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Climate of the Past Discussions

Interactive comment on "Middle Jurassic-Early Cretaceous high-latitude sea-surface temperatures from the Southern Ocean" *by* H. C. Jenkyns et al.

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This review presents many and varied opinions and also manages, in our view inappropriately, to offer negative comments on a previously published paper by the authors on the first palaeotemperature determinations from the Cretaceous of the Arctic Ocean. In our opinion, obtaining high-latitude palaeotemperature data is essential in order to understand Mesozoic palaeoclimate.

We make the following remarks: the TOC data illustrated in figure 2 are generally accurate to better than 0.3%; the TOC data for Site 511 are taken from the Initial reports of the Deep Sea Drilling Project. Reproducibility of delta-13C is only relatively

poor for low-TOC samples – otherwise it is ~0.1‰. The application of the TEX-86 proxy to ancient sediments has been much discussed in the literature and we do not deem it useful to rehearse all these arguments again. Instead, we would refer to the literature.

Stratigraphy: we agree that a high-resolution study of both sediment cores would be more instructive than a lower resolution record. However, we repeat: you have to start somewhere and our initial work indicates that both these cores warrant further detailed study. Unfortunately, the stratigraphy of Site 511 remains problematic and Gröcke offers a new set of speculations as to the dating of the sequence. To illustrate the stratigraphic problem we note that, accepted at face value, the Sr-isotope data of Price and Gröcke suggest the presence of the Valanginian– but there is no unequivocal nannofossil evidence for the presence of this stage, according to Wise (Initial Reports of the Deep Sea Drilling Project). Our suggested age assignments offer a 'best-fit' that accommodates all available bio- and chemostratigraphy. We regard this methodology as the most sensible.

Recognition of the early Aptian OAE is made on the basis of the biostratigraphy, lithology and carbon-isotope stratigraphy. The fact that there is an extensive uppermost Jurassic–lowermost Cretaceous black-shale record in the 511 core is immaterial to the argument – what needs to be demonstrated is organic-carbon enrichment over the interval in question. Based on our extensive previous studies of OAEs we are well aware of the criteria necessary for their recognition. Obviously other palaeoceanographic mechanisms were in play to promote the deposition of organic-rich sediment in the latest Jurassic and earliest Cretaceous but this has no bearing on whether or not the OAE is recorded in Site 511. The early work of Bralower et al. clearly identifies the OAE interval on the basis of nannofossil biostratigraphy coupled with relative TOC enrichment and we agree with this interpretation. Gröcke's reference to Menegatti et al. is not relevant since the Tethyan sequences they described are pelagic and highly condensed, which compacts the shape of the carbon-isotope curve, particularly over the negative excursion. A key factor is the positive carbon-isotope excursion that post-dates

the early Aptian OAE, readily identifiable in the Site 511 chemostratigraphy. Because belemnite data are lacking from the upper part of this core, the remarks of the reviewer about the apparent lack of a diagnostic carbon-isotope excursion in skeletal calcite are beside the point.

Belemnite data: the palaeotemperature data for the belemnites in our Figure 3 are those given by Price and Gröcke. It is interesting that the reviewer wants to question his own interpretation by offering a whole series of potentially complicating factors that could influence the data. We are well aware of all the caveats that affect interpretation of delta-18O in belemnites. However, these are not readily tractable matters at the current state of knowledge, although we agree that they clearly introduce elements of uncertainty.

Regarding the habitat of belemnites in the water column, the papers cited were listed for a very good reason: they report oxygen-isotope data on benthonic bivalves and belemnites, and benthonic foraminifera and belemnites, which co-exist in the same section. Other papers cited by Gröcke do not illustrate this relationship. We also note that we cited not only a paper dealing with facies and faunas of the Callovian (an interval that may well overlap with the strata at the base of the 511 core, despite what he suggests) but another on the Maastrichtian. Several authors have suggested that belemnites were nektobenthonic, so the supposition that they inhabited deeper cooler waters is neither new nor particularly controversial. Specifically, a habitat below the thermocline is also suggested by Mutterlose et al. (2010), based on a comparison of oxygen-isotope and TEX-86 data from Cretaceous sediments in Germany. In contrast, the highly variable oxygen-isotope ratios from New Zealand belemnites are not accompanied by TEX-86 data.

Gröcke is correct to place the Exmouth Plateau Site at 53–54 degrees S in the Aptian–Albian. This adjustment, however, does not affect the fact that the fine-fraction delta-18O record from this site, if taken to represent SST, is incompatible with the TEX-86 records from the Southern Ocean given in this paper. They cannot both be right. So,

are all deep-sea nannofossil-foraminiferal carbonate-dominated sequences affected by sea-floor or sub sea-floor diagenetic recrystallization to lower apparent upper water temperatures? This is the thrust of the data coming out from isotopic study of the exquisitely preserved material sampled by the drilling project in Tanzania.

Reconstruction of the thermocline is admittedly speculative, hinging on the chosen delta-18O value of seawater and the exact values of oxygen-isotope ratios taken from sampled belemnites. The striking fact, however, is the relative uniformity of value over the Jurassic and Cretaceous sampled interval. The reconstructed thermocline value of $\sim$14 degrees C compares very well with modern values in the subtropics.

The evidence for cold snaps obviously does not come from the Falkland Plateau record but data from Europe – both isotopic (belemnites, fish) and palaeontological (ammonites) – are persuasive. As we stated in our paper, what is at issue is the magnitude of any such falls in temperature, particularly at high-latitude sites where ice may or may not have accumulated. We agree that our record is too low in resolution to offer definitive answers but evidence for continuous warmth, albeit with minor cooling episodes, throughout the latest Jurassic–earliest Cretaceous is, we believe, a significant result, a view endorsed by the review of C. Lecuyer.

Interactive comment on Clim. Past Discuss., 7, 1339, 2011.