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# First quantitative constraints on the Pliensbachian-Toarcian warming in polar regions

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One of the most dramatic warming episodes of the Mesozoic occurred near the Pliensbachian-Toarcian transition (Early Jurassic). The occurrence of abundant exotic clasts and glendonites in marine strata of Siberia suggests cold conditions during the late Pliensbachian, which may have led to the episodic growth of high latitude ice-sheets. These conditions ended abruptly during the early Toarcian when temperature rose rapidly across an episode of global biogeochemical perturbation known as the Toarcian Oceanic Anoxic Event (T-OAE). The rapid marine transgression coinciding with the T-OAE onset has been tentatively attributed to the rapid demise of these polar ice-sheets, which possibly released large amounts of methane in the atmosphere through permafrost thawing. Nevertheless, the scarce quantitative estimates of Pliensbachian-Toarcian temperatures have exclusively been obtained from low paleolatitude sites. Plus, existing temperature records are mostly based on oxygen isotope thermometry and hence remain equivocal in the absence of constraints on the ocean oxygen composition of Pliensbachian-Toarcian oceans and its temporal variability. Clumped isotope ($\Delta_{47}$) data from aragonite bivalve shells from one NE Siberian site have recently provided the first quantitative evidence for extreme Toarcian polar warmth, with marine temperature estimates exceeding ~15°C north of the Anabar shield. In this study, we present new $\Delta_{47}$ data from bivalve samples from Tyung River, south of the Anabar shield that allow to substantially expand this record both spatially and temporally. Clumped isotope data from aragonite shells confirm elevated marine temperatures (~13°C) at the end of the T-OAE in polar areas some 850 km away from the previous record. Upper Pliensbachian calcite shells of *Harpax* collected from coastal to deltaic, boulder-bearing deposits of a nearby site record much lower temperature (~3°C) and extreme $^{18}$O-depletion of environmental waters ($\delta^{18}$O = -6.5‰VSMOW). These results provide the first quantitative evidence for near-freezing polar temperatures during the Late Pliensbachian, which is a key prerequisite for the hypothesis of episodic ice-sheet growth prior to the T-OAE. Beyond glacio-eustasy, our new data offer a rare glimpse of extreme changes in polar temperatures across a transition from coldhouse to greenhouse climate and will certainly prove useful for future earth system simulations of Mesozoic climates.