Jurassic of Wales


Distribution of Jurassic strata in Cardigan Bay and the Bristol Channel (after Tappin et al., 1994). P916203.

Lower Jurassic sequence of the Cardiff area. Figure 59b Schematic cross-section through the Lower Jurassic, Vale of Glamorgan, not
Cliff section and reefs of alternating limestone and mudstone of the Porthkerry Member (Jurassic) viewed south from Dunraven to Whitmore Stairs (MFH P662435).

Jurassic strata: correlation of Mochras and offshore boreholes (adapted from Tappin et al., 1994). P916205.

Mid Jurassic palaeogeography (after Penn...
Introduction

The Rhaetian marine transgression across southern Britain advanced over an extensive area of low relief. Consequently, widespread uniform depositional conditions persisted into early Jurassic times. Throughout the Jurassic much of Europe lay beneath a generally shallow sea, which supported a rich fauna, particularly of ammonites. These allow the Jurassic sequence to be divided into 12 stages and about 75 zones, and facilitate precise correlation. The region probably lay some 10° south of its present latitude; the climate was warm and generally damp and the land areas were densely vegetated. However, seasonal drier conditions are reflected in the restricted development of red beds and in the presence of some anhydrite horizons.

In Wales, Jurassic outcrops are restricted to the Vale of Glamorgan where, south of Bridgend, the Lower Lias sequence forms a dissected, gently inclined surface. However, around Wales, thick Jurassic sequences abut Palaeozoic rocks on all sides — in the Cheshire, Celtic Sea, Bristol Channel and Cardigan Bay basins. The juxtaposition of these sequences is mainly the result of post-Jurassic tectonism although there is evidence for contemporaneous extensional basin development that allowed a thick sequence of Jurassic strata to accumulate. There is no evidence to suggest that the Welsh Palaeozoic terrain formed an upland area in early Jurassic times, but there is evidence of small islands over parts of south Wales.

Lower Jurassic

The base of the Jurassic is placed at the base of the Planorbis Zone, just above the base of the Lias Group, at the first appearance of the ammonite *Psiloceras planorbis*. Thus the lowermost beds of the Lias Group are of Triassic age but the entire group is described here.

The Lias Group rests conformably on the Penarth Group and, in the Vale of Glamorgan, lies mainly within the Hettangian and lower Sinemurian stages. It comprises up to 150 m of thinly interbedded limestone and calcareous mudstone, a facies that has been widely recognised in southern Britain and is now termed the Blue Lias Formation. As with the Triassic sequence, sedimentation was influenced by the presence of small islands of Dinantian limestone, and a marginal facies developed in their vicinity. The sequence has been subdivided into three members on the basis of the ratio of limestone to mudstone.

The lowermost St Mary’s Well Bay Member, exposed between St Mary’s Well Bay and Lavernock Point, comprises about 20 m of mudstone with interbedded limestone in approximately equal proportions; the conformable base of the Planorbis Zone, and therefore the Jurassic, lies some 5 to 7 m above the base. At the base of the member, the Paper Shales consist of delicately interlaminated pale grey calcareous siltstone and silty mudstone with abundant bivalves, *Liostrea hissingeri*, *Modiolus* sp., and echinoderm debris. Shallow water, attached suspension feeders dominate the bivalve macrofauna in the overlying strata (Bull Cliff Member), which consists of thin tabular limestone beds with subordinate mudstones. The limestone is mainly blue-grey, burrowed and argillaceous with bivalves, ammonites, brachiopods and echinoderm debris. The mudstones are variably calcareous and contain similar faunas. The mudstone–limestone contacts appear to be gradational because of diagenetic modification. Less common are argillaceous limestones with carbonaceous laminae and laminated bituminous mudstones that occur at three distinct levels in the Planorbis Zone. The lithologies are remarkably persistent over some 10 km in the coastal outcrops and the only lateral variation occurs in individual beds, particularly the nodular limestones, which
are more common in the upper part of the member. The marginal facies comprise thin conglomeratic lags with mudstone flakes and concretionary dolomitic pebbles from the underlying Penarth Group, and locally, as at Witland, these deposits infill a markedly incised substrate. The top of the formation is marked by a prominent limestone bed that lies in the lower part of the Liasicus Zone of the Hettangian Stage.

The type section of the overlying Lavernock Shales Member lies between St Mary’s Well Bay and Lavernock Point. The member is up to 12 m thick, lies entirely within the Liasicus Zone and comprises blue-grey, calcareous mudstone with subordinate thin beds of nodular limestone. The mudstone is burrowed; crinoid and echinoid fragments, ostracods, bivalves and a few ammonites are variably distributed. The marginal facies of thinly bedded conglomerates with angular clasts of Dinantian limestone, and interbedded mudstones is well exposed between Whitmore Stairs and Temple.

At the top of the Blue Lias Formation, the Porthkerry Member, up to 120 m thick, is an alternating sequence of limestone and mudstone similar to the St Mary’s Well Member, but without the laminated lithologies. The Porthkerry Member is equivalent to Truman’s ‘Upper Limestone Series’ and is the main component of the spectacular cliffs of the Glamorgan coast (P662435). The sequence is characterised by a varied fauna of bivalves, including Pinna and Plagiostoma, with echinoids, ammonites and gastropods; ‘nests’ of Gryphaea are common in the shales and the large branching burrowing systems of Thalassinoides are widespread. Four informal lithostratigraphical units, based on the bedding characters and the limestone:mudstone ratios, have been determined. The limestone beds increase in abundance and thickness into the upper part of the Bucklandi Zone, where the beds are replaced locally by the marginal facies that prograded into the offshore area. The member lies mainly in the Angulata Zone and the overlying Bucklandi and Semicostatum zones of the lower Sinemurian.

The distinctive alternations of limestone and mudstone of the Blue Lias Formation reflect deposition in a shallow sea, but the nature of the alternations, whether primary or secondary, has been controversial; a primary origin is supported by the widespread lateral extent of individual beds. Generally aerobic bottom conditions prevailed and burrows infilled with pale limestone are present within the mudstone substrate, but the presence of bituminous shales indicates a lack of oxygen from time to time. Alternatively, it has been argued that the limestones represent diagenetically altered beds of winnowed shell concentrates, deposited within storm wave-base. Studies of sequences showing less secondary modification indicate that mudstone deposition represented deepening and that subsequent slow regression caused progressive accumulation of condensed limestone. The patterns suggest a delicate interplay of eustatic sea-level fluctuations and local tectonism. In the Vale of Glamorgan, primary cycles are difficult to substantiate because of the diagenetic overprint, but it is likely that deposition occurred predominantly within storm wave-base.

The offshore distribution of Lower Jurassic strata (P916203), like that of the Permo-Triassic deposits, is controlled by the Bristol Channel and South Celtic Sea basins in the south, and by the St George’s Channel and Cardigan Bay basins farther north. Cores and geophysical records indicate some 350 m of Blue Lias Formation on the flanks of the Bristol Channel Syncline where it is dominantly a mudstone sequence with few limestones. The Blue Lias Formation is overlain by mudstone of the Lower Lias Clay (now referred to the Charmouth Mudstone Formation), which is not exposed onshore in south Wales. To the west, in the South Celtic Sea Basin, the Blue Lias sequence thickens to 604 m and the proportion of limestone increases markedly. Similarly, thin Pleinsbachian-Toarcian sequences (Middle Lias and Upper Lias) of the Bristol Channel Basin also thicken westwards.

At the edge of Cardigan Bay, the Mochras Borehole proved the thickest Lower Jurassic sequence (1305 m) in the British Isles; all four stages are present (P916205). The sequence is dominated by
massive calcareous mudstone and siltstone, which are extensively bioturbated. There is little evidence of coarse clastic debris, slump structures or other indications of a contemporaneous shoreline or fault scarp despite the proximity of the Cambrian sequence on the flank of the Harlech Dome. However, such a thickness clearly demonstrates that the extensional basin development initiated during the Permo-Triassic, or earlier, continued into the Jurassic. The ‘Lower Lias’ is 896 m thick and it is possible that the lowest 150 m of dark grey mudstone in which there are some thin, interbedded limestones and a suggestion of possible rhythms may be the equivalent of the Blue Lias. Offshore seismic reflection profiles suggest that the thickness of ‘Lower Lias’ at Mochras is maintained along the axes of the St George’s Channel and Cardigan Bay basins.

The ‘Middle Lias’ in the Mochras Borehole comprises some 147 m of interbedded siltstone and mudstone, with proportionally more siltstone than the ‘Lower Lias’, few thin limestones, a sandstone and a conglomerate layer; bituminous mudstones are present locally. The beds contain ammonites, belemnites, crinoid debris and plant fragments and are bioturbated in places. A similar thickness, with some thin sandstones at the base, occurs in St George’s Channel Basin. In the South Celtic Sea Basin, the lowermost grey calcareous mudstone passes into red-brown mudstone in places, with some thin sandstone interbeds and a variable silt and glauconite content; two thin coals have been recorded. The change reflects the passage from shallow marine to subaerial conditions.

In the Mochras Borehole, the ‘Upper Lias’ (Toarcian) is 262 m thick, and comprises grey mudstone, with sparse siltstone and limestone beds and calcareous ironstone nodules, overlain mainly by micaceous mudstone with silty interbeds and locally abundant plant debris. To the south-west, in St George’s Channel Basin, a well penetrated 291 m of grey calcareous, slightly micaceous mudstone of an equivalent Toarcian age.

**Middle Jurassic**

The Middle Jurassic strata, which crop out extensively in England from Yorkshire to the Dorset coast, are shallow water deposits that display complex facies changes and erosion surfaces. It is reasonable to assume that similar strata encroached onto the Welsh landmass that had emerged from the Jurassic sea by up-warping and a fall in sea level in late Toarcian times, but all evidence has been removed by subsequent erosion. However, Middle Jurassic strata have been preserved in the deeper parts of the Bristol Channel, St George's Channel and Cardigan Bay basins, and these sequences (up to 1000 m) are markedly thicker than those onshore. In the central parts of these basins, sedimentation was probably continuous, but on the basin margins there is evidence of uplift and erosion. Over the St Tudwal’s Arch an estimated 650 m of Lias Group strata were probably removed, and north of the Pembroke Ridge the Upper Lias sequence is missing. In the Cardigan Bay and St George’s Channel basins, Middle Jurassic strata form the cores of the synclines that plunge south-westwards beneath the Cainozoic cover.

Elements of the onshore stratigraphy have been recognised in the Welsh offshore basins. In St George’s Channel Basin, two units equivalent to the Lower and Middle Inferior Oolite Upper Jurassic and the Upper Inferior Oolite have been distinguished. The lower unit consists of pale grey, fine-grained sandstone with interbedded soft grey mudstone; the upper unit consists of grey calcareous siltstone with fewer sandstone beds. The lithofacies reflect a fluviodeltic setting. Farther south, in the South Celtic Sea Basin the sequence is thinner and consists predominantly of glauconitic mudstone indicating marine conditions. In the Bristol Channel Basin, the groups are difficult to distinguish in the uniform calcareous marine mudstone sequence.

The Great Oolite Group, largely Bathonian in age, is up to 800 m thick and has a similar outcrop in the offshore basins. All the stratigraphical subdivisions (Fuller’s Earth, Great Oolite, Forest Marble
and Cornbrash) of the onshore sequences have been distinguished, but all are thicker. In St George’s Channel Basin, deposition appears to have kept pace with rapid subsidence; the lithologies are broadly comparable with the onshore sequences. The distinctive geophysical signature of the pale nodular limestones and calcareous mudstones of the Cornbrash, which span the Bathonian–Callovian boundary, has been recognised in both the St George’s Channel and Bristol Channel basins. In the latter, the Cornbrash rests unconformably on lower to middle Bathonian beds of the Great Oolite Group. At the top of the Middle Jurassic, the onshore sequence of the Kellaways Formation and Lower and Middle Oxford Clay (now referred to the Peterborough and Stewartby members, respectively) has been determined in the offshore basins. In St George’s Channel Basin, the Kellaways Formation comprises grey-green silty mudstone that passes up into fine- to coarse-grained calcareous sandstone. The geophysical signature seen in the Kellaways Formation is repeated in the overlying Lower and Middle Oxford Clay, reflecting an increase in sandstone towards the top of each depositional cycle. The signature is similar to that which occurs in places in the onshore outcrop and is thought to reflect shallower marginal marine conditions.

In the western Bristol Channel Basin, the Lower and Middle Oxford Clay are mainly olive-grey mudstone without the distinctive geophysical signature seen farther north. However, to the east, the sequence is lithologically similar to the onshore sequence in southern England.

**Upper Jurassic**

The systematic cycles of basin subsidence and infill continued into the beginning of Late Jurassic times. The thick sequence in St George’s Channel indicates that subsidence kept pace with sedimentation. South of the Pembrokeshire Ridge, only the lowest part of the succession is preserved and, in the Bristol Channel, a marginal marine to deltaic sequence suggests uplift and erosion in the south.

The base of the Upper Jurassic, which coincides with the base of the Upper Oxford Clay (now the Weymouth Member onshore), can be recognised in the geophysical logs of onshore boreholes, and has been correlated offshore. The broad stratigraphical elements of the onshore sequence can be distinguished in the offshore basins although there are significant lithological variations. In St George’s Channel Basin, the Upper Oxford Clay Member, and the West Walton and Ampthill Clay formations have been determined in a sequence of blue-grey silty mudstone and soft grey-brown calcareous mudstone interbedded with loose- to well-cemented sandstones, with some upward-fining cycles. The sandstones are interpreted as fluviodeltaic, coastal plain sand bodies, and a few anhydrite beds indicate periodic desiccation. In the Bristol Channel Basin, equivalent grey-green, fine-grained sandstones, with common glauconite and lignite fragments and a dwarfed molluscan fauna suggest transitional estuarine or deltaic conditions.

The Kimmeridge Clay Formation has been determined in boreholes in both the St George’s Channel and the Bristol Channel basins. In the St George’s Channel Basin, the formation, which rests conformably on the Ampthill Clay Formation, comprises mudstone with traces of glauconite and lignite, interbedded with pale grey limestone and sandstone with a few anhydrite layers. The sequence, up to 958 m thick, reflects considerable syndepositional subsidence. The lower and upper subdivisions of the onshore succession are not clearly defined on the geophysical profiles, and there are significant differences. There is no indication of the presence of oil shales, and although the sediments suggest marine deposition the microfauna includes some freshwater forms of a lagoonal or fluvial overbank setting. The Kimmeridge Clay Formation forms the core of the Bristol Channel Syncline, and the dark grey mudstone and siltstone with lignite fragments are comparable with the onshore organic-rich shales.
Portlandian strata of the uppermost Jurassic have been determined beneath the Cainozoic cover in the centre of St George’s Channel Basin and at the western edge of the Bristol Channel Basin. In the former, the strata consist of yellow and red-brown, variably calcareous mudstone with few interbedded, coarse-grained loosely cemented sandstones. One borehole in the Bristol Channel Basin proved that the sequence lies directly on the Oxford Clay Formation, although the contact is probably faulted. The beds have been divided into the Portland Group, yellowish grey calcareous mudstone with pale to dark-grey limestone at the top, overlain by the Purbeck Group. The facies associations are characteristic of freshwater conditions. The Jurassic–Cretaceous boundary is currently taken very near the base of the Purbeck Group in onshore sequences.

Jurassic strata have been recognised in the small Berw Basin on the north-east side of Anglesey.

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