

**TITLE**

Comment on "New insights in the pattern and timing of the Early Jurassic calcareous nannofossil crisis" by M. E. Clémence et al. [Palaeogeography Palaeoclimatology Palaeoecology 427 (2015) 100–108]

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1 **Comment on “New insights in the pattern and timing of the Early Jurassic**  
2 **calcareous nannofossil crisis” by M. E. Clémence et al. [*Palaeogeography***  
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26 The recent paper by Clémence et al. (2015) provides extensive data on the evolution of  
27 calcareous nannofossils through a well-documented core representing the late Pliensbachian  
28 to early Toarcian interval of the Early Jurassic in the south of the Paris Basin. The study  
29 focuses on an interval recording a  $-6\text{‰}$  negative carbon isotope excursion (CIE) in bulk  
30 carbonate and the onset of black shale deposition related to the Toarcian Oceanic Anoxic  
31 Event (T-OAE). The study by Clémence et al. (2015) takes advantage of a particularly well-  
32 documented mineralogical, geochemical and cyclostratigraphic framework at Sancerre  
33 comprising an epicontinental record in the NW European realm (Hermoso et al., 2009, 2012;  
34 Boulila et al., 2014; Hermoso and Pellenard, 2014). Using calcareous nannofossil counts and  
35 morphometrics of *Schizosphaerella punctulata* calcispheres, it is suggested that a  
36 “biocalcification crisis” affected the phytoplankton due to global warming and, in turn, that  
37 reduced export of carbonate-ballasted particulate organic matter (POM) to the seafloor  
38 contributed to the expression of the negative CIE. If correct, this hypothesis would challenge  
39 our understanding of the nature of the largest carbon isotope excursion of Mesozoic and  
40 Cenozoic eras, and of the mechanisms responsible for the formation of a major hydrocarbon  
41 source rocks. However, here we question the arguments presented for assigning reduced  
42 calcareous nannofossil abundance in sediment to a temperature control and most importantly  
43 the interpretation that reduced pelagic calcification led the oceanic carbon pool towards  
44 depleted isotopic values. We emphasize that the negative CIE recorded during the Toarcian  
45 OAE was not caused, or significantly enhanced, by diminished efficiency of the biological  
46 pump during a period characterised globally by substantial production and accumulation of  
47 organic matter.

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49 Clémence et al. (2015) have related to global warming the drop in *Schizosphaerella*  
50 *punctulata* abundance that seems to be observed also elsewhere, as in the Peniche section

51 (Suan et al., 2008). Before a global picture can be drawn on the relationship between the  
52 environmental perturbations and nannofossil abundance, it is of paramount importance to  
53 establish robust causal links for the particular section being studied here. It is true that  
54 increased sea surface temperature has been suggested by numerous studies at the scale of the  
55 Early Toarcian predominantly deriving from geochemical evidence (see review by Jenkyns,  
56 2010). At Sancerre, a warming is compatible with a protracted negative shift in  $\delta^{18}\text{O}$  of  
57 carbonate, but that is recorded three metres higher in the core, coincident with deposition of  
58 black shale at 348.25 m (Hermoso et al., 2012). As a matter of fact, there is no direct evidence  
59 for an increase in sea surface temperature concomitant with the interval marked by decreased  
60 *S. punctulata* abundance from 351 m upwards in the Sancerre core (Fig. 6 of Clémence et al.,  
61 2015) raising into question a dominant control on the production by this taxon by  
62 temperature. Rather, the level at which *Schizosphaerella* spp. show a drastic decrease in  
63 abundance and calcisphere size is coincident with a number of other profound environmental  
64 changes such as inferred increase in  $\text{CO}_2^{\text{atm}}$  (and presumably lower pH) and relative sea level  
65 fall (Hermoso et al., 2012, 2013).

66 The size of *S. punctulata* calcispheres is the most striking observation used by  
67 Clémence et al. (2015) to argue for reduced pelagic carbonate production prior to the CIE, as  
68 size reduction cannot be ascribed to enhanced calcite dilution by detrital minerals (quartz and  
69 clays). The observation of decreased calcisphere size is not only registered in the Paris Basin,  
70 but was previously reported from the Peniche section in the Lusitanian Basin (Suan et al.,  
71 2008). In modern phytoplankton, increased specific growth rate sets the generation time of the  
72 extant phytoplanktonic population with consequences on cell size (Tang, 1995). Ecological  
73 models predict that if cells divide often, their cellular volume will tend to get smaller (Van  
74 Rijssel and Giekes, 2002; Atkinson et al., 2003). As such, there is a conundrum between  
75 micropalaeontological interpretation and ecological prediction under the assumption that

76 unfavourable conditions reduced biocalcification of *S. punctulata*. In the context of Early  
77 Toarcian environmental settings, it could be hypothesised that enhanced nutrient supply  
78 accompanying the major carbon cycle disturbance (Cohen et al., 2004; Hermoso et al., 2012)  
79 promoted nitrogen-rich cells, circumstances under which phytoplankton with relatively low  
80 growth rate and small cell size flourish (Marañón, 2015). We note that this hypothesis may be  
81 supported by the recognition of a “fertility event” by Clémence et al. (2015) from 351 m up to  
82 the onset of black shale deposition. In any case, there is not a straightforward explanation that  
83 can account for this palaeoecological feature. Thus, we would like to stress that it remains  
84 rather undemonstrated from a biogeochemical perspective that a postulated global warming at  
85 Sancerre was detrimental for *S. punctulata* growth (including its abundance and size).  
86 Considerable debate around the ecology of this taxon (Cobianchi and Picotti, 2001; Erba,  
87 2004; Mattioli and Pittet, 2004; Tremolada et al., 2005; Bour et al., 2007) additionally makes  
88 it very difficult to relate patterns in nannofossil abundance and size with environmental  
89 forcing.

90         The importance of biominerals produced by the calcareous phytoplankton (coccoliths  
91 and calcispheres) as a means of enhanced flux of POM to the seafloor is well argued (e.g.,  
92 Deuser et al., 1981; Lam et al., 2011; Raven and Crawford, 2012). The sensitivity of the  
93 “physical” carbonate pump is all the more important in the Early Jurassic, as this time period  
94 lacked the diatoms and planktonic foraminifera of the present day. Diminished efficiency of  
95 this component of the biological pump, if recognised at a global scale, may have therefore  
96 reduced the ballasting of <sup>12</sup>C-rich POM to the seafloor, as suggested by Clémence et al.  
97 (2015). However, in this paper, it is suggested that reduced calcification had an effect on the  
98 global isotopic carbon cycle through reduced ballasting of POM to the seafloor, hence  
99 decreasing carbon isotope values of the surface of the ocean. However, compelling global-  
100 scale sedimentological and geochemical evidence indicates substantially high primary

101 productivity during the CIE and the T-OAE, with widespread accumulation of organic matter  
102 on the seafloor (e.g., Jenkyns, 1988; Jenkyns, 2010), and the age model adopted by Clémence  
103 et al. for the Sancerre core does not indicate any significant local condensation, arguing  
104 against slow sedimentation as a cause of organic enrichment.

105 In such proximal settings as the Paris Basin with very high quartz and clay content in  
106 sediments, the ballast of organic matter through a relatively thin water column probably also  
107 remained important, regardless change in calcite content (Kennedy et al., 2002). During the  
108 CIE, there was significant increase in the riverine run-off and discharge of detrital sediment to  
109 the basin (Cohen et al., 2004; Hermoso and Pellenard, 2014), potentially aiding export of  
110 POM to the seafloor.

111 In conclusion, it cannot be established from the presented data that the nannofossil  
112 trends observed at Sancerre – specifically decrease in abundance and size of *S. punctulata* –  
113 correspond to a “biocalcification crisis” due to increased temperature. A causal link between  
114 diminished pelagic carbonate production and carbon isotope composition of sediments  
115 appears unlikely considering continuously high primary productivity and organic carbon  
116 export to the seafloor during the Oceanic Anoxic Event, and the time lag of more than ~ 120  
117 kyr (cf. Fig. 6) that separates the onset of the supposed *S. punctulata* ‘crisis’ and the negative  
118 CIE.

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