Chapter 5 The East Midlands Shelf

Introduction

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The East Midlands Shelf occupies an extensive area to the north-east of the Severn Basin, northwest of the London Platform and south of the Cleveland Basin ((Figure 1.2), Chapter 1). The Lower Jurassic succession crops out as a strip, typically 10–15 km wide, extending from Warwickshire to the River Humber (Figure 5.1), with a narrow outcrop passing across the Market Weighton High before expanding once again into the Cleveland Basin. Major bounding basement faults, manifested in the Lower Jurassic succession as the asymmetric Vale of Moreton Anticline, define the western boundary between the Severn Basin and East Midlands Shelf ((Figure 4.1), Chapter 4). To the south-east there is progressive onlap of Lower Jurassic strata onto the Palaeozoic basement of the London Platform (Donovan *et al.,* 1979). The northern boundary is defined by the Market Weighton High, across which there is a greatly attenuated Lower Jurassic sequence, separating the East Midlands Shelf from the Cleveland Basin. The eastern margin lies offshore in the southern North Sea and corresponds to the western bounding fault of the Sole Pit Trough (Bradshaw *et al.,* 1992) into which the Lower Jurassic strata thicken considerably (van Hoorn, 1987b). Across the East Midlands Shelf the Jurassic strata dip gently to the east or south-east and have experienced little disruption by faulting or folding. Some authors (e.g. Green *et al.*, 2001) have subdivided the region into two tectonic areas; the Midland Platform lying to the north and west of the London Platform and bounded to the west by faults on the eastern edge of the Severn Basin, passing gradually into the East Midlands Shelf *sensu stricto* that forms the western margin of the North Sea Basin.

The Lower Jurassic outcrop is of rather subdued relief and, in the absence of any coastal outcrop, there are very few natural exposures. Most significant exposures were associated with extraction of material for the production of building stone, bricks, cement or iron, but very few of these workings are still active today. Consequently documentation of the Lower Jurassic succession is biased towards those parts of economic value. All of the GCR sites on the East Midlands Shelf are associated with disused workings or with railway cuttings.

Lithostratigraphy and facies

Individual parts of the succession have been described in numerous accounts published over the past 150 years, but there appears to be only one overview of Lower Jurassic stratigraphy across this area, that by Hallam (1968a). The stratigraphy of the Lower and Middle Lias (Hettangian to Upper Pliensbachian) has been described by Brandon *et al.* (1990) and that of the Upper Lias (Toarcian) by Howarth (1958, 1978, 1980, 1992). The lithostratigraphical nomenclature has been revised by Cox *et al.* (1999) (Figure 5.2).

Across the southern part of the shelf the lithostratigraphy is closely similar to that in the Severn Basin, but gradual changes are seen in passing northwards. The Blue Lias Formation comprises regular alternations of mudstone and argillaceous limestone little different from that seen elsewhere in southern England. In the south, the basal part of the formation, extending down into the 'Pre-Planorbis Beds', is exposed at the Newnham (Wilmcote) Quarry GCR site. Higher parts of the Blue Lias Formation, encompassing the (Hettangian and lower Sinemurian) Liasicus, Angulata, and Bucklandi zones, are spectacularly exposed in a working quarry at Southam [SP 419 629] (Clements, 1975) and a disused quarry at Rugby [SP 493 759] (Clements, 1977). Within the Blue Lias Formation Cox *et al.* (1999) recognized three members; the Wilmcote Limestone Member at the base, the Saltford Shale Member in the Liasicus Zone, and the Rugby Limestone Member for remaining strata up to the top of the formation. The succeeding Charmouth Mudstone Formation in the south is a mudstone-dominated sequence, which encompasses the (lower Sinemurian to late Lower Pliensbachian) Semicostatum to lower Davoei zones. It is not exposed at any of the GCR sites on the East Midlands Shelf.

Farther north and east on the East Midlands Shelf the Blue Lias Formation becomes a mudstone-dominated facies termed the 'Scunthorpe Mudstone Formation', which extends up to near the top of the Oxynotum Zone (upper

Sinemurian). The succeeding Charmouth Mudstone Formation, which extends to the Davoei Zone (late Lower Pliensbachian), much like in the southern part of the shelf, is therefore of shorter duration in this area.

Local developments of ironstone and sandstone are a significant feature of the Scunthorpe Mudstone Formation on the more northern parts of the East Midlands Shelf (Brandon *et al.,* 1990). The most important of these economically is the Frodingham Ironstone Member of the Humberside region. The Frodingham Ironstone Member, and part of the succeeding Charmouth Mudstone Formation, are well exposed at the Conesby Quarry GCR site, located towards the north of the East Midlands Shelf.

The formation of iron-rich sediments, including iron oolites, at the present time, is very localized, and hence their origin in the geological record remains controversial (Taylor and Curtis, 1995; Sturesson *et al.,* 1999). It is likely that several different processes may produce them and suggestions for iron oolites range widely for example ooid formation in tropical lateritic soils and subsequent incorporation into marine sediments (Madon, 1992); undercoatings of microbial films (Chidlaw, 1987; Burkhalter, 1995); or formed directly in the marine environment by lateral accretion in a similar way to calcareous ooids (Sturesson *et al.,* 1999). The source of the iron-rich sediment is widely thought to be tropical lateritic soils (Young, 1989) and recently this has been extended to include volcanic ash (e.g. Sturesson *et al.,* 1999).

The major difficulty with understanding the formation of ferruginous grains, matrix and cement is that often they are composed of the iron silicate minerals berthierine and chamosite. These are chemically stable only in reducing conditions yet faunal assemblages and sedimentary structures in the host sediments often indicate formation in well-aerated, high-energy conditions. Berthierine will convert to chamosite if heated to 120–160°C, or buried to depths greater than 3 km, so the latter mineral is more common in Palaeozoic iron-rich sediments. Recent consensus suggests that the most favoured origin for the berthierine and chamosite is a diagenetic one (Taylor and Curtis, 1995). Clay minerals and iron oxides, brought into the depositional environment from adjacent land areas, combine to form berthierine in poorly oxygenated conditions below the surface of the loose sediment, with the berthierine precipitated as laminae around nuclei (e.g. shell fragments, faecal pellets) to form ooids. Disturbance of the sediment, such as by current action or bioturbation, will move some of the berthierine ooids into the well-oxygenated zone near or at the surface of the sediment, causing the berthierine to be converted to iron oxides. Subsequent sediment disturbance could carry these grains back into the reducing conditions below, so that the iron oxides are converted back into berthierine. The process could be repeated many times, so that, depending on where the oolitic grains are transported in the sediment, they may range in composition from wholly berthierine through a mixture of berthierine/ iron oxide laminae, to wholly iron oxides. In such circumstances the more frequently the sediment is disturbed, the greater is the likelihood that the ooid laminae will be entirely of iron oxide. Ferruginous pisoids and coatings on shell fragments could be produced by the same basic mechanism.

The base of the succeeding Dyrham Formation is strongly diachronous within the East Midlands Shelf region. Towards the south, as in the Severn Basin, its base is marked by an upward change from mudstones to siltstones and fine sandstones, and lies approximately in the mid-Davoei Zone. Passing northwards the base moves into the Margaritatus Zone in Nottinghamshire, and, still farther north, the entire formation passes into mudstones (Brandon *et al.,* 1990). The upper part of the Dyrham Formation is well exposed at three GCR sites on the East Midlands Shelf; Napton Hill Quarry, Neithrop Fields Cutting and Tilton Railway Cutting. The Marlstone Rock Formation is also exposed at these three sites in lithologies that are typical of the region. Sandy or oolitic ironstones commonly are the dominant facies and the formation may be divisable into the Tilton Sandrock and Banbury Ironstone members. The formation locally exceeds 10 m in thickness and encompasses the Spinatum Zone and part of the Tenuicostatum Zone (Howarth, 1980). In some parts of Lincolnshire and across the Market Weighton High, the formation is absent through intra-Jurassic erosion (Howarth, 1958).

The Whitby Mudstone Formation (Toarcian) shows consistency across the East Midlands Shelf. It is developed largely in dark mudstones with subordinate limestones (Howarth, 1978), lithologies similar to those in the Severn Basin. The youngest Whitby Mudstone Formation mudstones recorded on the shelf are of Bifrons Zone (late Lower Toarcian) age. Younger Lower Jurassic strata were removed by erosion prior to the deposition of the succeeding Middle Jurassic sediments. This erosive break increases in severity towards the Market Weighton High, where all later Jurassic strata were removed prior to the depostion of late Cretaceous strata.

Basin development

Compared with fault-bounded basins to the south-west, where the Lias Group may show substantial thickness changes over distances of only a few kilometres, the total thickness of the Lias Group remains remarkably constant across much of the East Midlands Shelf (Whittaker, 1985) at about 200–250 in. This is also substantially less than the maxima recorded for the major fault-bounded basins (Cleveland Basin > 400 m; Severn Basin > 500 m; Wessex Basin > 700 m). To the south-west and to the east there is a rapid thickening into the Severn Basin and Sole Pit Trough respectively, while to the south and to the north there is a relatively gentle thinning onto the London Platform and the Market Weighton High respectively. The onlap of progressively younger zones onto the London Platform during the Hettangian to Lower Pliensbachian interval has been described by Donovan *et al.* (1979); Brandon *et al.* (1990) have indicated that higher parts of the Lower Jurassic sequence were subsequently removed by erosion so that Lias Group strata are now absent from an extensive area of the London Platform. However, the palaeogeographical reconstructions of Bradshaw *et al.* (1992) imply that the London Platform remained an area of non-deposition throughout early Jurassic times. The effects of the Market Weighton High have also been discussed at some length (Kent, 1955) and there is a marked overall thinning and development of hiatuses within the Lias Group succession towards this positive structure. The Market Weighton High was attributed at one time (Sellwood and Jenkyns, 1975) to the effects of halokinesis associated with Permian evaporites, but there is little evidence to support this; more recent geophysical evidence suggests that it is due to the presence at depth of a granite body (Bott *et al.,* 1978). Much of the reduction in overall thickness of the Lias Group, however, can be attributed to post-Jurassic erosion and overstep by late Cretaceous strata.

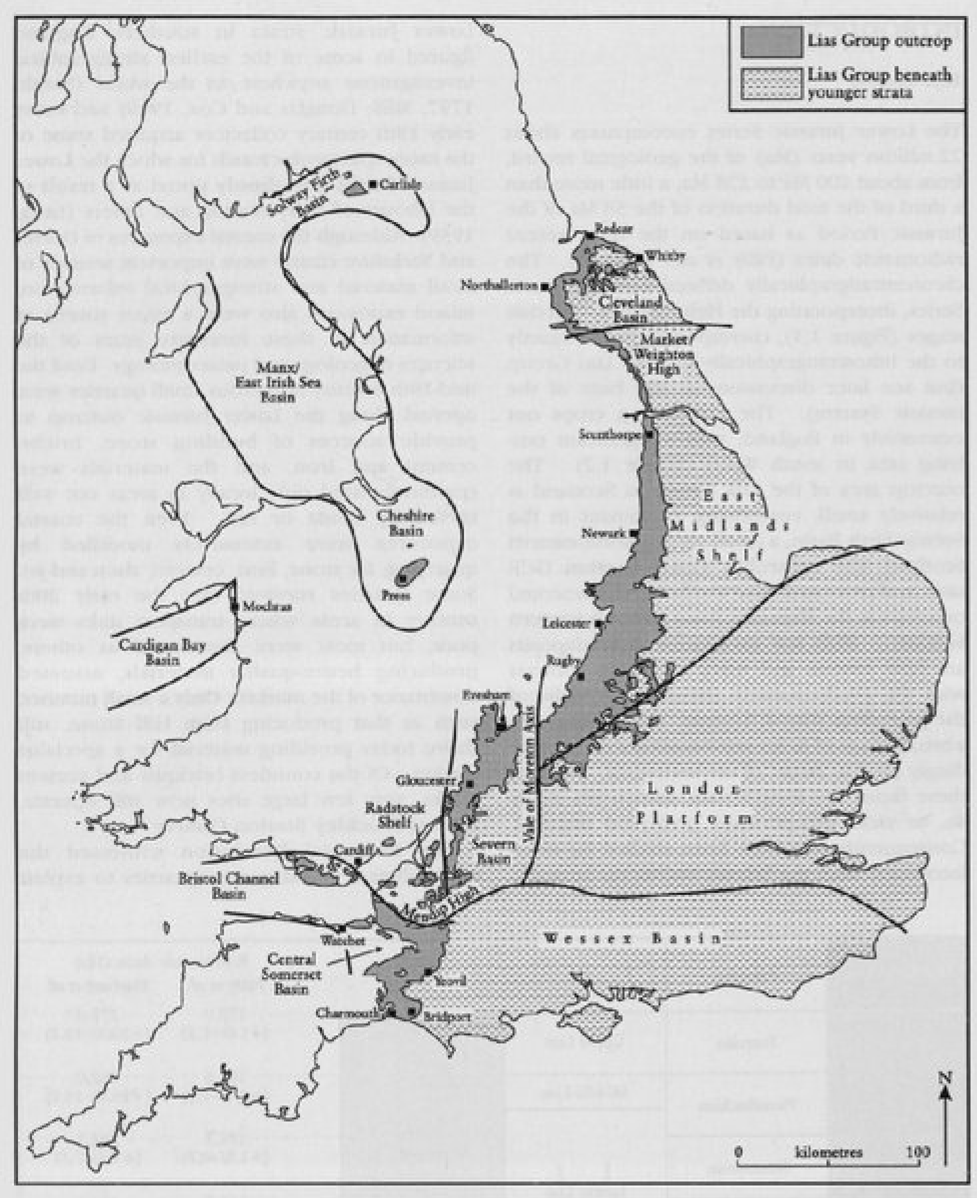
Between these positive areas to north and south, and the rapidly subsiding basins to east and west, the East Midlands Shelf appears to have experienced a prolonged period of slow stable subsidence. The only major regional hiatus, evident also across much of the Cleveland Basin, is that which truncated the Toarcian succession above the Bifrons Zone. Whittaker (1985) observed that over much of eastern England, with the exception of the Cleveland Basin, subsidence was not directly associated with normal faulting but was primarily a peripheral effect of extension beneath contemporaneous North Sea basins. Similarly, the regional hiatus between the Toarcian and the Middle Jurassic successions may be due to events in the North Sea. The stability of the East Midlands Shelf may in part be linked to the presence of deeply buried granite batholiths (Donato, 1993; Donato and Megson, 1990) beneath the eastern part of the shelf. Within the East Midlands Shelf some facies and thickness variations may reflect syn-depositional fault movement and localized differences in subsidence rates, these being perhaps most evident in the Marlstone Rock Formation.

Comparison with other areas

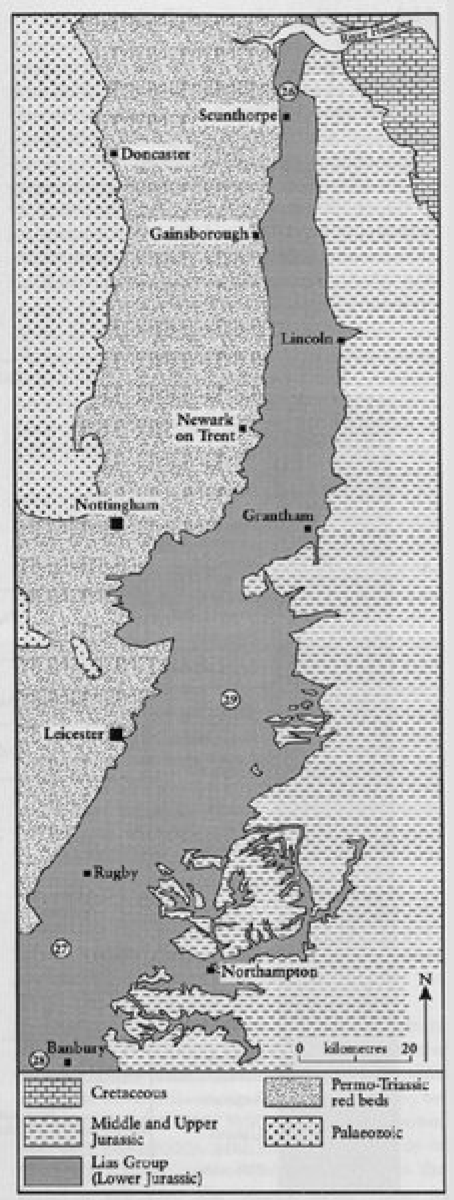
The lithostratigraphical succession developed on the East Midlands Shelf shows an essentially gradual transition between that seen in the Severn and Wessex basins to the south-west and that in the Cleveland Basin to the north. The mudstones and limestones of the Blue Lias Formation, typical of basins to the south and west, pass northward across the shelf into the shell beds and ironstones of the Scunthorpe Mudstone Formation, marking a change from low-energy to higher-energy depositional environments. Higher in the succession the Marlstone Rock Formation and Whitby Mudstone Formation bear considerable similarity to correlative formations in the south-west. Unlike the Severn and Wessex basins to the south, though comparable to the situation across much of the Cleveland Basin, post-Bifrons Zone strata of the Whitby Mudstone Formation are absent, apparently removed by erosion prior to deposition of Middle Jurassic sediments.

For the most part Lias Group faunas across the East Midlands Shelf are not substantially different from those elsewhere in Britain, with any differences largely reflecting facies control. However, the late Upper Pliensbachian fauna shows a distinct provincialism and exemplifies the transition between the north-east and the south-west. *Pleuroceras* ammonite faunas documented by Howarth (1958) differ markedly between the Cleveland Basin and the Severn and Wessex basins, while specimens are rarely encountered at all on the East Midlands Shelf. Similar north-east/south-west distinction is evident among brachiopod faunas, as documented by Ager (1956a), although, unlike the ammonites, brachiopods form a major element of benthic faunas on the East Midlands Shelf and comprise a faunal province distinct either from that to the north-east or to the south-west.

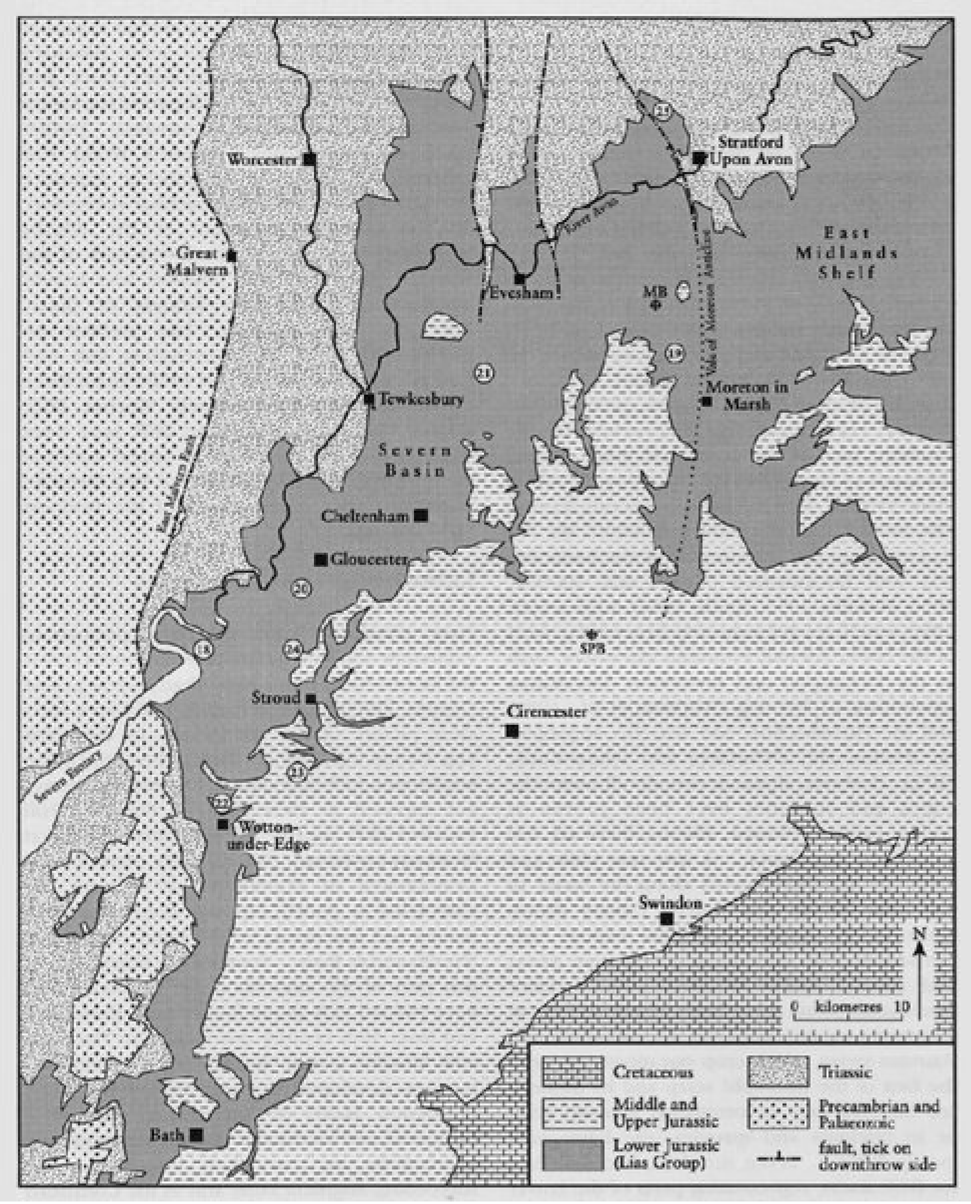
[References](#)



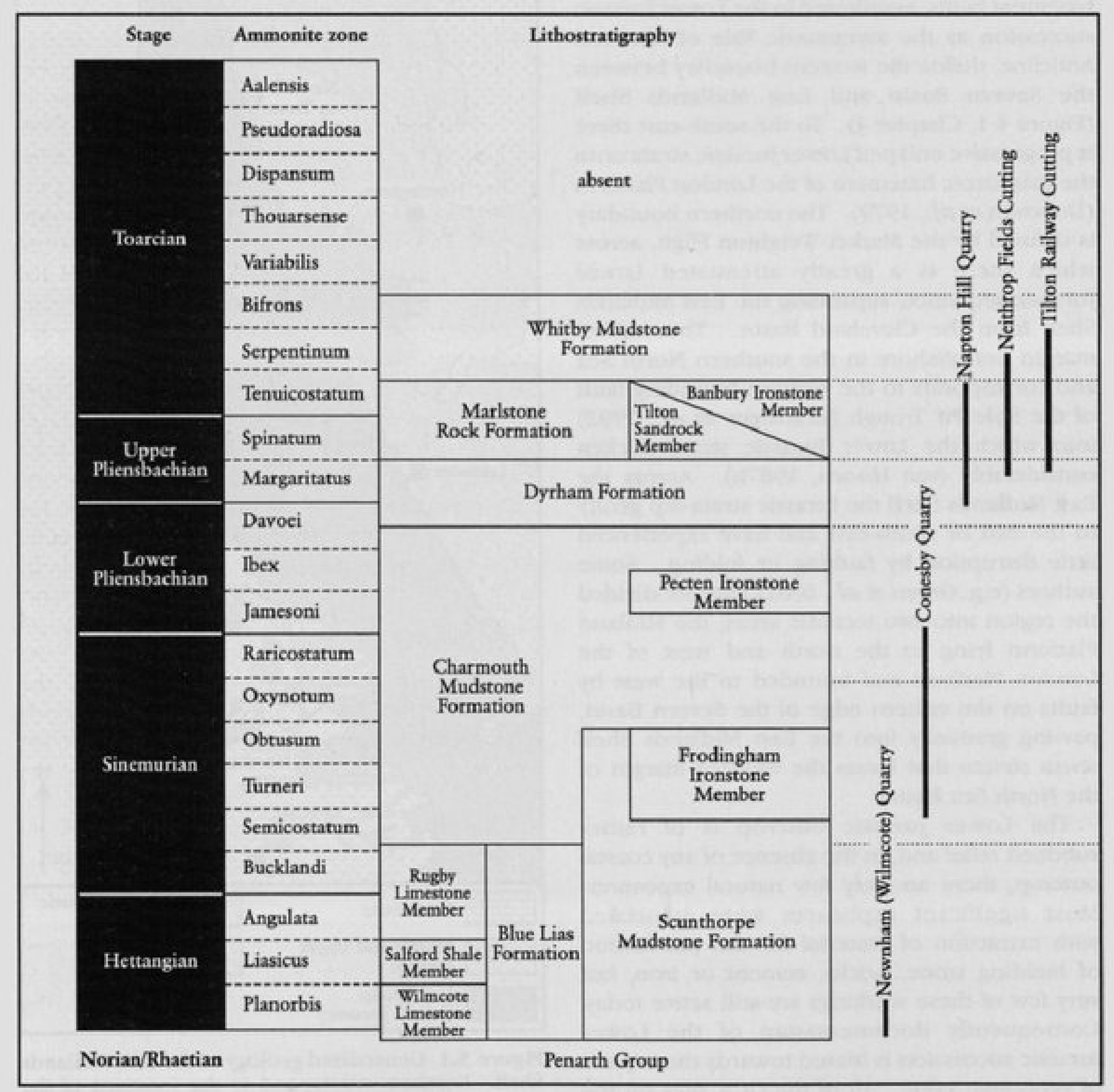
(Figure 1.2) Outcrop and subcrop map for the Lias Group in England and Wales showing the location of the main sedimentary basins. After Cox et al. (1999).



(Figure 5.1) Generalized geology of the East Midlands Shelf. Numbers correspond to the locations of the GCR sites: 26 — Conesby Quarry; 27 — Napton Hill Quarry; 28 — Neithrop Fields Cutting; 29 — Tilton Railway Cutting.



(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 5.2) Lithostratigraphical subdivisions and stratigraphical ranges of GCR sites for the Lias Group of the East Midlands Shelf