure 6.4) Unconformable contact between the St David's Granophyre (Precambrian) below and conglomerates of the Caerfai Group (Cambrian) above, exposed in a farm track to the north-west of Porth Clais, St David's Peninsula, Pembrokeshire. The level of the unconformity lies at the position of the hammerhead. (Photo: S. Howells.)