

Avalon Terrane, Precambrian and ?Cambrian, Wales

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[Jump to navigation](#) [Jump to search](#)

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Llyn Padarn, Llanberis. Pale crags to the left are acidic ash-flow tuffs of the Padarn Tuff Formation, which are overlain by sandstones, locally conglomeratic, and thin acid tuffs of the Fachwen Formation. P007267.



Maiden's Castle, north of Treffgarne. Denuded crags of flow banded, autobrecciated, locally nodular rhyolite. (Precambrian). P662391.

Introduction

The Avalon Terrane lies to the south-east of the Menai Straits Fault System and includes all the remaining Precambrian outcrops in mainland Wales and the Welsh Borderland. The lithologies in

these outcrops display marked differences, from slightly metamorphosed sedimentary rocks to gneisses, with both volcanic rocks and more deep-seated magmatic intrusions. The intermediate to acid calcalkaline igneous rocks have been interpreted as the products of subduction-related arc volcanism. The general lithologies are considered to reflect the development of sedimentary basins and the accumulation of much volcanoclastic sediments on a dominantly igneous basement. The small and disparate outcrops inhibit more detailed palaeogeographical interpretation.

The Sarn Complex, of mainly calc-alkaline granitic to dioritic rocks, lies at the north-western edge of the Avalonian terrane. It forms a narrow outcrop on Llŷn, between Porth Dinllaen and Aberdaron, and is separated from the Gwna Group, to the north-west, by the Llŷn Shear Zone (Menai Straits Fault System). To the east, it is overlain by lower Ordovician, Arenig, sedimentary rocks. The most north-easterly exposures, on Mynydd Cefnamlwch, are of a pale adamellite granite, which is referred to as the Sarn Granite. To the south-west, both homogeneous and foliated gneissic diorites, with unfoliated granite and dolerite veins, are exposed. Many of the exposures within the complex are of mixed, commonly xenolithic, hybridised, biotite-rich rocks, locally with hornblende and clinopyroxene. One of the best exposures, at Meillionydd, shows composition ranging from diorite to granite with local foliation. The petrology and geochemistry has suggested emplacement in a subduction-related arc environment. A gabbro from within the complex has yielded a U-Pb age of 615 ± 2 Ma. The final disposition of the terranes along the Menai Straits Fault System was probably accomplished prior to the formation of the Sarn Complex and the blueschists.

The Parwyd Gneiss forms a restricted outcrop on the east cliff of Parwyd cove. It comprises coarse, foliated orthogneiss, mainly hornblende-garnet amphibolite, with much green hornblende and lesser pale pink garnet crystals. Locally the composition is more acidic and invariably these rocks display intense cataclasis. The Parwyd Gneiss has been included within the Sarn Complex, although they may not be related. Even so, a whole-rock, Rb-Sr isochron age of 542 ± 17 Ma is comparable with the 549 ± 19 Ma age obtained from a granitic rock within the complex. However, both dates must be regarded as minimum ages, markedly different from the age of the metagabbro within the complex.

The Arfon Group crops out in two areas in Caernarvonshire, in close proximity to the Menai Straits Fault System, and in small outliers on Anglesey. On the mainland, the larger outcrop, between Pen y Groes and Deiniolen, lies on the south-east side of the Aber-Dinlle Fault and the smaller outcrop lies close to Port Dinorwic, on the south side of the Dinorwic Fault. Four formations have been recognised, the Padarn Tuff, Minffordd, Bangor and Fachwen formations, but only the Padarn Tuff Formation has yielded a Precambrian age.

The Padarn Tuff Formation ([P007267](#)) consists mostly of grey-green, bleach-weathered, acidic ash-flow tuffs. Despite good exposure, there is no indication of separate flow units. The tuffs are strongly welded and contain conspicuous crystals of bipyramidal quartz and albite feldspar. Locally the tuffs are intruded by high level rhyolite intrusions and, elsewhere, thin beds of possible air-fall tuffs have a very restricted distribution. The orientation of welding fabrics in the well-exposed area about Llyn Padarn suggests that the tuffs are at least 800 m thick, and geophysical models indicate a possible thickness of up to 2000 m. The great thickness of the tuffs and the uniform lithology suggests that the rapidly erupted tuffs were entrapped in a volcanotectonic depression. U-Pb dating of volcanogenic zircon indicates that eruption occurred at 614 ± 2 Ma, which confirms a Precambrian age broadly coeval with the Coedana Granite and raises the possibility that Anglesey was close to its current position in early Cambrian times. On Anglesey, the Bwlch Gwyn Tuff (Greenly's 'felsite') and the Baron Hill Formation comprise closely comparable acidic ash-flow tuffs that form isolated exposures within the Berw Shear Zone. However, their contacts are not exposed and it is possible that they occur within fault slices at the edge of the Monian Composite Terrane.

In southern Snowdonia, probable Precambrian rocks, the Brynteg Volcanic Formation, were proved

in the Brynteg Borehole, sited on the axis of the Harlech Dome. The sequence comprises sedimentary and volcanoclastic rocks with minor primary volcanic rocks of intermediate composition that were possibly generated in an island-arc setting.

South-west Wales and the borders

The Precambrian, Avalonian terrane rocks of Pembrokeshire occur in a series of inliers from St David's eastwards, in north Pembrokeshire, and some smaller inliers, from Talbenny eastwards, in south Pembrokeshire. Away from the limited coastal sections, both sets of outcrops are poorly exposed. The rocks are intensely altered, and their relationships and associations are extremely difficult to distinguish. It is not surprising that the outcrops have received so little attention in recent years. The rocks are mainly the products of igneous activity. In 1877, Hicks divided them into two units, the Pebidian, comprising lavas and tuffs, and the Dimetian, a suite of intrusions. These names have persisted to the present day. In the outcrops in the vicinity of St David's, the Precambrian age is drawn from their position beneath the Cambrian basal conglomerate. In the southern outcrops, a recent radiometric age possibly confirms this conclusion.

The Pebidian comprises volcanoclastic sedimentary rocks, pyroclastic rocks and lavas, which are best exposed south-west of St David's, in the coastal section westwards from Porthllysgi. Nearly 100 years ago, Green subdivided these outcrops into four units, which would probably be regarded as groups in modern nomenclature. In upward succession, they are the Penrhiw, Treginnis, Caerbwdy and Ramsay 'groups'. The rocks were described as 'sericitic tuffs', 'greenish acid rocks with bands of halfefflinta and conglomerate', 'hard gritty rocks with abundant trachytic pumice' and 'red keratophyre boulders', and are difficult to categorise in modern terms. A cursory examination shows that the sequence has been subjected to considerable tectonism and secondary alteration, which is locally so intense that most of the original structures have been obscured. In a recent petrochemical study, the rocks have been characterised as basic to intermediate lavas with related volcanoclastic rocks, and acidic tuffs with minor basic intrusions.

East of St David's, in the Hayscastle inlier, a lower group of andesitic tuffs overlain by a group of rhyolitic tuffs and flowbanded rhyolite has been distinguished. The rhyolites outcrop between Roch Castle and the Cleddau valley and include the prominent crags at Maiden Castle ([P662391](#)). The rhyolites are green-grey, bleach-weathered, fine-grained and recrystallised; they are possibly overlain by flaggy fine-grained tuffaceous siltstone. The determination of original lithological characters in the rhyolites at outcrop is made difficult by intense jointing and nodular recrystallisation. In south Pembrokeshire, Pebidian rocks are restricted to thrust slices in the Variscan thrust zone, in a small inlier near Benton. They are highly altered, fine-grained tuffs and breccias with flow-banded and spherulitic (possible nodular) rhyolites.

The Dimetian comprises a suite of granite and diorite intrusions within the Pebidian but, because of poor exposure, the exact relationships are difficult to determine. The most significant intrusion is the St David's granophyre, which is much altered and sheared and is now a coarse-grained, quartzofeldspar aggregate with much chlorite. An associated quartz porphyry is regarded as petrographically similar, possibly representing a late-stage intrusion. At Hollybush, a medium- to coarse-grained diorite intrusion, with biotite and large hornblende crystals, has been included within the Dimetian suite.

The inliers at Talbenny and Johnston include diorite and quartz diorite intrusions, which locally grade into rocks of more granitic composition. Thin dykes of quartz dolerite with chilled margins are common. In the Bolton Hill quarry near Johnston, the thrust contact between the diorites and the Carboniferous Coal Measures is frequently exposed during excavation. Close to the Variscan thrust

zone, for example near Talbenny, these rocks have been overprinted with a pronounced gneissic texture.

The Precambrian Coomb Volcanic Formation of the Llangynog inlier, south-west of Carmarthen, comprises devitrified rhyolite lavas that are flow banded in places. They are overlain by shallow water, volcanoclastic siltstone, which contains medusoids and trace fossils of Ediacaran age. Basaltic lavas, autobreccias and rare hyaloclastites, which are characteristic of subaqueous emplacement, and acidic tuffs, are interbedded within the siltstone. The rocks are in faulted contact with Ordovician strata and are overlain unconformably by both Cambrian and Old Red Sandstone strata.

In Powys, Precambrian strata crop out in two fault-bound inliers within the Church Stretton Fault Zone. The Old Radnor inlier exposes intensely brecciated sandstone and silty mudstone that are closely comparable with the type Longmyndian sequence seen farther north. The dominantly sandy Strinds Formation and the finer grained Yat Wood Formation have been interpreted as products of a braided alluvial delta and a possible subaqueous delta, respectively. The composite Hunter and Stanner inlier comprises dolerite and gabbro sheets intruded by fine-grained felsite and granophyric dykes. Some of the dykes closely resemble granophyres in the nearby Uriconian of Shropshire, and similar lithologies have been determined as clasts in Longmyndian conglomerates. The acid intrusion on Stanner Hill has been dated at 702 ± 8 Ma. The patterns of alteration in these rocks suggest they may possibly be part of a subvolcanic complex.

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Contents

[Introduction](#)

[History of geological research](#)

[Geotectonic setting](#)

[Precambrian and ?Cambrian](#)

[Monian Composite Terrane](#)

[Coedana Complex](#)

[Blueschist Terrane](#)

[Monian Supergroup](#)

Avalon Terrane

[South-west Wales and the borders](#)

Cambrian

[Comley Series](#)

[St David's Series](#)

[Merioneth Series](#)

Ordovician

[Tremadoc](#)

[Arenig](#)

[Llanvirn](#)

[Caradoc](#)

[Ashgill](#)

[Ordovician volcanism](#)

[Silurian](#)

[Llandovery](#)

[Wenlock](#)

[Ludlow](#)

[Přídolí](#)

[Caledonian orogeny](#)

Devonian

Lower Old Red Sandstone

Lochkovian

Pragian—Emsian

Upper Old Red Sandstone

Carboniferous

Dinantian

Tournaisian

Visean

Silesian

[Namurian](#)

[Westphalian](#)

[Coal](#)

[Variscan orogeny](#)

[Mineralisation](#)

[Mesozoic](#)

[Permian—Triassic](#)

[Jurassic](#)

[Lower Jurassic](#)

Middle Jurassic

Upper Jurassic

Cretaceous

Lower Cretaceous

Upper Cretaceous

Oil and gas

Cainozoic

Palaeogene—Neogene

Quaternary

[Pleistocene](#)

[Holocene](#)

[Geology and man](#)

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[Category:](#)

- [Regional Geology of Wales](#)

Navigation menu

Personal tools

- Not logged in
- [Talk](#)
- [Contributions](#)
- [Log in](#)
- [Request account](#)

Namespaces

- [Page](#)
- [Discussion](#)

Variants

Views

- [Read](#)
- [Edit](#)
- [View history](#)
- [PDF Export](#)

More

Search

Navigation

- [Main page](#)
- [Recent changes](#)
- [Random page](#)
- [Help about MediaWiki](#)

Tools

- [What links here](#)
 - [Related changes](#)
 - [Special pages](#)
 - [Permanent link](#)
 - [Page information](#)
 - [Cite this page](#)
 - [Browse properties](#)
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