

## PLANKTIC FORAMINIFERA FROM THE PROPOSED GSSP FOR THE OXFORDIAN STAGE: REDCLIFF POINT, NEAR WEYMOUTH

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In the course of the stratigraphical and palaeontological investigations for the Global Stratotype Section and Point (GSSP) for the base of the Oxfordian Stage at Redcliff (near Weymouth) an assemblage of planktic foraminifera has been described. Planktic foraminifera are exceptionally rare in the Jurassic of the United Kingdom and only a few records have been reported in the last few years. At Redcliff, the assemblage is preserved as pyrite steinkerns, but the fauna contains a number of morphotypes which match onto known species from this interval (*Globuligerina oxfordiana*, *Compactogerina stellapolaris*) while others have no described species to which they can be ascribed. The samples in which the planktic taxa are most abundant were collected from just above the boundary horizon (defined by the ammonite assemblages) and appear to represent proximity to a maximum flooding surface. The same horizon in Normandy has also yielded *Globuligerina oxfordiana* while a coeval level in the Mariae Chronozone on the banks of the Fleet has also yielded this assemblage. The occurrence of this Redcliff assemblage, close to the Callovian/Oxfordian boundary, is important in both the evolution of the planktic foraminifera and our understanding of the palaeobiogeography of the time.

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### INTRODUCTION

Redcliff Point near Weymouth (Dorset, South-West England) exposes one of Europe's most complete Callovian/Oxfordian boundary sequences and has been the subject of rigorous multidisciplinary research (Figures 1, 2). The boundary sequence, which has been proposed as a candidate GSSP (Global Stratotype, Section and Point) for the base of the Oxfordian Stage (Page *et al.*, 2006, *in press*), lies entirely within the clay facies of the Oxford Clay Formation. Ammonites, in particular, are conspicuous and in some cases retain their aragonite shell. By convention the stage boundary is drawn at the first occurrence of the genus *Cardioceras*, which has been interpreted as corresponding to the transition between '*Quenstedtoceras paucicostatum* (Lang) and *Cardioceras* ex gr. *scarburgense* (Young and Bird), specifically at the first occurrence of *C. woodhamense* Arkell *sensu* Callomon (*non* Marchand). This transition is recorded at Redcliff and provides the primary means through which the boundary can be correlated.

Samples for micropalaeontological analysis were collected throughout the boundary sequence. Splits of these samples were provided to Dr Paul Bown (University College, London) for an investigation of the calcareous nannofossils while the bulk of these samples were prepared for an analysis of the foraminifera and Ostracoda by MBH at the University of Plymouth. All the samples were disaggregated using the 'Solvent Method' described by Brasier (1980). This method disaggregates the samples gently causing minimal (if any) damage to the fauna. Samples were washed on a 63 µm stainless steel sieve, dried in a cool (<40°C) oven and inspected in splits of >500 µm, 500-250 µm, 250-125 µm and 125-63 µm.

### FORAMINIFERA OF THE OXFORD CLAY FORMATION

The foraminifera of the Oxford Clay Formation have been investigated by a number of workers in recent years (Barnard, 1952, 1953; Cordey, 1962; Gordon, 1965; Shipp, 1978, 1989). More recently PhD theses by Henderson (1997) and Oxford (2004) have up-dated much of the taxonomy. Page *et al.*, (2003, figure 7) have illustrated some of the species of foraminifera and ostracoda recorded in a pilot investigation of the Redcliff succession. The fauna is quite well preserved although some of the epistominids (which have an aragonite test) show signs of dissolution and/or are infilled with pyrite. Many of the agglutinated taxa are compressed, the chitinous inner wall allowing the specimens to collapse during burial and compaction (Page *et al.*, 2003).

At the time of this pilot investigation of the Redcliff succession no planktic foraminifera were recorded, probably because the upper levels of the succession were not investigated at that time. None of the earlier workers on the Oxford Clay Formation in the UK had ever recorded the presence of planktic foraminifera and, indeed, none had been expected during that research. However, in 2001, Melissa Oxford discovered an assemblage of planktic foraminifera (preserved as pyrite steinkerns) from the Furzedown Clays of the Mariae Chronozone exposed on the shore of the Fleet just west of Wyke Regis (see House, 1993; figure 14). This assemblage was described by Oxford *et al.* (2002) and the problems of its preservation discussed.

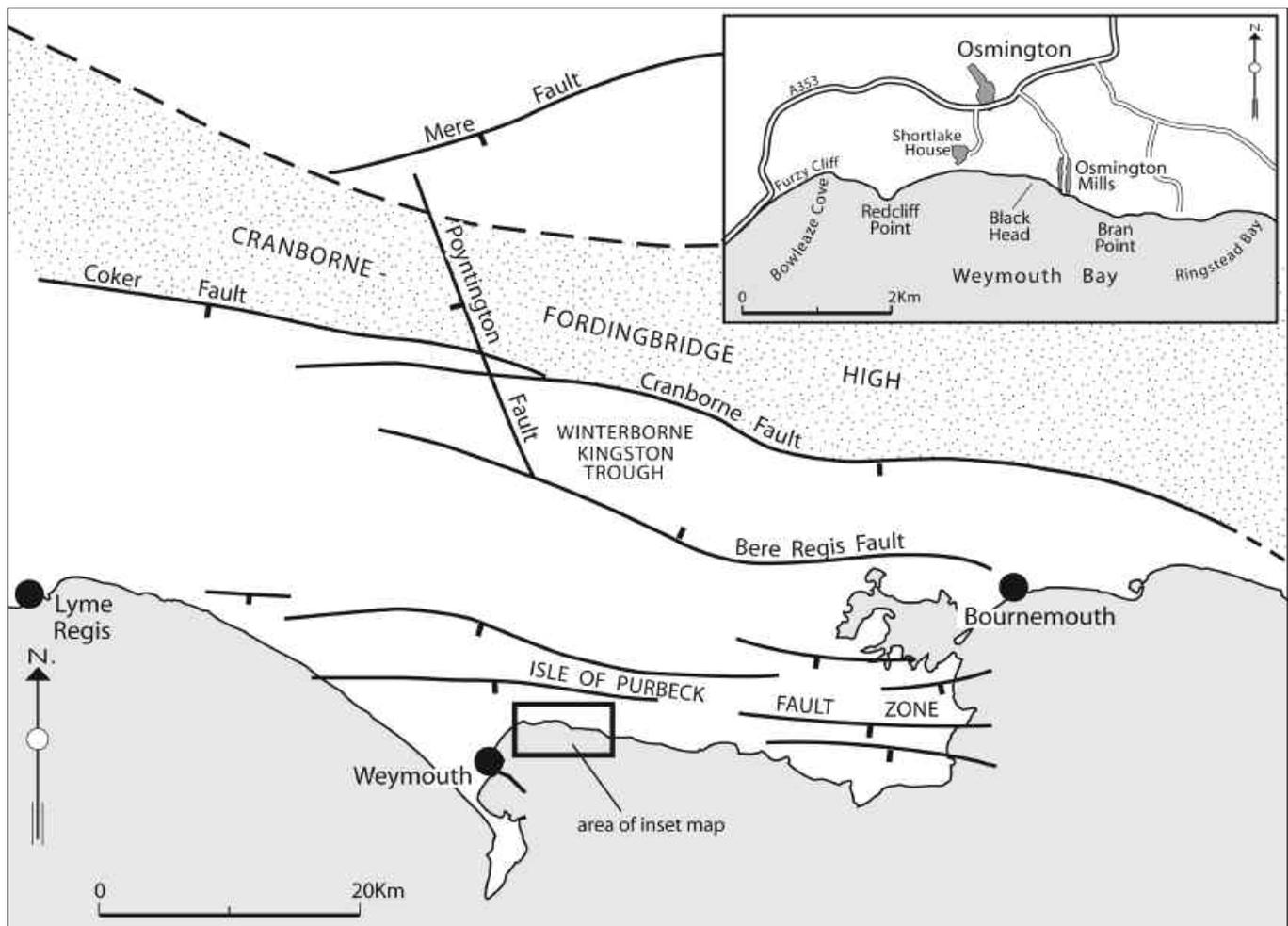


Figure 1. Location map and general structural features of Dorset. After Page et al. (2003).

### JURASSIC PLANKTIC FORAMINIFERA

Over the last 50 years, our knowledge of early planktic foraminifera has changed markedly. In a recent review Simmons *et al.* (1997) describe 16 species from the late Bajocian to early Valanginian interval. The majority of these taxa were first described from Eastern Europe and parts of the former Soviet Union (Grigelis, 1958, 1974, 1975; Hofman, 1958; Morozova and Moskalenko, 1961; Pazdrowa, 1969; Fuchs, 1967, 1970, 1973, 1975; Grigelis *et al.*, 1977; Grigelis and Gorbachik, 1980; Kuznetsova and Gorbachik, 1980, 1985; Kasimova and Aliyeva, 1984; Gorbachik, 1986). *Globuligerina oxfordiana* is, almost certainly, one of the most widely recorded of the Jurassic species, although this could be illusory as this is invariably the name used for almost 'any' Jurassic planktic forms. It was, therefore, something of an anomaly that *Globuligerina oxfordiana* was well known from the Marnes de Villers of the 'Vaches Noires' cliffs of Normandy (Bignot and Guyader, 1966, 1971; Samson *et al.*, 1992) and yet had not been found in coeval strata of similar facies in the UK. Work by Melissa Oxford (2004), Malcolm Hart and Matthew Watkinson on the Normandy coast sections between Villers-sur-Mer and Houlgate confirmed the presence of *Globuligerina oxfordiana* in the uppermost part of the Marnes de Villers Formation, uppermost Scarbursense Subchronozone, Mariae Chronozone (Oxfordian). These specimens can be favourably compared with the illustrations of Bignot and Guyader (1971; figures 1-4) and Samson *et al.* (1992; plate IV). It was this work in Normandy that prompted the sampling of the Mariae Chronozone of the Dorset Coast and led to the discovery of the fauna described by Oxford *et al.* (2002). It was, however, a surprise that this work recorded three possible species (*Globuligerina oxfordiana*, *Haeuslerina helvetojurassica* and *Compactogirina sellapolaris*)

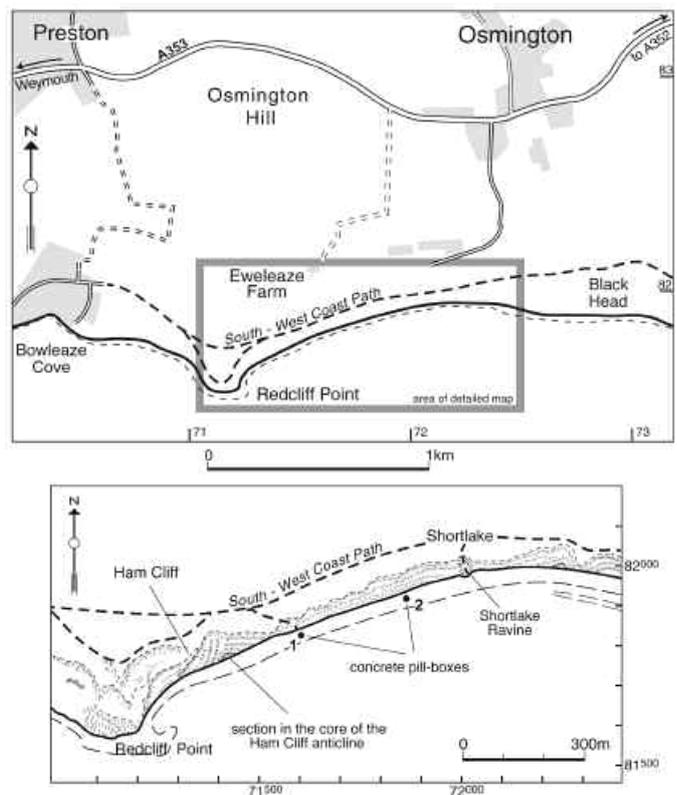


Figure 2. Location of the studied section at Redcliff Point, Weymouth. The easiest access is via the coastal path walking east from Bowleaze Cove.

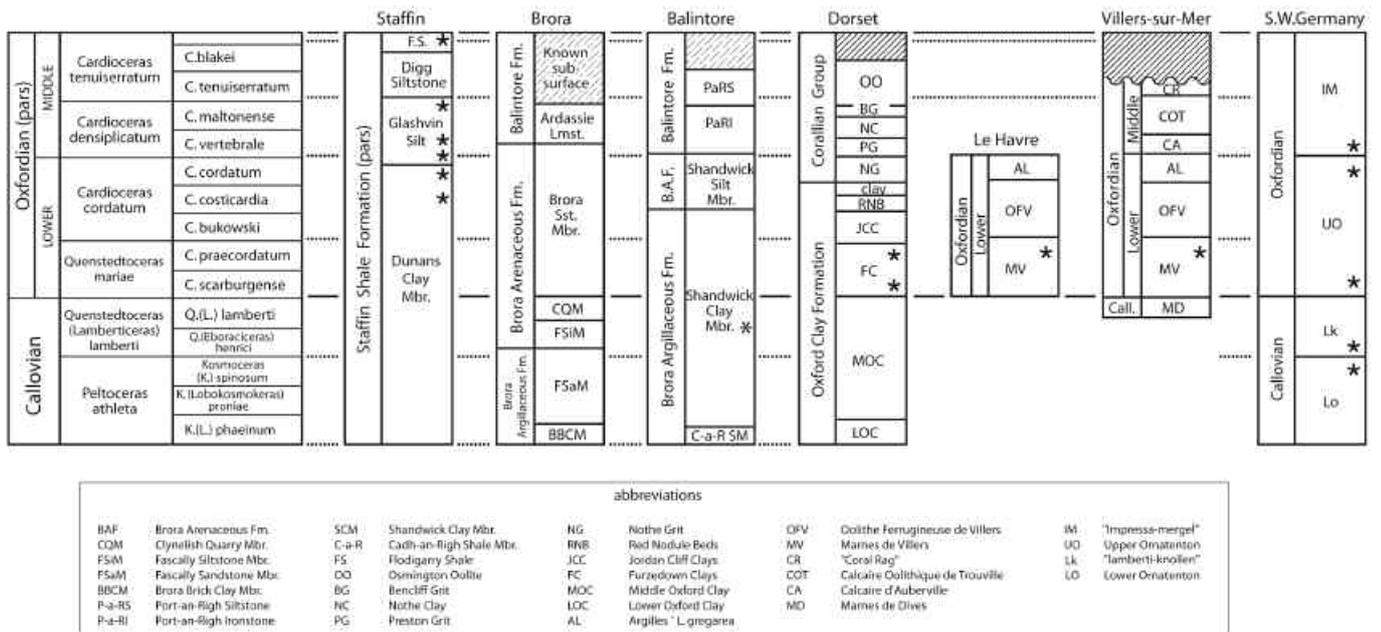


Figure 3. Sections through the uppermost Callovian to mid-Oxfordian succession from which planktic foraminifera (\*) have been recorded. Based on Oxford et al. (2002) with data added from Riegraf (1987a, b) for southwestern Germany.

rather than the one species that was expected. None of the other taxa had been recorded by Bignot and Guyader (1966, 1971) and Samson *et al.* (1992) in the Normandy succession.

In the Redcliff succession the planktic foraminifera have been recorded as pyrite steinkerns and are mainly found in the lowermost part of the Mariae Chronozone (Scarburgense Subchronozone). This is slightly older than the records from the shores of the Fleet and in Normandy but are in line with other known 'floods' at, or about, this level (Figure 3). In Poland the glauconitic sands and clays exposed at Ogradzieniec (north-west of Krakow) also record floods of such forms, although in that succession the preservation of the fauna is in the form of glauconitic moulds (see Fuchs, 1973).

The newly discovered Redcliff assemblage of planktic foraminifera is abundant and contains a variety of taxa (Figure 4). Dominant are the typically 4-chambered *Globuligerina oxfordiana* morphotypes. The generic determination of this species is, however, problematic as a series of emendations by Bignot and Guyader (1966, 1971) have almost certainly changed the initial concept of the taxon, although Grigelis and Gorbachik (1980) have attributed this to the 'better preservation of the French material'. Simmons *et al.* (1997), following these emendations, identify *Globuligerina* on the basis of its loop-shaped aperture (as distinct from the low arch which is characteristic of *Conoglobuligerina*). This separation is, however, only partly successful as any assemblage contains a range of forms with both arched and loop-shaped apertures as well as a range of spire heights. When dealing with the glauconitic moulds of Ogradzieniec and the pyrite steinkerns of Redcliff this differentiation is impossible as the original test material is not present. Some of the Redcliff specimens are also irregular in form and this is probably a result of the preservation process.

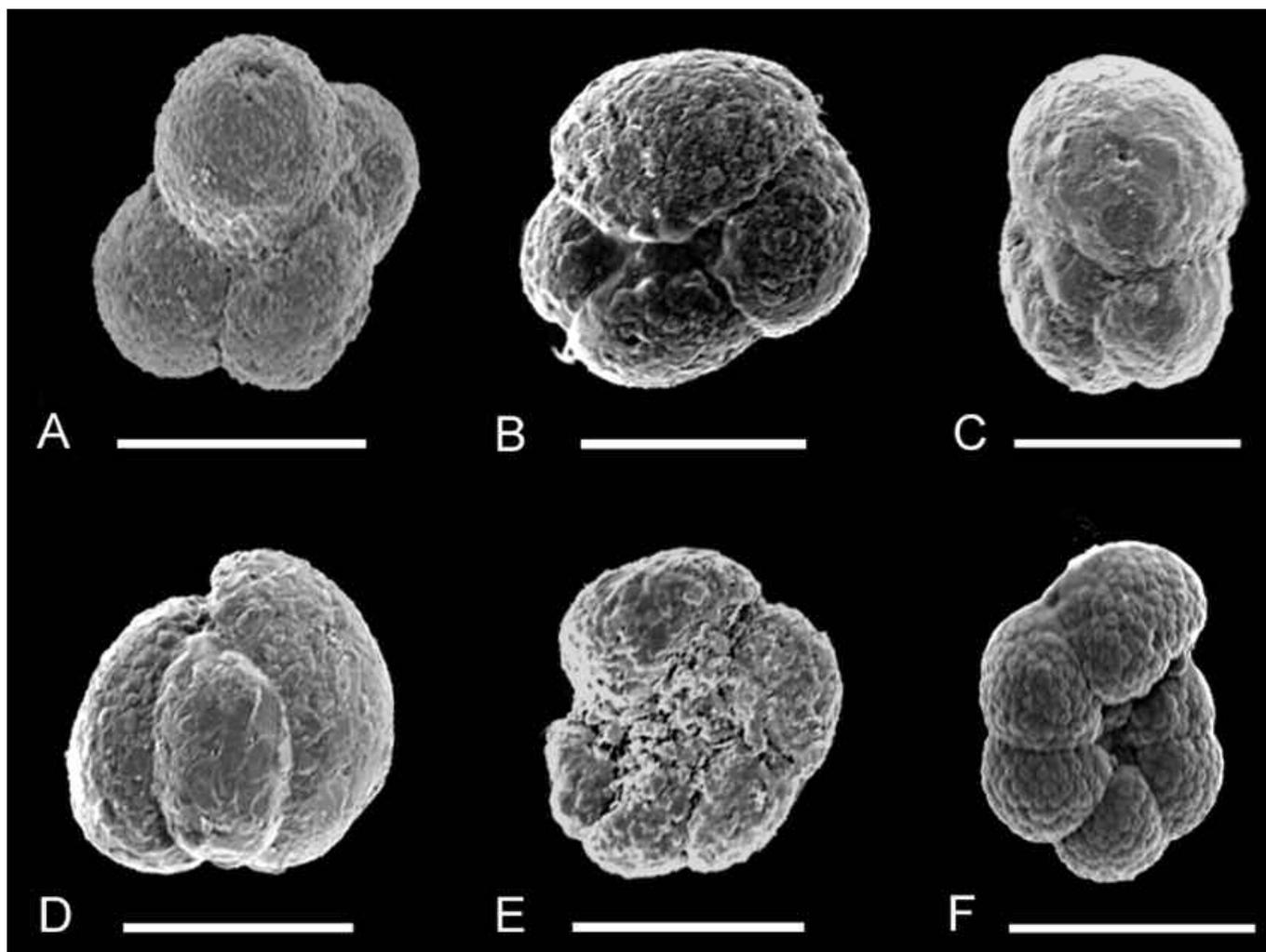
Some of the other Redcliff specimens are attributed to *Compactogenerina stellapolaris*. This determination is following Simmons *et al.* (1997), despite some workers (e.g., Riegraf, 1987a/b) placing this species in the synonymy of *Globuligerina oxfordiana*. The other Oxfordian species, *Haeuserina helvetojurassica*, with its umbilical-extraumbilical aperture may also be present but the mode of preservation makes its identification very difficult.

One problem that remains unresolved is the presence of some low trochospiral forms with 5-7 chambers in the final whorl and an almost extraumbilical aperture. Such forms

(Figure 4F) are almost hedbergellid in appearance and the nearest genus might be *Praehedbergella*. There are two problems in such a determination. Firstly, the specimen shown in Figure 4F shows a quite unusual surface ornamentation. This is, of course, not an 'external' feature but preserves an internal feature of the chamber wall, now lost in the steinkern preservation. Secondly, there is the problem of age. *Praehedbergella* appears in the early Cretaceous (Hauterivian) according to BouDagher-Fadel *et al.* (1997) and there are no confirmed records of any praehedbergellids being found in Jurassic strata (although a similar unidentified species has been found in the clays of the Wootton Bassett Mud Springs by Henderson, *pers. comm.*). It is impossible to consider a change in the range of *Praehedbergella* on the basis of these few specimens as they do not show any of the typical morphology of the test. On the other hand the preservation does not allow for the creation of a 'new' taxon as none of the generic and specific features of the calcareous (probably aragonite) test are preserved. This problem can only be resolved if an assemblage containing this fauna is discovered elsewhere in normal preservation. As planktic foraminifera have not previously been reported from Jurassic strata in Southern England despite over a century of research, it is only just possible that fresh material may be found elsewhere with the aragonite test preserved. Material from the Jurassic of Scotland described by Gregory (1986, 1989) remains unpublished.

### SEQUENCE STRATIGRAPHY AND PALAEOGEOGRAPHY

The occurrence of this planktic fauna in the Scarburgense Subchronozone is distinctive and confirms the Mariae Chronozone as a flooding horizon across Dorset, Normandy and Bavaria. The Mariae Chronozone is close to the maximum sea-level highstand recorded within Jurassic sequence 8 of Jacquin *et al.* (1988). This is also the same stratigraphical level as the abundant planktic fauna at Ogradzieniec (Poland). The sequence stratigraphy model of Emery and Myers (1996, figure 6.14a) would predict that such 'floods' of planktic taxa should be associated with maximum flooding surfaces (or events). The sea level highstand in the early Oxfordian is also supported by Pearce *et al.* (2005, figure 2) who show the maximum sea levels in the Mariae Chronozone. This interpretation appears to be largely based on the work of Hesselbo and Coe (2000). This highstand event appears to conflict with the climate evidence



**Figure 4.** Examples of planktonic foraminifera preserved as pyrite steinkerns. (**a, c**) *Globuligerina oxfordiana* (Grigelis); (**b, d**) *Compactogerina stellapolaris* (Grigelis); (**e**) unknown form; (**f**) unknown taxon with distinctive low trochospiral coil, umbilical-extraumbilical aperture and ornamentation; this genus/species is very reminiscent of *hedbergellids* or *praehedbergellids* that are previously undescribed from Jurassic strata. Scale bars 100  $\mu\text{m}$ .

provided by oxygen isotopes (Tremolada *et al.*, 2006) and the occurrence of glendonite in northeastern Asia (Chumakov and Frakes, 1997), both of which suggest a cooling at this time and the possible presence of polar ice. This evidence indicates that temperatures began to fall (in Europe) in the latest Callovian (Athleta Chronozone) and lasted into the earliest Oxfordian (Dromart *et al.*, 2003). The stable isotope data from belemnite guards indicate a cooling of some 6–7°C in Russia, Poland and the UK (Podlaha *et al.*, 1998; Barskov and Kiyashko, 2000; Jenkyns *et al.*, 2002). Further evidence of a cooling at this time comes from cool gymnosperm floras in the Upper Callovian and Lower Oxfordian of Germany and France (Philippe and Thevenard, 1996) and palynomorphs of cool aspect in the North Sea Basin (Abbink *et al.*, 2001). The most striking feature appears to be an influx of 'Boreal' ammonites (cardioceratids and kosmoceratids) in southeastern France (e.g., Fortwengler, 1989) and elsewhere in N.W. Europe (Page, *pers. comm.*). The palaeogeography at the time (Figure 5) certainly shows a connection between the UK, France, Germany, Poland and areas in Russia such as the Pechora Basin, from which *Compactogerina stellapolaris* was first described. Even if a cold-water connection to the north can be demonstrated at the time of the Callovian/Oxfordian boundary, this does not appear to support the view that the Mariae Chronozone marks a highstand which allows the migration of planktic foraminifera into the Wessex Basin. In modern oceans aragonite is preferentially preserved in cooler (glacial) intervals with, for example, floods of pteropods preserved in Marine Isotope

stages 2 and 6 (Chen, 1968; Gardulski *et al.*, 1990; Wang *et al.*, 1997). If there was a 'cooling' episode associated with the latest Callovian and earliest Oxfordian then this might also account for the relatively widespread preservation of planktonic foraminifera at this stratigraphic level.

## SUMMARY

A fauna of planktic foraminifera is described for the first time from the Mariae Chronozone at Redcliff, Dorset. This is almost coeval with comparable faunas known from the banks of the Fleet and further away on the Normandy Coast, Bavaria and in Poland (northwest of Krakow). Its occurrence in the proposed GSSP succession for the base of the Oxfordian Stage is important, even though it exacerbates the dilemma between a cooling event and a sea level highstand at, or just above, the Callovian/Oxfordian boundary.

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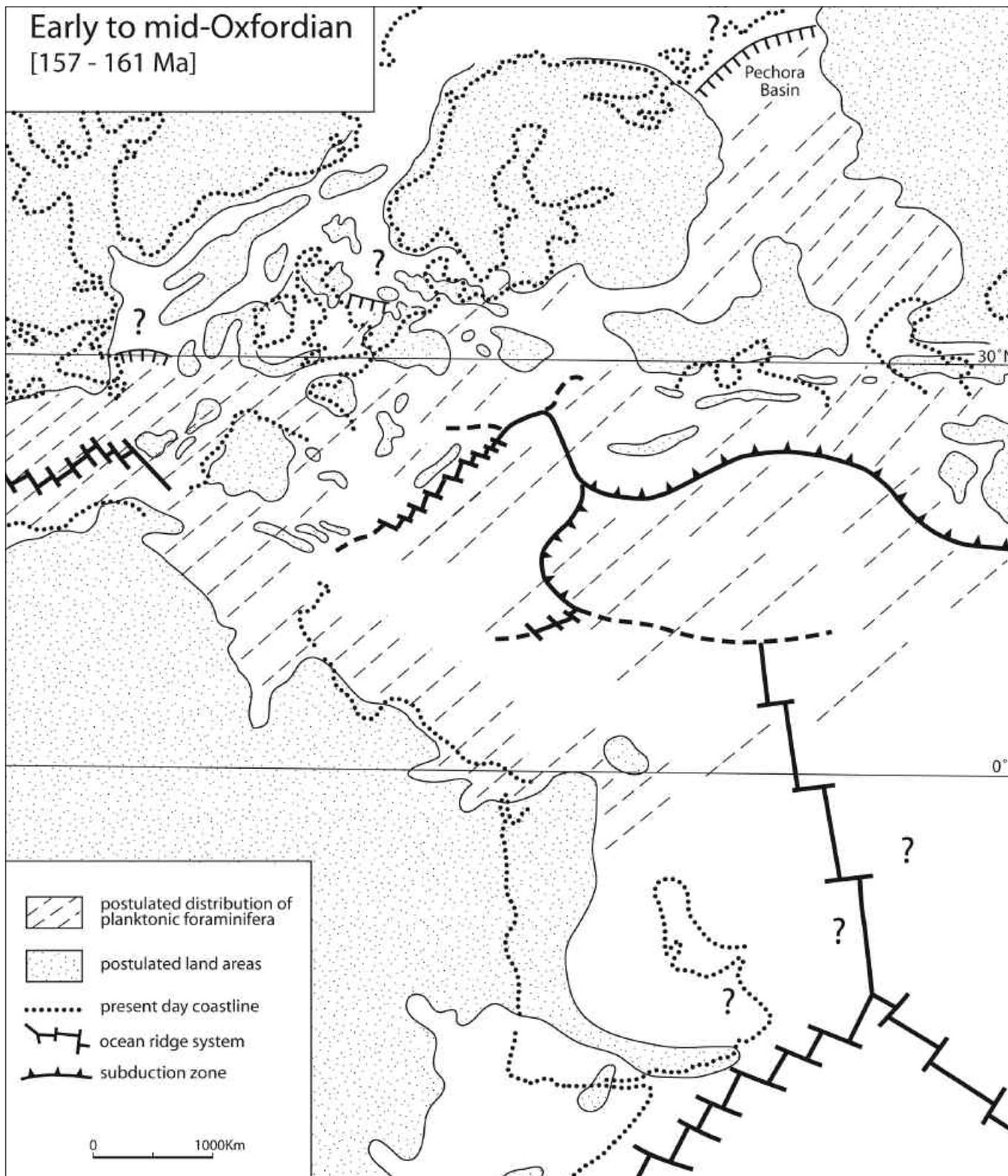


Figure 5. Early Oxfordian palaeogeographical map. The outline is based on Thierry (2000).

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