Chapter 5 The Middle Jurassic stratigraphy of North Yorkshire

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Introduction

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The coastal exposures of Middle Jurassic rocks in Yorkshire have a long history of investigation dating back to the early part of the 19th century when Young (1817), Young and Bird (1822) and Phillips (1829) produced their pioneer geological accounts. William Smith was also active here; in 1821, his geological map of Yorkshire was published and, from 1828 to 1834, he was employed as land agent on the Hackness estate, a little inland, during which time he mapped the Hackness Hills (Rayner, 1974). At various times during his life he lodged in Scarborough and remained there from 1835 until his death in August 1839 (Cox, 1942). In 1845, the [British] Geological Survey began its systematic mapping of the county and its work on the Jurassic rocks culminated in the memoir by Fox-Strangways (1892) based on earlier district memoirs by Fox-Strangways (1880), Fox-Strangways and Barrow (1882) and Fox-Strangways *et al.* (1885). During this period, John Leckenby, a bank manager in Scarborough and local fossil collector, made an important early contribution to the palaeontology and stratigraphy of the Callovian strata exposed on the coast (Leckenby, 1859).

By this time, it was already well understood that the Aalenian–Bathonian rocks in Yorkshire were quite unlike their correlatives in southern England (see Chapters 2, 3 and 4), being mainly deltaic, estuarine, fluvial or alluvial, but including four, relatively thin, discrete marine units. Debate and discussion about the depositional environments has continued for over 100 years (see below). A number of the early investigators, for example Wright (1860), Hudleston (1874) and later Richardson (1911c), were particularly concerned with the differences between this part of the Yorkshire succession and that in southern England. The Callovian succession is likewise different, being predominantly marine sandstones in Yorkshire and marine mudrocks in southern England. The geological events and structural setting that led to these contrasting facies are now understood. Tectonic activity in the British area early in the Jurassic Period led to the development of a local extensional basin over North Yorkshire that became separated from the shallower shelf to the south (East Midlands Shelf) by a hinge (Market Weighton High) bounded on the north side by a fault zone (Howardian–Flamborough Fault Belt) (Figure 5.1). The western limit of this so-called 'Cleveland Basin' was probably defined by the Pennine High. Throughout the Early Jurassic Epoch, marine, predominantly argillaceous, sediments (Lias Group) accumulated in the rapidly subsiding Cleveland Basin but, in the very latest part of the Toarcian Age, regional uplift was initiated, associated with thermal doming and accompanying volcanic activity in the central North Sea (Bradshaw and Cripps, 1992; Underhill and Partington, 1993). During the Aalenian and Bajocian ages, sediments were eroded from the newly emergent Mid North Sea High, transported southwards by rivers and deposited as a fluvio-deltaic succession over Yorkshire and the adjacent Sole Pit Trough, whilst the East Midlands Shelf remained covered by a warm, shallow shelf-sea. Overall, the evidence suggests small prograding deltas that ultimately coalesced into a large, coastal alluvial-plain rather than a large single river-system feeding a large delta (Rawson and Wright, 1992, 1995). The thin marine strata that are intercalated with the fluvio-deltaic succession bear witness to times when seawater encroached into the basin from the south and possibly east (Holloway, 1985). Movement along the margins (Peak and Red Cliff faults) of the narrow graben known as the 'Peak Trough' (Milsom and Rawson, 1989), which cuts obliquely across the present coastline, also took place at this time. Early in the Callovian Age, the sea again transgressed into the Cleveland Basin, and marine sandstones were deposited. Apart from Richardson's (1911c) account, other published work dating from the early part of this century includes that on the fossil floras of the non-marine beds by Seward (1900), the basal beds by Rastall (1905), the Callovian succession by S.S. Buckman (1913), fossil footprints by Hargreaves (1913) and a second edition of Fox-Strangways and Barrow's memoir (1915). Later, Black (1928, 1929, 1934) elucidated sedimentological aspects of the 'deltaic' succession, including a description of channelling phenomena, and also discovered new palaeobotanical localities. Another significant newcomer on the scene at this time was John Edwin Hemingway (1906–1997) who joined Rasta in a series of largely petrographical studies (Rastall and Hemingway, 1935, 1939, 1940a,b, 1941, 1943, 1949), a topic on which Smithson (for example, 1934, 1937, 1942) also published.

The fossil floras were described in a series of papers by Harris (1942–1953, 1953, 1961–1979), trace fossils by Farrow (1966) and fossil footprints by Sarjeant (1970). Many sections, both coastal and inland, in the predominantly non-marine Middle Jurassic beds were recorded by Bate (1959, 1964, 1965, 1967b) during his investigation of the fossil ostracod faunas.

From the 1970s onwards, interest in the Middle Jurassic rocks of Yorkshire has been heightened because of their value as facies analogues of oil-producing horizons in the North Sea Basin. Detailed sedimentological, palynological and palaeoenvironmental research, and sequence-stratigraphical studies have been undertaken on the coastal exposures, leading to a continuing output of publications including Knox (1973), Nami (1976), Parsons (1977b), Nami and Leeder (1978), Leeder and Nami (1979), Hancock and Fisher (1981), Livera and Leeder (1981), Whyte and Romano (1981, 1993), Riding (1984), Kantorowicz (1984, 1985, 1990), Fisher and Hancock (1985), Alexander (1986, 1987, 1989, 1992a,b), Romano and Whyte (1987), Milsom and Rawson (1989), Riding and Wright (1989), Knox *et al.* (1991), Eschard *et al.* (1991), Gowland and Riding (1991), Lott and Humphreys (1992), and Alexander and Gawthorpe (1993). Much unpublished work has also been undertaken by and for commercial oil companies and consultancies. The coastal exposures also feature in three recently published field guides (Rawson and Wright, 1992, 1995; Scrutton, 1994) that supersede earlier ones (e.g. Hemingway *et al.,* 1968), as well as van Konijnenburg-van Cittert and Morgans' (1999) field guide to the fossil flora.

After his early work with Rastall (see above), Hemingway, who had a lifelong association with the Yorkshire Jurassic rocks (see, for example, Hemingway (1974) and references therein), initiated the development of a modern lithostratigraphical scheme for the predominantly non-marine beds that eventually led to the current scheme shown in (Figure 5.2) (Hemingway, 1949; Sylvester-Bradley, 1949; Hemingway and Knox, 1973; Parsons, 1977b; Powell and Rathbone, 1983; Gowland and Riding, 1991). For the youngest (Callovian) part of the Middle Jurassic succession in Yorkshire, the current lithostratigraphical nomenclature follows Wright (1968, 1977, 1978) and Page (1989), although many of the terms date back to the time of William Smith.

Apart from the ammonitiferous Callovian strata, chronostratigraphical dating of the Yorkshire Middle Jurassic succession is not tightly constrained and has been the subject of debate. Ammonites, which allow recognition of the standard zones, occur only in the Dogger and Scarborough formations (Parsons, 1980a). The other formations cannot even be assigned accurately to a stage or substage, and chronostratigraphical boundaries can be positioned only tentatively. Sparse dinoflagellate cyst floras give some control; the Moor Grit and basal Long Nab members of the Scalby Formation have yielded very sparse assemblages of latest Bajocian to Bathonian age and, inland, the latter member has yielded a Bathonian assemblage (Riding and Wright, 1989). A once-postulated non-sequence whereby most of Bathonian time was unrepresented in the rock succession (Leeder and Nami, 1979) is thought now not to exist.

In the following list of sites, (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 5.3). A summary of the main lithologies and depositional environments is shown in (Figure 5.4), and more specific details are included in the site descriptions.

Whitwell Quarry, North Yorkshire (A)

Gristhorpe Bay (A), Yons Nab (B) and Red Cliff–Cunstone Nab (C), North Yorkshire

Osgodby Point, North Yorkshire (C)

South Toll House Cliff, North Yorkshire (C)

North Bay, Scarborough, North Yorkshire (C)

Hackness Rock Pit, North Yorkshire (C)

Havern Beck, Saltergate, North Yorkshire (C)

Hudson's Cross Crags, Newton Dale, North Yorkshire (C)

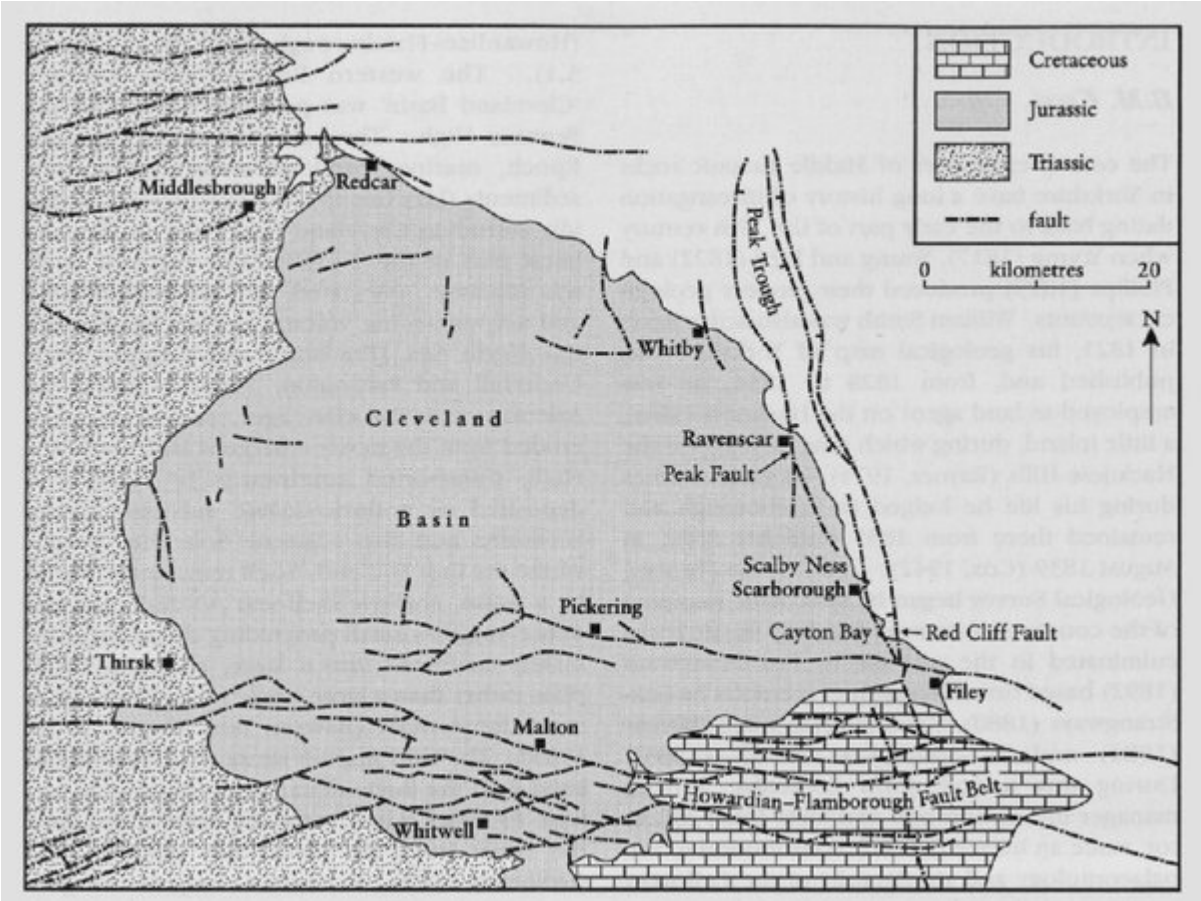
Fairy Call Beck, North Yorkshire (C)

Iron Scar–Hundale (A) and Hundale Point–Scalby Ness, North Yorkshire (B)

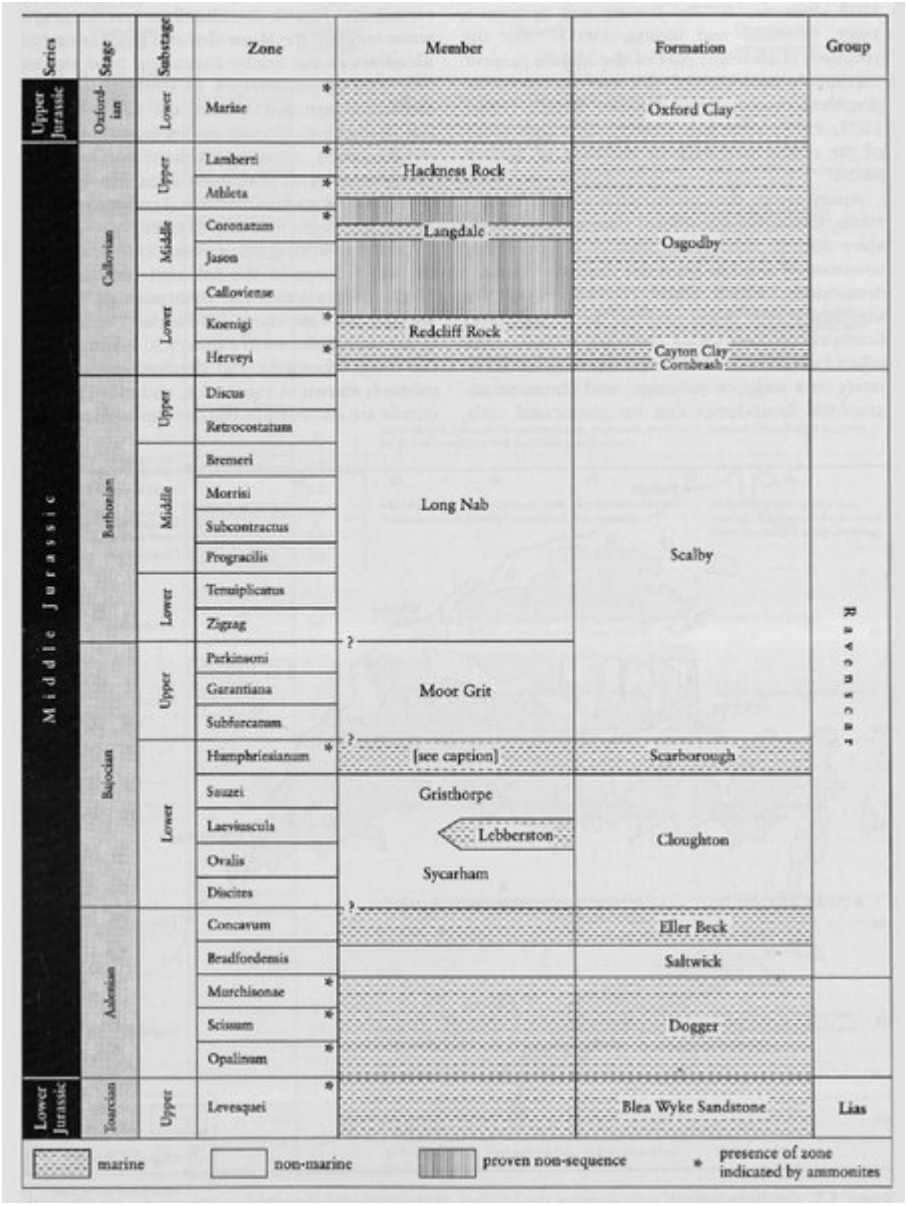
Blea Wyke, North Yorkshire (A)

Hawsker Bottoms, North Yorkshire (A)

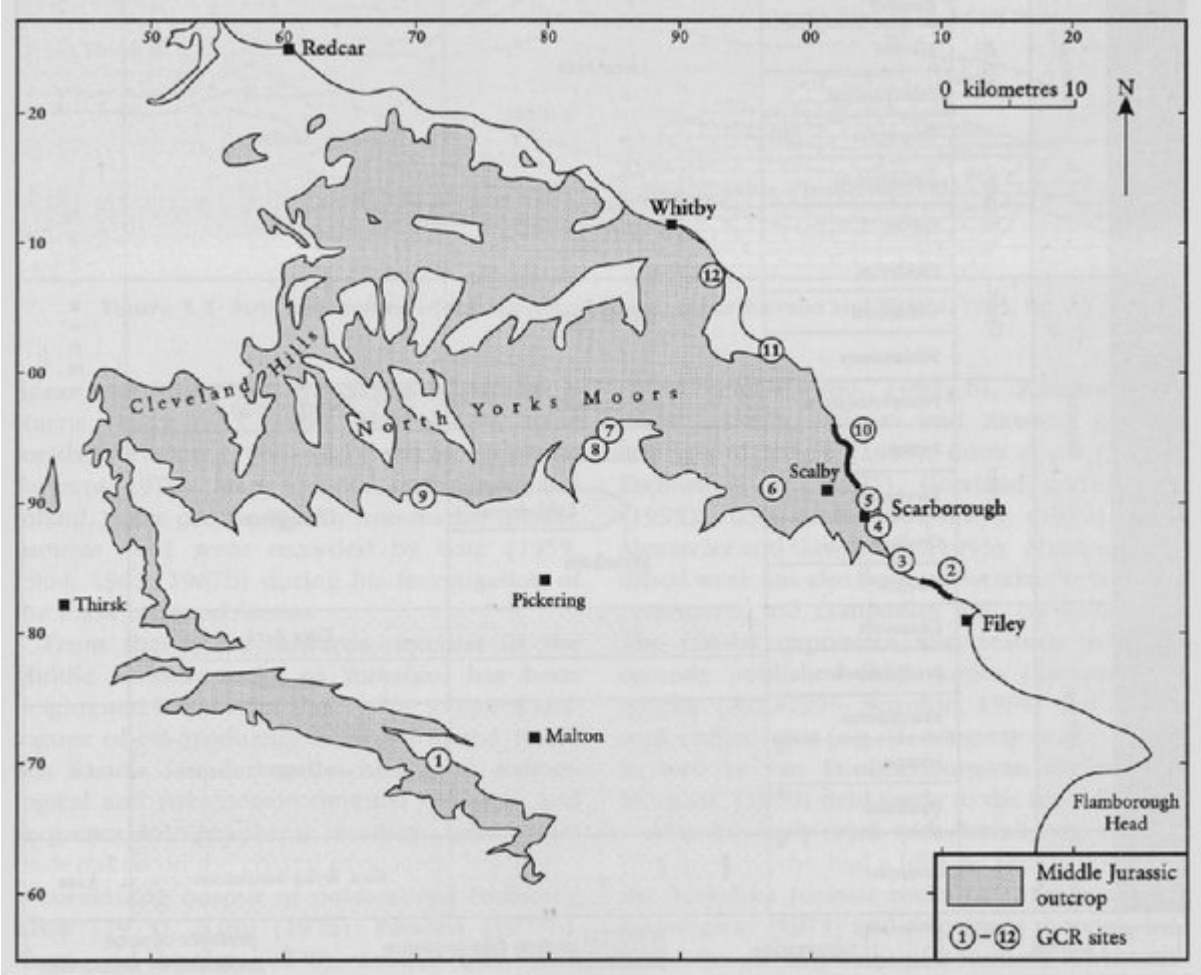
References



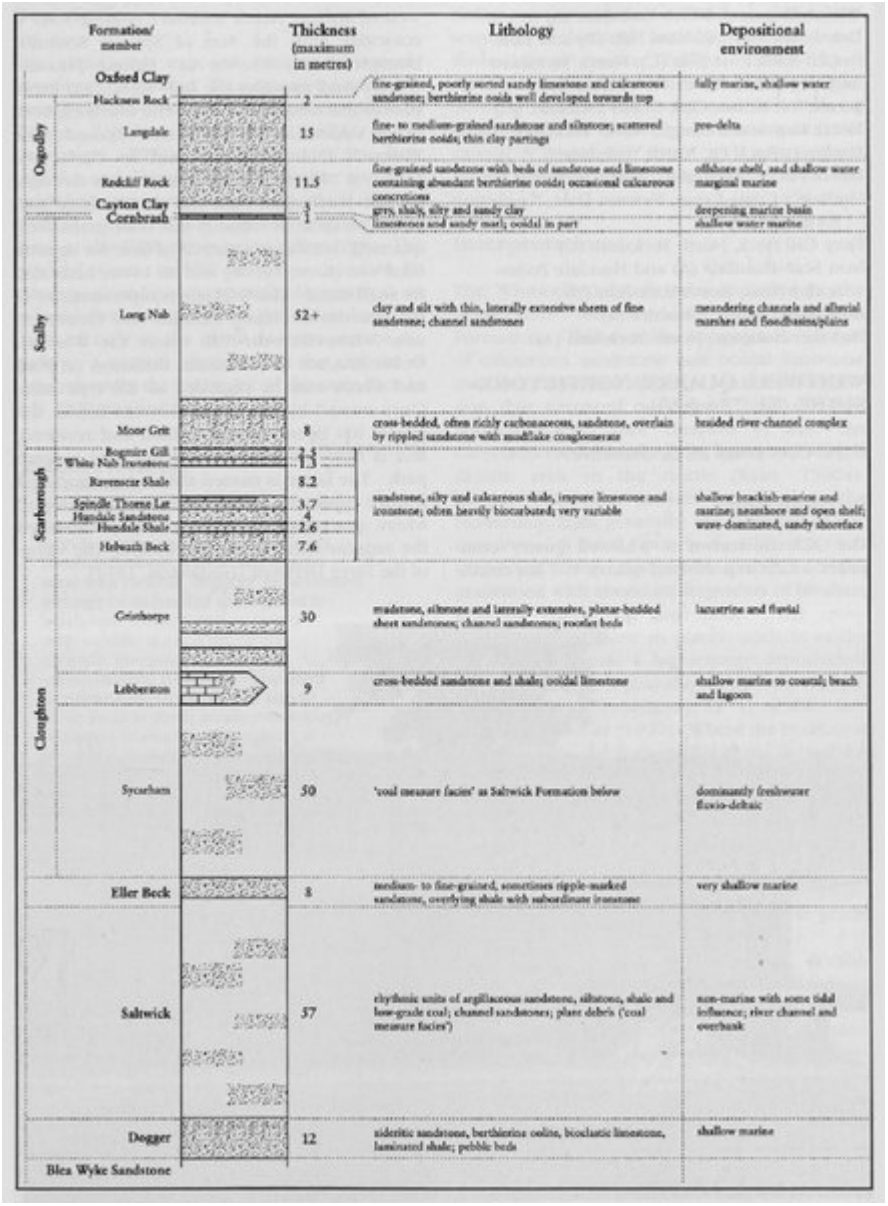
(Figure 5.1) Structural setting of the Cleveland Basin. (After Rawson and Wright, 1995, fig. 2.))



(Figure 5.2) Lithostratigraphy of the Middle Jurassic rocks of Yorkshire. At its type locality, the Scarborough Formation has been divided into seven members (Parsons, 1977b; Gowland and Riding, 1991). From below, these are named Helwath Beck, Hundale Shale, Hundale Sandstone, Spindle Thorn Limestone, Ravenscar Shale, White Nab Ironstone and Bogmire Gill. Not to scale.)



(Figure 5.3) Geological sketch map showing the location of the GCR sites described in Chapter 5. (1) Whitwell Quarry; (2) Gristhorpe Bay, Yons Nab and Red Cliff–Cunstone Nab; (3) Osgodby Point; (4) South Toll House Cliff; (5) North Bay, Scarborough; (6) Hackness Rock Pit; (7) Havern Beck, Saltergate; (8) Hudson's Cross Crags, Newton Dale; (9) Fairy Call Beck; (10) Iron Scar–Hundale and Hundale Point–Scalby Ness; (11) Blea Wyke; (12) Hawsker Bottoms.)



(Figure 5.4) Summary of main lithologies and depositional environments of the North Yorkshire coast Middle Jurassic succession. (Compiled from various sources; see text.))