# Rhaetian (RTN)

# Block Description

Visit https://jncc.gov.uk/gcr-site-list, for more information on GCR blocks and sites
For Mesozoic-Tertiary Stratigraphy GCR block descriptions and GCR site lists,
visit https://jncc.gov.uk/gcr-blocks-mesozoic-tertiary-stratigraphy

# Introduction

The GCR sites selected for this GCR Block represent the British geological record of Earth history from about 210 to 205 million years ago (Ma). This interval is the last part of the Late Triassic Epoch, which spans from 227 to 205 Ma. Rocks that formed during the Late Triassic Epoch (part of the Triassic Period, 250–205 Ma) constitute the Upper Triassic Series (part of the Triassic System). British rocks of Rhaetian age include the Penarth Group, the formal lithostratigraphical name for rocks formerly called the 'Rhaetic' in Britain. However, owing to the formal definition of the Rhaetian Age, British Rhaetian strata include the uppermost part of the Triassic Mercia Mudstone Group, and the lowermost part of the otherwise Jurassic Lias Group. The main focus of this GCR Block is the Penarth Group sediments.

The Penarth Group comprises the Westbury Formation and the succeeding Lilstock Formation. The Group represents a dramatic change in sedimentation style throughout the British Isles and much of western and central Europe at the end of the Triassic Period. The mainly continental, red and yellow mudstones and sandstones of the Germanic Keuper and of the Mercia Mudstone Group, come to an abrupt halt, and are succeeded by grey, marine mudstones, limestones, and sporadic, thin, bone beds. This change has long been interpreted as reflecting a major marine transgression that apparently flooded much of north-west and central Europe a few million years before the end of the Triassic Period, a prelude to the marine Lower Jurassic Series (= Lias).

The change in sedimentary style that marks the onset of the Penarth Group, from red bed to dark-coloured marine sediments, is dramatic, but it is local to central and western Europe, and not a worldwide phenomenon, and it is not associated with major faunal and floral changes. Such changes occur higher in the succession, around the Triassic–Jurassic boundary, as formally defined.

The Penarth Group is noted for its sharp, unconformable boundary with the underlying Blue Anchor Formation of the Mercia Mudstone Group, probably marking the level at which the Rhaetian sea waters flooded across the playas and brackish sabkhas. Penarth Group sediments are marine, as indicated by their fossil content, including, for example, dinoflagellate cysts, corals, brachiopods, bivalves, echinoderm debris and ichthyosaur bones). The sediments consist predominantly of blue, grey, and black shales and limestones, arranged in laterally extensive, but generally thin, units. Bone beds, units containing abundant transported bones, teeth, coprolites, and phosphatic debris of mixed marine and continental derivation occur in places. A basal bone bed occurs at some locations, but there are in fact 'Rhaetic' bone beds at several horizons.

The Westbury Formation overlies the Blue Anchor Formation, the uppermost unit of the Mercia Mudstone Group, usually unconformably. In many places, a thin, laterally impersistent bone bed, the 'Rhaetic bone bed', occurs at the base of the Westbury Formation. The remainder of the formation consists of dark grey mudstones or shales with subordinate thin limestones and sandstones. The overlying Lilstock Formation is bounded above by the base of the 'Paper Shale' of the Pre-planorbis beds of the Lower Lias.

The Pre-planorbis beds and the Triassic–Jurassic boundary

The position of the Triassic–Jurassic boundary has been a subject of debate for many years.

Up to 1980, the base of the Jurassic System in Britain was traditionally taken to be the base of the Lias Group, the succession of generally grey-coloured mudstones and limestones so characteristic of the Lower Jurassic Series throughout much of Europe. This interpretation placed the boundary at the base of the lithologically defined 'Blue Lias', in particular placing the Pre-planorbis Beds in the Jurassic System. However, this characterization of the base of the system in Britain was purely lithological, and a formal, biostratigraphical definition has been placed at the first appearance of the ammonite Psiloceras planorbis, which thereby marks the base of the Hettangian Stage. Therefore the Pre-planorbis beds of the Blue Lias Formation are of Triassic, not Jurassic, age.

## Palaeoenvironment and palaeogeography

The Penarth Group reflects the widespread establishment of marine environments following a transgression that spread northwards through central and north-western Europe into Britain. At the same time, there was major rifting and volcanism in southern Europe, North Africa, and eastern North America, as proto-North Atlantic rifting opened up linear structures parallel to the current coastline of eastern North America, from Nova Scotia where thick lacustrine sediments of the Newark Supergroup accumulated.

The marine rocks of the Penarth Group succeed the greyish and greenish, dolomitic mudstones of the Blue Anchor Formation, formerly the ‘Tea Green Marls’ and ‘Grey Marls’, the highest formation in the Mercia Mudstone Group. These marine influences in the upper Norian strata in the UK were followed by full-scale marine conditions in the Rhaetian .

The Penarth Group sediments mark the marine transgression proper. The top of the Blue Anchor Formation is often intensely burrowed, and clasts of Blue Anchor Formation mudstones commonly occur in the basal Westbury Formation. The unconformable base of the Penarth Group is also marked here and there by bone-rich arenaceous units, the ‘Rhaetic bone beds’, and these are overlain by beds containing marine fossils such as oysters, pectinid bivalves, and echinoids.

The timing of the transgression is unclear in Britain. It appears to have occurred rapidly, perhaps sweeping from the south to the north. After the initial flooding, dark shales of the Westbury Formation accumulated. This facies is typical of the English Penarth Group, and is also seen throughout the region of the transgression, from the Alps to the Baltic area. The black shales throughout this whole area contain a limited fauna, predominantly the bivalve Rhaetavicula contorta, hence the former name of the unit, the ‘contorta Zone’. Rhaetavicula is a specialized epifaunal bivalve that was presumably adapted to unfavourable conditions, particularly anoxic bottom waters, evidenced by the black colour of the shales and by associated pyrite.

## The Westbury Formation bone beds

There are bone beds at several horizons in the Westbury Formation, not just at its base. In all cases the bones are heavily phosphatized and may be in superb and apparently unworn condition, or extensively rolled and abraded. The contrast in styles of preservation is best brought out by a comparison of material from the bone beds at Westbury Garden Cliff, on the north bank of the River Severn, and Aust Cliff, on the south.

In both cases, bones, spines, teeth, and scales, have been swept in by storm activity of some kind. The remains represent aquatic, and presumably marine, vertebrates for the most part (fishes, ichthyosaurs, plesiosaurs, choristoderes), but there are some unequivocal dinosaur bones. Hence, the bone beds indicate a shallow marine setting, confirmed by the associated trace fossils and shelly fossils. Perhaps the transgressing sea swept over the playas and sabkha plains of the Mercia Mudstone Group, engulfing the remains of dinosaurs and other terrestrial fauna, and mixing them with those of fishes and marine reptiles living in the newly expanding sea.

## The Lilstock Formation

The black shales of the upper part of the Westbury Formation are overlain by grey-green and grey marls of the Cotham Member of the Lilstock Formation..

The environment in southern England was probably an extensive inhospitable hypersaline tidal flat. Such conditions are indicated by a range of sedimentary structures in the Cotham Member sediments. In places, domal stromatolites have been reported, formed by the growth of cyanobacteria and calcareous sediments, and indicating desiccating saline conditions. Locally, these form the famous landscape Cotham Marble in the Bristol district.

The Langport Member consists mainly of limestones with dark shales, and indicates a renewal of fully marine conditions. The Langport Member often contains a rich fauna of

oysters, pectinid bivalves, echinoids, solitary corals, and trace fossils, all indicative of shallow marine conditions. In Devon, the member is represented by limestones formerly known as the ‘White Lias’.

The Penarth Group sediments document an apparently rapid marine transgression at the base of the Westbury Formation, followed by shallowing and local exposure as hypersaline tidal flats during Cotham Member times, and a further inundation in the Langport Member times. The sea apparently deepened into Jurassic times.

## GCR site selection

Penarth Group sediments have been described from a large number of sites, especially in the south-west of England and South Wales, but also from occurrences in Gloucestershire, Hereford and Worcester, Warwickshire, Staffordshire, Cheshire, Leicestershire, Nottinghamshire, Lincolnshire, Yorkshire and Cumbria. The goup was also identified in Scotland (Morayshire, Hebrides, Arran) and in Northern Ireland, as well as from boreholes in the North Sea, the Irish Sea, the Western Approaches, and in south-east England.

GCR sites on the north and south shores of the Severn Estuary, and on the Dorset coast are selected for the GCR to represent the sedimentary, stratigraphical and palaeontological features of the Penarth Group, according to four regional networks:

- South Wales
- South Gloucestershire
- North Somerset
- East Devon.

## Palaeontology, fauna and flora

The fossils of the Penarth Group include a range of predominantly marine forms including foraminifera, corals, annelids, gastropods, bivalves, crustaceans, echinoderms, brachiopods, conodonts, and fishes (sharks, chimaeras, bony fishes, coelacanth), and organic-walled microplankton (dinoflagellate cysts and acritarchs), but also including continental organisms (plants, insects, lungfish, dinosaurs).

Fossil fish remains include abundant isolated teeth, dermal denticles, and fine spines (‘ichthyodorulites’) of sharks: Polyacrodus, Lissodus, ‘Hybodus’, Nemacanthus, Palaeospinax, Synechodus, and Vallisia. Rare tooth plates of chimaeroids include the genera Myriacanthus and Agkistracanthus. Bony fishes are represented by teeth, scales, and isolated bones of the actinopterygians Gyrolepis, Birgeria, Severnichthys, and others, a coelacanth, and tooth plates of the lungfish Ceratodus. Amphibians were reported, based on massive teeth with labyrinthine infoldings, and heavy jawbones, but these have been found to belong to the bony fish Severnichthys.

Penarth Group tetrapods are represented mostly by isolated teeth, vertebral centra, limb bones, and occasional ribs. Fossil marine reptiles from the Penarth Group are primarily from the basal bone bed: ichthyosaurs, plesiosaurs, placodonts, and the choristodere Pachystropheus rhaeticus, a small, superficially crocodile-like animal. Isolated remains of terrestrial reptiles reported from a number of bone-bed sites include the dinosaurs Camelotia and (?) Megalosaurus, and the phytosaur ‘Paleosaurus’. In addition, isolated teeth of mammal-like reptiles and mammals have been noted (the cynodont Tricuspes and the haramiyids Haramiya and Hypsiprimnopsis). These scattered elements of terrestrial animals were presumably washed from landmasses some distance away, and incorporated into the essentially marine bone beds.