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Supplementary information

Compilation of Jurassic-Eocene proxy data

Our compilation (Table DR4) regroups published measurements from marine biogenic carbonates (molluscs, brachiopods, corals, foraminifera, belemnites) Δ_{47} data (Keating-Bitonti et al., 2011; Douglas et al., 2014; Petersen et al., 2016b, a; Evans et al., 2018; Wierzbowski et al., 2018; Meyer et al., 2018; Vickers et al., 2019, 2020, 2021; Price et al., 2020; Brigaud et al., 2020; Fernandez et al., 2021; de Winter et al., 2021), TEX_{86}^{H} paleothermometry data (Jenkyns et al., 2012; Lunt et al., 2012; Douglas et al., 2014; Frieling et al., 2014; Robinson et al., 2017; O'Brien et al., 2017; Cramwinckel et al., 2018; O'Connor et al., 2019; Ruebsam et al., 2020), and marine turtles phosphate $\delta^{18}O$ data (Billon-Bruyat et al., 2005; Coulson et al., 2011; van Baal et al., 2013).

Paleolatitude of each site was revaluated based on modern site location using the online paleolatitude calculator paleolatitude.org (van Hinsbergen et al., 2015) computed with the model of Torsvik et al. (2012). Distinction was made between the different proxies (TEX_{86} data, Δ_{47} data from biogenic marine carbonate, and phosphate $\delta^{18}O$) as each proxy can be interpreted differently. TEX_{86}^{H} is commonly used as a SST proxy from which we chose to show published SST derived from the hyperbolic core-top calibration of Kim et al. (2010). Carbonate Δ_{47} can both resolve calcification temperature and calcifying fluid $\delta^{18}O$. Most of the Δ_{47} data in this compilation were acquired before the introduction of interlaboratory carbonate standardization of the proxy (Bernasconi et al., 2018, 2021). The data Δ_{47} could not have been reprocessed in the I-CDES reference frame to fit with our data and other recent data, as it was done for modern biogenic carbonates and laboratory precipitated carbonates

(Anderson et al., 2021). In consequence we used the published Δ_{47} temperature for each publication. The calcification Δ_{47} temperature of biogenic carbonates is interpreted as marine temperature, which may be interpreted differently depending on the ecology of the calcifying organism (living depth, shell growth dynamics, locomotion…). Calcifying fluid $\delta^{18}O$ were derived from Δ_{47} calcifying temperatures using different isotopic fractionation equations depending on the calcifying organism, and are interpreted as representing sea water $\delta^{18}O$ ($\delta^{18}O_{sw}$), except for belemnite rostra. Belemnite calcite Δ_{47} data yielded unrealistically high $\delta^{18}O_{sw}$ estimates (Wierzbowski et al., 2018; Price et al., 2020; Vickers et al., 2021) using widely used fractionation equations. Using Coplen (2007) equation has resulted in the most realistic $\delta^{18}O_{sw}$ estimates from belemnite rostra (Price et al., 2020). We followed this practice and used this equation to derive $\delta^{18}O_{sw}$ from belemnite calcite Δ_{47} data in our compilation, but there is no evidence that any published fractionation equation is well suited to describe belemnite rostra oxygen isotope fractionation. Therefore, belemnite-based $\delta^{18}O_{sw}$ values should not be taken as absolute $\delta^{18}O_{sw}$ estimates but only as recording relative changes in $\delta^{18}O_{sw}$. We used the equation of Erez and Luz (1983) for foraminifera data, the equation of Grossman and Ku (1986) for biogenic aragonite samples (ammonite shells, aragonite bivalves and belemnite phragmocones), and the equation of Epstein et al. (1953) for calcite bivalves. There is a linear relationship between modern aquatic turtle bone phosphate $\delta^{18}O$ and living water $\delta^{18}O_w$ (Barrick et al., 1999; Coulson et al., 2008). We derived past $\delta^{18}O_{sw}$ from fossil marine turtle $\delta^{18}O_p$ data using the equation of Barrick et al. (1999) normalized to the most recent NBS120c accepted value (Pouech et al., 2014).

These revised values were used to build Figure 5, and illustrate Jurassic-Paleocene temperature and $\delta^{18}O_{sw}$ latitudinal gradient. For this compilation, data was time sliced in 8 intervals corresponding to chronostratigraphic epochs. Late Cretaceous data were further divided into two intervals to highlight long term difference between the "super-greenhouse" Cenomanian-Santonian interval and cooler Campanian-Maastrichtian interval. When only absolute age model was available (most TEX_{86}^{H} data), each data was arbitrarily attributed to its corresponding interval based on absolute date of stage boundaries from the International Chronostratigraphic chart v2020/03 (Cohen et al., 2013; updated). For each time interval and each proxy, we plotted mean temperature or $\delta^{18}O_{sw}$ values for one site or a collection of nearby sites (sites from the same basin within 0.5° of latitude) with error bars representing the total range of the data (maximal to minimal value).

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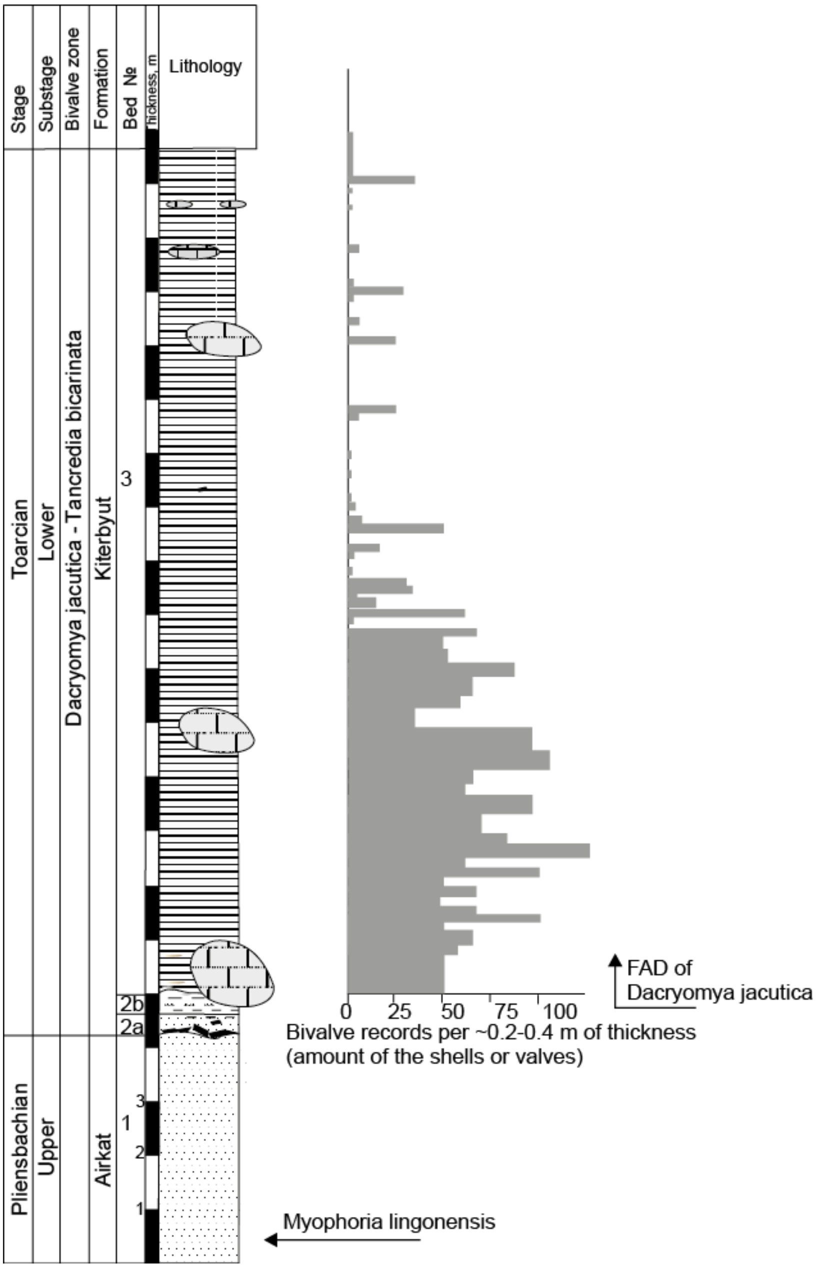

Figure S1. Stratigraphic log of the Polovinnaya River section and the number of reported occurrences of *Dacrymoya jacutica*.