Chapter 4 Upper Jurassic stratigraphy in North Yorkshire

Introduction

J.K. Wright

The region covered by this chapter extends from the coast at Scarborough westwards through the Tabular Hills to the Hambleton Hills, and then south-west into the Howardian Hills, incorporating the low-lying Vale of Pickering (Figure 4.1). It broadly coincides with the southern half of the Jurassic depositional area known as the 'Cleveland Basin' (Rawson and Wright, 2000, fig. 2). The southern limit of the basin is defined by the Market Weighton High (= Market Weighton Block; BGS, 1996), a positive area that was repeatedly uplifted during the Mesozoic Era, so that the thick sequence of Oxfordian and Kimmeridgian sediments of the Cleveland Basin thins and is eventually overstepped by Lower Cretaceous sediments as Market Weighton is approached.

The basic subdivisions of the Oxfordian and Kimmeridgian are shown in (Figure 4.2). At the base there is a comparatively thin representative of the Oxford Clay Formation. As in southern England, the overlying Corallian Group is well developed as a varied clastic–carbonate sequence. It is divided into three formations, the Lower Calcareous Grit and the Upper Calcareous Grit, separated by the Coralline Oolite. The succeeding Ampthill and Kimmeridge Clay formations make up over three-quarters of the Oxfordian–Kimmeridgian time interval, as estimated by the number of ammonite zones, and they are as thickly developed in proportion to time as the Corallian strata.

Most of the GCR sites display strata within the Corallian Group. This is basically the result of the limited exposure of clay formations in northeast Yorkshire, particularly the Kimmeridge Clay. In marked contrast to Dorset, where there are magnificent cliff exposures of Kimmeridge Clay (see cover photo), in north-east Yorkshire coastal exposures of Kimmeridge Clay are minimal, the outcrop being covered by a thick blanket of glacial drift. Occasional abandoned clay pits reveal some Ampthill and Kimmeridge Clay, but much of the uppermost Oxfordian and Kimmeridgian sequence has no exposures, natural or man-made, and some parts have only been seen in borehole cores. In contrast, there are numerous excellent cliff and quarry exposures of Corallian Group strata.

In the Cleveland Basin, as elsewhere in Britain, the Oxfordian Age began with clay sedimentation, represented by the Weymouth Member of the Oxford Clay Formation. The facies of the Weymouth Member in this area is that of a proximal, silty clay with influxes of clastic sediment derived from the Mid North Sea High (Figure 1.2)D. There was a gradual tendency for the Cleveland Basin to infill with shallow-water sediments, so that the Weymouth Member becomes increasingly silty upwards. This comparatively short argillaceous episode was then succeeded by deposition of the Corallian Group, a thick sequence of shallow marine sandstones and limestones that form an extensive, horseshoe-shaped outcrop round the north, west and south-west sides of the Vale of Pickering, itself a broad, synclinal structure (Figure 4.1).

On the north side of the Vale of Pickering, the Corallian Group is well developed as an alternating series of clastic and carbonate sediments (Figure 4.3). The initial Tenants' Cliff Member of the Lower Calcareous Grit Formation is a *Rhaxella* sponge spiculite containing only a small proportion of fine-grained quartz sand, and laid down under gentle, offshore marine conditions. The succeeding Saintoft Member in contrast is a fine-grained, shelly sandstone marking a distinct shallowing. A phase of very shallow-water sedimentation then began, with deposition of the Coralline Oolite Formation. The lowest member, the Passage Beds, marks the transition from the Lower Calcareous Grit. Initial medium-grained quartz sands are succeeded by bioclastic, ooidal and coralliferous limestones, as a warm, shallow, tropical, carbonate shelf sea was established throughout the area.

A prolonged period of deposition of ooidal and shelly sediments then followed. (Figure 4.3) shows the localized subdivisions of this predominantly carbonate sequence made possible by periodic uplifting of source areas around the margins of the basin. Lenses of siliclastic sediments identified as local members (Birdsall and Middle Calcareous Grits) divide the ooidal carbonate succession into Hambleton and Malton Oolites, and the Hambleton Oolite into Upper and

Lower Leafs. The close of carbonate sedimentation was marked by deposition of the Coral Rag, a transgressive sequence, with shelly, coral-rich bioclastic limestone overlain by a complex of coralliferous limestones and muddy, lagoonal sediments laid down in an extensive coral reef complex.

After a major erosive episode, there followed the transgression of predominantly clastic sediment, the Upper Calcareous Grit Formation, over much of the basin. The initial sedimentation was argillaceous (Newbridge Member), succeeded by shelly, fine-grained shelf sandstones (Spaunton Member). The youngest Upper Calcareous Grit sediments (Snape Member) comprise very fine-grained sandstones laid down under more gentle, offshore shelf conditions. There followed a major marine transgression, which led to the deposition of the fine-grained mudstones of the Ampthill and Kimmeridge Clays over the whole area. In the central part of the Vale of Pickering, the thickness of the Kimmeridge Clay is substantially greater than that of the Oxfordian strata (Figure 4.2). However, in the south-east, the Kimmeridgian succession is much attenuated (BGS, 1998a).

On the southern side of the Vale of Pickering (Figure 4.4), the Lower Calcareous Grit is again represented by sponge spiculites (Wright, 1983). The Passage Beds are missing owing to a major period of erosion affecting much of the western and southern parts of the Cleveland Basin. There is a substantial development of Birdsall Calcareous Grit, yielding an exceptionally preserved ammonite fauna at Flassen Gill in the Hambleton Hills (Figure 4.51). This sand facies, together with that of the Middle Calcareous Grit, passes eastwards into oolite facies, so that in the central Vale of Pickering there is one continuous oolite succession comprising Hambleton and Malton Oolites. The Birdsall Calcareous Grit is, however, well developed in the south, around Malton. The Coral Rag is present throughout except where it has been removed by erosion beneath the Upper Oxfordian beds.

After a major period of erosion or non-deposition, the Upper Oxfordian was laid down in the centre of this strip as a predominantly clastic sequence. The succession here is similar to that seen in the north; however, Spaunton Sandstone is transgressive across Newbridge Member silts in the Nunnington and Oswaldkirk areas.

Westwards and southwards, much of the Upper Oxfordian succession is represented by the argillaceous limestone facies of the North Grimston Cementstone, this passing north-eastwards into the silty sponge spiculites of the Newbridge Member.

In the area south of Malton, sediments occur that occupy part of the hiatus between Middle and Upper Oxfordian sediments that is present to the north (C.D. Wright, 1976). The Langton Clay, which appears to rest on Coral Rag, contains Middle Oxfordian cardioceratids, and is overlain by the silty, calcareous Limekiln Member coming in beneath the North Grimston Cementstone (see Wright, 1980, col. 015). Uppermost Oxfordian Ampthill Clay occurs as elsewhere, and the Kimmeridge Clay is well developed south of Ma1ton as well. Recent studies have shown that the sub-Late Cretaceous unconformity does not cut down gently to the south (BGS, 1993). Kimmeridge Clay continues under the Chalk to a point 12 km south of Ma1ton, where Late Jurassic–Early Cretaceous movement faults it against Lower Jurassic Redcar Mudstone at the margin of the Market Weighton 'Block'.

As in southern England, sedimentation during the Jurassic Period in the Cleveland Basin was affected by syndepositional faulting. This occurred in two principal areas: in the Peak Trough in the east, and in the Vale of Pickering/ Wolds area to the south-west. This latter area was bounded on its northern side by the Kilburn and Helmsley Faults and on its southern side by the Gilding Fault and the Flamborough Head Fault Zone (Figure 4.1). Fault movements in the Peak Trough (Milsom and Rawson, 1989) occurred principally during the Mid Jurassic Epoch, when they had a marked affect on sedimentation (Rawson and Wright, 2000). Fault movements in the Vale of Pickering/Wolds area occurred principally in the Late Jurassic and Early Cretaceous epochs.

The extent of the effect on sedimentation of fault movements during the Oxfordian is uncertain, however. The Asenby–Coxwold Graben, with its eastwards continuation as the Flamborough Head Fault Zone, is considered to have begun subsiding only in late Kimmeridgian times (Kirby and Swallow, 1987). Recent research has shown that the area affected by synsedimentary faulting was much greater than envisaged by Kirby and Swallow (1987). The whole of the eastern Vale of Pickering was the site of a major synsedimentary graben structure in the Late Jurassic Epoch (BGS, 1998a). Most of the information available concerns the Kimmeridge Clay, whose thickness increases, for instance, from

c. 320 m to 410 m across a branch of the Helmsley Fault south of Ayton. The effect of this fault movement on Oxfordian strata is less clear, but on the south side of the structure there are substantial fault-controlled northward increases in the thickness of the underlying 'Upper–Middle Jurassic strata (undivided)', some of which must inevitably be of Oxfordian age. Evidence will be presented in the Shaw's Gate and Nunnington GCR site reports (this volume) suggesting that movement on the Kilburn Fault may have begun during the Oxfordian Age.

According to Callomon (1964), by a process of elimination, north-east Yorkshire is deduced to be the type area for the Oxfordian Stage. As such, the Oxfordian ammonite faunas of north-east Yorkshire have considerable international interest. The zones and subzones of the stage are listed in (Figure 4.2), with an indication of the range of strata present at each site, and representative ammonites are also figured (Figure 4.5). The locations of the sites are given in (Figure 4.6).

The Cornelian Bay site has yielded well-preserved *Cardioceras* belonging to the initial Scarburgense Subzone of the Oxfordian (Figure 4.5)P, and both here and at the Tenants' Cliff site there are representative ammonites of the overlying Praecordatum Subzone (Figure 4.50). An exceptionally well-preserved ammonite fauna of the Bukowskii Subzone of the Cordatum Zone is present at the Tenants' Cliff site (Figure 4.5)L–N. The Filey Brigg site yields a Cordatum Subzone fauna ((Figure 4.5)H), though the best representatives are found in the Hambleton Hills (Figure 4.51). A Middle Oxfordian fauna from the Vertebrale Subzone is found at the Spikers Hill site (Figure 4.5)J, K. The Upper Calcareous Grit contains abundant ammonites at both the Newbridge and Nunnington sites. These ammonites belong both to the Boreal cardioceratid family (Figure 4.5)A–E and the Sub-Boreal perisphinctid family ((Figure 4.5)F, G). Traces of Sub-Mediterranean province perisphinctids are also found (Wright, 1996a), and the Yorkshire faunas are thus of considerable importance in correlating the Oxfordian of widely separated areas where representatives of one or other of these families are indigenous.

Research on the Yorkshire Oxfordian and Kimmeridgian strata occurred in four phases. The initial work was begun early in the 19th century by Young and Bird (1822). These authors collected and figured many Oxfordian ammonites, and their names are still in use today. William Smith also became involved. He lived at Hackness, near Scarborough, during the 1820s and mapped the Corallian beds in the Hackness Hills (Smith, 1829–1830). Smith also encouraged his nephew John Phillips to publish his (Smith's) full stratigraphical synthesis of the Yorkshire Corallian (Phillips,1829).

The second phase was ushered in by the work of Hudleston (1876, 1878) and Blake and Hudleston (1877). These authors carried out a detailed study of the Corallian beds and set up many of the stratigraphical subdivisions still in use. The area was then mapped by the Geological Survey in the 1880s, with the production of meticulous, beautifully drawn maps. The results were summarized by Fox-Strangways (1892, 1904).

The major phase of work carried out during the early years of the 20th century on the English Oxfordian and Kimmeridgian by Buckman (1909–1930) and Arkell (references listed in Cope *et al.,* 1980) was in southern England. The Yorkshire succession had been so well mapped and described that there seemed to be little more to do. However, Wilson (1933, 1949) refined the stratigraphy and carried out detailed palaeontological studies.

The fourth phase of study, which is still ongoing, was initiated by Wright (*in litt,* 1960), who mapped Corallian rocks at the western end of the Vale of Pickering, and subsequently produced a synthesis of Corallian stratigraphy (Wright, 1972). Several PhD theses were completed in the area (Twombley, 1965; Lee, 1971; Hitchins, 1983), while general syntheses were produced by Hemingway (1974) and Kent (1980b). Wright published detailed studies of the stratigraphy and faunas of the Lower Oxfordian (Wright, 1983, 1992), the Middle Oxfordian (Wright, 1997) and Upper Oxfordian (Wright, 1996a, b) strata. Powell *et al.* (1992) provided a detailed study of the Corallian beds in the Hambleton Hills, while Coe (1995) redescribed sections through the Corallian beds at Filey Brigg and at Newbridge Quarry, and compared these with successions in Dorset. Boreholes drilled in the 1970s enabled the first recognition of the youngest Oxfordian strata in clay facies (Richardson in Institute of Geological Sciences, 1974; Pyrah, 1977; Cox and Richardson, 1982).

Study of the Kimmeridge Clay Formation has suffered from lack of exposure. Cope (1974) produced a synthesis of previous work, with some new records from temporary exposures. Wignall (1993) described the Upper Kimmeridgian section at Golden Hill Pit, and figured numerous ammonites. Investigation of the Kimmeridge Clay by the Institut Francais

du Petrole in 1987, with the drilling of four cored boreholes in the Vale of Pickering, led to a succession of papers on the Kimmeridgian stratigraphy and fauna in that area (Herbin *et al.,* 1991, 1993, 1995; Herbin and Geyssant, 1993; Geyssant, 1994; Oschmann, 1994).

Details of the main lithologies and depositional environments are included in the site descriptions that follow. In the following list of sites (arranged east to west) (O) indicates that the site belongs to the Oxfordian GCR Block and (K) to the Kimmeridgian GCR Block. The location of sites is shown in (Figure 4.6).

Speeton Sands (K)

Filey Brigg (O)

Tenants' Cliff Cayton Bay (O)

Cornelian Bay (O)

Hackness Head (O)

Betton Farm (O)

Spikers Hill (O)

Newbridge (O)

Green Lane Pit (K) and Golden Hill Pit (K)

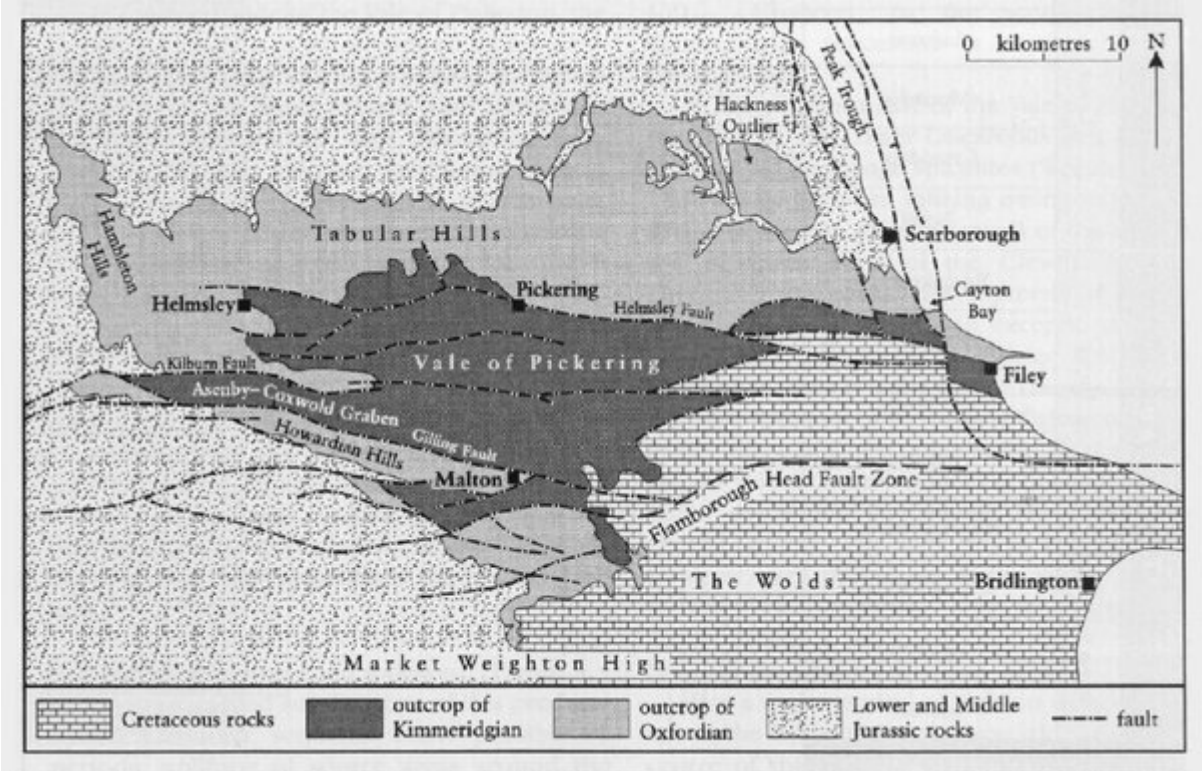
Shaw's Gate Quarry (O)

Snape Hill (O)

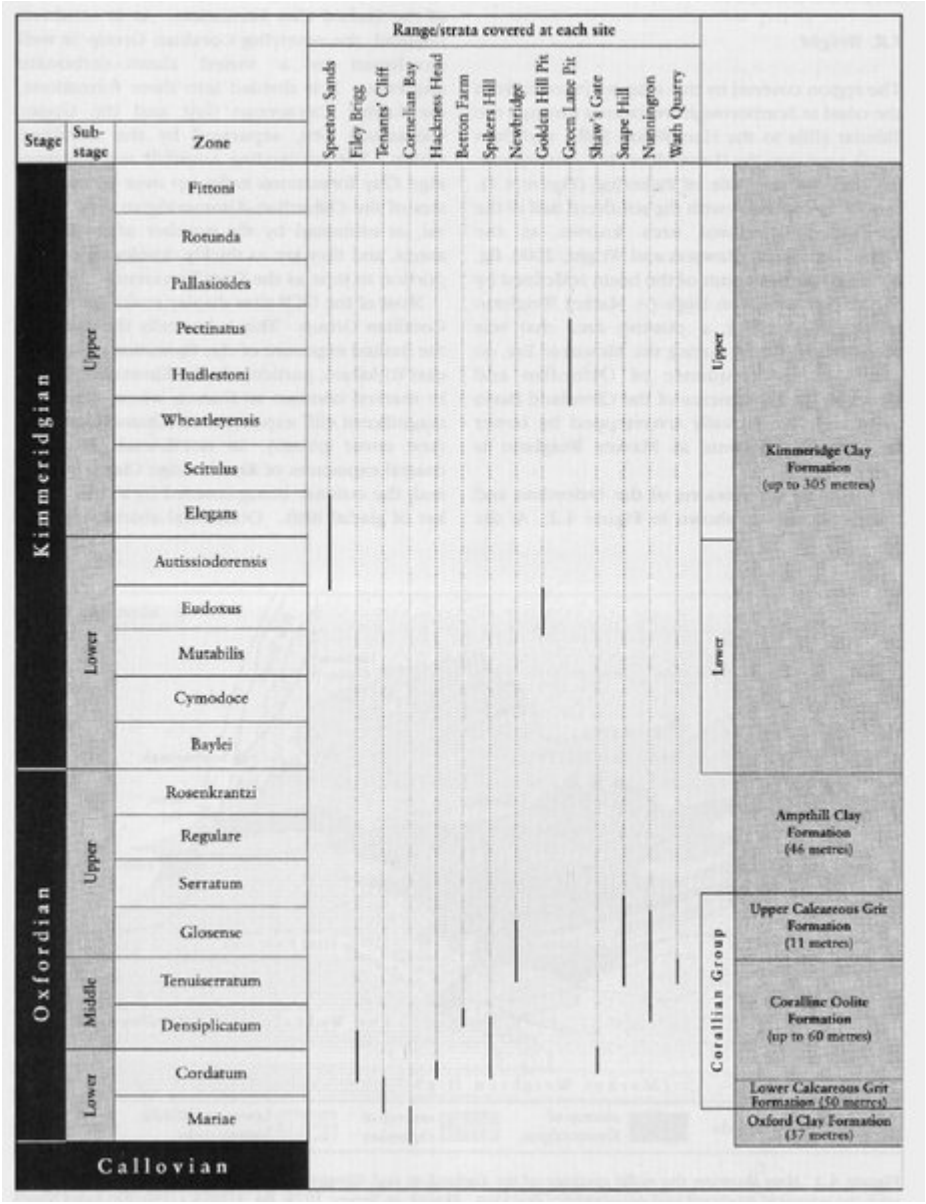
Nunnington (O)

Wath Quarry, Hovingham (O)

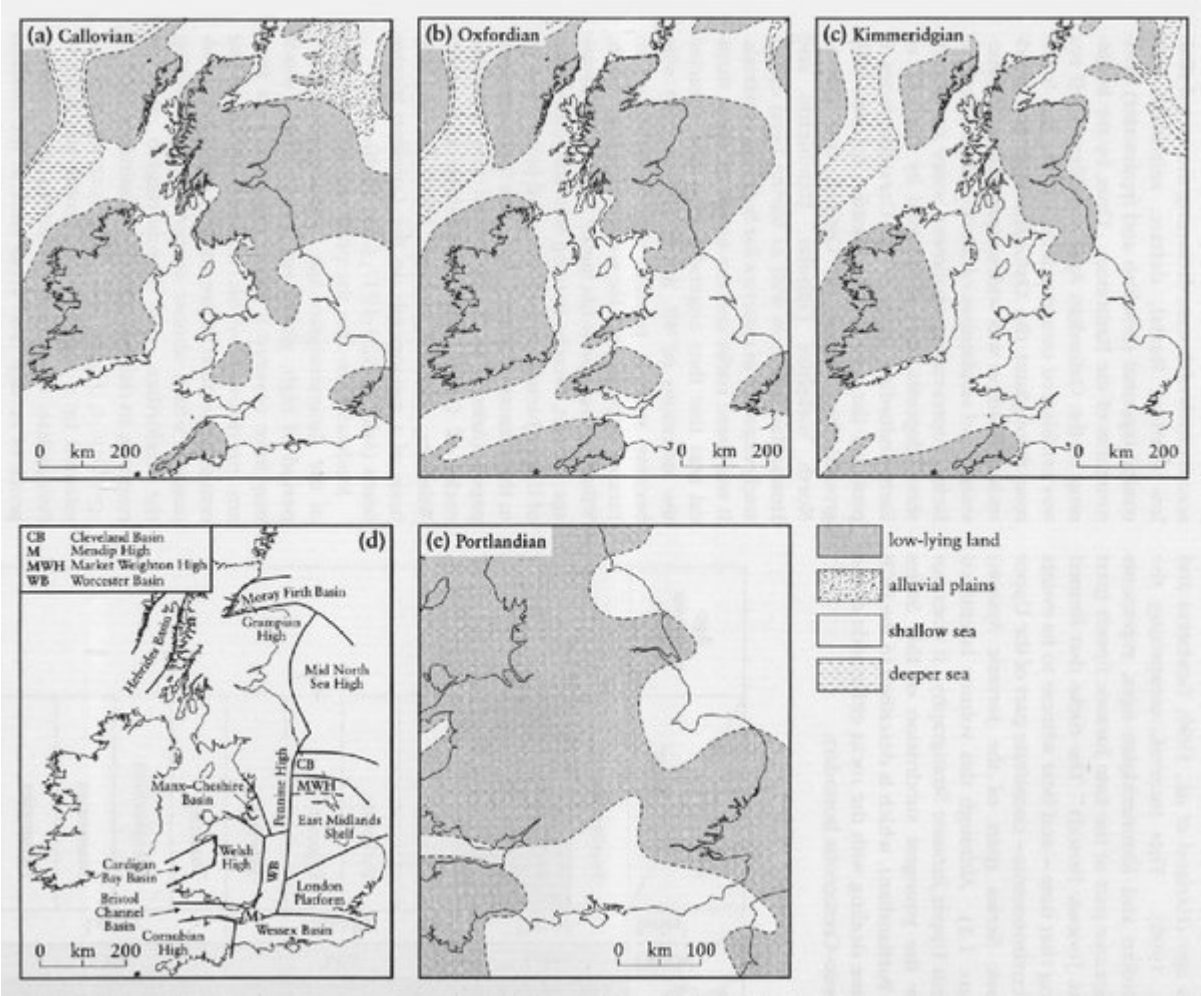
References



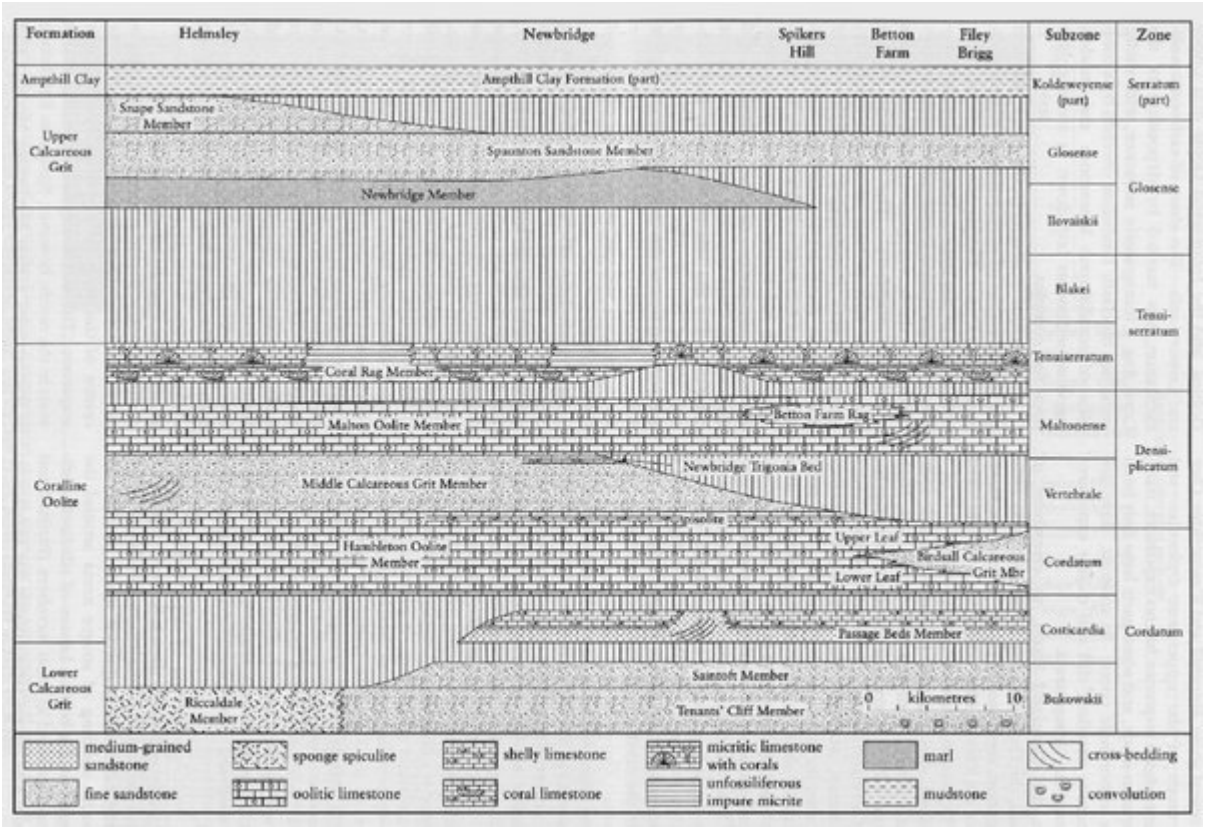
(Figure 4.1) Map showing the solid geology of the Oxfordian and Kimmeridgian beds in the Cleveland Basin, with the principal stuctural and geographical features. (Based on Versey, 1929, fig. 1; BGS 1:250 000 Solid Sheet 54N 02W (Tyne-Tees) (1981); BGS 1:1 500 000 Tectonic map of Britain, Ireland and adjacent areas (1996) and BGS 1:50 000 Sheet 54 (Scarborough) (1998)). In the Vale of Pickering there is a thick cover of Quaternary lacustrine deposits.



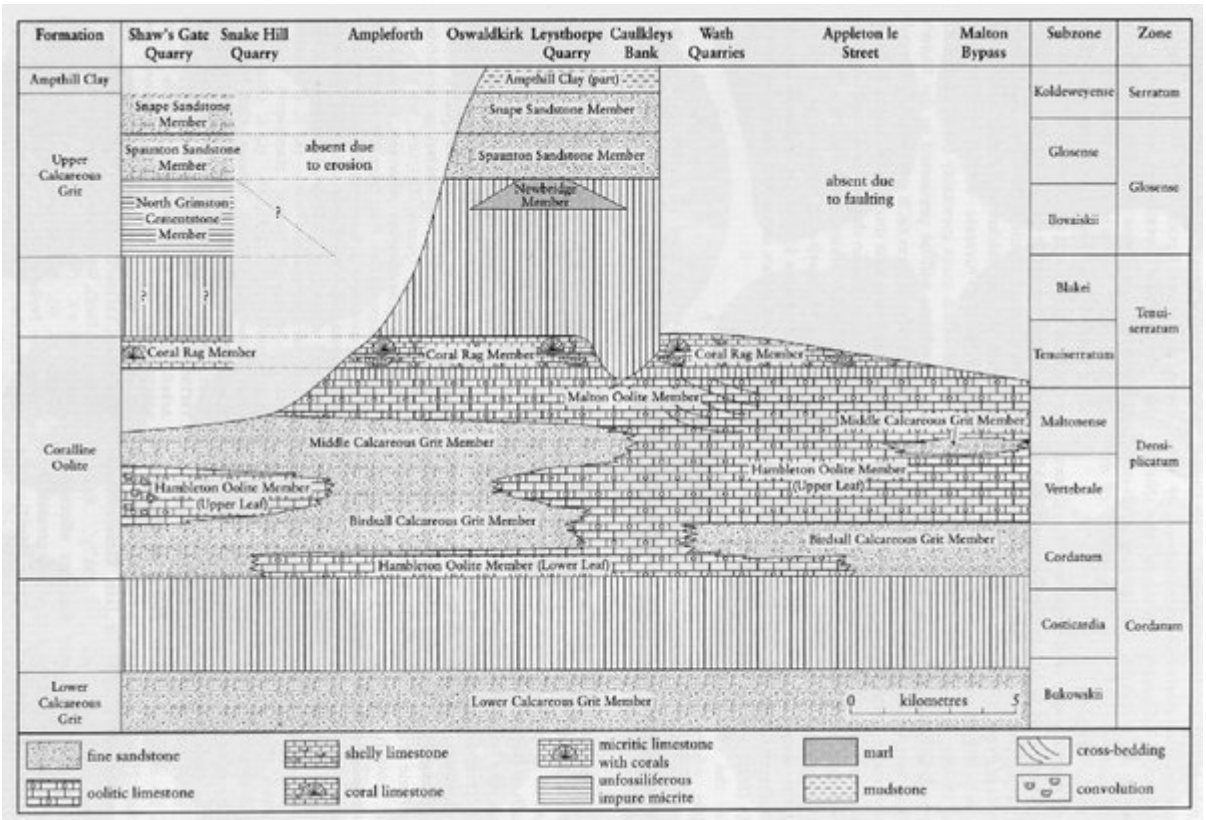
(Figure 4.2) Zones of the Oxfordian and Kimmeridgian stages, showing the stratigraphical ages of each of the formations present in the Cleveland Basin, and the age range of the exposure at each GCR site.



(Figure 1.2) (a)–(c), (e) Palaeogeographical reconstructions for the British area during the late Mid and Late Jurassic (based on Cope and Rawson in Bradshaw et al., 1992; Cope, 1995b). In many cases, the extent of land areas is uncertain. (d) Main structural elements affecting sedimentation in the British area in the Mid-Late 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.)

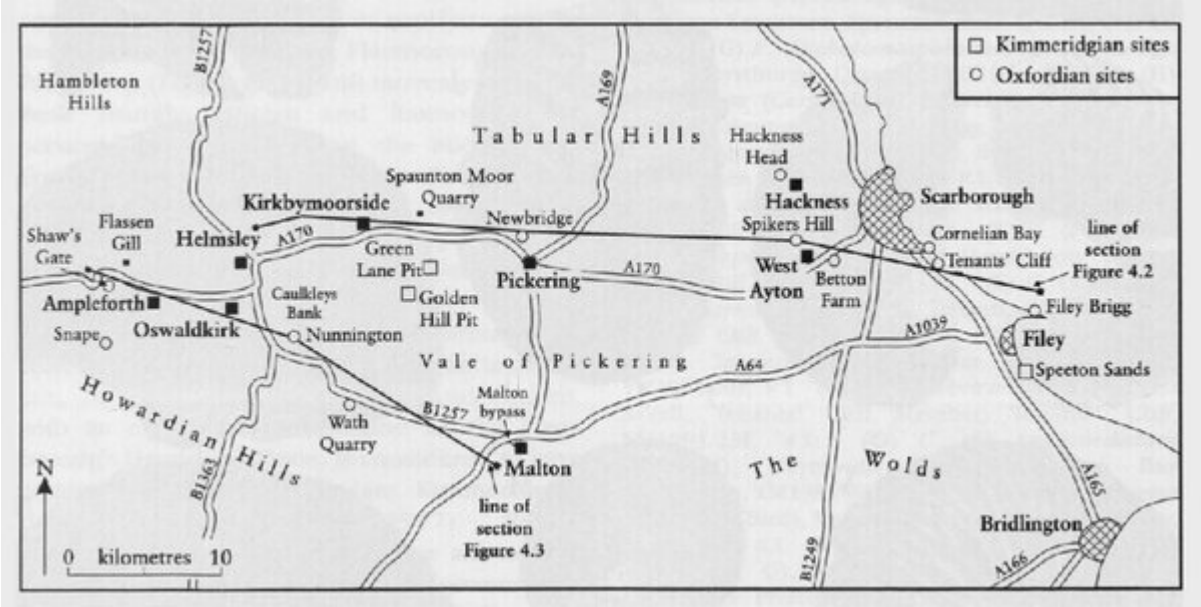


(Figure 4.3) Stratigraphical cross-section of the Yorkshire Corallian Group on the north side of the Vale of Pickering from Helmsley to Filey (after Rawson and Wright, 1995, fig. 15).



(Figure 4.4) Stratigraphical cross-section of the Yorkshire Corallian Group on the south-west side of the Vale of Pickering from the I Iambleton Hills to Malton.

(Figure 4.5) P Selection of ammonites from the Corallian Group of the Cleveland Basin. (A) Amoeboceras nunningtonense Wright (holotype), Spaunton Sandstone, Leysthorpe Quarry, m27, x 1. (B) A. glosense (Bigot and Brasil), Newbridge Member, Leysthorpe Quarry, U/1/14, x 1. (C) A. transitorium Spath, Newbridge Member, Leysthorpe Quarry, U/1/5, x 1. (D) A. ilovaiskii (M. Sokolov), Spaunton Sandstone, Newbridge Quarry, U/2/38, x1. (E) A. newbridgense Sykes and Callomon, Spaunton Sandstone, Newbridge Quarry, U/2/20, x 1. (F) Perisphinctes (Pseudarisphinctes) pachachii Arkell, Spaunton Sandstone, Spaunton Moor Quarry, U/3/63, x0.33. (G) P. (Dichotomosphinctes) sp. Newbridge Beds, Leysthorpe Quarry, U/1/103, x0.7. (H) Cardioceras (Cardioceras)persecans S. Buckman, Birdsall Calcareous Grit, Filey Brigg, YM1983/45F, x 1. (I) C. (C.) cordatum (J. Sowerby), Birdsall Calcareous Grit, Flassen Gill, YM1983/36F, x 1. (1) C. (Vertebriceras) aff. dorsale S. Buckman, Hambleton Oolite, Spikers Hill Quarry, C/2/17, x 1. (K) C. (Plasmatoceras)popilaniense Boden, Hambleton Oolite, Spikers Hill Quarry, C/2/59, x 1. (L) C. (Scarburgiceras) harmonicum Arkell, Tenants' Cliff Member, Tenants' Cliff, YM1983/17F, x 1. (M) C. (S.)reesidei Maire, Tenants' Cliff Member, Tenants' Cliff, YM1983/20F, x 1. (N) C. (Vertebriceras) aff. phillipsi Arkell, Tenants' Cliff Member, Tenants' Cliff, YM1983/23F, x 1. (O) C. (S.)praecordatum (Douvillé), Weymouth Member, Cayton Bay Waterworks, YM1983/9F, x 1. (P) C. (S.)scarburgense (Young and Bird), Weymouth Member, Cornelian Bay, YM1983/3F, x 1. (Photos: (A-E), (H, I), (L–P), J.K Wright; (F, G), K. D'Souza; (J, K) K. Denyer. Collections: Prefixes 'U', 'C', J.K. Wright Collection; 'YM', Yorkshire Museum Collection, York; 'm', Woodend Museum, Scarborough.)



(Figure 4.6) Map showing the locations of Oxfordian and Kimmeridgian GCR sites in north-east Yorkshire, and other localities mentioned in the text.