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# Chapter 1 General introduction to the Aalenian to Callovian stratigraphy of Great Britain

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## Introduction

The GCR sites described in this volume are representative of the British geological record of Earth history from about 178 to 157 million years ago (Ma) (Harland *et al.*, 1990). This interval is known as the Mid Jurassic Epoch (part of the Jurassic Period), and the rocks that formed during that time, and bear witness to its events and environments, constitute the Middle Jurassic Series (part of the Jurassic System) (Figure 1.1).

## Palaeoenvironment and palaeogeography

During the Early Jurassic Epoch, Britain was largely covered by shallow shelf-seas; Lower Jurassic rocks and their fossils indicate fully marine environments. However, towards the end of the epoch, there was a significant fall in sea level accompanied by domal upwarping and contemporaneous volcanicity in the central North Sea Basin (Bradshaw and Cripps, 1992). Consequently, Middle Jurassic rocks reflect a variety of depositional environments including shallow marine, fluvial, deltaic, saltmarsh and coastal lagoonal (brackish-water and freshwater). In addition, carbonate (limestone) as well as elastic (mudstone, siltstone, sandstone) sedimentation was often widespread. This has generally been thought to be the result of warmer climates in Mid Jurassic times (e.g. Ager, 1975; Frakes, 1979; Bradshaw and Cripps, 1992) although, paradoxically, Frakes (1992) reported a cooling trend. These two factors — depositional environments and increased carbonate sedimentation — are largely responsible for the distinctive characteristics of the Middle Jurassic succession in Britain which, for the most part, is in marked contrast to the marine mudstone-dominated Lower and Upper Jurassic successions.

## The Middle Jurassic Outcrop

On maps showing the solid geology of England, Middle Jurassic rocks crop out in an almost continuous strip from the Dorset coast to the North Yorkshire coast, broken only in the Market Weighton area, north of the Humber Estuary (Figure 1.2). They also occur beneath younger rocks in the whole of the land area to the east of the outcrop, with the exception of a large area beneath East Anglia and the Thames Valley (an area corresponding with the so-called 'London Landmass'; see (Figure 1.6)). In Scotland, Middle Jurassic rocks crop out in Ardnamurchan, on the Hebridean islands of Skye, Raasay, Eigg, Muck, Mull and possibly Shiant, and on the north-east coast at Brora (in the former county of Sutherland) and near Balintore (in the former county of Ross and Cromarty).

## Stratigraphical nomenclature

The Middle Jurassic Series is divided into four stages — the Aalenian, Bajocian, Bathonian and Callovian stages. With the exception of the Aalenian Stage, which was introduced by Mayer-Eymar (1864), these stratal divisions were established by d'Orbigny (1850a), although the term 'bathonien' had been used earlier by d'Halloy (1843) (Figure 1.1). For many years, British geologists included the Callovian Stage in the Upper Jurassic Series because the base of the Callovian succession in England (its type area; Callomon, 1964) approximately coincides with the end of the paralic and carbonate sedimentation that characterizes the bulk of the Middle Jurassic strata. The contentious subject of where the Middle-Upper Jurassic boundary should be drawn has been discussed by Melville (1956) and Torrens (1980a), and at various international colloquia (Callomon, 1965; Maubeuge, 1970). However, following Arkell (1946, 1956a), the original three-fold gross lithological division proposed by von Buch (1839) for the Jurassic strata of Germany is now used as the basis of subdivision of the Jurassic System throughout the world, and current practice thereby takes the base of the Upper Jurassic Series at the base of the Oxfordian Stage. The position of the base of the Middle Jurassic Series, at the

base of the Aalenian Stage, has also been the subject of debate, as reviewed by Torrens (1980a). Although the Bathonian and Callovian stages take their names from localities in Britain (Bath, in Somerset, and Kellaways, in Wiltshire, respectively), neither of them will be formally defined here, as more complete sequences through their basal boundaries (on which definition of stages depends) exist elsewhere in Europe.

The four stages of the Middle Jurassic Series are the basis of the GCR 'Blocks' (site selection categories) documented in this volume. The Aalenian and Bajocian strata are included together in one GCR Block because they are generally closely associated one with the other in general lithology; over much of southern England, they approximately equate with the old stratal term 'Inferior Oolite'. In fact, for a long time, the Aalenian was not recognized in Britain and the Bajocian Stage was used in an extended sense.

### **Middle Jurassic zones and subzones**

The traditional means of subdividing stages in the Jurassic System is by means of ammonites, abundant and diverse nektonic cephalopod molluscs that, because of their rapid evolution, prove to be almost ideal 'zone fossils'. The Middle Jurassic stages are no exception and, although ammonites are rare or absent from many horizons because of unfavourable depositional environments, the succession of ammonite faunas provides the basis of the standard stratal subdivisions (zones and subzones) (Figure 1.3). In those parts of the succession where ammonites are abundant (e.g. the Callovian rocks of the East Midlands), a particular zone or subzone may correspond precisely with an ammonite biozone or sub-biozone and be identified on that basis. However, in many areas — for example the Aalenian–Bajocian strata of the Cotswolds and East Midlands where ammonites are rare — it is not possible to apply an ammonite biozonation from first principles and, clearly, in areas where ammonites are completely absent, as in much of the Bathonian succession in both England and Scotland, ammonite biozonation is impossible.

In such situations, the standard ammonite-based zones are identified, wholly or in part, by indirect or circumstantial evidence (e.g. by using ostracod faunas or by event-marker correlation). In this account, the Middle Jurassic zones and subzones, into which the succession is divided without gaps or overlaps, are therefore treated as chronostratigraphical subdivisions of stages. They may be *recognized* by ammonite faunas but are not *defined* by them. They are labelled with the name of an ammonite species but these are written in Roman font with an initial capital; they are thereby differentiated from biozones/sub-biozones, which take the full italicized taxonomic name of their index species. The standard zonation used herein follows Parsons (1980a) as modified by Callomon and Chandler (1990) and Callomon (in Callomon and Cope, 1995) for the Aalenian and Bajocian strata; Torrens (1980a) as modified by Dietl and Callomon (1988), Callomon (in Callomon and Cope, 1995) and Page (1996a) for the Bathonian strata; and Callomon (1964) as modified by Callomon and Sykes (1980), Callomon *et al.* (1989) and Page (1989) for the Callovian strata (Figure 1.3).

Although ammonites are rare or absent at many levels of the Middle Jurassic succession, at others the ammonite faunas are sufficiently abundant and well known that they have been used to develop ever more sophisticated schemes of stratal subdivision and correlation. The early Mid Jurassic Epoch is a time of exceptional interest for students of ammonite evolutionary history (Callomon and Chandler, 1990). A major radiative expansion saw the appearance of three ammonite superfamilies the Haplocerataceae, Stephanocerataceae and Perisphinctaceae — which thereafter dominated the shelf seas of the world well into the Cretaceous Period. It was such ammonites in the Aalenian–Bajocian succession of Dorset that led S.S. Buckman (1860–1929) to undertake his detailed assessment of their stratigraphical occurrence and develop his scheme of so-called 'hemerae' (from the Greek word *hemera* meaning 'day'), each representing a relatively short period of geological time, and characterized by particular ammonite taxa. Unfortunately, this early and valuable work of Buckman (1893a, 1902a) was somewhat discredited by his later work, which became less based on accurate field observation and more on intuition and guesswork. However, in recent years, the Aalenian and Bajocian ammonite stratigraphy of Dorset has been re-investigated, and Buckman's early findings have proved to be entirely reliable (Callomon and Chandler, 1990; Callomon, 1995; Callomon in Callomon and Cope, 1995). This has led to the concept of so-called 'ammonite faunal horizons' or 'biohorizons' (Callomon, 1985a,b; Page, 1995; (Figure 1.4)). For the time duration of individual horizons, Buckman's term 'hemera' might still be used, but the horizons themselves are perceived as a bed, or series of beds, characterized by a particular assemblage of ammonites and within which no further stratigraphical refinement — on the basis of the contained ammonite fauna — can be made. They are usually named after a suitable index species, as well as being consecutively numbered or lettered. It is important to appreciate that there may be

intervals of geological time between biohorizons that are unrepresented in the ammonite record. Consequently, biohorizons do not form part of the chronostratigraphical hierarchy of terms (system, stage, series, etc.) in which the rock succession is divided into sequential subdivisions without gaps or overlaps, and each unit of higher rank (e.g. a series) is a grouping of units of lower rank (in this example, stages). A scheme of ammonite biohorizons has also been established for the Lower Callovian Substage (Callomon and Page in Callomon *et al.*, 1989) and, according to Callomon (1995), the beds into which Brinkmann (1929a) divided the Callovian Oxford Clay Formation of Peterborough (see Chapter 4), on the basis of the kosmoceratid ammonite faunas, conform almost ideally with the definition of biohorizons. Work is still ongoing to establish and finalize a scheme of ammonite biohorizons for the Bathonian succession, based on the more ammonitiferous successions of southern Europe (Callomon in Westermann and Callomon, 1988; Mangold and Rioult, 1997). Most recently, Page (1996a) has made a first attempt at formulating a scheme of ammonite biohorizons for the Bathonian succession of southern England; these should be regarded as provisional. Indeed, the complete listing of biohorizons shown in (Figure 1.4) is open to continual revision. Many of them have no published specifications regarding their particular and diagnostic ammonite assemblages and, in many cases, further descriptive systematic and taxonomic work is required to clarify definitions.

## Middle Jurassic fauna and flora

As well as the ammonites, there were many other animals and plants living in Mid Jurassic times (Oakley and Muir-Wood, 1967; Gould, 1993; for descriptions of Mesozoic palaeontological GCR sites see Benton and Spencer, 1995 (fossil reptiles); Dineley and Metcalf, 1999 (fossil fishes); and Cleal *et al.*, 2001 (fossil plants)). The many different depositional environments that developed in Britain during that time mean that the fossil record is rich and varied (Figure 1.5). In the clear warm seas in which the limestones formed, calcareous seaweeds (red algae) were common. Invertebrate faunas living on the seabed included simple and compound corals, calcareous sponges and bryozoa, which sometimes formed small patch reefs. Abundant bivalve molluscs burrowed in the soft sea-floor sediments (both carbonate and mud), and some surface-dwellers, for example oysters, built up shell reefs. Oysters, being able to tolerate the more brackish waters of some coastal environments, are common throughout a range of sediment types. Gastropods (snails), asteroids (starfish) and echinoids (sea urchins) browsed on the sea floor where crinoids (sea lilies) also grew. The snail *Viviparus* inhabited the less saline environments such as near-coastal lagoons, and the bivalve *Unio* lived in freshwater habitats; microscopic crustaceans (ostracods and conchostracans) were common to both these environments. Smooth terebratulid and ribbed rhynchonellid brachiopods occurred in an abundance that was never repeated on such a scale in later geological times, probably because of competition from the bivalve molluscs. Microscopic organisms included foraminifera, ostracods (also present in brackish-water and freshwater habitats) and phytoplankton (dinoflagellates and coccolithophorid algae). Lobster-and shrimp-like crustaceans dwelt in both muddy and carbonate seabed environments, often leaving characteristic burrows within sediments, and belemnites, squid-like relatives of the ammonites, swarmed in the muddy seas. Belemnites and fish were probably the main food of the aquatic reptiles, which were the largest vertebrate animals in the sea. These included ichthyosaurs, plesiosaurs, pliosaurs, crocodiles (steneosaurs and teleosaurs) and turtles. The fish included both holostean and teleostean bony fishes as well as sharks and rays (Dineley and Metcalf, 1999).

On land, dinosaurs had already become established but in the Mid Jurassic, new groups such as sauropods, large theropods, avialan theropods (bird-relatives), stegosaurs and ankylosaurs appeared. Some dinosaurs, for example *Cetiosaurus*, were vegetable feeders, many of which waded in swamps; others, for example *Megalosaurus*, were flesh-eaters. Apart from the dinosaurs, crocodylians radiated extensively, and a range of meat- and fish-eaters evolved. Mammal-like reptiles, lizards and amphibians, such as frogs and salamanders, were also part of the terrestrial fauna in which primitive mammals, probably no bigger than rats, formed a minor but important part. Some of the mammals had teeth adapted for feeding on insects; others may have lived mainly on plant fruits. Land plants in Mid Jurassic times were varied and abundant, but of particular prominence were the gymnosperms, notably conifers, cycads and ginkgoes (the maidenhair tree). Ferns and horsetails were also abundant. True flowering plants (angiosperms) had not yet appeared although some of the cycads (e.g. *Williamsonia*) bore flower-like cones (Cleal *et al.*, 2001). Insect life included forms such as dragonflies, crickets, cockroaches, bugs and beetles but other familiar forms, such as bees, wasps and butterflies, did not appear until the flowering plants became established in the Early Cretaceous Epoch.

## GCR site selection

The rationale behind the selection of sites follows that of the Geological Conservation Review in general; i.e. the selected sites are (a) those of importance to the international community of Earth scientists because they are type localities for time intervals or their boundaries, or for fossil species, or are of historical significance in the development of the science; (b) those that contain exceptional geological features; and (c) those that are nationally important because they are representative of a geological feature, event or process that is fundamental to Britain's Earth history (Ellis *et al.*, 1996). The last-named category is particularly relevant to the present volume in which the type localities or best representative sections of named rock units or their boundaries are conspicuous. Many Middle Jurassic sites in Britain also belong to category (a). The philosophy behind site selection also states that there should be a minimum of duplication of interest between sites and that it should be possible to conserve selected sites in a practical sense. Sites that are least vulnerable to potential threat, are more accessible, and are not duplicated by other sites are preferred (Ellis *et al.*, 1996).

The Middle Jurassic sites were originally selected in the early 1980s by C.F. Parsons (Aalenian–Bajocian Block), D.W. Cripps (Bathonian Block) and K.L. Duff (Callovian Block); other Earth scientists with relevant experience were also consulted. The documentation and justification for the site selection, presented in this volume, has thus been compiled retrospectively, which has inevitably led to some difficulties. Working quarries that provided fine sections 15 or 20 years ago may have become degraded, or the exposure changed in some other way as working has proceeded. In addition, some of the selected sites are not recorded in the published geological literature but only in unpublished postgraduate theses or field guides. Nevertheless, the credentials of individual sites that originally justified their selection generally remain valid, as described in the site reports that follow. A number of additional sites have subsequently been added as their national and international importance has been established.

## Invertebrate fossils in the GCR

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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. Invertebrate fossils are important in stratigraphy because they help to characterize stratal units. In practice, stratigraphy is at its most secure where adequate fossils are found. One of the main tasks of stratigraphers is to determine the relative ages of strata and to compare or correlate them with strata of the same age elsewhere. Fossils have long provided one of the most reliable and accurate means of approaching these problems. Therefore, some 'stratigraphy' GCR sites are selected specifically for their faunal content, which facilitates stratal correlation and enables the interpretation of the environments in which the animals lived. Other 'stratigraphy' GCR sites are of crucial importance palaeontologically and palaeobiologically, because they yield significant assemblages of invertebrates that provide evidence for past ecosystems and the evolution of life. Moreover, some sites have international significance because they have yielded fossils that are the 'type' material for a species.

In contrast to the manner in which most invertebrate fossils are represented in the GCR, fossils of vertebrates (Benton and Spencer, 1995; Dineley and Metcalf, 1999; Benton *et al.*, in prep.), arthropods (except trilobites) (Palmer *et al.*, in prep.) and terrestrial plants (Cleal *et al.*, 2001) do have their own dedicated selection categories, owing to the relative rarity of the fossil material.

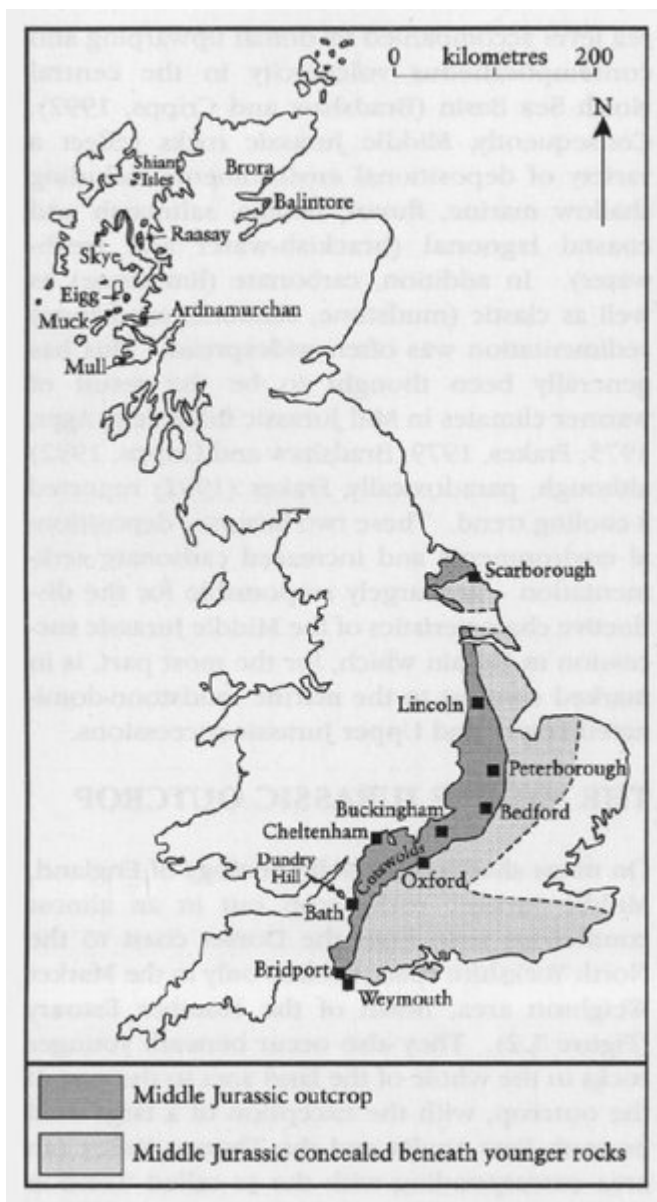
## Volume structure

Within this volume, the sites are arranged geographically from south to north. The chapters into which the sites are divided (Wessex, Cotswolds, East Midlands, North Yorkshire and Scotland) reflect the Mid Jurassic depositional setting, which was largely controlled by deep-seated structural features (Figure 1.6). The sites in Wessex and North Yorkshire represent respectively the Wessex and Cleveland basins. Those in the East Midlands represent the East Midlands Shelf, and those in the Cotswolds represent the Worcester Basin and its surrounding shelf areas. The Scottish GCR sites represent the Moray Firth and Hebrides basins.

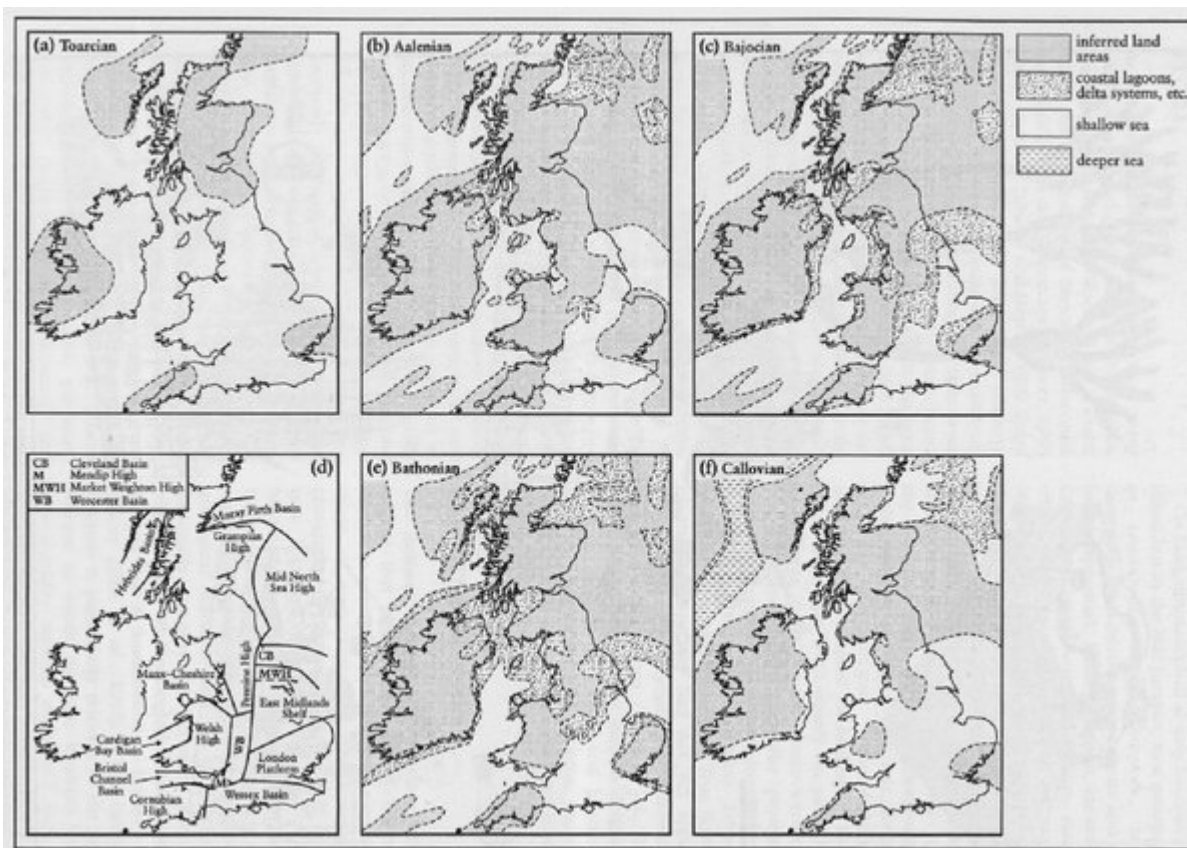
[References](#)

Period <sup>1</sup> System <sup>2</sup>	Epoch <sup>1</sup>	Series <sup>2</sup>	Age <sup>1</sup>	Age in millions of years
			Stage <sup>2</sup>	
<b>J u r a s s i c</b>	Late	Upper	Portlandian	
			Kimmeridgian	
			Oxfordian	
	Mid	Middle	Callovian	157.1 <sup>†</sup> 159.4 <sup>*</sup>
			Bathonian	161.3 <sup>†</sup> 164.4 <sup>*</sup>
			Bajocian	166.1 <sup>†</sup> 169.2 <sup>*</sup>
			Aalenian	173.5 <sup>†</sup> 176.5 <sup>*</sup>
			Toarcian	178.0 <sup>†</sup> 180.1 <sup>*</sup>
	Early	Lower	Pliensbachian	
			Sinemurian	
			Hettangian	

(Figure 1.1) Major Jurassic subdivisions. (<sup>1</sup> = Geological time terms; <sup>2</sup> = Chronostratigraphical (time-rock) terms; † = Harland et al. (1990); \* = Gradstein and Ogg (1996) (95% confidence level).)



(Figure 1.2) Simplified sketch map showing the main British Middle Jurassic outcrops (onshore area only.)



(Figure 1.6) (a–c,e,f) Palaeogeographical reconstructions for the British area during the late Early and Mid Jurassic (slightly modified from Cope, 1995); (d) main structural elements affecting sedimentation in the British area in the Mid Jurassic (terminology as used in this volume). The 'London Platform' is a structural high, the limits of which remained generally constant. The emergent part of the Platform, the position and limits of which varied, is referred to as the 'London Landmass'. (Compiled from various sources.)

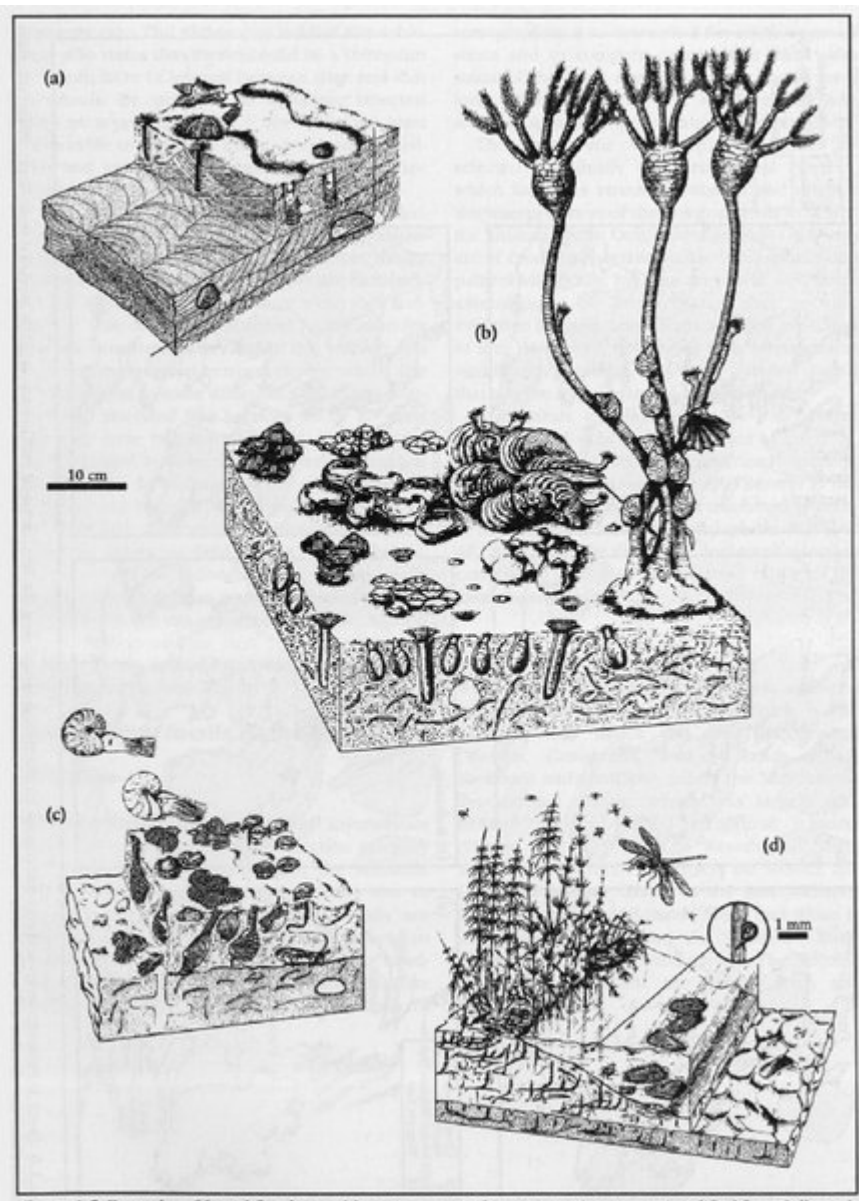
Stage	Zone	Subzone	Stage	Substage	Zone	Subzone	Stage	Substage	Zone	Subzone	Stage	Substage	Zone	Subzone
Aalenian	Concavum	Formosum	Bajocian	Upper	Parkinsoni	Bornfordi	Bathonian	Upper	Discus	Discus	Callovian	Upper	Lamberti	Lamberti
		Concavum				Truellei				Hollandi				Henrici
	Bradfordensis	Gigantea			Garantiana	Acris			Retrocostatum	Hannoverense			Athleta	Spinosum
		Bradfordensis				Tetragona				Blanzense				Protiae
	Marchisonae	Marchisonae			Subfurcatum	Dichotoma			Bremeri	Querciaus			Phaetum	Phaetum
		Obtusiformis				Baculata				Fortescostatum				Grossouvrei
	Scissum	Haugi			Humphriesianus	Polygyralis			Motrisi	Bullatimorphus			Coronatum	Obductum
		Opalium				Banksi				Subcontractus				Jason
					Blagdeni	Humphriesianum			Tenuiplicatum	Progracilis			Calloviense	Enodatum
														Romani
		Sattzi	Laeviuscula	Zigzag	Yeovilensis	Koenigi	Gaillaei							
		Laeviuscula					Trigonalis	Maccrescens	Curtilobus					
		Ovalis	Sayti	Convergens		Herveyi	Gowerianus							
		Discites						Kamptus						
							Terebratus							
							Kepleri							

(Figure 1.3) Chronostratigraphical subdivisions of the Middle Jurassic Series (for sources, see text.)

Stage/ Substage	Zone/Subzone	Ammonite biohorizon	Substage	Zone/Subzone	Ammonite biohorizon		
<b>Lower Bajocian</b>	Humphriesianum	Bj-19	<i>Iboceras coronatum</i>	<b>Lower Callovian</b>	Enodatum	XVIII	<i>Sigaloceras anterior</i>
		Bj-18	<i>Iboceras blagdeni</i>			XVIIb	<i>Sigaloceras enodatum</i> β
		Bj-17	<i>Stephanoceras blagdeni/forse</i>			XVIIa	<i>Homosophaletes difficilis</i>
		Bj-16	<i>Stephanoceras gibbosum</i>			XVI	<i>Sigaloceras enodatum</i> α
		Bj-15	<i>Stephanoceras humphriesianum</i>			XV	<i>Sigaloceras micans</i>
	Romani	Bj-14b	<i>Climacoceras arigleti</i>		Calloviense	XIV	<i>Sigaloceras calloviense</i>
		Bj-14a	<i>Climacoceras driphinum</i>			XIII	<i>Kepplerites galilaei</i>
		Bj-13	<i>Stephanoceras amballicum</i>			XIII	<i>Kepplerites trichophorus</i>
	Saxei	Bj-12	<i>Stephanoceras rhytum</i>		Curtlobus	XIIb	<i>Kepplerites indigenus</i>
		Bj-11b	<i>Nannina evoluta</i>			XIa	<i>Caloceras "gregarium" MS</i>
		Bj-11a	<i>Otoceras saxei</i>	X		<i>Kepplerites curtlobus</i>	
	Laeviuscula	Bj-10	<i>Witcheikia laeviuscula</i>	Gowerianus	IX	<i>Kepplerites gowerianus</i>	
		Bj-9	<i>Witcheikia ruber</i>		VIII	<i>Kepplerites mucronatus</i>	
		Bj-8b	<i>Sibiriceras trigonali</i>		VII	<i>Macrocephalites polyptychus</i>	
	Trigonalis	Bj-8a	<i>Witcheikia nodatipunguis</i>	Kamptus	VI	<i>Macrocephalites kamptus</i> β	
		Bj-7b	<i>Witcheikia comata</i>		V	<i>Macrocephalites kamptus</i> α	
	Sayni	Bj-7a	<i>Witcheikia gelatina</i>	Terebratus	IVb	<i>Macrocephalites terebratus</i> γ	
		Bj-6c	<i>Witcheikia "pseudoromanus" MS</i>		IVa	<i>Macrocephalites terebratus</i> β	
	Ovalis	Bj-6b	<i>Fusuloboceras gignense</i>	Keppleri	III	<i>Macrocephalites terebratus</i> α	
		Bj-6a	<i>Euboceras euboceras</i>		II	<i>Macrocephalites ovatus</i>	
		Bj-5	<i>Witcheikia romanoides</i>		I	<i>Kepplerites keppleri</i>	
		Bj-4	<i>Bradfordia inclusa</i>				
	Discites	Bj-3	<i>Hyperboceras subocellum</i>	<b>Upper Bathonian</b>	Discus	Bt-20	<i>Cydoniceras hochstetteri</i>
		Bj-2b	<i>Hyperboceras malacitites</i>			Bt-19	<i>Cydoniceras discus</i>
		Bj-2a	<i>Hyperboceras soulieri</i>		Hollandi	Bt-18	<i>Cydoniceras hollandi</i>
		Bj-1	<i>Hyperboceras politum</i>			Bt-17	<i>Cydoniceras cf. scholtes</i>
	Concavum	Aa-16	<i>Euboceras acanthoides</i>		Hannoverianus	Bt-16	<i>Homosophaletes</i> sp.
		Aa-15	<i>Gophoceras formosum</i>			Bt-15	<i>Procerites nobilissimus</i>
Aa-14		<i>Gophoceras concavum</i>	Quercinus		Bt-14	<i>Procerites hodani</i>	
Aa-13	<i>Gophoceras carinatum</i>	Bt-13			<i>Procerites quercinus</i>		
Bradfordensis	Aa-12	<i>Brasilia decipiens</i>	Fortescottianum		Bt-12	<i>Wagnericeras latholicum</i>	
	Aa-11	<i>Brasilia gigantea</i>			Bt-11	<i>Bullatimorphites bullatimorphus</i>	
	Aa-10	<i>Brasilia bradfordensis, similis</i>	Morrisoni	Bt-10	<i>Morrisoniceras morrisoni</i>		
Aa-9	<i>Brasilia bradfordensis, luyisi</i>	Bt-9		<i>Talites modiolaria</i>			
Marchisonae	Aa-8	<i>Brasilia bradfordensis, subcomata</i>	Subcontractus	Bt-8	<i>Bullatimorphites ex gr. rugifer</i>		
	Aa-7	<i>Ludwigia marchisonae</i>		Progracilis	Bt-7	<i>Procerites imitator</i>	
Obtusiformis	Aa-6	<i>Ludwigia patellaria</i>	Tenuiplicatus		Bt-6	<i>Procerites progracilis</i>	
	Aa-5	<i>Ludwigia obtusiformis</i>		Bt-5	<i>Procerites/prolectoceras</i>		
Scissum	Aa-4	<i>Ancolliceras opalinoides</i>	Yeovilensis	Bt-4	<i>Apholites tenuiplicatus</i>		
	Aa-3	<i>Leioceras bifidatum</i>		Bt-3b	<i>Procerites fallonicus</i>		
Opalinum	Aa-2	<i>Leioceras lineatum</i>	Macrescens	Bt-3a	<i>Procerites foveolatus</i>		
	Aa-1	<i>Leioceras opalinum</i>		Bt-2	<i>Morphoceras macrescens</i>		
<b>Upper Bajocian</b>	Subfucatum	Carnotian	Parkinsoni	Zigzag	Bomfordi	Bt-28	<i>Parkinsonia bomfordi</i>
						Bt-27c	<i>Parkinsonia pseudoferruginea</i>
	Banksi	Bt-27b	<i>Strigoceras banksi</i>	Tretlei	Bt-27a	<i>Parkinsonia parkinsoni</i> α	
		Bt-26b	<i>Parkinsonia rarecostata</i>		Bt-26a	<i>Parkinsonia rarecostata</i>	
	Polygyralis	Bt-25	<i>Carnotianus tetragonus</i>	Acris	Bt-25	<i>Carnotianus tetragonus</i>	
		Bt-24	<i>Carnotianus dichotoma</i>		Bt-24	<i>Carnotianus dichotoma</i>	
	Banksi	Bt-23	<i>Leptosphinctes davidsoni</i>	Tetragona	Bt-23	<i>Leptosphinctes davidsoni</i>	
		Bt-22	<i>Carnotianophinctes polygyralis</i>		Bt-22	<i>Carnotianophinctes polygyralis</i>	
	Banksi	Bt-21	<i>Carnotianophinctes apicatus</i>	Banksi	Bt-21	<i>Carnotianophinctes apicatus</i>	
		Bt-20	<i>Iboceras banksi</i>		Bt-20	<i>Iboceras banksi</i>	

(Figure 1.4) Ammonite biohorizons recognized in the British Middle Jurassic Series (for sources, see text.)





(Figure 1.5) Examples of faunal-floral assemblages in some Mid Jurassic environments (modified from Sellwood, 1978).  
 (a) High-energy, open marine oolite shoal assemblage; (b) clear-water, firm substrate marine assemblage; (c) low-energy, shallow-marine shelf assemblage; (d) freshwater—brackish-water assemblage.)