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Callovian oxygen and carbon isotope records of the Russian Platform: indices of oceanographic and climatic changes

Wierzbowski H.[1], Ippolitov A.P.[2], Gulyaev D.B.[3], Rogov M.A.[2]

[1] Polish Geological Institute – National Research Institute, Warsaw, Poland; hubert.wierzbowski@pgi.gov.pl
[2] Geological Institute of the Russian Academy of Sciences, Moscow, Russia; ippolitov.ap@gmail.com, russianjurassic@gmail.com
[3] Interdepartmental Stratigraphic Committee (ISC) of Russia, Yaroslavl, Russia; dbgulyaev@gmail.com

Oxygen and carbon isotope records of the Middle–Upper Jurassic boundary of the Russian Platform and other European basins have been for a long time a matter of debate. An increase in belemnite and fish tooth $\delta^{18}O$ values at the Callovian–Oxfordian boundary was interpreted as an evidence of a severe cooling (e.g. Dromart et al., 2003) or a result of changes in water circulation (Lécuyer et. 2003; Wierzbowski et al. 2013). A pronounced increase in the $\delta^{18}O$ values in the Upper Oxfordian–Lower Kimmeridgian interval was linked to a gradual climatic warming or shallowing of marginal marine basins (Dromart et al., 2003; Nunn et al., 2009; Price and Rogov, 2009; Wierzbowski et al., 2013). A recent clumped isotope study of Wierzbowski et al. (2018) has, however, shown that the belemnite $\delta^{18}O$ record of the Russian Platform is affected by salinity variations. The clumped isotope data indicate a constant seawater temperature (ca. 16°C) of the Middle Russian Sea throughout the latest Callovian–mid-Kimmeridgian and its progressive freshening (Wierzbowski et al., 2018). Observed differentiation of uppermost Callovian–Oxfordian belemnite $\delta^{13}C$ values among various European basins is, in turn, connected to local changes in burial rate of organic carbon and restriction of (Sub) boreal sedimentary basins (Wierzbowski, 2004; Wierzbowski and Rogov, 2011).

A compilation of new and published belemnite data of Barskov and Kiyashko (2000) and Wierzbowski et al. (2013) from the so far poorly studied Callovian strata of the Russian Platform is presented. Newly collected belemnite samples were carefully screened for the preservation state using cathodoluminescence observations and chemical analyses. The studied rostra are non-luminescent and characterized by low Mn (≤ 10 ppm), Fe (≤ 35 ppm) and high Sr (≥ 883 ppm) contents.

Belemnite $\delta^{18}O$ values are scattered and vary between -0.4 to 2.4‰ VPDB (**Fig. 1**). Three positive excursions (in the lowermost Callovian, at the Lower–Middle Callovian boundary and in the uppermost Callovian) are observed. High belemnite $\delta^{18}O$ values coincide with elevated $\delta^{13}C$ values (up to 4‰ VPDB). A moderate, statistically significant correlation ($R = 0.46$) is observed between belemnite all $\delta^{18}O$ and $\delta^{13}C$ values in the new dataset, similar correlation ($R = 0.48$) is found within the sole cylindroteuthidid data.

Positive $\delta^{18}O$ shifts, which mostly coincide with transgressions and the periods of prevalence of (Sub)boreal cephalopod faunas, could have resulted from decreased water temperatures (cf. Sahagian et al., 1996; Kiselev and Rogov, 2018). Palaeotemperatures calculated for these intervals using a constant seawater $\delta^{18}O$ value of -1‰ VSMOW characteristic of non-glacial periods are, however, very low (**Fig. 1**). This feature of the oxygen isotope record along with a partial co-variance between belemnite $\delta^{18}O$ and $\delta^{13}C$ values may point to salinity variations rather than the temperature changes. In addition, relatively high $\delta^{18}O$ values (0.2 to 1.9‰ VPDB) measured from the lowermost Callovian and the Lower–Middle Callovian boundary proves complex history of palaeoceanographic changes with at least three episodes of cooling or increased water salinity in the Middle Russian Sea during the Callovian. This is contrary to the oxygen isotope records of Western and Central Europe (cf. Dromart et al., 2003; Wierzbowski et al., 2009).

The fluctuations of the Callovian belemnite $\delta^{18}O$ and $\delta^{13}C$ values should, therefore, be related to multiphase changes in the circulation pattern of waters of the restricted Middle Russian Sea basin. Although the Middle Callovian isotope record needs further studies due to the scarcity of results the newly presented data show a domi-

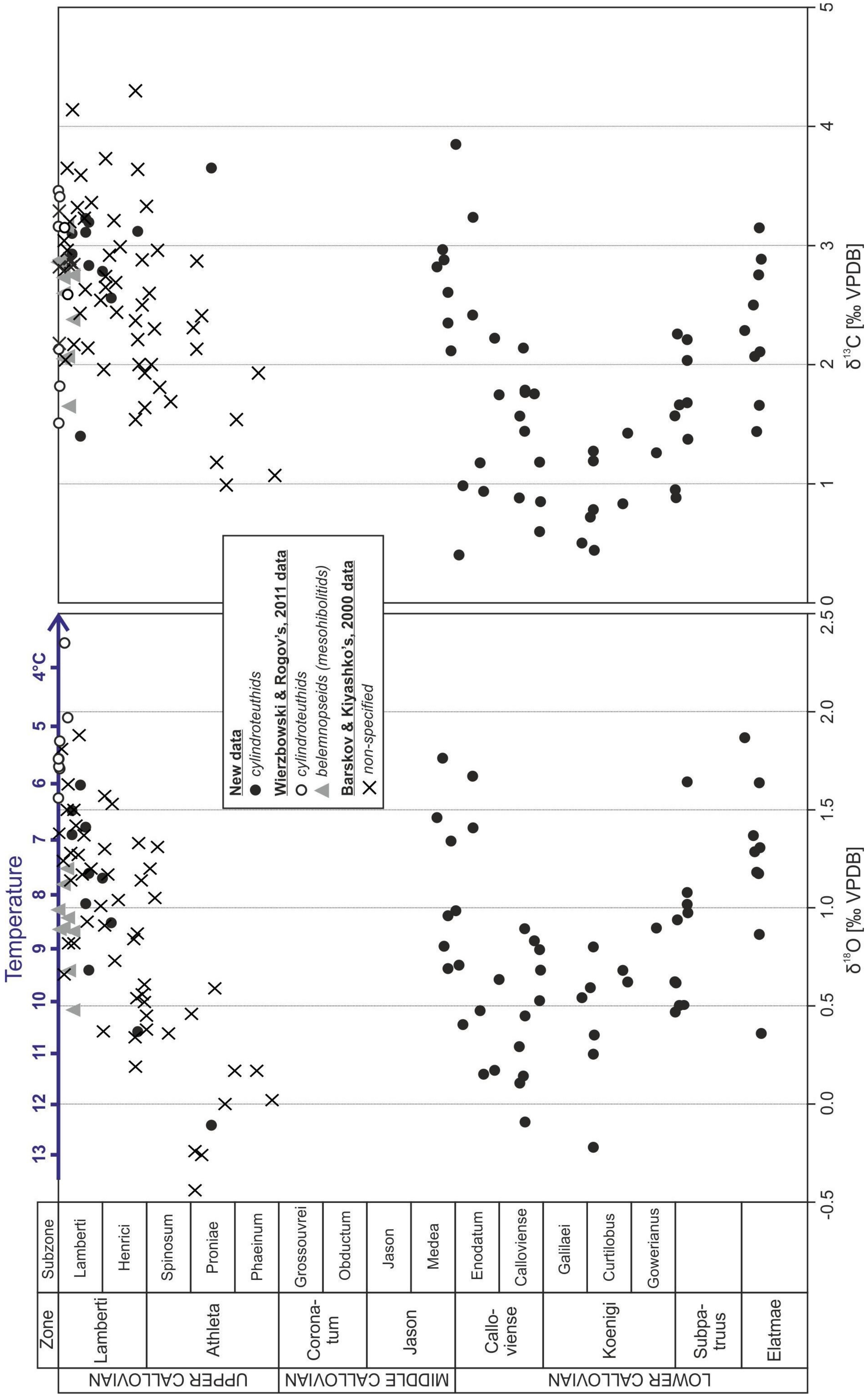

Fig. 1. $\delta^{18}O$ and $\delta^{13}C$ values of Callovian belemnite rostra from the Russian Platform and palaeotemperatures calculated using a temperature equation of Anderson and Arthur (1983) and a constant $\delta^{18}O_{water}$ = -1‰ VSMOW.

nant role of local or regional effects on the belemnite isotope record of the Russian Platform. The presented data also contradict a theory of one-directional climatic changes in the Callovian, particularly the existence of a warmer period in the Early or the Middle Callovian followed by a prominent cooling in the Late Callovian (cf. Dromart et al. 2003; Donnadieu et al. 2011).

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