Studland Bay, Dorset

[SZ 438 230]–[SZ 037 828]

Highlights

The relatively thin Reading Formation and London Clay of Studland represent proximity to the western margins of the Palaeogene sedimentary basin. The Studland Bay site may demonstrate the early regression of the London Clay sea in contrast with its far longer persistence to the east. Alternatively, it may have originally been thicker and later considerably eroded prior to the deposition of the fluvial Redend Member of the Poole Formation.

Introduction

The site extends from the unconformable contact with the Upper Cretaceous Chalk northwards to just beyond Redend Point. Apart from the few instances where sediments of possible Tertiary age infill solution pipes in the Chalk, such as is seen in St Oswald's Bay, to the east of Durdle Door [SY 812 802], Studland Bay is the most westerly locality in southern England where the Palaeogene/Chalk unconformity is exposed. The Palaeogene strata present are the Reading Formation, the London Clay and the Poole Formation, represented by the Redend Member (Redend Sandstone) and the basal few metres of the Corfe Member.

Aspects of Studland were referred to by Lyell (1827) in his pioneer survey of the Tertiary succession in the Hampshire Basin but little was written about it until Monkton (1910) reported a visit by the Geologists' Association. Arkell (1947) gave a more detailed account in which the post-London Clay strata were referred to as the Bagshot Beds.

Little has been published since Arkell's description, with a few exceptions, such as a brief discussion of the plant fossils of the Corfe Member by Chandler (1962, p. 4) and that recording a short visit by the Tertiary Research Group (Cooper *et al.,* 1976). Microplankton have been obtained from the London Clay (Williams and Downie, 1966; Bujak *et al.,* 1980) which was also sampled by Costa and Downie (1976) in their work on the dinoflagellate zonation of the Palaeogene. A relatively brief reference to the London Clay and Redend Sandstone of this locality was made by King (1981) in his wider and comprehensive account of the London Clay of southern England. More recently, his unpublished PhD thesis includes a stratigraphical log of the London Clay (King, 1991, fig. A16).

Although referring to an area to the north and east of this site, the recent Bournemouth Memoir (Bristow *et al.,* 1991) provides considerable information that also assists interpretation here (see (Figure 6.1) which summarizes the stratigraphy of the Palaeogene strata in the western part of the Hampshire Basin).

Recently (December, 1998), the author has learned that, following re-mapping by the British Geological Survey, doubts have been expressed as to whether the lithostratigraphical assignment of much of the succession to the Reading Formation and the London Clay is valid (see later discussion).

Description

The Palaeogene succession at Studland Bay (Figure 6.2) and (Figure 6.3), in ascending order, comprises the Reading Formation, the London Clay and the Poole Formation, the last of these represented by the Redend Member and a few metres of the Corfe Member. It rests unconformably on the Upper Cretaceous Chalk.

The unconformity

The contact between the Reading Beds and the underlying Chalk is a particularly striking example of the irregular surface which is often associated with this unconformity. Erosional cavities up to 3 m wide and containing Palaeogene material extend down into the underlying Cretaceous strata. Those which are internally well-stratified indicate incremental, primary

sediment accumulation. The junction of the Reading Formation and the Chalk is also marked by scattered, well-rounded flint pebbles mixed with unabraided flint nodules with strongly limonitized crusts. The latter may have been derived from the in-situ dissolution of the Chalk below the Palaeogene cover after the latter had accumulated.

Recent work by the British Geological Survey has shown that the nature of the Chalk/Palaeogene surface in Dorset has in places been affected by tectonism. For example, the hummock of Chalk to the north of the main Chalk outcrop in Studland Bay mentioned by Arkell (1947, p. 221) is now thought to be a fault block (C.M. Barton, pers. comm.).

Lithological succession

Thin basal sands and granule conglomerates of the Reading Formation occur above the sub-Palaeogene unconformity whilst the top of the succession at the northern end of the bay consists of ferruginous sandstones (the Redend Member) with a thin sequence of lignitic sands and muds above. Very few exposures occur in the central part of the bay but the succession here (the upper part of the Reading Formation and the London Clay) is predominantly argillaceous. As Arkell (1947, p. 222) pointed out, the thickness of the Palaeogene strata present in Studland Bay is difficult to measure. He estimated a total of 305 feet (93 m) of which *c.* 44 m was allocated to the Reading Formation and London Clay combined, and *c.* 42 in to the Redend Sandstone (Figure 6.4).

Stratigraphy

The lower part of the Reading Formation, including some 2 m of the Reading Basement Bed of Edwards and Freshney (1987b) (formerly the 'Bottom Bed' of earlier authors), is exposed at the southern end of the bay. At the present time, the upper part is concealed by slips and vegetation although colour-mottled muds have been observed below the London Clay (C. King, pers. comm.).

The London Clay is very poorly exposed on slumped and strongly vegetated slopes above shore level but King (1991, fig. A16) was able to recognise some 22 m resting on the muds of the Reading Formation. King assigned the lowest part of the London Clay (just over 8 m of sands and silts) to his Tilehurst Member (now included in the Harwich Formation, Ellison *et al.* 1996). This is in part glauconitic and contains the brachiopod *Lingula* one to two metres or so from the top. The next 8 m comprise mainly bioturbated silty clays assigned to his informal division A3 on the basis of their stratigraphical position, and on an assemblage of agglutinating foraminifera similar to that found by King in his division A3 in Alum Bay. A thin sand occurs about a metre below the top of this interval. It is overlain by a 1.5 m sand with a pebbly base that King (1991) considered as probably a thin representative of division B1, whilst his measured log is completed by 2 m of sandy silts with sparse pebbles at the base, tentatively referred to division B2.

An unexposed interval of uncertain thickness separates the measured 22 m log from the overlying Redend Member and it may be that, at least in part, this includes strata assignable to the London Clay.

Curry *et al.* (1978) used both the terms Redend Sandstone and Redend Member for the sandstone which succeeds the London Clay at Studland (Figure 6.3). It comprises the lowest of the three members of their Poole Formation, later formally defined by Edwards and Freshney (1987b) and included in the Bournemouth Group of these authors. The member would have been part of the Lower Bagshot Beds of Gardner (1879a) and also the 'Studland Series' mentioned briefly by King (1981, p. 32). The Redend Member is not represented at other more easterly localities.

Biostratigraphy

Bujak *et al.* (1980) reported dinoflagellate-barren sediments near the base of the London Clay but found material indicative of the Deflandrea phosphoritica dinoflagellate Assemblage Zone (LC–1) 0.9 m from the top of the formation. Costa and Downie (1976, p. 604) collected the zone fossil *Wetzeliella meckelfeldensis* within 2 m of the top, presumably from the same sample as quoted by Bujak et al. (1980). The position of this sample is *c.* 17 m above the base of the London Clay (Bujak *et al.,* text-fig. 4), which, if accurate, would place it near the division A/division B boundary. It is probable that they took the sand with a pebbly base (see above) as the base of the 'Bagshot Sands'. In sites further eastwards, in both the Hampshire Basin and the London Basin, the upper part of the London Clay contains younger zone

fossils of the genus *Wetzeliella* (*sensu lato*).

The stratigraphical affinities of the Redend Member are unclear. The *W. meckelfeldensis* age of the uppermost London Clay below suggests a possibility that it corresponds to the Warmwell Farm Sand found to the north (cf. Bristow *et al.,* 1991, fig. 8) and whose lateritic cementation is compatible with the limonitization here. However, in the absence of zone fossils, its age and correlation with other strata elsewhere is far from clear (see later discussion).

Sedimentology

The Reading Basement Bed comprises sparsely glauconitic muddy sand. Above, some 15–20 m of cross-bedded, mainly clean, quartzose sands to granule conglomerates with thin beds of silty clay locally containing fragmentary plant material, contrasts with the dominantly argillaceous sequences of Alum and Whitecliff Bays to the east. Clay mineral studies by Gilkes (1968) indicated a predominantly illite–kaolinite composition at Studland. The basal 2 m was, however, exceptional in containing abundant smectite.

Whilst the London Clay is very poorly exposed, its marine origin is supported by the glauconitic nature of its lower part, the presence of *Lingula* and agglutinating foraminifera. C. King (pers. comm.) considers that the sediments present are similar to those of the London Clay elsewhere and may be interpreted as marine, although calcareous fossils have been destroyed by post-depositional decalcification.

Lithologically, the Redend Member comprises relatively well-lithified, fine to medium sandstones. These are essentially clean, well-sorted sands, now strongly limonitized. King (1981, p. 91) considered that the base is 'certainly marine', whilst suggesting that the upper part, with several fining-upwards cycles, is fluvial in origin.

Parallel-laminated, sometimes lignitic, sands and black sandy muds follow the Redend Member. Cooper *et al.* (1976) noted the abundance of plant fragments, and whilst referring this unit to the Pipeclay Series of Arkell (1947) (the Corfe Member of Curry *et al.,* 1978), remarked how different the muds here were from the 'sterile ball clays' elsewhere.

Macroflora

Chandler (1962, p. 4) referred in somewhat more detail than Cooper *et al.* (1976) to the plant macrofossils of the Corfe Member, together with references to earlier studies of this flora, and referred to the tropical affinities of some of the forms present.

Interpretation and evaluation

Studland Bay is the most westerly site in the Hampshire Basin to show the contact between the Cretaceous and the Palaeogene, together with an overlying succession of Palaeocene and lower Eocene strata. Hence, the succession here provides some insight into the palaeogeographical development towards the western end of the Hampshire Basin in early Palaeogene times. Other data which could throw light on the development of the remainder of the Palaeogene succession in this area have arisen from the local exploration and exploitation of ball clay but some of this information is commercially 'sensitive' and not in the public domain.

Comparison with other localities

Compared with the sections in Whitecliff Bay and Alum Bay on the Isle of Wight, that at Studland is limited in stratigraphical range but it demonstrates both similarities with and differences from the Palaeogene successions found further to the east.

Rounded pebbles and the presence of glauconite at the bottom of the Reading Formation indicate the presence of the Reading Formation Bottom Bed (also recognized in English China Clay's Rempstone Borehole just south of Poole Harbour; Bristow *et al.,* 1991) but the remainder of the Reading Formation at Studland varies both in thickness and lithologically from the Isle of Wight sections. The 15–20 m present here, compared with the 24.6 m at Alum Bay and

around 45 m at Whitecliff Bay, indicates a considerable westerly thinning of strata above the Reading Basement Bed. Indeed, it is now known that elsewhere in the north-west part of the Bournemouth District (*sensu* BGS), it is actually overlapped by the London Clay (Bristow *et al.,* 1991).

Compared with more easterly localities, there is only a thin development of the London Clay at Studland and it is clear that it is essentially the younger part of the formation that is absent. In this regard, the discovery by Costa and Downie (1976) of W *meckelfeldensis* within 2 m of the top of the London Clay here is particularly significant, for at Alum Bay *D. similis* occupies this position, with the even younger *D. varielongituda* at the top of the formation (*sensu* King, 1981) in Whitecliff Bay. Costa and Downie (1976) suggested that such a lateral change is a clear indication of the diachronous nature of the top of the London Clay, the consequent inference being that a regressive development began much earlier in this more westerly area. C. King (pers. comm.) believes now that the top of the London Clay may not have been diachronous and that its attenuated succession in Studland Bay may have resulted from erosion in this area prior to deposition of the Poole Formation.

Depositional environment and palaeogeography

The concentration of smectite in the Reading Formation Basement Bed was interpreted by Gilkes (1968) as insoluble residue from the Chalk. Edwards and Freshney (1987a, p. 16), who found similar concentrations of this mineral elsewhere in the Basement Bed, have, however, suggested that a volcanic origin is more likely. Such a possibility is compatible with the occurrence of contemporaneous ash bands in the southern North Sea and in the London Basin (Knox and Harland, 1979).

Above the Reading Formation Basement Bed, the sands and granule conglomerates at Studland are quite different from the colour-mottled muds so characteristic of the Reading Formation in Alum Bay and Whitecliff Bay. They are also markedly coarser than the sands from the sandy facies described by Edwards and Freshney (1987a, p. 17) from the Southampton area. These authors considered that most of the Reading Formation sands in the latter area were fluvial in origin. No detailed study has been undertaken of those at Studland, but their clean, quartz-rich composition is not immediately compatible with such an origin.

Since the London Clay is so poorly exposed at Studland, discussion must inevitably be limited. It is, however, far thinner here than further to the east, an indication that the Studland area represents the western margin of the London Clay sea. Indeed, some of the palynomorphs recently found by BGS in the Studland Bay section are paralic in character rather than marine as in the London Clay further east (J.B. Riding, pers. comm.). There is some indication that, in some places, the London Clay was subaerially exposed relatively soon after deposition since, in the north-western part of the Bournemouth District (*sensu* BGS), strata formerly considered as 'Reading Beds' are now thought of as pedogenically reddened London Clay, the latter resting directly on the Chalk (Bristow *et al.,* 1991, p. 20).

Costa and Downie (1976) suggested a major unconformity at the base of the Redend Sandstone. Although King (1981, p. 91) originally felt that this was unlikely, he now is inclined to agree (pers. comm.). Having earlier (1981) thought that this unit was probably correlatable with higher horizons in the London Clay further to the east, he now considers it to be part of a fluvial succession younger than the London Clay. However, since the unit has, as yet, yielded no zone fossils, its age remains uncertain. It is unfortunate that Townsend and Hailwood (1985) did not include Studland in their revealing magnetostratigraphical work on the Palaeogene, since this might very well have shed more light on this problem.

Recent alternative lithostratigraphical interpretation

Recent re-mapping of this part of Dorset by the British Geological Survey (BGS) (Sheet 342/343, Swanage, in press) has led to an alternative lithostratigraphical interpretation of the Studland Bay section incompatible with the assignment of the succession to the Reading Formation, London Clay and Poole Formation. C.M. Barton, C.R. Bristow and J.B. Riding of the BGS (pers. comm.) believe this tripartite assignment to be inappropriate and, on the basis of both palynology and field mapping, consider that the succession should be assigned in its entirety to the Poole Formation. Barton (pers. comm.) has suggested that the sands and granule conglomerates considered to be Reading Formation in this account should be assigned to the Creekmore Sand (Poole Formation) and, furthermore, that the Reading Formation is totally

absent in the area covered by the Swanage sheet, the Weymouth sheet (341/342) (in press) and the recently published Dorchester sheet (328). BGS has the Creekmore Clay succeeding the Creekmore Sand with the younger Redend Member mapped as part of the 'Broadstone and Oakdale Sands, undivided'.

The suggestion that the London Clay is absent in the Studland Bay section is not supported by evidence of its occurrence found by King (1991). Clearly further investigation is necessary to resolve the apparent incompatibility of the two interpretations. As this account goes to press, BGS is about to re-evaluate the palynofloral evidence (J.B. Riding, pers. comm.). This may turn out to be very revealing since the palynomorphs found by BGS did not preclude the presence of the London Clay on biostratigraphical grounds but were thought to represent a different, more paralic, biofacies than that which characterized the typically marine London Clay farther to the east.

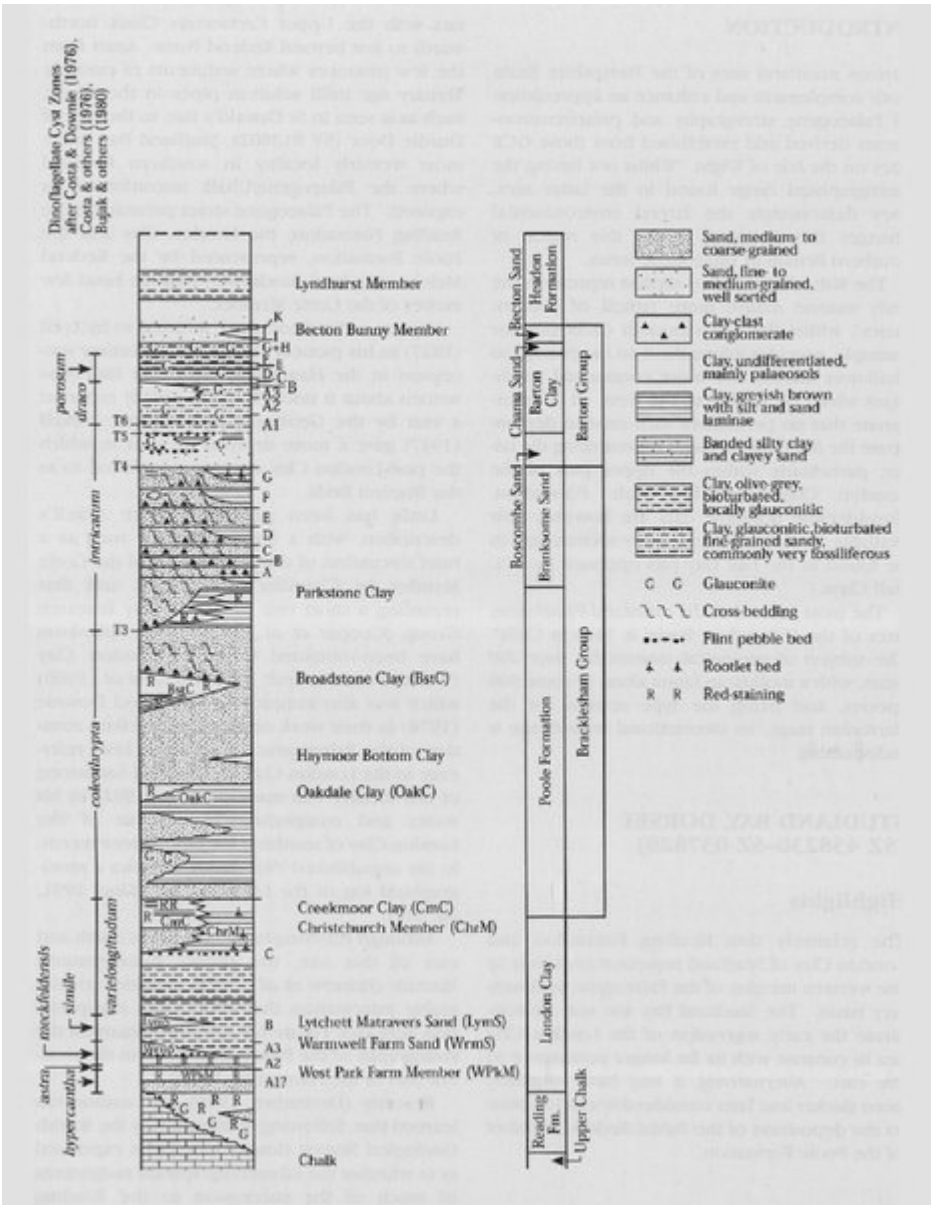
Conclusions

Although stratigraphically limited in extent, the Studland section is important in that it throws light on the palaeogeography of Palaeocene and early Eocene times towards the western end of what is now the Hampshire Basin.

Both the Reading Formation and the London Clay are much thinner here than further to the east. Such developments appear to reflect the former close proximity of a land area not far to the west. The top of the London Clay has been dated by using species of the dinoflagellate zonal genus *Wetzeliella* and has proved to be far older here than it is further to the east in the remainder of the Hampshire Basin and in the London Basin. Either the regression of the London Clay sea began much earlier here than further east or the upper part of this formation was locally eroded away prior to the deposition of the Poole Formation.

The fluvial Redend Member, unrepresented at more easterly localities, may correlate with younger parts of the London Clay elsewhere to the east but alternatively may be younger than the latter and separated from it by an unconformity.

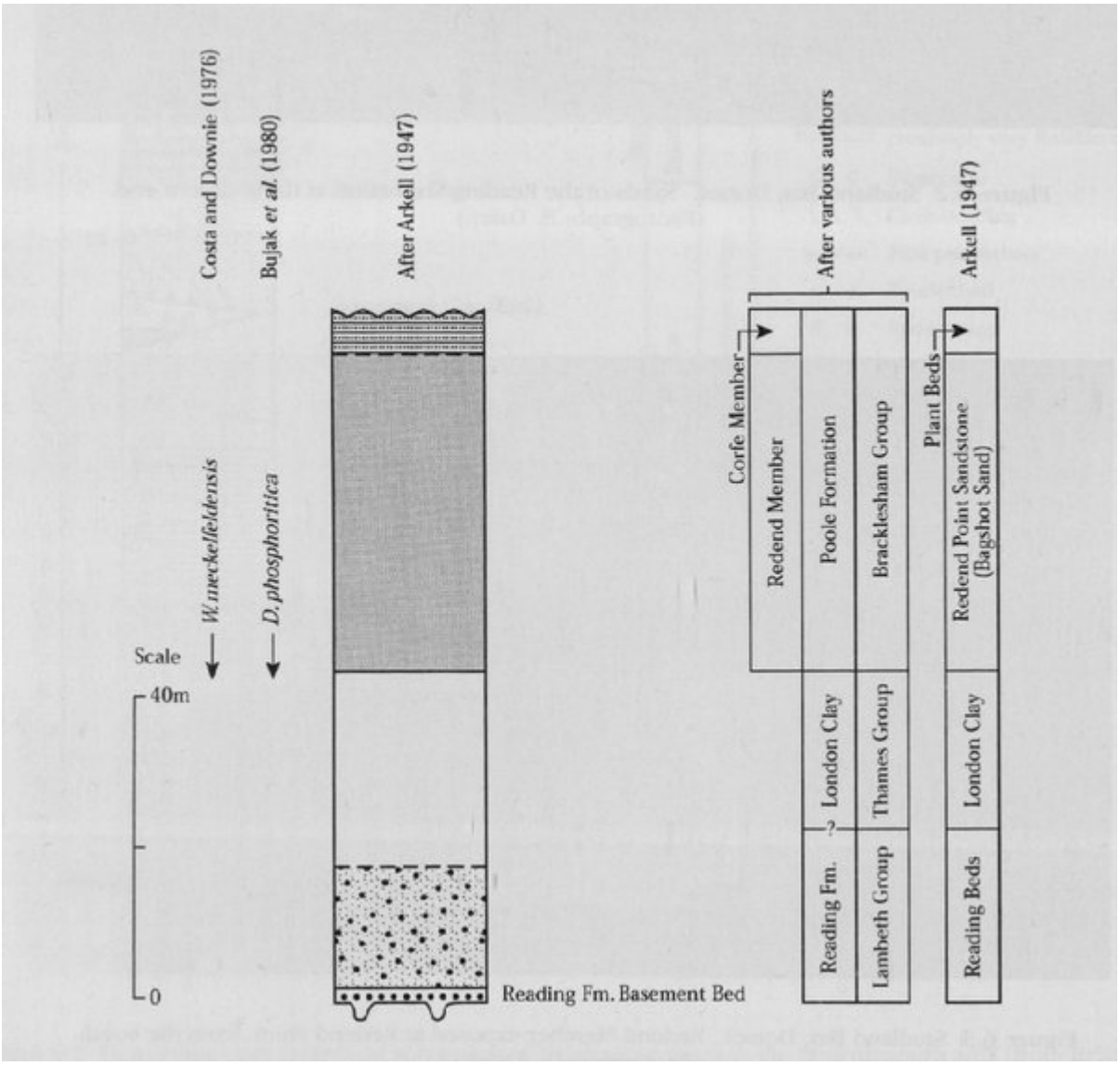
References



(Figure 6.1) Generalized stratigraphical succession of Palaeogene strata in the Bournemouth area (from Bristow et at., 1991, fig. 8). Units Al? to C (London Clay) after King (1981), A to G (Branksome Sand) after Plint (1983a) and Al to K (Barton Group) after Burton (1933). 'T' numbers denote surfaces produced by marine transgressions.

(Figure 6.2) Studland Bay, Dorset. Sands of the Reading Formation at the southern end. (Photograph: B. Daley.)

(Figure 6.3) Studland Bay, Dorset. Redend Member exposed at Redend Point, from the south. (Photograph: B. Daley.)



(Figure 6.4) Reading Formation to Poole Formation succession in Studland Bay, Dorset (after various authors).