Chapter 10 British Permian fossil fishes sites

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Introduction: palaeogeography and stratigraphy

Late Carboniferous earth movements and the closure of the Hercynian (mid-European) ocean greatly enlarged the northern continent of Laurussia and brought it into contact with the southern supercontinent, Gondwanaland. The British Isles area was affected by folding in the south-west of England and block-faulting elsewhere. During the early Permian, much of Britain was upland, with molasse troughs and desert basins extending from the southern North Sea-North German Basin across the eastern side of England, and passing across the Solway Firth area into the Irish Sea Basin (Harwood and Smith, 1986). The depositional areas touched onshore in Northern Ireland, the Hebrides, Morayshire, and in a thin strip from Bristol to east Devon. Early Permian sediments in Britain are red water-laid breccias and conglomerates, derived from neighbouring uplands. They pass up into typical thick dune sandstones, with desert lake and sabkha evaporites that can be correlated to the thick Rotliegendes deposits of mainland Europe. By the end of the Early Permian time most of the area of Britain had been reduced to a low rolling peneplain, generally an arid desert (Smith, 1992). At Kenilworth in the English Midlands the Lower Permian provides a single site for an amphibian–reptile association, which is discussed below. The Permian outcrops in Britain are shown in (Figure 10.1).

The Late Permian began with a major marine transgression of the Zechstein epicontinental sea over central Europe, the North Sea and the Irish Sea, and extending to the eastern margin of England (Figure 10.2). In north-east England the Zechstein deposits consist of five major sedimentary cycles, each commencing with shelf carbonates, and grading up into evaporites. The base of the first Zechstein cycle (Figure 10.3) in England is represented by the Marl Slate, the only unit to contain significant fish faunas.

While the sedimentary cycles provide a broad framework for lithostratigraphy, correlation elsewhere is difficult on account of the diversity and rapid variation of facies and the absence of fossils. Plants and palynomorphs provide some biostratigraphical control (Pattison *et al.,* 1973). Vertebrates occur in red beds around Elgin in Scotland (Benton and Spencer, 1995) where two GCR Permian reptile sites are designated; Middridge, Co. Durham, is the single proposed GCR Permian fish site. It is a singularly small record, though of great importance in offering a view of vertebrate communities existing during a time of stress in the history of both terrestrial and marine forms of life.

The Marl Slate is a thin, but laterally continuous, bed of bituminous silty shale in north-east England, traceable south from Durham as far as the equivalent Lower Permian Marl near Nottingham. It is correlated with the Kupferscheifer of Germany that contains a similar fauna, and is renowned for its rich fossil assemblage, including algae, ferns and actinopterygian fishes.

The Marl Slate lies immediately below the feature-forming Lower Magnesian Limestone. It rests unconformably upon the Early Permian Yellow Sands, which were dunes filling hollows in the sub-Permian surface, and it passes gradationally up into the Raisby Formation. Over much of the Zechstein Basin, the Marl Slate is less than 0.8 m thick, but in the north-east of England it commonly reaches 1–2 m. The formation is a silty sapropelic dolomite-shale containing sulphide minerals and showing considerable lithological variation. Generally speaking, quartz silt is abundant towards the base, and there are well-developed carbonate laminites in the upper part. There is no bioturbation, and the biota indicates deposition in an anoxic environment (Turner and Magaritz, 1986).

Environments

The Marl Slate is the initial deposit of the Zechstein transgression (Smith, 1979, 1980, 1992), and represents a relatively short time interval, probably less than 20 000 years. The Rotliegendes desert basin of the southern North Sea was below the contemporary sea level and was rapidly submerged as the Boreal Ocean flooded in from the north to form the Zechstein Sea. This sea covered northern Germany and was bounded to the south by the Bohemian and Rhineland massifs (Figure 10.4). Rise in global sea level was possibly brought about by major deglaciations in the south polar region (Crowell, 1978, 1982). The Zechstein transgression was probably a catastrophic event and the early Zechstein sea may have had a substantial depth (up to 250 m), as implied by the preservation of large (up to 60 m high) dune ridges in Durham, immediately underlying the Marl Slate deposits (Smith, 1980). Faunal and floral explosions accompanied the formation of the Zechstein Sea, and this was then followed by a progressive impoverishment of the biota as the seas dwindled (Pattison *et al.,* 1973).

Deposition of the Marl Slate was seasonal (Brongersma-Sanders, 1965, 1971), which produced alternating carbonate-rich and organic-rich layers. The organic-rich layers are considered to be the result of seasonal phytoplankton blooms (Brongersma-Sanders, 1971). Removal of organic material depleted the water mass of essential nutrients, which caused a reduction in productivity, leading in turn led to a decrease in numbers of phytoplankton blooms, thus causing the greater separation of organic layers as seen in the laminites. It is likely that in some years no organic layer was formed.

Turner and Magaritz (1986) concluded that the anoxic events were of much shorter duration than 20 000 years, the first sapropelic event lasting 5000 years, the second only a few hundred years. The freshwater flooding peaks represent less than 1000 years, indicating that there were drastic and rapid changes taking place not only in the Zechstein Sea but also involving ocean-wide chemical cycles.

Fish faunas

Permian fossil fish faunas are not well known, being very limited in number and distribution worldwide. No record of Permian agnathans has been discovered and the placoderm fishes had become extinct by Early Carboniferous time. It is not known to what extent this is related to the gathering of the continents to Pangaea, where extremely arid, hot climates prevailed in the north and glaciations covered much of the southern latitudes. Certainly there would have been a reduction in the variety of habitats that had existed in the Carboniferous times. The demise of the acanthodians also may have been similarly related to habitat reduction as well as to the rise of new competitive groups. The osteolepiform lobe-fins, too, died out in Early Permian time. The Chondrostei, however, more than survived, diversifying and giving rise to the holostean stock from which the teleosts later evolved. Coelacanth fishes are known from a few Permian rocks.

Diminishing numbers of chondrichthyans survived in both marine and freshwater environments; the elasmobranchs were soon to recover and continue a gradual expanding diversity from then on. During the Permian, cladoselachian sharks were replaced by hybodonts, which are considered to be ancestral to all modern sharks, skates and rays. Hybodontiform sharks are poorly known apart from isolated mineralized skeletal elements, and it is difficult to establish a classification (Maisey, 1982; Duffin, 1985). The pleuracanth sharks entered fresh waters, while the hybodonts continued successfully in the marine realm.

Permian fishes have been described from several parts of the world and from both marine and non-marine deposits. The relatively well-preserved and locally numerous examples from the Kuperschiefer of Germany attracted attention early in the 19th century (Schlotheim, 1820; Germar, 1842). Those in the Marl Slate of Co. Durham were discovered at about the same time and were described a little later (King, 1850). Very little research has been done recently. Permian fish faunas from other parts of the world have been recorded in North America (Hussakof, 1911), Greenland (Aldinger, 1937), Australia, Brazil and East Asia.

Amphibian faunas and sites

From several localties in the English Midlands the Permian rocks have provided evidence of tetrapods, the footprints of several varieties of amphibians and/or reptiles. In particular, the Keele Group of red terrigenous elastic rocks of latest Carboniferous — earliest Permian age has yielded these trace fossils, some being of relatively large animals up to 2 m in length. The rocks contain abundant evidence of rigorous continental conditions — arid deserts with periodic flash floods and violent river erosion and deposition. Footprint beds occur at a number of localities, both as outcrop and in boreholes, around Birmingham (Wills, 1950). The fossils have been compared with those from the Rotliegende (Lower Permian) in

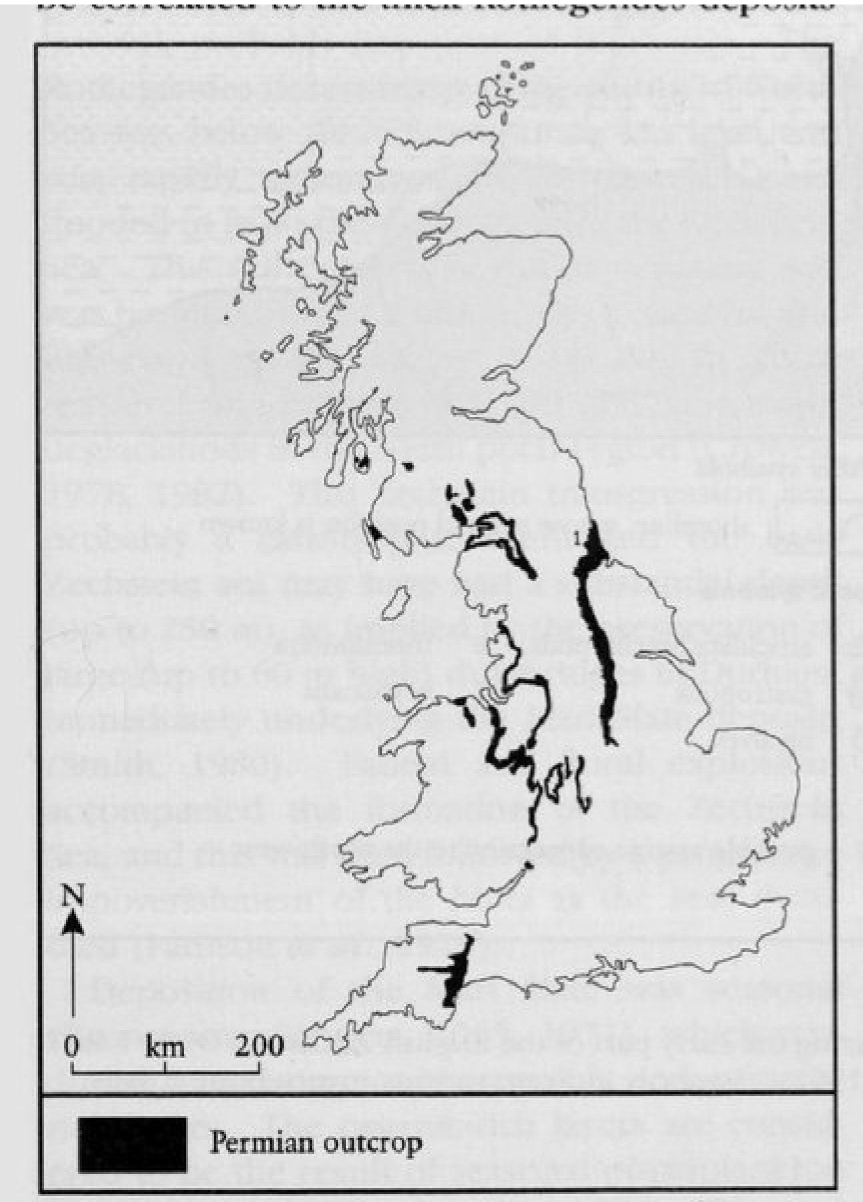
Germany. However, one site has more tangible evidence of tetrapods.

From Kenilworth many years ago bones were recovered from a red breccia in the Enville Group; the most noteworthy is the skull of the stegocephalian labyrinthodont *Dasyceps bucklandi* Lloyd (von Huene, 1910) and the maxilla of the theromorph reptile *Oxyodon.*

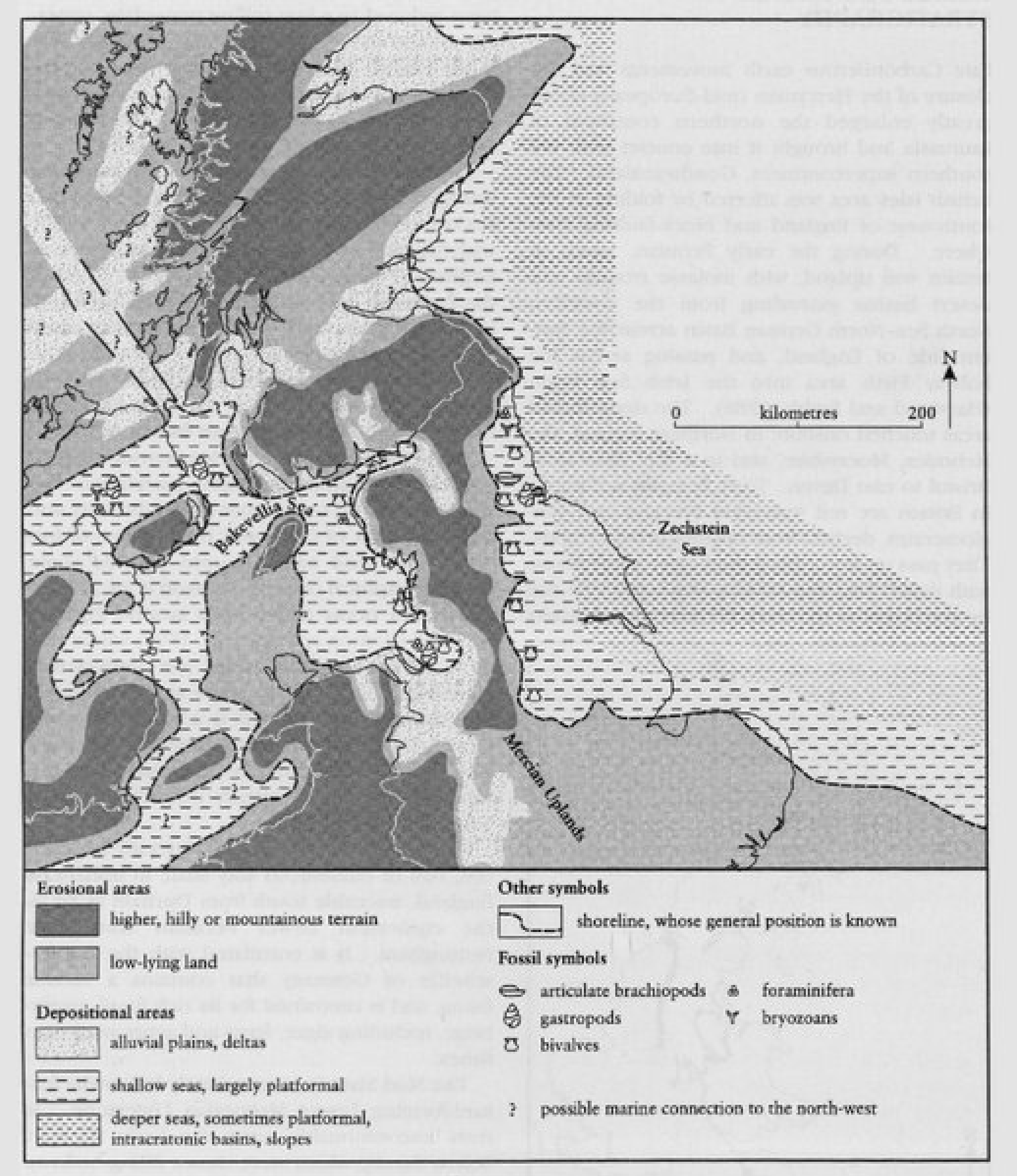
Fish sites

Several fish sites have been reported in the Marl Slate of the Durham area, but the most productive fossil locality is Middridge, and it is selected as a potential GCR fish site.

[**References**]



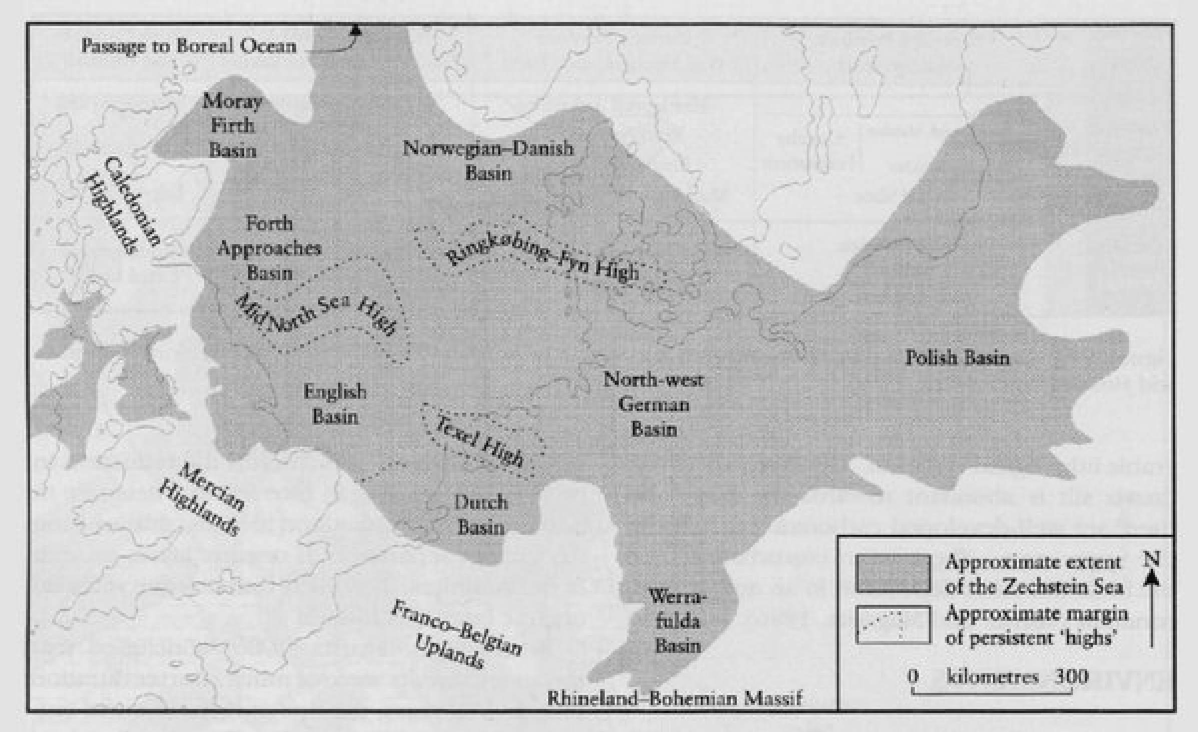
(Figure 10.1) Map showing the outcrop of Permian rocks in Great Britain, with the Middridge GCR site indicated (1).



(Figure 10.2) Palaeogeographical map showing Britain during the early part of the English Zechstein Cycle 1 and equivalents, c. 255 Ma (after D.B. Smith, in Cope et al., 1992). Symbols indicate various invertebrate fossils.

Groups	Cycles	Yorkshire Province (outcrop area)	Durham Province (Co. Durham, east Tyne)	Yorkshire Province (East and North Yorkshire)	North Germany and Holland
Upper Permian Don Group	EZ1 b		Hartlepool Anhydrite	Hayton Anhydrite	Werraanhydrit
		Sprotbrough Member — Cadeby Formation	Ford Formation	Cadeby Formation	Zechsteinkalk
	EZ1 a	Wetherby Member — Cadeby Formation	Raisby Formation		
		Marl Slate	Marl Slate (*Middridge site*)	Marl Slate	Kuperschiefer
Lower Permian		basal Permian (yellow) sands and breccias	Yellow (basal Permian) sands and breccias	basal Permian sands and breccias	Rotliegendes (red beds)

(Figure 10.3) Correlation of part of the Permian succession of northern England with that in North Germany and Holland (after Smith, 1989).



(Figure 10.4) The Zechstein Sea, showing the major sub-basins and the land masses (after Smith, 1992). Sea depth was nowhere more than 30 m; the English Basin was less than 250 mm deep.