



## **Carboniferous - Permian Igneous (C-P-IG)**

### **Block Description**

Visit <https://jncc.gov.uk/gcr-site-list>, for more information on GCR blocks and sites  
For Igneous and Mineralogy GCR block descriptions and GCR site lists,  
visit <https://jncc.gov.uk/gcr-blocks-igneous-and-mineralogy>

## Introduction

This GCR Block encompasses the British volcanic rocks and associated intrusions that were emplaced north of the Variscan Front (**see Variscan Structures of South-West England (VAR-STR-SW) and Variscan Structures of South Wales and the Mendips (VAR-STR-WM)**) during the Carboniferous and Permian periods (from about 354 to 251 million years ago (Ma)). At this time the geological basement of Great Britain was part of the supercontinent of Pangaea, which was drifting slowly northwards through tropical latitudes, sequentially developing semi-arid river flood-plains, shallow tropical seas with carbonate reefs, thickly vegetated coastal deltas with coal-forming swamps and finally, deserts (for details of stratigraphy **see Dinantian of Devon & Cornwall (DIN-DV-CW); Dinantian of Northern England & North Wales (DIN-N-E-WL); Dinantian of Scotland (DIN-SC); Marine Permian (MAR-PER); Namurian of England & Wales (NAM-E-WL); Permian - Triassic (PER-TRI); Westphalian (WPH)**). Stretching and thinning of the Earth's outer layers, well to the north of the nearest zone of continental collision, facilitated melting of the underlying mantle. Rifting provided weaknesses along which the resulting magmas could reach the surface or near-surface and volcanoes erupted across the wide range of geographical and climatic settings. Their products are dominantly basaltic but during Early Carboniferous time in central Scotland, the ascent of the magmas was interrupted locally, allowing a wide range of more-evolved compositions to form.

## Outcrop pattern

The Carboniferous and Permian igneous rocks are widely scattered along the length of Great Britain, from the Bristol Channel in the south to the Orkney Islands in the north. By far the greatest concentration of outcrops is in and around the Midland Valley of Scotland, with significant but less extensive outcrops around the Solway Firth, along the England–Scotland border, and in Derbyshire. Small outcrops occur in the West Midlands of England, in the western Mendip Hills and in south-east Wales). In addition, a concealed widespread volcanic field underlies younger rocks in the East Midlands, a sill-complex crops out and extends beneath a large area of north-east England and dyke swarms extend across parts of the Highlands of Scotland. Igneous rocks to the south of the Variscan Front, that is, south of the Mendip Hills, are included in the Igneous Rocks of South-West England GCR Block. **See Igneous Rocks of South-west England (IGN-SW-E).**

## Tectonic setting and evolution

Following the end of the Caledonian Orogeny, in Late Devonian time (c. 370 Ma), the area of continental crust that now makes up the British Isles was part of the supercontinent of Laurussia (informally known as the 'Old Red Sandstone Continent'). This had formed during the orogeny by the amalgamation of several pre-existing continents. The crust of Scotland and the far north-east of England had lain on the margin of the continent of Laurentia, which included Greenland and most of North America, whereas England and Wales were part of the microcontinent of Avalonia. The junction between these two plates, now concealed beneath younger rocks, is called the 'Iapetus Suture' and trends approximately north-east from the Solway Firth to the coast of Northumberland, around Seahouses.

From Late Devonian times onwards, the southern continent of Gondwana was in collision with the southern margin of Laurussia, leading to the Variscan Orogeny, and creating the supercontinent of Pangaea. The main orogenic belt associated with this collision was located far to the south of Great Britain in the Iberia–Armorica–Massif Central region. However, the northern limit of strong Variscan deformation, commonly known as the 'Variscan Front', migrated northwards during the orogeny and the final limit extends across southern Britain, between the Thames and Severn estuaries. To the north of this orogenic front, back-arc extension controlled structure, sedimentation and igneous activity in the British Isles throughout Late Devonian and Carboniferous times.

Five main sedimentary depositional 'provinces', separated from each other by important palaeogeographical highs, have been recognized:

- The Scottish Province, consisting essentially of the Midland Valley of Scotland, bounded by the Caledonian Highlands to the north and the Southern Upland High to the south.
- The Pennine Province of central and northern England, bounded by the Southern Upland High to the north and the Wales–London–Brabant High to the south.
- The Irish Province in the west.
- The Southern Province, south of the Wales–London–Brabant High.
- The Culm Basin of Devon and Cornwall.

The Scottish, Pennine and Southern provinces comprise the tectonic settings for the igneous rocks encompassed by this GCR block. The Culm Basin, south of the Variscan Front, is the setting for those covered by the Igneous Rocks of South-west England GCR Block.

The earliest magmatism occurred during the Tournaisian Epoch (c. 354–342 Ma) and is represented mainly by volcanic rocks around the Solway Firth and the England–Scotland border, although the volcanic rocks in the Mendips span from late Tournaisian to early Visean times. The most voluminous and widespread igneous activity occurred during the Visean Epoch (342–327 Ma), resulting in vast lava fields in the Midland Valley of Scotland, lavas and sills in Derbyshire, and minor volcanic sequences around the England–Scotland border. During the Namurian and Westphalian ages, volcanism became more localized in the Midland Valley of Scotland and in the East and West Midlands of England, with an increasing tendency for the magma to be emplaced as sills, and all activity died out in late Westphalian times. Following a major change in tectonic conditions, a short-lived episode of regional dyke and sill intrusion occurred in north-east England and across central Scotland in early to mid-Stephanian times, and late Stephanian and Early Permian times saw the emplacement of widespread but localized lavas, sills and dykes that now extend from the eastern Irish Sea to the north-west Highlands. Evidence of Late Permian igneous activity in Britain is restricted to dykes in the Orkney Islands.

The Carboniferous and Permian magmatism in Great Britain was of typical intraplate type, largely controlled throughout the Carboniferous Period by back-arc extension to the north of the Variscan orogenic front and, during Permian times, by major intracontinental rifting that heralded the eventual break-up of the supercontinent of Pangaea. In Scotland, the magmas were dominantly of transitional to mildly alkaline character, becoming generally more highly alkaline and silica-undersaturated with time. Some very primitive and compositionally extreme, alkali-rich lamprophyric and foiditic (feldspathoid-bearing) rocks characterized Early Permian lavas and intrusions of the Midland Valley as well as many of the dykes of the Scottish Highlands and Islands. However, many of the Tournaisian lavas around the Solway Firth and along the Scotland–England border are tholeiitic and the Visean lavas of Derbyshire are entirely tholeiitic. Some tholeiitic lavas also occur in the Westphalian rocks of the East Midlands, but other igneous rocks of central and southern England are alkaline. The principal exception to this overall pattern is the short-lived Stephanian event, which resulted in widespread intrusion of tholeiitic magmas as dykes and sills across much of central Scotland and north-eastern England.

## **GCR site selection**

The sites illustrate the variety and distribution of the rocks and highlight critical localities of historical and continuing national and international importance, and can be ascribed to various suites in their full geological context, and the magmatism related to the overall tectonic history of north-west Europe.

The six GCR Networks for this GCR Block are based upon petrological affinity, age and geographical distribution. Some sites have features that fall within more than one network, but can be assigned to a network on the basis of their dominant features.

1. Dinantian volcanic rocks of the Midland Valley of Scotland and adjacent areas.
2. Dinantian rocks of Northumberland, Solway and Tweed basins
3. Silurian and Early Permian volcanic rocks of Scotland
4. Alkaline basic sills and dykes of Scotland
5. Tholeiitic sills and dykes of Scotland and northern England
6. Carboniferous and Permian igneous rocks of central England and the Welsh borderland.