Chapter 4 The Middle Jurassic stratigraphy of the East Midlands

B.M. Cox, M.G. Sumbler, R.J. Wyatt and K.N. Page

Introduction

B.M. Cox and M.G. Sumbler

The region covered in this chapter extends from Oxfordshire northwards to the East Riding of Yorkshire (Figure 4.1), and broadly coincides with the Mid Jurassic depositional area and structural feature known as the 'East Midlands Shelf' (see (Figure 1.6)d, Chapter 1). The northern limit is defined by the Market Weighton High, which, in Jurassic times, acted as a hinge between the rapidly subsiding Cleveland Basin to the north (see Chapter 5) and the more gently subsiding East Midlands Shelf to the south. Major uplift, centred on this structure during the Early Cretaceous Epoch, led to the erosion of much of the Jurassic succession that had been deposited over and adjacent to it. For this reason, Middle Jurassic strata are discontinuous and largely absent in the Market Weighton area (Kent, 1980a). The southern limit of the region covered in this chapter is marked by the so-called 'Oxfordshire Shallows', which, in Aalenian–Bajocian times, were an area of shoals at the western end of the island, of subdued relief, which occupied much of the London and Thames Valley areas as well as East Anglia (the 'London Landmass' — the western part of the Anglo-Brabant Landmass). Deposition was greatly reduced there and only a small part of the Cotswold Aalenian–Bajocian succession (see Chapter 3) is represented; most is missing owing to non-sequence (Figure 4.2). Northwards, the Aalenian–Bajocian succession thickens but there are still significant non-sequences. The Aalenian sediments show a major change to less carbonate facies, including paralic, brackish-water and freshwater, associated with the low-lying coastal plain that fringed the London Landmass. In Bajocian times, these were replaced by marine limestone facies, more reminiscent of the Cotswold succession, as the coastal plains receded. In Late Bajocian and Bathonian times, although the 'Oxfordshire Shallows' did not persist, the Oxfordshire area was nonetheless one of transition, separating the Cotswold region (see Chapter 3) of mainly continuous marine sedimentation from one of discontinuous, generally non-marine sedimentation to the north; the Bathonian succession in the transitional area is complicated by rapid variations in lithology and thickness associated with the changing environments of deposition. The eustatic rise in sea level that heralded the start of the Callovian Age brought with it a return to marine clastic deposition throughout the whole area.

The main stratal divisions of the East Midlands Shelf area are shown on the first edition of William Smith's geological map of England published in 1815, and he is known to have visited here on a number of occasions to investigate the geology (e.g. see Swinnerton and Kent, 1981). However, significant contributions to an understanding of the detail and complexities of the Middle Jurassic stratigraphy largely stem from the latter part of the 19th century when individual investigators, such as Brodie (1853), Morris (1853, 1869), Sharp (1873) and Cross (1875), produced early accounts of local sections and successions, including Sharp's demonstration of the 'Inferior Oolite age' of the Lincolnshire Limestone. Both Samuel Sharp (1814–1882) and the Rev. John Edward Cross (1821–1897) subsequently had biostratigraphically important Middle Jurassic brachiopod species (*Kallirhynchia sharpi* Muir-Wood and *Acanthothiris crossi* (Walker)), named after them. The [British] Geological Survey was also mapping in the region at this time and produced district memoirs by Judd (1875), Jukes-Browne (1885), Ussher *et al.* (1888) and Ussher (1890), as well as Woodward's (1894) stratigraphical memoir. The next major spate of publications on the Middle Jurassic succession did not come until the 1930s when Thompson's (1930) paper on the 'Upper Estuarine Series' of Northamptonshire and north Oxfordshire, and Douglas and Arkell's (1932) review of the Cornbrash Formation were published. During this decade, Linsdall Richardson (1881–1967), who had already published extensively on the Middle Jurassic rocks of the Cotswolds (see Chapter 3), turned his attention to the succession in Lincolnshire (Richardson, 1939a,b, 1940) where he was joined by Percy (later Sir Peter) Kent (1913–1986) who became the most prolific author on the Middle Jurassic rocks of this region in recent times (Richardson and Kent, 1938; Kent, 1938, 1941, 1948, 1953, 1966, 1967, 1970, 1972, 1975; Kent and Baker, 1938; Swinnerton and Kent, 1949, 1981). His work coincided with a second phase of [British] Geological Survey activity in the region, which was mainly concerned with investigations of the Northampton Ironstone at the base of the Middle Jurassic succession (Hollingworth and Taylor, 1946a,b, 1951; Taylor, 1946, 1963). Sylvester-Bradley (1968) described this stratum, which was extensively quarried throughout most of the area from Towcester, Northamptonshire, as far north as

Lincoln, as the most important source of iron exploited in the country. It was much in demand during and after the Second World War, but its extraction was phased out between 1968 and 1974 in favour of higher-grade imported ore (Kent, 1975). Other contributions from this time, including publications by Muir-Wood (1939, 1952) on brachiopod faunas and Bate (1967a,b) on ostracod faunas, culminated in the regional synthesis entitled *The Geology of the East Midlands* edited by Sylvester-Bradley and Ford (1968); this included chapters on the Aalenian–Bajocian rocks by Sylvester-Bradley, on the Bathonian rocks by Torrens (with a contribution by C.J. Aslin), and on the Callovian rocks by Callomon. Since 1970, important postgraduate research has been undertaken by Ashton (1977, 1980), Parsons (1974b, 1980a,b), Bradshaw (1978), Cripps (1986) and Page (1988, 1989); that of Bradshaw and Cripps remains essentially unpublished (except in Bradshaw and Cripps, 1983, 1992) but both have allowed data from their theses to be quoted. Other recent work is referred to below and in the individual GCR site reports that follow.

The current lithostratigraphical scheme for the Middle Jurassic rocks of the East Midlands divides the succession into the Inferior and Great Oolite groups; the latter is succeeded by the Kellaways and Oxford Clay formations, which, in this region, are assigned to the Ancholme Group. The term 'Redbourne Group', which Gaunt *et al.* (1992) introduced for the combined Inferior and Great Oolite groups in the north of the region, is not used in the present volume. The current lithostratigraphical classification of the Aalenian–Bajocian rocks covered by this chapter is shown in (Figure 4.2). The term 'Grantham Formation' was first used by Kent (1975) in place of the earlier term 'Lower Estuarine Series'. As shown by Bradshaw (1978), this unit is absent in the south of the region, and any 'Lower Estuarine Series' that has been described there actually belongs to the Stamford Member of the Rutland Formation or, in the south-west, to the newly defined Horsehay Sand Formation. The classification of the Lincolnshire Limestone Formation follows Ashton (1977, 1980) except that a two-fold subdivision into Lower and Upper is preferred to his three-fold subdivision (Figure 4.3). The distinction between the Lower and Upper divisions, as used herein, is fundamental. The Lower Lincolnshire Limestone is dominated by low-energy micritic packstones and wackestones, whereas the Upper Lincolnshire Limestone largely comprises high-energy ooidal grainstones; there is often an undulating erosive contact between the two. The sedimentology and diagenesis of the Lincolnshire Limestone Formation have been investigated by Emery *et al.* (1987, 1988), Emery (1991) and Emery and Dickson (1991). Although not mappable entities, Ashton's (1977, 1980) 'members' (Figure 4.3) can be used for descriptive purposes in individual sections although they are mostly only of local correlative value. The lithostratigraphical classification of the Bathonian rocks covered by this chapter is shown in (Figure 4.4). The term 'Rutland Formation', and the named rhythms within it, were introduced by Bradshaw (1978) in his unpublished D. Phil. thesis in place of the earlier term 'Upper Estuarine Series'. Bradshaw's nomenclature has since been used, with his consent, by the British Geological Survey in various maps and memoirs. Gaunt *et al.'s* (1992) term 'Glentham Formation', which includes the strata of the Rutland Formation, is now redundant. Higher in the succession, the White Limestone and Forest Marble formations of the Cotswolds (see Chapter 3) are replaced by the Blisworth Limestone and Blisworth Clay formations in the greater part of the region. The diagenesis of the limestone formations has been investigated by Hendry (1990, 1993).

Ammonites are common only in the Callovian part of the Middle Jurassic succession in this region (see Peterborough Brickpits GCR site report, this volume), although there is some limited ammonite control in the Inferior Oolite Group where the Scissum, ?Murchisonae, Discites, Ovalis and Laeviuscula zones are proved (Ashton, 1977, 1980; Parsons, 1980a). For the Great Oolite Group, dating and correlation has to be inferred on the basis of sedimentary rhythms recognized in the Rutland Formation, and by apparently quasi-isochronous event horizons (Excavata, Ardleyensis, Bladonensis, Sharpi and Digonoides beds) in the White limestone and Blisworth Limestone formations. It should be noted that the brachiopods *Kallirhynchia sharpi* and *Digonella digonoides* (S.S. Buckman), on which the Sharpi and Digonides beds are based, are facies faunas that also occur at several other levels; the other event horizons listed, although named after particular gastropods, are associated with hard-grounds and are thus sedimentological events. Ostracod faunas and palynomorphs have also been used to provide some age control. For example, placement of the Bajocian-Bathonian boundary within the 'White Sands' of the southwest of the region (Horsehay Sand Formation herein; see Horsehay Quarry GCR site report, this volume) is based on a palynostratigraphical investigation by Fenton *et al.* (1994, 1995), and the Thorncroft Sand of the Humber area has been assigned to the Lower Bajocian Humphriesianum Zone (and possibly the underlying Sauzei Zone) on the basis of dinoflagellate cysts (Riding, 1987; Gaunt *et al.,* 1992). However, the beds from which the latter floras were recovered belong to a transitional facies that may be better placed with the Lincolnshire Limestone Formation (see for example, Bradshaw and Penney, 1982). The overlying Thorncroft Sand 'proper' is almost

certainly the equivalent of the Stamford Member of the Rutland Formation as shown in (Figure 4.2).

Details of the main lithologies and depositional environments are included in the site descriptions that follow. In the following list of sites (arranged south to north), (A) indicates that the site belongs to the Aalenian–Bajocian GCR Block, (B) indicates the Bathonian GCR Block and (C) the Callovian GCR Block. The location of the sites is shown in (Figure 4.1).

Woodeaton, Oxfordshire (B)

Ardley Cuttings and Quarries, Oxfordshire (B)

Stratton Audley, Oxfordshire (B)

Blisworth Rectory Farm, Norhamptonshire (B)

Roade Railway Cutting, Northamptonshire (B)

Irchester Old Lodge Pit, Northamptonshire (B)

Finedon Gullet, Wellingborough,

Northamptonshire (B)

Cranford St John, Northamptonshire (B)

Thrapston, Northamptonshire (B and C)

Peterborough Brickpits, Cambridgeshire (C)

Collyweston, Northamptonshire (A)

Ketton Quarry, Rutland (A and B)

Clipsham Quarry, Rutland (A)

Castle Bytham, Lincolnshire (A)

Sproxton Quarry, Leicestershire (A)

Copper Hill, Lincolnshire (A)

Metheringham, Lincolnshire (A)

Greetwell Quarry, Lincolnshire (A)

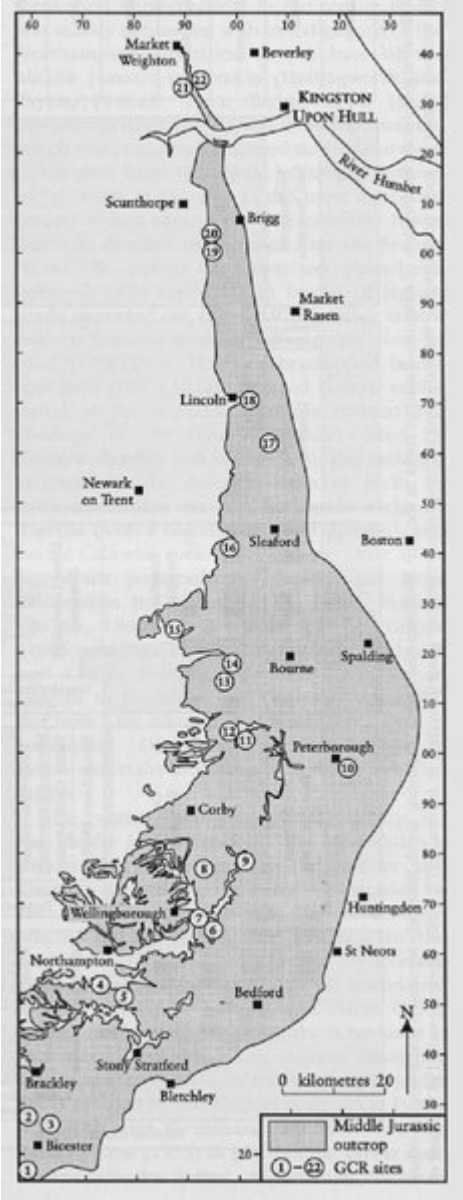
Cliff Farm Pit, East Riding (A)

Manton Stone Quarry, East Riding (A)

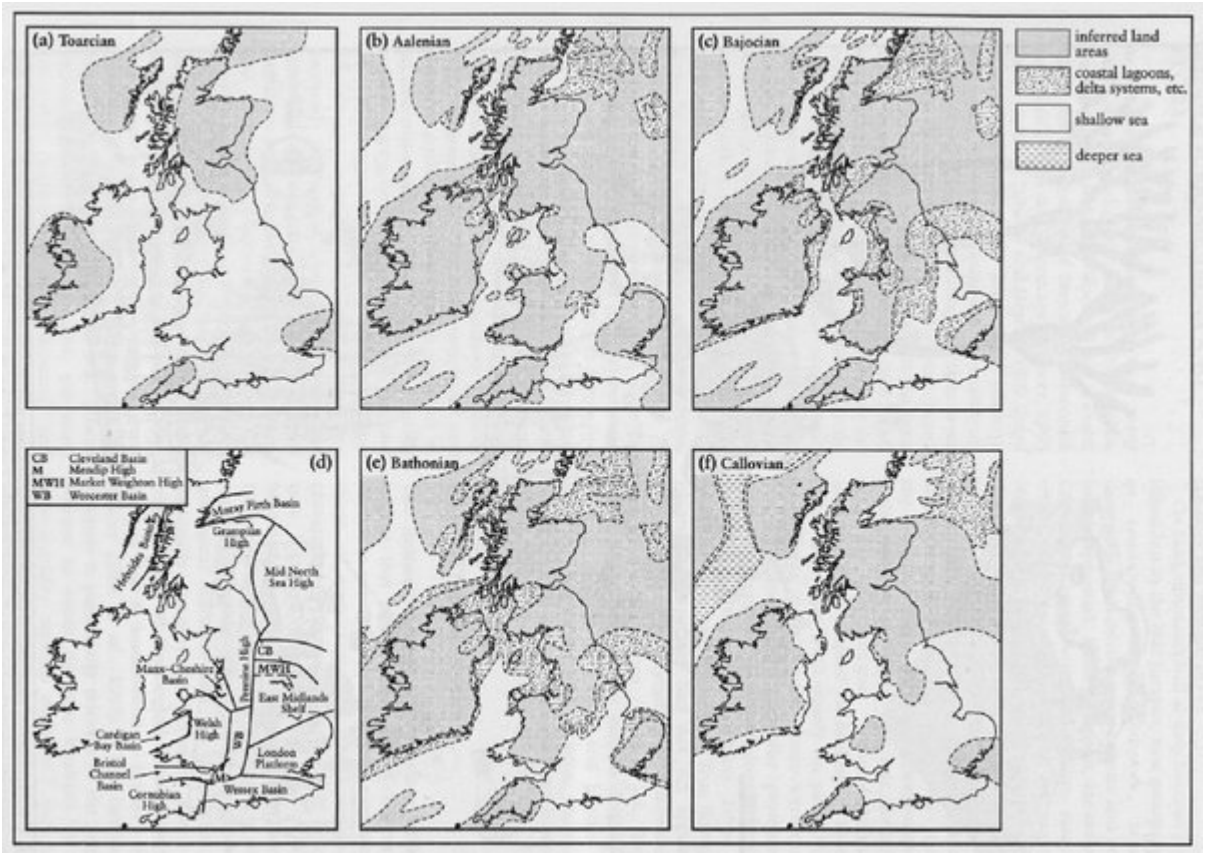
Eastfield Quarry, East Riding (A)

Drewton Lane Pits, East Riding (C)

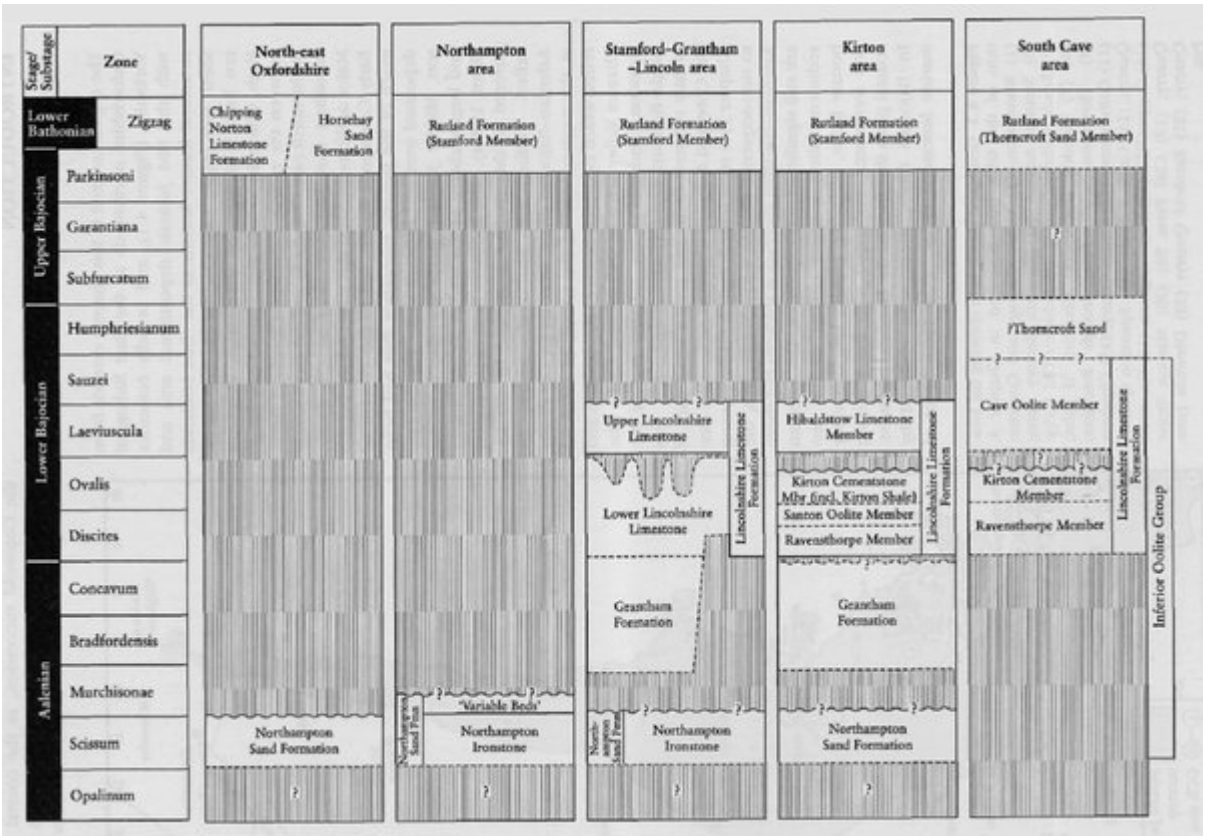
References



(Figure 4.1) Geological sketch map showing the location of the GCR sites described in Chapter 4. (1) Woodeaton; (2) Ardley Cuttings and Quarries; (3) Stratton Audley; (4) Blisworth Rectory Farm; (5) Roade Railway Cutting; (6) Irchester Old Lodge Pit; (7) Finedon Gullet; (8) Cranford St John; (9) Thrapston; (10) Peterborough Brickpits; (11) Collyweston; (12) Ketton Quarry; (13) Clipsham Quarry; (14) Castle Bytham; (15) Sproxton Quarry; (16) Copper Hill; (17) Metheringham; (18) Greetwell Quarry; (19) Cliff Farm Pit; (20) Manton Stone Quarry; (21) Eastfield Quarry; (22) Drewton Lane Pits.)

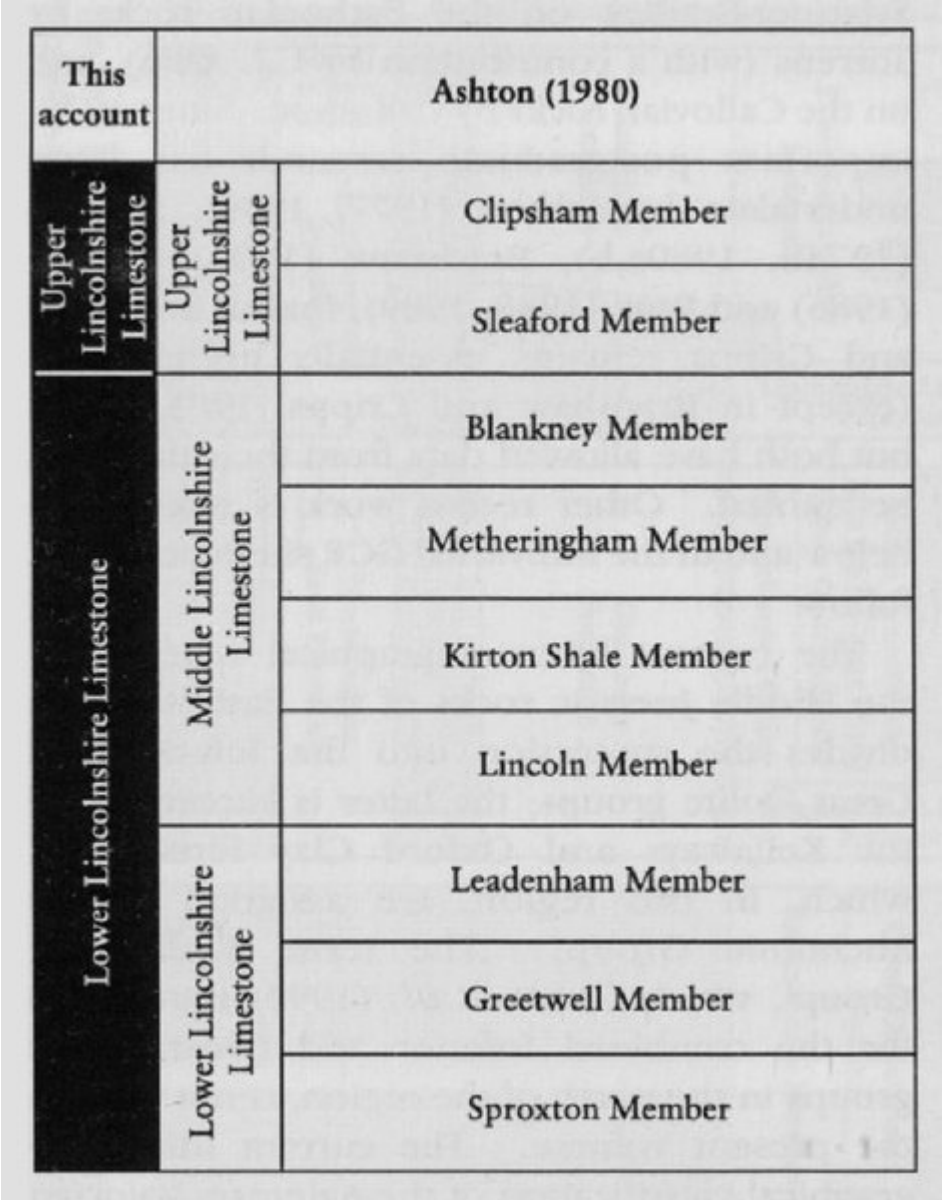


(Figure 1.6) (a–c,e,f) Palaeogeographical reconstructions for the British area during the late Early and Mid Jurassic (slightly modified from Cope, 1995); (d) main structural elements affecting sedimentation in the British area in the Mid Jurassic (terminology as used in this volume). The 'London Platform' 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.))

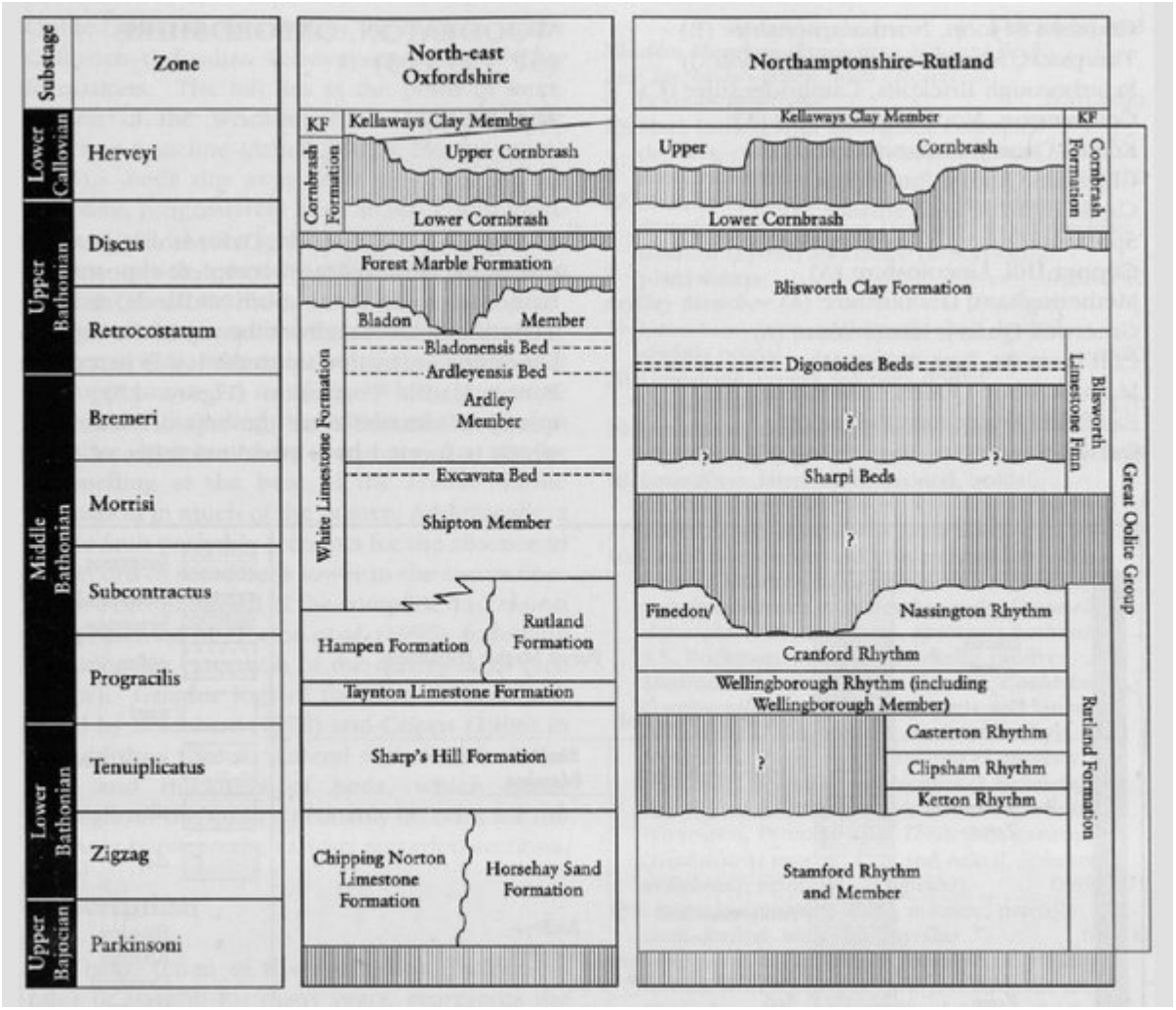


(Figure 4.2) Lithostratigraphical classification of Aalenian–Bajocian rocks in the East Midlands Shelf area. Columns are deliberately separated one from the other because of the tenuous nature of some correlations. Vertical ruling indicates

non-sequence. (Based on data in Ashton, 1977, 1980; Horton et al., 1987; Gaunt et al., 1992; Wyatt, 1996a,b.))



(Figure 4.3) Main subdivisions of the Lincolnshire Limestone Formation in the Stamford–Grantham–Lincoln area.)



(Figure 4.4) Lithostratigraphical classification of the Bathonian and overlying Callovian rocks in the southern part of the East Midlands Shelf area. Columns are deliberately separated one from the other because of the tenuous nature of some correlations. Vertical ruling indicates non-sequence. (Based on data in Bradshaw, 1978; Cripps, 1986; Horton et al., 1987; Page, 1989; and Wyatt, 1996a.) (KF = Kellaways Formation.))