Marine Permian (MAR-PER)

Block Description

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For Palaeozoic Stratigraphy GCR block descriptions and GCR site lists,
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Introduction

The GCR sites selected for this GCR Block represent the British geological record of Earth history as represented by the suite of carbonate rocks known collectively as the 'Magnesian Limestone', mainly types of limestone and dolomite that was formed near the margins of shallow tropical seas during the last 6 million years of the Permian Period. This period is the last of the Palaeozoic Era (540–250 Ma). The greatly varied character of the rocks indicates formation in a complex mosaic of tropical shallow-water marine sub-environments, ranging from lagoons to barrier bars, reefs to basin-margin slopes.

Outcrop pattern

The distribution of marine Permian strata in mainland Britain emphasizes a great disparity between the widely scattered but mainly small occurrences in north-west England and the wide extent and almost continuous outcrop in north-east England.

Palaeoenvironment and palaeogeography

This GCR Block is concerned with rocks laid down in and near epicontinental tropical seas that covered low-lying tracts of northern Europe perhaps for 5–7 million years during the late part of the Permian period; Britain then lay deep within the Laurasian supercontinent, with a climate that was both hot and dry.

During early Permian and early Late Permian times, northern Europe was part of one of the world's great deserts, with a topographic and climatic range matching much of that of the present Sahara; widespread barren uplands created during the Armorican earth movements were gradually ground down as early Permian desert erosion led to extensive peneplanation of vast areas of Carboniferous rocks (especially Westphalian Coal Measures), and post-orogenic and extensional subsidence resulted in the formation of extensive, sub-sea-level, inland drainage basins in areas now occupied by the Irish and North seas and some adjoining land areas. It was these basins, surrounded by persistent and inhospitable deserts, that were flooded to form the Bakevellia and Zechstein seas.

The inferred mode of creation of the two seas gave rise immediately to classic barred basins, with sills that remained sensitively close to world sea levels. Both seas were particularly prone to relative sea-level changes and the thick sedimentary sequences formed in them display an extraordinary variation in their facies and extent. The sea-level changes stemmed from the complex interplay of several main mechanisms, including glacio-eustatic oscillations, isostatic effects, deepening and shallowing caused by periodic reversals in the relative rates of sedimention and subsidence, and, when the sills became emergent during oceanic low-stands, rapid evaporative downdraw. Cyclicity, caused at least partly by these relative sea-level changes, is on a range of scales and is expressed both by incomplete marginal sequences resulting from repeated transgressions and regressions and in a wide variety of carbonates and evaporites. Some variation of lithology and biota also stemmed from repeated and protracted phases of basinal anoxicity, a natural outcome of restricted circulation in a barred basin; benthic communities at these times were confined to marginal and shoal areas above an oscillating pycnocline.

The age of Zechstein and Bakevellia Sea strata in world chronostratigraphic terms is uncertain because these seas lay in the Boreal Realm and their faunas evolved almost independently of those in the Tethyan Realm upon which late Permian stages are now mainly based; a late Permian age is generally agreed.

Although few late Permian shorelines in the British Isles can be recognized with certainty, projection of sedimentological and thickness trends suggests that the Bakevellia and Zechstein seas generally extended no more than a few kilometres beyond the present outcrops of late Permian strata and remained separated by a Proto-Pennine barrier that waned with time but was surmounted by the sea only briefly and locally during the third of four main cycles of the English Zechstein sequence. The Zechstein Sea itself was divided

into several sub-basins, and early Zechstein Basin marginal depositional environments in north-east England fell into distinct Durham and Yorkshire provinces, separated by the Cleveland High.

The low relief and aridity of the Proto-Pennines and most other hinterlands, together with the prevalence of onshore trade winds, ensured that the Zechstein Sea in England received relatively little terrigenous sediment and most of the late Permian marine rocks there contain less than 2% of siliciclastic grains (mainly wind-blown); in contrast, the hinterland of much of the Bakevellia Sea was generally more elevated and rugged than that of most of the English Zechstein Sea, and terrigeneous input was correspondingly greater. In both basins, occasional storms resulted in flash floods which swept coarse continental debris far across the coastal plains and led to the formation of marginal breccia lenses and wedges.

GCR site selection

Together the sites represent two networks that covers most of the geology of the Late Permian marine sequence in northern England.

• Late Permian marine and associated strata in north-west England and adjoining areas. The strata are widespread beneath the eastern Irish Sea, but extend far inland only in the Solway Firth and south Lancashire/north Cheshire areas where arms of the Bakevellia Sea extended eastwards. The sequence is up to about 350 m thick in the basin centre, where hydrocarbon exploration has disclosed much new information, but thins sharply towards the basin margins where sequences are condensed and incomplete. Exposures on land are concentrated in these basin-marginal areas, especially in west and south Cumbria and around Greater Manchester, and most include intercalations of continental strata that indicate periodic proximity to cyclically migrating shorelines.

• Late Permian marine and associated strata in north-east England. The strata crop out almost continuously (partly beneath drift) from Tynemouth southwards to the outskirts of Nottingham and comprise a sequence of mainly dolomitized limestones that individually and together thicken progressively eastwards. These carbonate rocks form the basal part of three main evaporite cycles (EZ1 to EZ3), and at depth farther east are separated by evaporites which, in present coastal districts of Yorkshire and much of the North Sea Basin, form most of the sequence. At outcrop the carbonate units are separated by erosion or emersion surfaces, some in combination with siliciclastic beds or evaporite dissolution residues, and some have been affected by large-scale dissolutional foundering. The main Cycle EZ2 carbonate unit does not crop out in Yorkshire but is thick and widespread in County Durham and Tyne and Wear.

Although the relatively common invertebrate fossils do not have a separate selection category in the GCR in their own right, the scientific importance of many stratigraphy sites lies in their fossil content. Therefore, some of the GCR sites are selected specifically for their fossil fauna, which facilitates stratal correlation and enables the interpretation of the environments in which the animals lived. Moreover, some sites have international significance because they have yielded fossils that are the ‘type’ material for a taxonomic group.

Palaeontology, fauna and flora

See Permian - Triassic (PER-TRI).