



# The Platycopid Signal deciphered: Responses of ostracod taxa to environmental change during the Cenomanian–Turonian Boundary Event (Late Cretaceous) in SE England

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## ABSTRACT

A multi-proxy investigation of the Cenomanian–Turonian Boundary Event (CTBE) near Dover in southern England previously demonstrated that, coincident with a major global positive carbon stable-isotope excursion during Oceanic Anoxic Event 2 (OAE 2), the diversity of nanoplankton, dinoflagellates, planktonic and benthonic foraminifera and ostracods was severely reduced. This was attributed to decreasing levels of dissolved oxygen, consequent on an intensification and expansion of the oceanic Oxygen Minimum Zone (OMZ) into shelf seas. In the case of the ostracods, it was noted that as podocopid taxa became locally extinct, platycopids became the dominant component of the fauna. Subsequently the “Platycopid Signal” Hypothesis (PSH) claimed that dominance of platycopids in ostracod assemblages could be regarded as a signal of dysaerobic conditions on the sea floor, based on the premise that the filter-feeding platycopids, able to pass more water over their respiratory surface, were better-equipped than other benthonic ostracods to survive in water of reduced oxygen concentration. The PSH has been widely accepted and applied in palaeoenvironmental reconstructions of stratigraphic intervals ranging from the Palaeozoic to the Quaternary. However, the modern biological and ecological support claimed for the Platycopid Signal has been challenged; platycopids are occasionally dominant in modern OMZs, but often they are not, and in any case the same can be said about some podocopids. Apparently precise calibration scales published by some authors are not justified by available data; furthermore, Platycopid Signal indications of dysaerobic intervals in the English Chalk succession often conflict with the evidence of macrofossils and trace fossils. Here we review old and new data from two CTBE sites in SE England, Dover and Eastbourne, and advance an alternative interpretation of the Platycopid Signal, based on the concept of the spread of oceanic oligotrophic conditions into the European Chalk Sea during OAE2. We propose that ostracod assemblages overwhelmingly dominated by platycopids signify oligotrophy, because living platycopids appear to be adapted to filter-feed on nano- and picoplankton which are predominant in oligotrophic conditions.

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## 1. Introduction

According to the Platycopid Signal Hypothesis (PSH) of Whatley (1991), ostracod assemblages dominated by species belonging to the Order Platycopida can be interpreted as indicating dysaerobic conditions on the sea floor, thus offering a valuable tool for the study of Oceanic Anoxic Events (OAEs). Platycopids, as filter feeders, were considered by Whatley to be more efficient at circulating water through the domiciliar space inside the carapace, for both feeding and

respiration purposes, and thus better-adapted than non-filter feeders to survive at low levels of dissolved oxygen (Whatley, 1991; Brandão and Horne, 2009). Originally developed on the basis of data from the Cenomanian–Turonian Boundary Event (CTBE) (also known as OAE 2) in SE England, the PSH has been applied to the interpretation of ostracod assemblages from the Quaternary to the Palaeozoic (Boomer and Whatley, 1992; Whatley and Arias, 1993; Whatley et al., 1994; Aiello et al., 1996; Steineck and Thomas, 1996; Majoran et al., 1997; Majoran and Widmark, 1998; Boomer, 1999; Gebhardt, 1999a; Crasquin-Soleau and Kershaw, 2005; Bergue et al., 2007).

The PSH was developed beyond its early concept by Lethiers and Whatley (1994, 1995) who applied it to Late Palaeozoic ostracod assemblages in NW Europe and published comparative tables (e.g., Lethiers and Whatley, 1994, Fig. 2) in which the percentages of

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platycypid species in assemblages were matched to ranges of dissolved oxygen levels. Their analyses showed a good match (on a broad scale at least) with other proxy evidence indicative of, for example, low oxygen events in the Late Devonian and well-oxygenated, cooler waters associated with Early Carboniferous glaciation. However, it must be noted that while Lethiers and Whatley followed Adamczak (1969) in assuming all palaeocope ostracods to have been filter-feeders, Olempska (2008) presented and interpreted new morphological evidence (in particular adductor muscle, frontal and mandibular scars) from Silurian, Devonian and Carboniferous taxa and concluded that beyrichioidean palaeocopes (including paraparchitids) were not filter-feeders, but actively-feeding scavengers or carnivores. It remains to be seen what impact this re-interpretation of ostracod feeding modes may have on the PSH as applied to Palaeozoic assemblages.

Whatley (1995) presented a new version of his calibration table, with percentages of filter-feeders based on the relative abundance of individuals, not species as in the earlier version published by Lethiers and Whatley (1994, 1995). Subsequently these comparative values were refined and presented as a scale with an apparent precision of 0.5 ml/l dissolved oxygen (Whatley et al., 2003), reproduced herein as Table 1. In none of the above-cited papers was a full explanation given of how the calibrations shown in the tables were achieved; for example, Whatley et al. (2003: p. 360) simply stated that their improved table was based "...mainly on further considerations of the available literature on Recent ostracod ecology." In the same paper they went on to apply the PSH to the estimation of dissolved oxygen levels in the Late Cretaceous, giving values with a higher precision (0.05 ml/l) than that of their calibration table, which suggests the use of a regression line fitted to a data plot. While this technique might be implied it was not made explicit and consequently their method constitutes a "black box" that is not open to scrutiny by readers. This in itself does not mean that the method is not valid, but it makes it very difficult to test its validity.

Almost any fossil proxy is capable of yielding what appear to be plausible results; it is important to compare such results with those of other proxies to see whether they agree or disagree. In some intervals at least, the results of Whatley et al.'s (2003) application of the PSH to the Late Cretaceous Chalk of Norfolk stand in isolation from those provided by microfossils and trace fossils. To take just one example, the PSH led them to identify "a notable period of dysaerobia in the later part of the Weybourne Chalk (including the Catton Sponge Beds) culminating in an oxygen trough in the Beeston Chalk." (Whatley et al., 2003: 365). This is difficult to sustain, given the total fauna recorded through this interval; according to Mortimore et al. (2001) the Catton Sponge Bed (Hardground II) contains a rich assemblage of hexactinellid sponges together with moulds of originally aragonite-shelled bivalves and gastropods, and is penetrated by an extensive *Thalassinoides* burrow system. Inoceramid bivalves, echinoids, foraminifera, belemnites and the ammonites have all been recovered from the associated levels. This is evidence of a well-oxygenated environ-

ment above, at and below the sediment water interface. The Beeston Chalk, which according to Whatley et al. (2003) contains an oxygen trough, has yielded a high-diversity macrofauna and is rich in microfossils (Mortimore et al., 2001)—not the kind of assemblage normally associated with low oxygen levels.

In contradiction of the PSH, Gebhardt (1999b) found the platycypid *Cytherella* associated with podocypids in well-oxygenated palaeoenvironments in the Cenomanian–Turonian marine shelf sediments of NE Nigeria, while species of the podocypids *Cythereis* and *Ovocytheridea* characterised a group preferring normal oxygen concentrations (associated with limestones) but somewhat tolerant of lower levels (indicated by laminated black shales). Gebhardt and Zorn (2008), in a study of Cenomanian ostracod assemblages from the Tarfaya region of Morocco, noted that two genera were better adapted than others to oxygen depletion: the podocypid *Reticulocosta* and the platycypid *Cytherelloidea*, the former being the more abundant and the latter being absent from intervals of severe oxygen deficiency and/or deeper water. Commenting that their findings did not fully agree with Whatley's PSH, as podocypids always dominated their assemblages, they concluded that *Cytherelloidea* was not an indicator of very low oxygen levels.

There are two main ways in which the PSH can be tested:

1. Its uniformitarian basis can be tested by studying the biology, ecology and distribution of living marine ostracods to determine how well they support the claim that platycypids are dominant in OMZs.
2. Its effectiveness in application to fossil assemblages can be tested by comparing its predictions with the indications of other proxies for past oxygen levels, such as other microfossils, macrofossils and trace fossils.

The uniformitarian basis of the PSH has recently been questioned (Smith and Horne, 2002; Boomer et al., 2003; Horne, 2003, 2005); a detailed critique has concluded that there is no convincing support for it in modern distributional data and that the apparent precision of the calibration tables is unjustified (Brandão and Horne, 2009). However, this does not necessarily mean that the basic premise of the PSH is wrong; as Brandão and Horne (2009) observed in their conclusions, living marine ostracods are descended from taxa which survived OAEs in the past, so the responses of modern assemblages to changing oxygen levels may not be a reliable guide to how they responded in the Cretaceous. Here we examine and test the effectiveness of the PSH in determining past oxygen levels by comparing its indications with those from other proxies, using data from the CTBE in SE England.

## 2. Material and methods

We have used datasets from two CTBE localities in SE England (Fig. 1). One, from Abbots Cliff, near Dover (National Grid Reference TR 268385; Latitude 51° 06' 04' North; Longitude 1° 14' 19' East), comprises the ostracod assemblages described by Jarvis et al. (1988). The other comprises new ostracod data from the more expanded equivalent section at Eastbourne; samples were collected at the Beachy Head (Gun Gardens) section (National Grid Reference TV 588953; Latitude 50° 44' 12' North; Longitude 0° 15' 01' East) and processed by the same method as those of Jarvis et al. (1988) from Dover, using hydrogen peroxide followed by wet-sieving and picking ostracods from the >63 <3000 µm fraction.

## 3. Ostracod assemblages in the CTBE at Dover

In their detailed study of the Cenomanian–Turonian boundary interval near Dover, Jarvis et al. (1988) were the first to demonstrate the distinctive sequence of changes in the ostracod fauna in which Whatley (1990, 1991) initially recognized the Platycypid Signal. Jarvis et al. (1988) illustrated the occurrence of ostracod species through the

**Table 1**

Scale of actual oxygen values related to the percentage of species of filter-feeding ostracods in an assemblage; after Whatley et al. (2003: p. 360), with correction of an error on the original which showed 20–30% platycypids in the second cell from the bottom in the right-hand column.

>90% platycypids = <1.5 ml/l	80→90% platycypids = very low oxygen 2→<1 ml/l
80–90% platycypids = 2–1.5 ml/l	
70–80% platycypids = 2.5–2 ml/l	60–80% platycypids = low oxygen 3–2 ml/l
60–70% platycypids = 3–2.5 ml/l	
50–60% platycypids = 3.5–3 ml/l	40–60% platycypids = medium oxygen 4–3 ml/l
40–50% platycypids = 4–3.5 ml/l	
30–40% platycypids = 4.5–4 ml/l	20–40% platycypids = high oxygen 5–4 ml/l
20–30% platycypids = 5–4.5 ml/l	
<20% platycypids = >5 ml/l	<20% platycypids = very high oxygen above 5 ml/l

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