Osmington

[SY 697 816]–[SY 752 813]

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Introduction

The Oxford Clay Formation (Weymouth Member) and the Corallian Group are exposed in cliff and foreshore exposures for 5 km from Bowleaze Cove eastwards to Ringstead Bay (Figure 2.5). These exposures are the standard for the Oxfordian Stage in southern Britain, and constitute a site of international importance. A near-complete Lower and Middle Oxfordian succession is available, and the Upper Oxfordian is well developed, though having substantial gaps in the succession owing to intraformational erosion. The section has both stratigraphical and historical interest; it includes the type localities for several stratigraphical units, and has produced the type and figured specimens of many fossil species.

The geological prominence of the Osmington exposures first became apparent in the early 19th century when the site was described by Adam Sedgwick (1826). Both Fitton (1827) and Buckland and De la Beche (1836) later provided brief accounts. The first full descriptions of the stratigraphy were those given by Blake and Hudleston (1877, pp. 262–72), Damon (1884, pp. 22, 29, 38–46, plus map) and Woodward (1895, pp. 82–8). Woodward's account was based largely on the work of Blake and Hudleston (1877), these latter authors providing the most complete descriptions of the site in the 19th century.

Buckman (1923–1925, pp. 63–5) described the succession at the site, introducing several new stratigraphical terms, and figuring ammonites collected here. However, it was Arkell's classic studies of the rich bivalve and ammonite faunas (1929–1937, pp. 387–92 with distribution table and 1935–1948, pp. 66–7, 385–6 (lists of figured and cited specimens from the Dorset coast)) that best emphasize the key role played by this site in the studies of Oxfordian geology. Furthermore, Arkell's classic memoir on the geology of south Dorset (Arkell, 1947a), which describes the Osmington site in detail, is still in print some 60 years after it was written.

During the 1960s, 1970s and 1980s, important general descriptions of the Osmington section were published by Cope and Torrens (1969, pp. A43–6), House (1989) and MacFadyen (1970, pp. 110–14). Detailed, up-to-date reviews are given by Callomon and Cope (1995) and Coe (1995). The locality figured prominently in several specialist studies concerning Oxfordian stratigraphy, sedimentology, palaeogeography, palaeoecology and taxonomy (Barnard, 1953; Gordon, 1965; Wilson, 1968a, b; Talbot, 1971, 1973a, b, 1974; Fürsich, 1973, 1974, 1975, 1976a, b, 1977; Brookfield, 1973a, 1978; Wright, 1980, 1986a, b, 1998; Allen and Underhill, 1989; Sun, 1989, 1990; Goldring *et al.,* 1998a; Newell, 2000).

Description

For the purposes of this report, the stratigraphy of the Osmington Oxfordian succession is best illustrated by direct reference to the description of these beds published by Wright (1986a, b). The complete succession is given in (Figure 2.6), and the range of strata present within the standard zonal scheme, emphasizing the significant omissions of strata in the Upper Oxfordian, is given in (Figure 2.7). A generalized log of the Corallian Group is given in (Figure 2.8). The general dip of the succession is easterly, so that the beds young from west to east. However, faults and local steep dips interrupt the succession, which is partially repeated three times. Landslips and growth of vegetation mean that parts of the succession are rarely exposed or very difficult to access. Details of the various exposures are given below.

Oxford Clay Formation (Weymouth Member) (41.5 m)

S.S. Buckman (1923–1925) was the first to note the threefold subdivision of the 'Upper Oxford Clay' (now, following Cox *et al.* (1992), the Weymouth Member) in the Weymouth area. Wright (1986b) refined Buckman's work, and named the following informal subdivisons.

The Furzedown Clay, a mudstone containing pyritized *Cardioceras* (*Scarburgiceras*) *scarburgense* (Young and Bird) and *Quenstedtoceras* spp. now altered to limonite, is sometimes well exposed at the base of the cliff in the centre of the Redcliff Anticline at Shortlake [SY 716 818]. Under favourable conditions the contact with uppermost Callovian mudstone containing *Q.* (*Lamberticeras*) *lamberti* (J. Sowerby) is exposed in the very centre of the structure. The higher part of the Furzedown Clay is hidden by grass and slipped clay. The maximum thickness is probably 18 m.

The Jordan Cliff Clay, comprising 1 m of fissile clays overlain by 8 m of tough, silty, blocky mudstone, was formerly well exposed at the type locality of Furzy Cliff [SY 698 817]. However, much of this site was made inaccessible by the building of sea defences in 1985. A small exposure of silty clays containing *Gryphaea dilatata* J. Sowerby and *Modiolus bipartitus* J. Sowerby can be seen at present at the eastern end of the sea defences (Wright, 1986b), and the unit is well exposed on the northern side of Redcliff Point [SY 712 816], where well-preserved *Gryphaea dilatata* are very common.

The Bowleaze Clay (14.5 m) comprises a series of soft, plastic mudstones, which underlie the landslipped cliff between the sea defences and the holiday camp in Bowleaze Cove [SY 699 818]–[SY 702 819]. Incursions of dark, carbonaceous, silty clay are common, and about the middle of the unit is the well-known Red Nodule Bed, a double row of red-weathering, sideritic concretions. The Bowleaze Clay has yielded an abundant fauna of cardioceratids and a perisphinctid fauna unique to Britain (Wright, 1986b, figs 3, 4; see Figs 2.11G–K). The holotypes of *Peltoceras* (*Peltomorphites*) *hoplophorous* (S. Buckman), *Cardioceras* (*Vertebriceras*) *altumeratum* Arkell and *Goliathiceras* (*Pachycardioceras*) *anacanthum* S. Buckman were collected here. The preservation of the ammonites is often superb. A small exposure of these clays, yielding *Cardioceras* spp., is seen in the low cliffs at the south-eastern end of Redcliff Point [SY 7125 8155].

Redcliff Formation (29.2 m)

There is no one, complete section through the Nothe Grit Member, but the full thickness is thought to be 9 m (Wright, 1986a). The base of the member is exposed at Ham Cliff [SY 712 817]. The sharp, erosive junction reveals the presence of a non-sequence between the uppermost Oxford Clay and this fine-grained, argillaceous sandstone. The upper two-thirds of the formation is exposed in the low cliffs west of Redcliff Point. Scattered concretions contain ammonites (*Cardioceras* (*Cardioceras*) *cordatum* (J. Sowerby), *C.* (*C.*) *persecans* S. Buckman (holotype) and *C.* spp.) preserved in honey-coloured calcite (Wright, 1986a). A small exposure of Nothe Grit occurs at Osmington Mills, immediately east of the slipway [SY 735 816].

The Preston Grit Member forms the highest 1.5 m of the low cliff extending from the Bowleaze Cove holiday camp to Redcliff Point [SY 704 818]–[SY 710 817]. It consists in the main of medium-grained, shelly, calcareous sandstone, blocks of which weather out superbly on the upper shore section, revealing many bivalves, trace fossils and frequent ammonites, including the holotype of *Cardioceras* (*Cardioceras*) *cautisrufae* Arkell, and *C.* (*Subvertebriceras*) *zenaidae* Ilovaisky ((Figure 2.11)F) (Wright, 1986a, 1997). Blocks falling to the shore at Ham Cliff [SY 715 817] reveal numerous *Myophorella hudlestoni* (Lycett). A small exposure is seen at the top of the low cliff just east of the slipway at Osmington Mills [SY 735 816].

A sequence in the lower 8 m of the 12 m thick Nothe Clay Member can be examined at Redcliff [SY 706 818]. Fine-grained, plastic clay alternates with sandy limestones containing abundant bivalve faunas (Figure 2.8). The highest part of the Nothe Clay, and its junction with the Bencliff Grit, is seen at the base of the cliff east of Osmington Mills [SY 738 814]. There is a gradual increase in the clastic content of the clay upwards as the junction is approached, suggesting that the two members are part of the same sedimentary cycle.

The Bencliff Grit Member is very well exposed within the Osmington GCR Site. The section east of Osmington Mills [SY 740 814] was selected as the standard section of the Bencliff Grit by Wright (1986a), the original type section of Blake and Hudleston (1877) south of Weymouth having been built over. Blake and Hudleston's term 'grit' is something of a misnomer, for the standard section comprises 6.7 m of silts and very fine-grained, argillaceous sands showing spectacular swaley cross-stratification (Allen and Underhill, 1989; Sun, 1989; Goldring *et al.,* 1998a). All these authors publish photographs of the section showing the superb bedding structures, this being probably the best exposure of this rare type of cross-stratification in Britain. The cross-stratification is well displayed in the enormous, 1–2 m diameter calcareous concretions that envelop the sandier parts of the sequence. In between the concretions, the uncemented sandy beds have the distinct smell of heavy oil, showing that the rock was at one time an oil reservoir prior to the unroofing of the Weymouth anticline. Westwards, the fossil content of the Bencliff Grit becomes important, and in the rock platform beneath Redcliff [SY 708 818] there are many blocks consisting of Bencliff Grit concretions revealing excellent trace fossils (Fursich, 1975), and occasional bivalves and ammonites (Wright, 1986a).

Osmington Oolite Formation (16.6 m+)

Blake and Hudleston (1877) originated this formation, their definition restricting it to oolites and clays that would now be grouped largely within the Shortlake Member. Arkell (1936a) included lower beds (sandy basal beds of the Upton Member) and overlying beds (Nodular Rubble Member) within an enlarged formation (see site report for Sandsfoot, this volume). The thicknesses given in (Figure 2.6) are for Arkell's standard section at Bran Point. However, as was noted by Wright (1986a), there are considerable thickness variations across the outcrop.

The Upton Member (6.7–8.8 m) is the lowest member of this formation, and is of a more clastic nature than the succeeding members. At the type locality below Upton House, Bran Point [SY 742 813], the Upton Member consists of a regularly bedded series of sandy limestones followed by calcareous mudstones, which become increasingly sandy upwards. Oolite-filled burrows extend from the basal sandy oolite into the Bencliff Grit, emphasizing the abrupt contact. This oolite is succeeded by a distinctive thin development of pisolite or oncolite, containing abundant 10 mm algal pisoliths. The elongated calcareous nodules of the overlying clay suggest an origin in the infilling of *Thalassinoides* burrows. Sandy, bioturbated marl and concretionary limestone complete the Upton Member succession at Bran Point (Figure 2.9). A similar sequence, cut short by erosion beneath the Shortlake Member, is seen in the lower rock platform at Black Head [SY 725 819] (Wright, 1986a). At Red Cliff [SY 708 818], masses of the nodular clay regularly slip onto the beach, where they yield frequent, poorly preserved *Perisphinctes* spp..

The type section of the Shortlake Member is in the rock platform between Shortlake Steps and Black Head [SY 723 819]–[SY 725 818]. Here, it is 10.4 m thick, and contains a spectacular spread of cross-bedded oolites with westerly dipping foresets up to 1 m high. These alternate with bioturbated oolites and clays, and are seen dipping steeply northwards in the rock platform. Correlation of individual beds is only possible over short distances. Thus, the cross-bedded oolite seen at Shortlake passes eastwards into level-bedded oolite with *Diplocraterion* burrows at Bran Point (Figure 2.9). The member is only 5.2 m thick here. Westwards, strongly cross-bedded oolite is seen at the top of Redcliff [SY 708 818]. Profuse shale pellets indicate considerable scouring here. Occasional cardioceratids and perisphinctids are known, including *C.* (*Maltoniceras*) *maltonense* (Young and Bird), *P.* (*Kranaosphinctes*) aff. *decurrens* (Buckman) and *P* (*Dichotomosphinctes*) aff. *dobrogensis* (Simionescu) (Wright, 1986a).

The Nodular Rubble Member (3.2 m) was defined as the Nodular Rubble Limestone by Arkell (1936a) at Bran Point, where a complete section is visible at the base of the cliff It consists of irregularly bedded limestone and marl. The limestone bands are markedly nodular and cream coloured, alternating with calcareous clay in 0.5 m bands. Excellent *Thalassinoides* burrow networks are seen in the low cliffs at Black Head, emphasizing the origin of the calcareous nodules as infilled *Thalassinoides* burrows. Important ammonite records include *Perisphinctes* (*Perisphinctes*) *pumilus* Enay and *P. parandieri* de Loriol (Wright, 1986a).

Clavellata Formation (11 m)

Blake and Hudleston (1877) originated this formation as the 'Trigonia-beds' of Weymouth. Their type section is presumably that at Castle Cove (see Sandsfoot GCR site report, this volume). They included the Nodular Rubble Member, now part of the Osmington Oolite Formation. Wright (in press) included the overlying Sandsfoot Clay within an enlarged Clavellata Formation, the 'Trigonia-beds' becoming the lower Clavellata Member of the Clavellata Formation (Figure 2.6).

Arkell (1936a) chose the section at Bran Point as the standard section of the Clavellata Member (7.1 m) (Figure 2.9). He gave detailed measured sections of most of the coastal exposures, these being later reprinted (Arkell, 1935–1948, 1947a). Wright (1986a) considered that the Bran Point section had deteriorated so much due to weathering that it was better to use the nearby Black Head section [SY 726 819] on which the following description is based. The Clavellata Member is there divided into four informal subdivisions as follows.

The Sandy Block (2.42 m) consists of four or five beds of grey, argillaceous limestone with immature ooliths and fine shell debris. Only a limited amount of quartz sand (5%) is present.

Scattered *Myophorella* sp. and *Perisphinctes* sp. occur. The junction with the underlying Osming-ton Oolite Formation is bored and erosive.

The Chief Shell Beds (2.07 m) are distinguished by the incoming in profusion of *M clavellata* (Parkinson). There are five *M. clavellata*-rich layers containing largely dissociated valves preserved in impure oolite. Disseminated siderite weathers a pale reddish colour. Arkell (1936a) listed a prolific fauna including 20 species of bivalve from this member. Ammonites are common, Wright (1986a) recording *Amoeboceras glosense* (Bigot and Brasil), *Decipia lintonensis* Arkell and *Perisphinctes* (*Pseudarisphinctes*) spp..

The Clay Band consists of a 0.6 m thick incursion of silty, shelly, iron-rich clay.

The Red Beds (2.02 m) comprise layers of tough, grey, sideritic limestone weathering a bright red colour and giving this unit its very distinctive appearance. Softer, argillaceous oolite alternates with the sideritic limestones. Ammonites can be found quite commonly, sometimes exceptionally well preserved ((Figure 2.11)C, D). The following ammonite holotypes, figured by Arkell (1935–1948), were collected from the Dorset coast Red Beds: *Amoeboceras damoni* Spath, *Perisphinctes* (*Perisphinctes*) *cautisnigrae* Arkell, *P.* (*P.*) *uptonensis* Arkell, *P.* (*P.*) *boweni* Arkell, *P.* (*Arisphinctes*) *ringsteadensis* Arkell, *P.* (*A.*) *osmingtonensis* Arkell, *P.* (*Pseudarisphinctes*) *shortlakensis* Arkell, *P.* (*P.*) *damoni* Arkell, *P.* (*P.*) *pachachii* Arkell, *P.* (*F*) *durnovariae* Arkell, *P.* (*Discosphinctes*) *cautisrufae* Arkell, *P weymouthensis* Arkell, *P clothieri* Arkell, *P. branensis* Arkell, and *P. dubius* Arkell.

The succession at Bran Point is very similar to that at Black Head, though the Chief Shell Beds are only half the thickness seen at Black Head.

The Sandsfoot Clay Member (3.9 m) shows a threefold sequence (Wright, 1998), comprising (i) sandy mudstone (0.85 m) overlain by (ii) bioturbated, sandy clay (1.45 m), and this by (iii) fine, silty clay (1.6 m). Bed (i) is highly fossiliferous, with numerous *Myophorella clavellata* (Parkinson) and *Gervillella aviculoides* (J. Sowerby), and ammonites including *Perisphinctes* sp. and *Decipia decipiens* (J. Sowerby). The higher beds, though less fossiliferous, yield frequent bivalves including *Goniomya literata* (J. Sowerby) and *Pleuromya uniformis* (J. Sowerby). There is at present no exposure at Bran Point.

Sandsfoot Formation (11.3 m)

Wright (in press) has revised the Sandsfoot Formation, which now comprises three members: the Sandsfoot Grit overlain by the Ringstead Clay and the Osmington Mills Ironstone (Figure 2.6) and (Figure 2.8).

The Sandsfoot Grit Member (7.35 m) is poorly seen in the cliffs at Black Head [SY 725 819] (Coe, 1995). The three subdivisions of Brookfield (1978) are present. Unit I comprises poorly cemented sand with occasional limonite ooids (0.95 m). This is overlain by soft, uncemented, clayey sand (Unit II, 3.9 m). Unit III comprises fine- to medium-grained, iron-rich sandstone, intensely bioturbated towards the top, with bivalves, limonite ooids and quartz pebbles (2.5 m). From this matrix, Wright (1986a) recorded *Amoeboceras rosenkrantzi* Spath and *Microbiplices anglicus* Arkell (Rosenkrantzi Zone). There is no exposure of Sandsfoot Grit at Bran Point at present. Wright (1986a) demonstrated that erosion beneath the overlying Ringstead Clay Member has attenuated the Sandsfoot Grit in the Osmington area.

The Ringstead Clay Member (3.5 m) was initially described as the Ringstead Waxy Clay by Arkell (1936a). At the type locality of the member at Ringstead Bay [SY 748 813], under favourable beach conditions, up to 1 m of pale grey, very fine-grained, calcareous mudstone can be seen. Fossils are few. Numerous fine carbonate laminae are not affected by bioturbation, and only occasional small, thin-shelled bivalves are present. Above this pale grey mudstone is 0.5 m of reddish, laminated, silty mudstone with siltstone lenses and numerous sideritic concretions and nodules. Arkell (1947a) recorded *Ringsteadia anglica* Salfeld from this horizon. Exposures of the Ringstead Clay (3.5 m) in the cliffs between Black Head and Osmington Mills at [SY 728 829] and [SY 732 818] again show fossiliferous mudstone containing in the upper part abundant orange-weathering ferruginous concretions. These lens-shaped concretions are very diagnostic of the member throughout Dorset.

The Osmington Mills Ironstone Member (0.48 m) was a term introduced for the highest Oxfordian beds by Brookfield (1978). At the type locality in the cliffs at [SY 733 818], the member comprises 0.2 m of limonite-oolite calcareous mudstone containing *Ringsteadia evoluta* Salfeld ((Figure 2.11)A) overlying 0.28 m of dark, silty clay. Taken together, these two comprise bed 25 of Arkell (1936) (see (Figure 3.11)). The Ringstead Coral Bed, exposed to a thickness of 0.16 m in the base of the cliffs in Ringstead Bay [SY 748 813] occupies the same horizon as the calcareous mudstone, and is now regarded as a facies of this part of the Osmington Mills Ironstone Member (Brookfield, 1978). The lateral transition from limonite-oolite calcareous mudstone facies into Ringstead Coral Bed facies is visible in Ringstead Bay between [SY 745 813] and [SY 747 813]. The Ringstead Coral Bed contains tabular or foliaceous colonies of *Thamnasteria concinna* (Goldfuss). These are partly in life position, partly broken, bored or abraded, and set in a fine, micritic matrix along with occasional solitary *Thecosmilia annularis* (Fleming) and numerous bivalves. The latter include *Nanogyra nana, Lopha genuflecta* Arkell, *Astarte* sp. and *Chlamys nattheimensis* (de Loriol). Further coralliferous exposures of calcareous mudstone occur in the cliffs at Black Head (Coe, 1995).

Interpretation

The Oxford Clay is present in a variety of offshore marine facies laid down below the fair-weather wave base, though at a depth where the sediments were sometimes affected by storms. Thus, the fine, plastic, non-bituminous Furzedown Clay contains bottom-living forms such as *Gryphaea,* and cannot have been laid down at considerable depths under anoxic conditions. The Jordan Cliff Clay marks a shallowing, with an increase in the quartz sand content to 5%. A substantial epifauna is present, with numerous surface-dwelling bivalves. The Bowleaze Clay then marks a slight deepening, with the accumulation of pale, calcareous clays. Beds of carbonaceous, bioturbated, sandy clay mark moments when tropical storms swept rotting vegetation and quartz sand out to deeper water. A further deepening gave rise to the Red Nodule Bed. Surface-dwelling bivalves are not commonly preserved here, but deeper burrowing forms are. Siderite appears to have been precipitated as nodules in the topmost few centimetres of the sediment surface. Bivalves living within the sediment were thus preserved in life position without crushing. The conditions required for the precipitation of siderite within sediment are discussed in the Lynch Cove GCR site report (this volume).

The Corallian succession begins abruptly, the Nothe Grit resting on an eroded surface cut in indurated Oxford Clay. The sands of the Nothe Grit coarsen upwards, passing from offshore sandy silts into well-sorted, subtidal sands. Sedimentation of the Preston Grit then took place after a break and minor uplift. It marks the moment of transgression by the sea and is a shallow-water deposit that accumulated rapidly, with only a modicum of sorting under turbulent beach conditions.

Subsidence continued, and with the deeper sea there was the gradual change to deposition of the Nothe Clay. Shell sand was able to transgress repeatedly from the west, thick, shelly limestones being present at this level at Rodwell (see Sandsfoot GCR site report, this volume). Each of the shelly beds marks the building out of high-energy shell sand into a comparatively shallow sea in which clays were being deposited.

No satisfactory explanation of the mode of deposition of the Bencliff Grit has yet emerged. The situation is reviewed by Goldring *et al.* (1998a). Sedimentation occurred during five 'events'. Within each 'event', resting on an erosive surface, is a strongly cross-bedded sandy siltstone (Facies A) . This is overlain by laminated silty mudstone or mudstone (Facies B), passing up into flaser-bedded mud and fine-grained sand (Facies C). The 'event' sequence is completed by fine-grained, ripple-laminated sandstone (Facies D). Not all event sequences are complete. U-shaped, infilled burrows of *Diplocraterium parallellum* extend down from Facies D.

Facies A represents a pulse of sediment introduced under environmental conditions differing from those normally pertaining. Absence of mud drapes rules out intertidal conditions, and Goldring *et al.* (1998a), while keeping their options open, suggest the possibility of a lagoonal setting. Facies A would require unidirectional currents bringing washover sands that would spill into the lagoon landward of a barrier island to the south or south-east. Facies B and C would mark the progression towards more open-water marine conditions, still lagoonal, and Facies D would then represent shallow marine sedimentation in a storm-affected environment. During calmer conditions the area was rapidly colonized by bivalves (*Myophorella*) and by gastropods which left feeding trails (*Gyrochorte*) .

The Osmington Oolite Formation marks a return to predominantly carbonate sedimentation. The oolite, pisolite and concretionary limestone of the Upton Member contain some quartz sand, but also considerable amounts of clay, indicating offshore conditions away from winnowing currents. The sequence becomes progressively deeper, with deposition of nodular clay below the fairweather wave base. Ammonites had free access, and formed the sites for growth of some of the concretions. There is then a return to sandy, bioturbated marl laid down in shallower water.

The Shortlake Member is predominantly oolitic. Conditions were lagoonal or intertidal, with fine clays alternating with cross-bedded, sometimes heavily bioturbated, oolite. The strongly cross-bedded oolite was laid down as an ooid delta that migrated across the area. The cross-bedding dips to the west or south-west. This implies that to the north-east lay the lagoonal area wherein sea water was evaporated and supersaturated in calcium carbonate ready to precipitate as ooids in tidal channels. The Nodular Rubble was laid down after a break, under much quieter, offshore shelf conditions favouring the growth of the sponge *Rhaxella.*

The marine transgression that heralded Upper Oxfordian sedimentation in the area is marked by a marine bench cut into the Nodular Rubble, with substantial borings and colonization by burrowing organisms. This Clavellata Formation transgression was gradual and persistent, so that the sediments were deposited in progressively deeper water. The shallow-water sandy carbonates of the Sandy Block thus pass up into the prolifically fossiliferous *Myophorella* shell beds, the basis of the *Myophorella clavellata* association of Fürsich (1977). The association is dominated by shallow-burrowing and surface-dwelling bivalves, which lived in fine-grained, offshore sediment. The shells were brought together into huge shell banks during storms, with the valves frequently dissociated and convex upwards. Finally, the clay and ferruginous micrite of the Clay Band and the Red Beds point to deeper-water conditions below the wave base, with *Myophorella* frequently preserved with both valves together.

The basal Sandsfoot Clay is markedly sandy, averaging more than 50% fine sand, and is more properly called a sandy mudstone. The basal bed marks the rejuvenation of source areas prior to a more substantial transgression, which led to deeper-water marine clays being laid down over the whole area. These clays are seen particularly well at Black Head, where there is a progressive fining upwards.

After a prolonged period for which there is no sedimentary record (Figure 2.7), south Dorset was subject to renewed uplift, most marked in the present area. Erosion of the Sandsfoot Clay took place, so that some 10 m of beds present in the Fleet Lagoon area are absent here (Wright, 1998). Because of its cross-cutting relationship, the overlying Sandsfoot Grit bears no relation to the Sandsfoot Clay in the manner of a shallowing-upwards cycle. Much of the Sandsfoot Grit is quite coarse grained, and appears to be built up of shelly beach sands, which alternate with pebbly chamositic sands possibly laid down in lagoonal areas in between beach bars.

The Ringstead Clay, with its fine, unbioturbated, laminated sediment and limited fauna of thin-shelled bivalves, suggests deposition in shallow, sheltered, lagoonal conditions, possibly hypersaline. The presence of siderite concretions implies a lack of marine circulation. In these circumstances the bottom water becomes depleted in sulphate, and siderite forms in preference to pyrite. Such conditions are toxic to bottom life. Fully marine conditions were reestablished in the uppermost Oxfordian, with deposition of the Osmington Mills Ironstone and Ringstead Coral Bed. The sedimentation rate was very slow. Encrusting bivalves and serpulids proliferated to the west, with the input of limonite ooids, and eastwards at Ringstead the input of clay and clastic grains was sufficiently low that for a short period the shallow sea floor was colonized by both encrusting and phaceloid corals. This was a deep water accumulation, below the fairweather wave base. Foliaceous and branching corals were surrounded by areas of lime mud containing a prolific bivalve fauna. The coral–bivalve fauna was frequently reworked, but by currents not sufficiently strong to damage it, or to winnow away the lime mud.

Numerous stratigraphical breaks have been recognized within the Osmington Corallian attesting to episodes of infra-Oxfordian erosion. These relate to tectonic instability within the Wessex Basin, and have been used locally as marker horizons (Talbot, 1973a). The discontinuities, of which at least nine are recorded at Osmington (Wright, 1986a), lie at irregular stratigraphical intervals between highly variable lithologies. Many authors have tried to see a pattern of cyclic sedimentation, the cycles bounded by erosion surfaces (Arkell, 1947a; Talbot, 1973a; Sun, 1989). The cycle generally begins with an arenaceous unit, passing up into a clay unit that is frequently followed by oolitic limestone. British Jurassic strata often show evidence of such sedimentary cycles, which may be impersistent laterally or incomplete vertically. They are often interpreted as representing successive eustatic transgressions and regressions, although Wilson (1968b) has argued that they have more significance in terms of non-carbonate clastic deposition than the eustatic changes in sea level preferred by Hallam (1978). The unstable tectonic environment of southern England, witnessed by the many localized periods of uplift and erosion, suggests strongly that the cycles owe their origin to variable rates of tectonic subsidence.

Newell (2000) has taken the five principal erosion surfaces that bound the four formations into which the Corallian Group is divided, and produced a sequence stratigraphical interpretation of the Dorset succession. This is set out in (Figure 2.10).

Sequence 1 (Redcliff Formation)

The Nothe Grit, a distal shelf clastic deposit, sits a little uneasily as a lowstand systems tract at the base of Sequence 1. However, it is overlain by a clear transgressive systems tract comprising the Preston Grit and limestones of the Nothe Clay. The Preston Grit is interpreted as part of a transgressive sheet forming in a mid-ramp setting. This system was drowned around maximum flooding, and covered by mudstone containing bored micrites and bioclastic and sideritic limestones typical of the condensed zone formed under very low sedimentation rates around peak transgression. The highstand systems tract is represented by the fine mudstones of the upper part of the Nothe Clay.

The falling stage systems tract is represented by the Bencliff Grit. The sharp-based sandstone bodies of this member are typical of those formed under the control of relative sea-level falls. Here, the shoreface zone of wave scour moved basinwards, producing a regressive surface of erosion. This erosion surface is overlain by thin sand bodies that are smeared across the shoreface in response to falling sea level. Wave scour reworks and concentrates sufficient sand in an onshore direction to develop a prograding sand body.

Sequence 2 (Osmington Oolite Formation)

The Upton Member represents the transgressive systems tract, with sandy, bioclastic limestone overlain by deeper-water nodular clay. The high-stand systems tract is dominated by oolitic limestone. Highstands are generally the optimum time for carbonate production, because erosion of clastic sediment is at a minimum, and the area of shallow marine carbonate production has reached its maximum extent. The occurrence of trough and planar cross-bedding, mud drapes and tidal scours indicates the importance of tidal processes in ooid formation.

Newell includes the Nodular Rubble Member in Sequence 2. Though it obviously formed at a highstand, it appears to have formed during a transgressive event situated in between Newell's Sequence 2 and Sequence 3. This event is represented across much of England by the Coral Rag Member (Wright, in press). In Yorkshire, there is often a transgressive systems tract (shelly, coralliferous oolite), overlain by a high systems tract (micritic, coralliferous limestone) (see site report for Wath Quarry, this volume).

Sequence 3 (Clavellata Formation)

The transgressive systems tract follows the same pattern as in the underlying sequences, with sandy, bioclastic wackestone (Sandy Block) overlain by high-energy, skeletal–ooidal intraclast grainstone (Chief Shell Beds). The finer-grained Red Beds mark a maximum flooding condensed interval.

The highstand systems tract comprises calcareous, intensely bioturbated, sandy mudstone (Sandsfoot Clay Member), passing up, in beds only preserved in the Fleet Lagoon area (Wright, 1998), into fine clays with well-preserved, siderite-infilled bivalves and ammonites, a facies reminiscent of the Weymouth Member.

Sequence 4 (Sandsfoot Formation)

Sequence 4 as defined at Osmington begins with the medium-grained, bioturbated sands of the Sandsfoot Grit Units I and II (transgressive systems tract), followed by the phosphatic chamosite oolite sands of Unit III (condensed stage), the Ringstead Clay (highstand systems tract) and Osmington Mills Ironstone (condensed interval or falling stage systems tract).

The Osmington Mills Ironstone is then erosively overlain by the early Kimmeridgian Inconstans Bed (see site report for Ringstead, this volume), the beginning of the next sequence. Contrary to the view expressed by Newell (2000), Kimmeridgian strata should not be included in Sequence 4.

Biostratigraphy

The Osmington site is also of great importance to ammonite biostratigraphers. The Weymouth Member of the Oxford Clay has yielded excellently preserved *Cardioceras* spp. ((Figure 2.11)G–I, K) and *Perisphinctes* spp. ((Figure 2.11)J) (Costicardia Subzone). The cardioceratid fauna of the Costicardia Subzone Red Nodule Bed was listed by Arkell (1945) as being the principal fauna illustrative of this subzone. The perisphinctid fauna, which occurs just below the Red Nodule Bed, is so far unique, not having been described for any other locality.

The Nothe Grit and Preston Grit have yielded well-preserved ammonites of the Cordatum Subzone and the early Vertebrale Subzone respectively ((Figure 2.11)F). Unfortunately much of the remainder of the Middle Oxfordian contains few well-preserved ammonites.

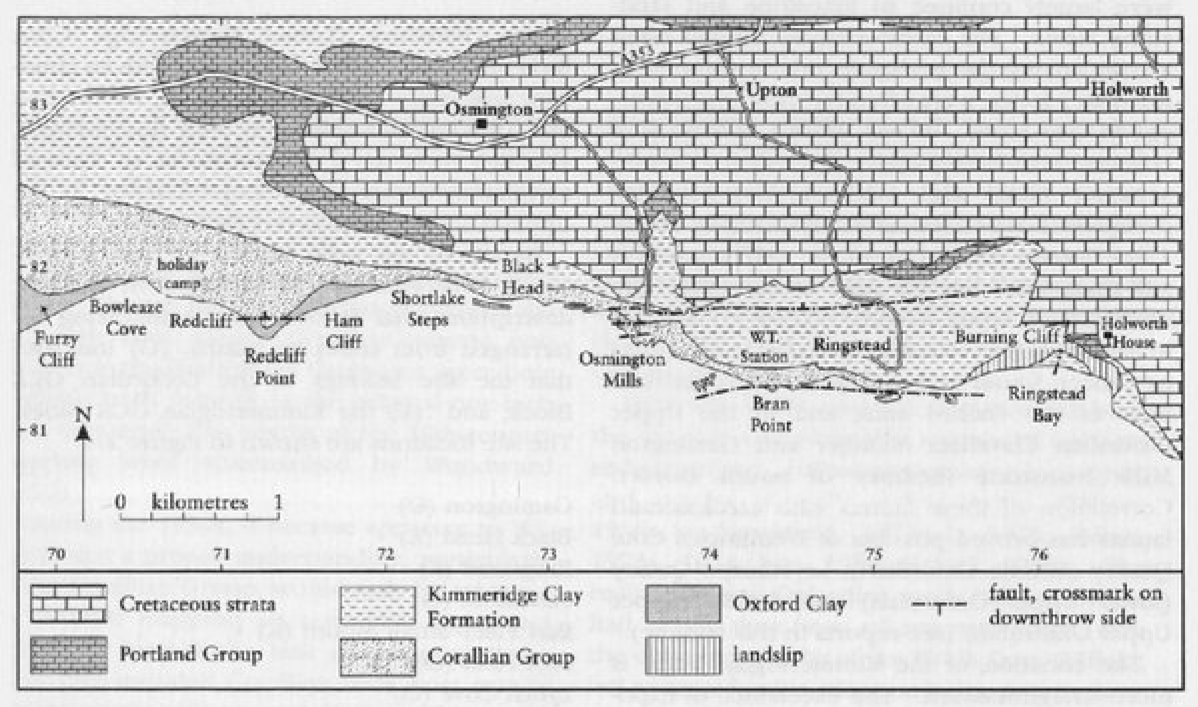
The Upper Oxfordian includes two very important ammonite faunas. The Clavellata Member yields the excellent perisphinctid fauna typifying the Sub-Boreal Cautisnigrae Subzone ((Figure 2.11)C, D), and numerous *Amoeboceras* typifying the Boreal Glosense Subzone ((Figure 2.11)B, E). The two subzones are thus coeval. The Osmington Mills Ironstone yields excellently preserved *Ringsteadia* spp. ((Figure 2.11)A), comprising the type fauna of the latest Oxfordian Evoluta Subzone.

Conclusions

The Oxfordian exposures at the Osmington GCR site are superior to those at any other locality in England. The site incorporates the stratotype localities for 11 formations and members of the Oxford Clay Formation and Corallian Group, including the Weymouth Member (Lower Oxfordian), the Preston Grit and Osmington Oolite (Middle Oxfordian) and the Clavellata Member, Ringstead Clay and Osmington Mills Ironstone (with Ringstead Coral Bed) (Upper Oxfordian). The site also displays the best exposures of the Nothe Grit (Lower Oxfordian) and the Nothe Clay and Bencliff Grit (Middle Oxfordian), whose type localities lie within the boundary of the neighbouring Sandsfoot GCR site (this volume).

The monographs of Arkell concerning both the bivalve (1929–1937) and ammonite faunas (1935–1948), respectively, emphasize the key biostratigraphical importance of the whole Oxfordian invertebrate assemblage that occurs at Osmington. The holotype specimens of no less than 46 species of bivalve and ammonite were collected here. Of the 15 constituent sub-zones of the Sub-Boreal subzonal scheme, 12 are represented by ammonite-bearing strata at the site. Both the Oxford Clay and the Corallian Group are of exceptional interest here due to the wealth and variety of sediments and sedimentary structures that they display and the richness and diversity of the Oxfordian faunas.

References

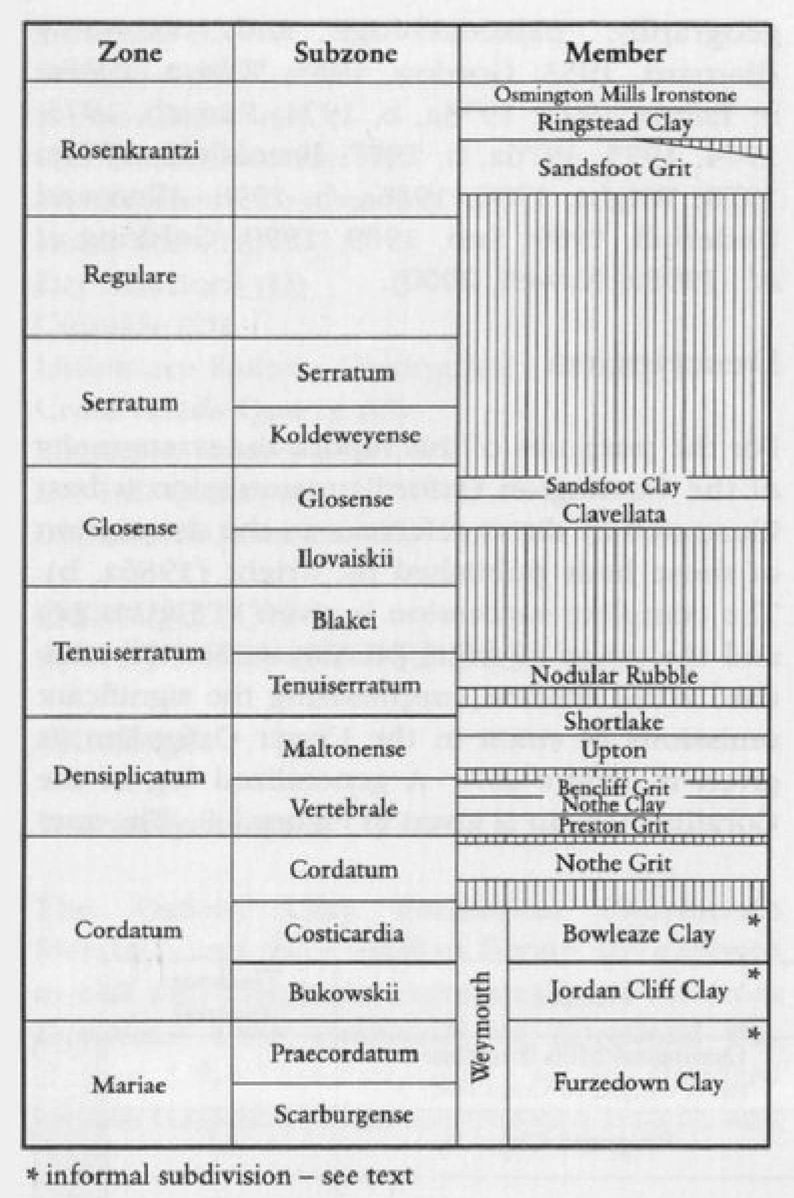


(Figure 2.5) Sketch map of the solid geology of the Furzy Cliff–Ringstead Bay area (based on Cox and Gallois, 1981, fig. 5 and BGS Sheet 341/342' (West Fleet and Weymouth) 1976).

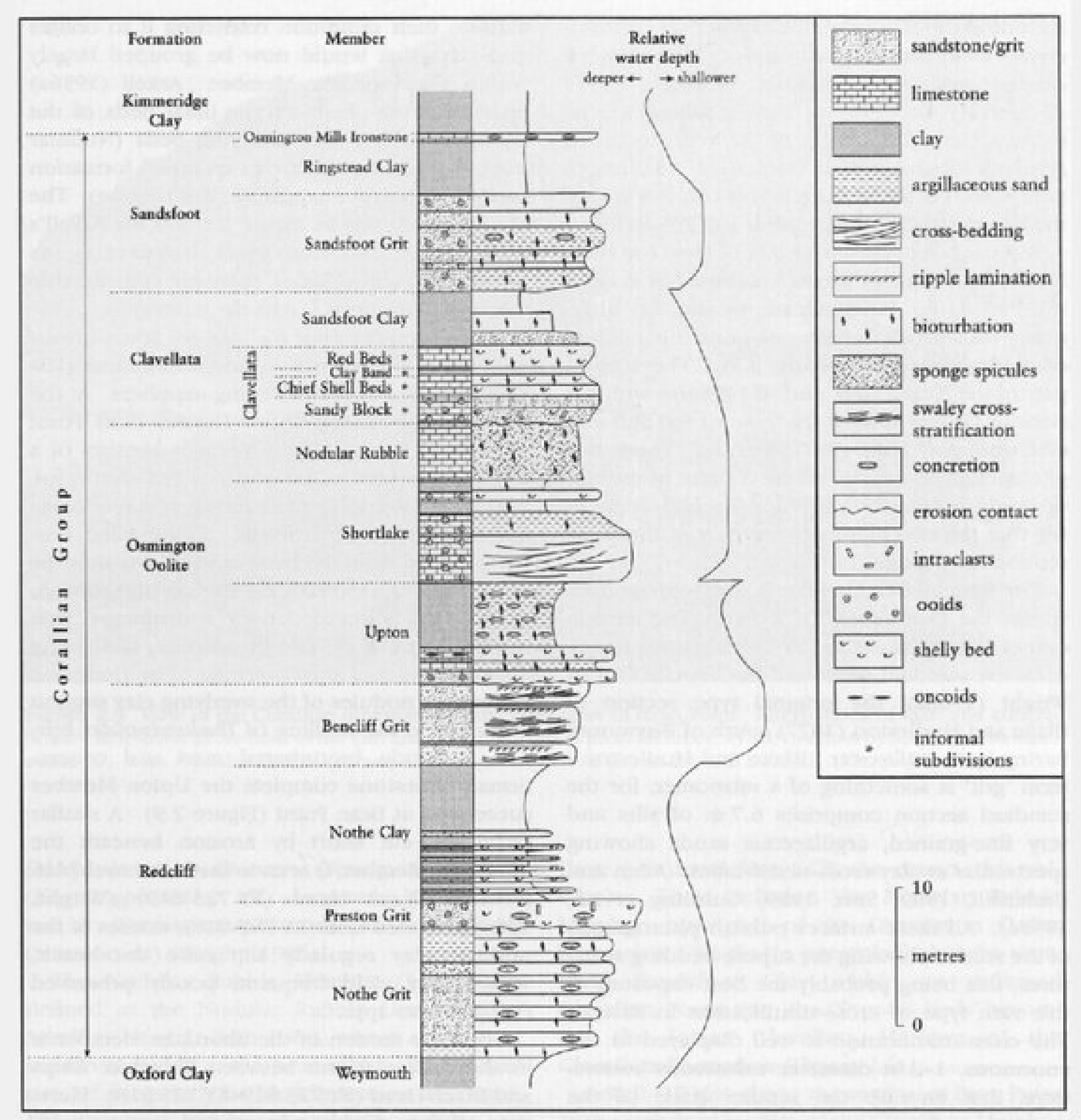
Substage	Formation	Member		Thickness (metres)	
Upper Oxfordian	Sandsfoot	Osmington Mills Ironstone (with Ringstead Coral Bed)		0.5	Corallian Group
		Ringstead Clay		3.5	
		Sandsfoot Grit		7.35	
		Sandsfoot Clay		3.9	
	Clavellata	Clavellata	Red Beds *	2.0	
			Clay Band *	0.6	
			Chief Shell Beds *	2.1	
			Sandy Block *	2.4	
Middle Oxfordian	Osmington Oolite	Nodular Rubble		3.2	
		Shortlake		5.1	
		Upton		8.3	
	Redcliff	Bencliff Grit		6.7	
		Nothe Clay		12.0	
		Preston Grit		1.5	
		Nothe Grit		9.0	
Lower Oxfordian	Oxford Clay	Weymouth Member	Bowleaze Clay (containing Red Nodule Bed) *	14.5	
			Jordan Cliff Clay *	9.0	
			Furzedown Clay *	18.0	

* informal subdivisions (see text)

(Figure 2.6) The complete stratal succession at the Osmington GCR site.

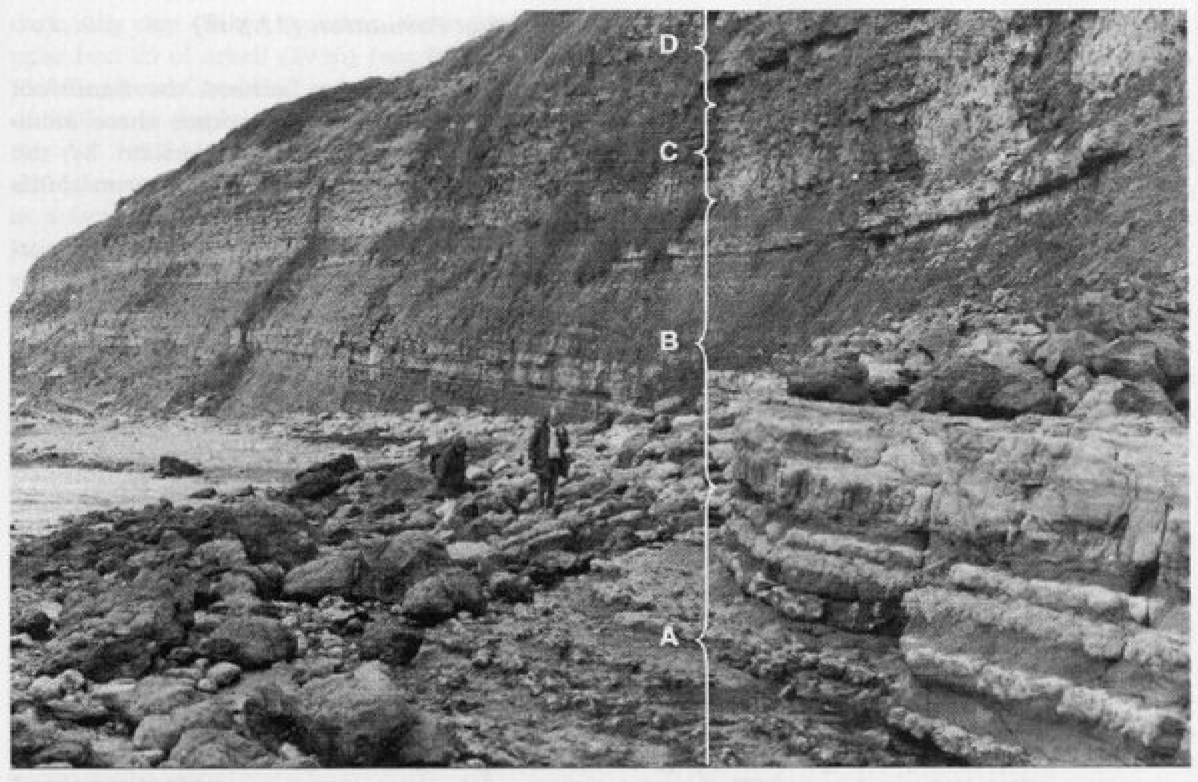


(Figure 2.7) The ammonite zones and subzones of the Oxfordian Stage showing the zonal range of the strata present at the Osmington GCR site.

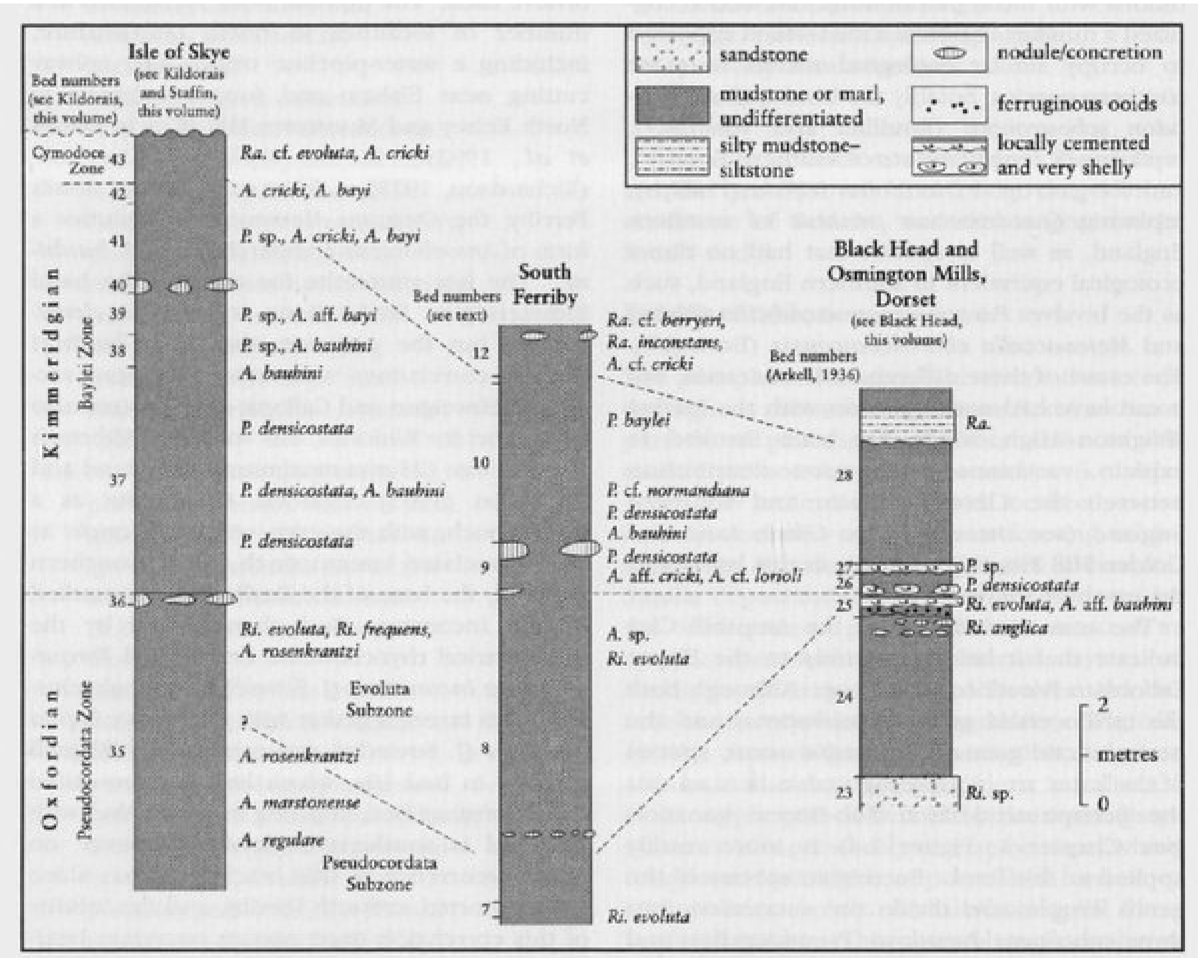


(Figure 2.8) Log of the Corallian Group at Osmington, (after Sun, 1989, figs 6, 7, 10 and 13).

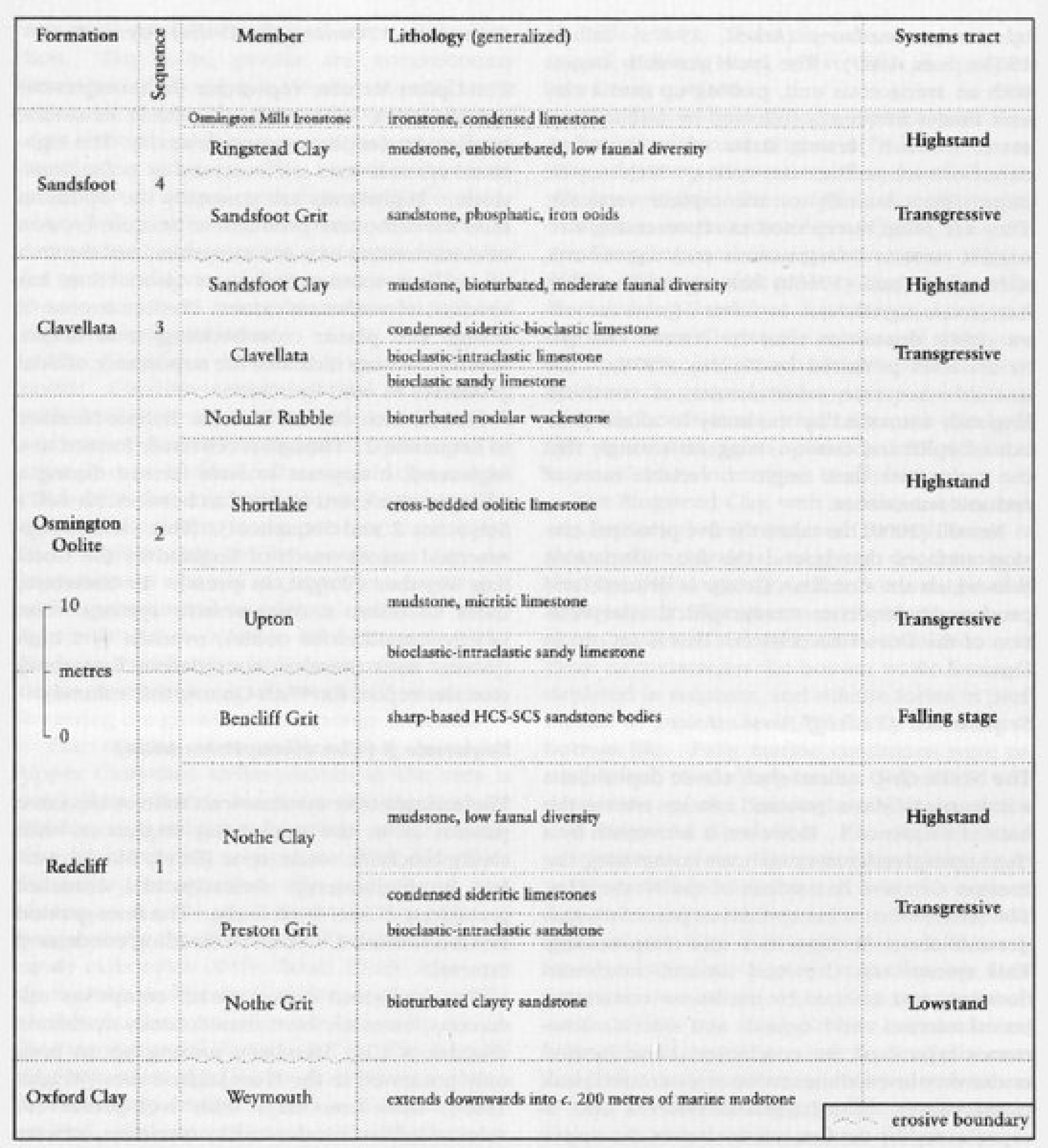
(Figure 2.11) Selection of Oxfordian ammonites from the Dorset coast Oxfordian exposures. (A) Ringsteadia evoluta Salfeld, Osmington Mills Ironstone, Black Head, J44969, x0.95. (B) Amoeboceras glosense (Bigot and Brasil), Clavellata Member, Black Head, D/C/25, x0.95. (C) Perisphinctes (Perisphinctes) uptonensis Arkell, Clavellata Member, Black Head, DC42, x0.80. (D) P. (Pseudarisphinctes) pachachii Arkell, Clavellata Member, Black Head, D/C/46, x0.48. (E) Amoeboceras ilovaiskii (M. Sokolov), Clavellata Member, Black Head, D/C/29, x1. (F) Cardioceras (Subvertebriceras) zenaidae Ilovaiski, Preston Grit, Redclig D/C/90, x 1. (G, H) Cardioceras (Vertebriceras) quadrarium S. Buckman. Red Nodule Bed, Furzy Cliff, D/O/35, x 1. (I) Cardioceras (Cardioceras) costicardia S. Buckman, Red Nodule Bed, Furzy Cliff, D/O/20, x 1. (J) Perisphinctes (Dichotomosphinctes) sp. Weymouth Member, Bowleaze Clay, Furzy Cliff, D/O/41, x0.58. (K) Cardioceras (Scarburgiceras) praecordatum Douvillé, East Fleet section, just north-west of the Lynch Cove GCR site, D/O/1, x 1. (Photos: (A, C, D) K. D'Souza; (F), K. Denyer; (B, E, G–K), J.K. Wright. Collections: Prefix 'D', J.K. Wright collection; prefix , Sedgwick Museum Collection, Cambridge.)



(Figure 2.9) View of the Corallian limestones in the cliffs west of Bran Point. Alternations of marl and concretionary limestone in the base of the cliff and rock platform (Upton Member, A) are overlain by Shortlake Member oolite (B), with Nodular Rubble (C) and Clavellata Formation (D) in the cliff behind. (Photo: J.K. Wright.)



(Figure 3.11) Correlation between the Oxfordian–Kimmeridgian boundary beds at South Ferriby and those in Dorset and Skye (after Page and Cox, 1995, fig. 2). A. = Amoeboceras, P. = Pictonia, Ra. = Rasenia, Ri. = Ringsteadia.



(Figure 2.10) Sequence stratigraphical interpretation of the Corallian sequence at the Osmington GCR site (after Newell, 2000, fig. 2).