Chapter 4 The Severn Basin

Introduction

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The Severn Basin, sometimes also known as the 'Worcester Basin' or 'Worcester Graben', is an elongate basin trending north-south containing a thick Mesozoic succession. Its eastern and western boundaries are well defined by the Vale of Moreton Anticline and the East Malvern Fault respectively (Figure 4.1), a width of about 50 km. The north and south limits of the basin are less clearly delimited but extend probably from the Kidderminster–Bromsgrove area in the north, southward to beyond Stroud, a distance of 90 km or more (Sellwood *et al.,* 1986). Lower Jurassic rocks crop out extensively in the southern part of the basin and attain a total thickness of almost 500 m. However, details of many parts of the succession are poorly known. The Stowell Park Borehole penetrated the full succession in the eastern part of the basin and was well documented (Green and Melville, 1956; Melville, 1956; Spath, 1956), with several other boreholes subsequently penetrating parts of the Lower Jurassic sequence elsewhere, such as the Hettangian and lowermost Sinemurian successions at Twyning (Worssam *et al.,* 1989) and the Pliensbachian and Toarcian sequences on Bredon Hill (Whittaker and Ivimey-Cook, 1972). However, although virtually all ammonite zones and subzones have been proven at surface outcrop (Simms, 2003b), there are few permanent exposures. A few low cliffs and foreshore exposures occur along the banks of the River Severn and Severn Estuary downstream of Gloucester, but these expose only Hettangian and lowermost Sinemurian strata and remain mostly undocumented. Later Sinemurian strata have been exposed only in temporary excavations while Pliensbachian and Toarcian strata, which crop out mostly on or at the foot of the Cotswold scarp and its outliers, are exposed only in occasional landslip scars or in brickpits and quarries, the latter now mostly defunct. Seven sites have been selected for GCR status, representing parts of the Lower Sinemurian and the Lower Pliensbachian, almost the entire Upper Pliensbachian, part of the Lower Toarcian and the Upper Toarcian sequences (Figure 4.2). Other parts of the succession are too poorly known or exposed to warrant designation of GCR sites.

By far the finest Lower Sinemurian exposure is at Hock Cliff. At the still active Blockley Station Quarry an exceptionally thick and fossiliferous sequence through part of the Lower Pliensbachian succession is exposed. Farther south the long disused Robin's Wood Hill Quarry still affords a magnificent exposure through much of the Pliensbachian succession. All the quarries excavated in the Whitby Mudstone Formation of the lower part of the Toarcian Stage are long disused and heavily overgrown. The most famous of these, Alderton Hill Quarry, has yielded an exceptional fossil fauna including fish and insects. In the southern part of the basin three Upper Toarcian sites, namely Wotton Hill, Coaley Wood and Haresfield Hill, have been selected to show the range of lateral variation within the Cotswold Cephalopod Bed Member, a unique facies development of the Bridport Sand Formation.

Lithostratigraphy and facies

Data obtained from the few permanent exposures and from temporary exposures across the Severn Basin over a more than 30-year period (Simms, 2003b) have helped to build up a fairly clear picture of the stratigraphy of this thick Lias Group succession. Typical Penarth Group mudstones with thin sandstones and limestones are exposed in river cliffs at Wainlode Hill [SO 845 257] north of Gloucester, and at Westbury-on-Severn [SO 717 129] (descriptions summarized in Macfadyen, 1970) and are succeeded by poorly exposed alternating mudstones and limestones of the basal Lias Group 'Pre-Planorbis Beds'. Some of the limestones in this part of the succession are laminated and have yielded rich insect faunas from these sites and from 19th century quarries. , The Planorbis and Liasicus zones are seldom well-exposed but are developed in fairly typical Blue Lias Formation facies of limestones, sometimes laminated, and mudstones. Limestone–mudstone alternations are particularly frequent in the succeeding Angulata Zone and in the Conybeari Subzone at the base of the Sinemurian Stage; this part of the succession is rather indifferently exposed on the foreshore and low cliffs along the Severn Estuary around Gatcombe [SO 685 057], Awre [SO 706 074] and Arlingham [SO 712 098]. Limestones are more widely spaced in the Rotiforme, Bucklandi and Lyra subzones, with dark laminated shales a conspicuous feature in the Rotiforme Subzone. This part of the succession is exposed at several points along the Severn

Estuary, on the foreshore at Awre, near Arlingham (Glass Cliff), at Maisemore [SO 818 216] (Richardson, 1906c) and especially at Hock Cliff. The remainder of the Sinemurian Stage is only ever represented by exposures of mudstones with few limestone beds in temporary excavations. They can be assigned to the Charmouth Mudstone Formation. The Semicostatum to Obtusum zones typically comprise blue-grey clays, commonly with cementstone nodules. Phosphatic nodules and fossils are common in the lower part of the Sauzeanum Subzone, suggesting a minor hiatus. The Denotatus Subzone is less than 0.5 m thick and there is a hiatus, indicated by bored and encrusted bivalves and belemnites, at the junction with the succeeding Simpsoni Subzone. The Oxynotum Zone and the ensuing Raricostatum Zone are quite thickly developed in blue-grey mudstones with an abundant, commonly pyritized, fauna (Simms in Hollingworth *et al.,* 1990; Simms, 2003b), equivalent to the Stonebarrow Pyritic Member of the Wessex Basin.

Lithostratigraphical descriptions of the Upper Sinemurian succession in the Severn Basin made by Murchison (1845) and by Wright (1878–1886) have influenced subsequent interpretation of this part of the sequence (e.g. Cope *et al.,* 1980a). Wright's observations were broadly correct and are still useful today, notably his recognition of a thin 'Coral Bed' packed with *Styllophylopsis rugosa.* However, it has proven impossible to reconcile Murchison's descriptions of the Upper Sinemurian to Lower Pliensbachian sequence with that deduced from abundant observations of temporary exposures across the Severn Basin over the last 30 years (Simms, 2003b). It appears to have little basis in realilty, despite incorporation into the Geological Society correlation volume of Cope *et al.* (1980a).

The Jamesoni Zone at the base of the Lower Pliensbachian Substage is developed in alternating light and dark mudstones, lithologically similar to the Belemnite Marl Member of the Dorset coast, with abundant belemnites and a diverse fauna of pyritized ammonites. The Ibex Zone comprises grey, commonly richly fossiliferous, mudstones with cementstone nodules and some shell beds, as exposed at the Blockley Station Quarry GCR site. The Davoei Zone is characterized by grey mudstones that become increasingly silty upwards and are transitional to the Dyrham Formation. A conspicuous sandy siltstone unit around the middle of the zone, the Capricornus Sandstone, is an important marker band that can be traced from at least Bredon Hill in the north (M.J. Simms, unpublished observations) southwards to the Stroud area (Palmer, 1971) and perhaps to Hawkesbury, 5 km south of Wotton-under-Edge (Cave, 1977). The entire Davoei Zone (including the Capricornus Sandstone) and Dyrham Formation is superbly exposed at the Robin's Wood Hill Quarry GCR site, this being the type locality for the formation (Cox *et al.,* 1999). Poor exposures are seen occasionally along the steep scarp of the Cotswold Hills and outliers to the west. The Dyrham Formation comprises silty mudstones with several distinctive, and often widely traceable, limestone or sandstone bands (Simms, 1990a). The overlying Marlstone Rock Formation shows considerable variation in facies and thickness, apparently related to underlying structural controls. The junction with the Dyrham Formation may represent a significant erosion surface (Simms, 1990a). The overlying Whitby Mudstone Formation is poorly exposed in the extensively slipped ground along the Cotswold scarp and the outlying hills. Recent observations (M.J. Simms, unpublished) and published accounts (Tomes, 1886; Richardson, 1929b; Whittaker and Ivimey-Cook, 1972) indicate that it is predominantly of blue-grey mudstone, sometimes finely laminated as in the Dumbleton Member of Alderton Hill Quarry, with subordinate argillaceous limestone bands. South of Cheltenham the upper part of the Toarcian succession is replaced by the Bridport Sand Formation, which may extend as low as the Bifrons Zone. It is not significantly different here from where it is better exposed on the Dorset Coast at the East Cliff GCR site, comprising dull yellow, commonly silty and extensively bioturbated, friable sands with harder bands of calcareous sandstone. Both in the north, on Bredon Hill (Buckman, 1903), and south, in the Wotton-under-Edge area, the upper part of the succession (Variabilis Zone and above) is developed in sandy bioclastic limestones with ammonites abundant at many levels. In the Wotton-under-Edge area this facies is particularly well-developed and has been distinguished as the Cotswold Cephalopod Bed Member. Together with the upper part of the underlying sandy facies of the Bridport Sand Formation, it is well exposed in various disused quarries, sunken lanes and natural exposures, including the GCR sites at Haresfield Hill, Wotton Hill and Coaley Wood.

In conclusion, the Severn Basin preserves a thick and almost complete Lower Jurassic succession in which every ammonite zone, and almost every subzone, is represented.

Basin development

Within the Severn Basin, Permian and Mesozoic sediments reach thicknesses of more than 2 km, with no borehole having penetrated the Palaeozoic basement (Chadwick, 1985). Palaeozoic and Precambrian rocks crop out immediately to the west of the basin, and to the east of the Vale of Moreton Anticline Palaeozoic strata have been proved at relatively shallow depth. Following suggestions that the margins of the basin were fault-controlled, Whittaker (1975) proposed that the Severn Basin was a post-Variscan graben bounded by faults on which intermittent movements occurred throughout Triassic and early Jurassic times. It is now clear that the main graben structure comprises a complex of horsts, grabens and half-grabens (Chadwick, 1985, pers. comm.), with many of these faults active at various times throughout the Mesozoic Era. Thickness changes in Cambrian strata across faults to the west of the East Malverns Fault suggest that the origins of the Severn Basin are pre-Caledonian, although its present north–south trend has been influenced by Caledonian and Variscan events. The basin experienced at least one episode of tectonic inversion. Palaeozoic sediments are preserved on footwall blocks on either side of the Severn Basin but are absent from the basin itself, with Permian and Mesozoic strata thought to rest directly on Precambrian basement (Chadwick, 1985). Whittaker (1972b) observed that the Lias within the basin thinned across N–S-trending anticlines and thickened into the intervening synclines, demonstrating that movement must have occurred during early Jurassic times. The Severn Basin has clearly had a long and complex history due to re-activation of pre-existing faults.

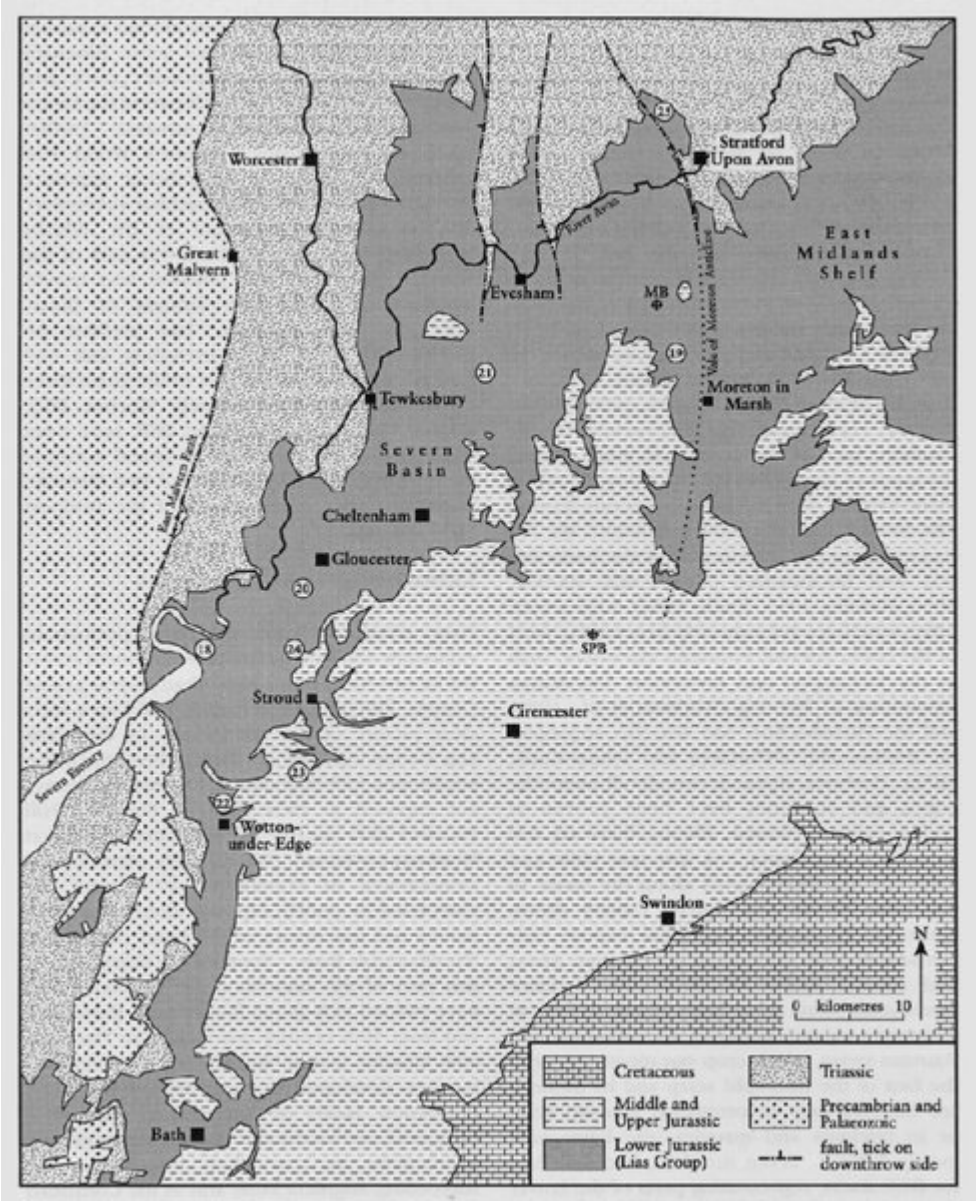
Fades variations within the basin must therefore reflect a range of structural controls as well as the effects of exogenous factors such as climate and sea level. In particular, major environmental changes occurred at the close of the Toarcian Stage, which affected deposition in the Severn Basin. Sea levels continued to fall and carbonate deposition expanded in response to climatic warming (Bradshaw *et al.,* 1992). A disconformity is recognized across the Severn Basin at the Early–Middle Jurassic boundary (Barron *et al.,* 1997), above which the Birdlip Limestone Formation was deposited. In the mid-Cotswolds, its base is marked by the Opaliniforme Bed, an iron-oolitic bioclastic limestone.

Comparison with other areas

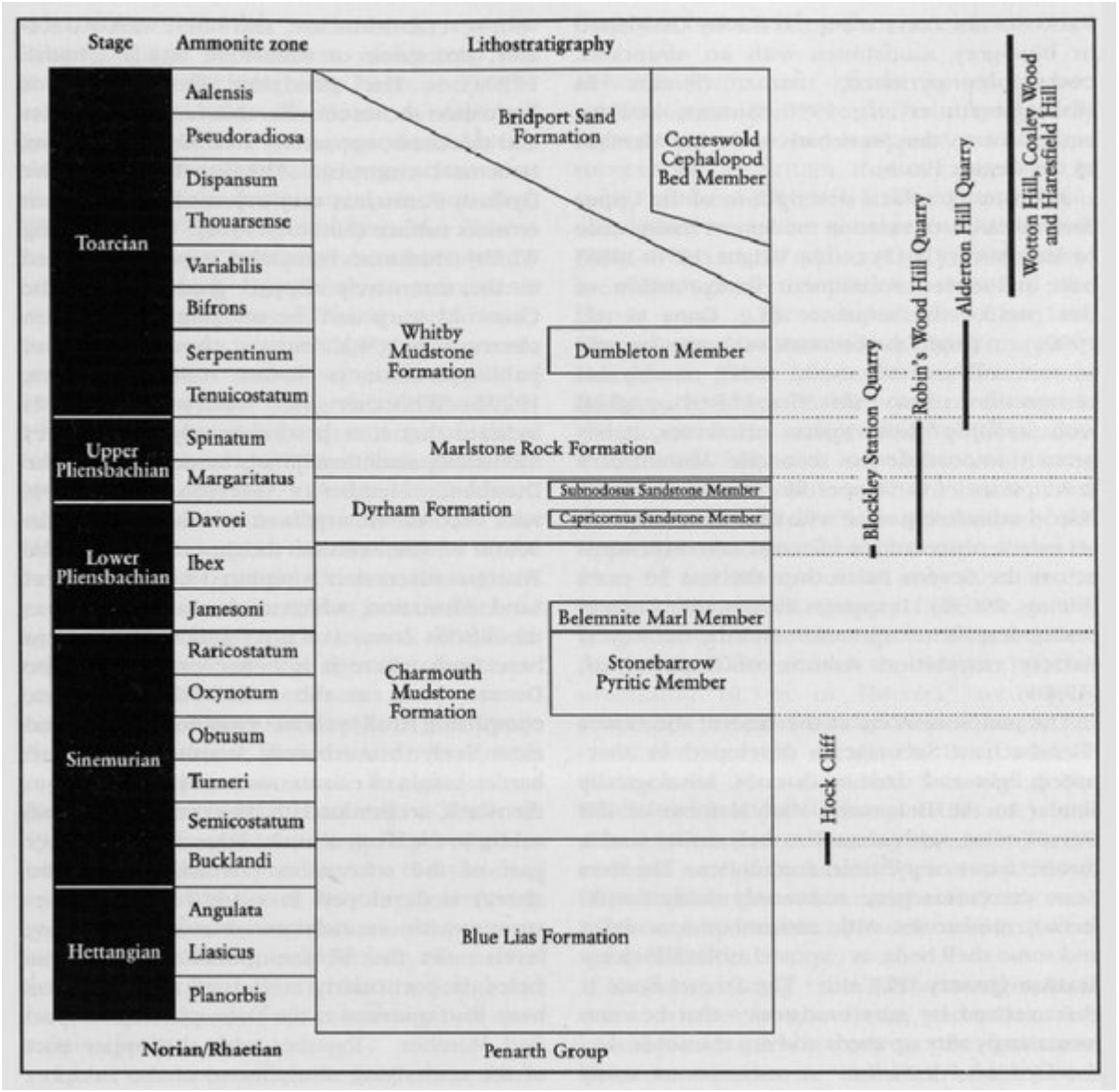
Although many parts of the Lower Jurassic succession in the Severn Basin are poorly known, they can be compared with other successions in Britain that are exposed at many of the GCR sites. The Severn Basin succession is similar to that in the Wessex Basin to the south, and most of the formations are lithologically similar to those of the Dorset coast. These include the Blue Lias, Charmouth Mudstone and Bridport Sand formations. There are, however, differences in thicknesses, which enable some of the underlying controls on early Jurassic sedimentation to be identified, and help in reconstructing the early Jurassic history of the basins. For example, in Dorset the Stokesi Subzone of the Upper Pliensbachian Substage is represented by 93 m of mudstone, but by only 20 m at the Robin's Wood Hill Quarry GCR site in the Severn Basin. In contrast, the Luridum Subzone (0.15 m in Dorset) and the Lower Toarcian succession (0.5 m in Dorset), are highly condensed in parts of the Wessex Basin, but correlative strata in the Severn Basin attain a thickness of 17 m (Luridum Subzone at the Blockley Station Quarry GCR site) and almost 100 m (Lower Toarcian succession) in the northern area of the basin (Cope *et al.,* 1980a). Depositional rates within each basin clearly were influenced by local factors such as re-activation along fault lines.

However, some thin lithostratigraphical units in the Severn Basin succession are laterally widespread, such as the laminated limestone nodules, or 'Fish Bed', of the Lower Toarcian Dumbleton Member. Similar nodules occur at closely comparable stratigraphical levels in the Ilminster area of Somerset (Moore, 1867b) and on the East Midlands Shelf (Howarth, 1978), indicating a wide-scale, probably eustatic, control. The distribution of the Bridport Sand Formation also has interesting implications for the history of both the Severn and Wessex basins. Its restricted areal distribution and diachronous nature, becoming younger southwards, precludes any purely eustatic control and indicates that the Mendip Massif did not present a significant barrier to north–south movement of clastic sediment at this time.

References



(Figure 4.1) Generalized geology of the Severn Basin and western edge of the East Midlands Shelf. Only the main basin-bounding faults are indicated. Numbers correspond to the locations of the GCR sites: 18 — Hock Cliff; 19 — Blockley Station Quarry; 20 — Robin's Wood Hill Quarry; 21 — Alderton Hill Quarry; 22 — Wotton Hill; 23 — Coaley Wood; 24 — Haresfield Hill; 25 — Newnham (Wilmcote) Quarry (Chapter 5); MB — Mickleton Borehole; SPB — Stowell Park Borehole.



(Figure 4.2) Lithostratigraphical subdivisions and stratigraphical ranges of GCR sites for the Lias Group of the Severn Basin.