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Paleoclimatic changes recorded by δD of *n*-alkanes and $\delta^{15}N_{org}$ in a continental section of central Asia (Early Jurassic)

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Major paleoenvironmental changes have been documented during the Early Jurassic (e.g. Morard et al., 2003; Suan et al., 2008). Most studies were carried out on European marine sediments, with little information on the environmental conditions that prevailed in terrestrial ecosystems. Here we present results on a continental section from Taskomirsai (South Kazakhstan) showing a succession of sedimentary cycles made of lignites, clayey layers and silty-sandstones most probably deposited in a fluvial/lacustrine environment with nearby swampy areas. Rock-Eval pyrolysis indicates an immature Type-III organic matter. A multi-isotope approach based on bulk organic nitrogen isotopes ($\delta^{15}N_{org}$) and hydrogen isotopic composition (δD) of *n*-alkanes was developed to document paleoclimatic changes in the area. To the best of our knowledge, it is the first time that these proxies are combined for a paleoclimatic approach in the Early Jurassic. In the literature, compound-specific δD is usually used to reconstruct paleohydrological conditions (Sachse et al., 2012). In the same way, $\delta^{15}N_{org}$ measured on modern or Quaternary plants has been positively correlated with temperature and negatively correlated with precipitations (e.g. Austin and Vitousek, 1998; Liu and Wang, 2008). Then, these concepts were successfully used to evidence humid/dry cycles around the Paleocene-Eocene transition (Storme et al., 2012).

In Taskomirsai, $\delta^{15}N_{org}$ values ranged from 0.5‰ to 4.5‰. The lowest values are found in lignite beds and interpreted as humid periods, whereas the highest ones are recorded in clayey layers and suggest drier periods. The δD values of *n*-alkanes (C_{17} to C_{35}) ranged from -248‰ to -151‰. Two groups of *n*-alkanes were distinguished based on their chain length and their δD values: an aquatic group (C_{17} to C_{23} ; -198‰ in average) and a terrestrial one (C_{25} to C_{35} ; -183‰ in average). In the aquatic group, low δD values in lignites (-219 ± 17 ‰; $n=10$) suggest humid and/or cool climate during their formation, whereas high values in clayey layers (-179 ± 13 ‰; $n=6$) suggest a drier and/or warmer climate. Based on main trends in the *n*-alkanes δD values, two "climatic units" are proposed named Unit 1 and Unit 2 (Figure 1). Decreasing δD values in Unit 1, recorded in the aquatic pool, suggest a cooling/humid climate trend (Figure 1). In contrast, drier/warmer conditions, inferred from high δD values, took over in Unit 2. δD values also suggest paleoclimatic variations at higher frequency than the two main trends described above. They seem to be linked with the sedimentary cycles. This finding rules out an autocyclic control on the sedimentation, which would have been generated by local sedimentary processes (e.g. moving channels of rivers). Thus, an allocyclic control driven by climate is most likely.

The Average Chain Length (ACL) and amount of the *n*-alkanes in lignites are in agreement with the above interpretations. Indeed, decreasing ACL and *n*-alkane amount could be the result of decreasing temperature and increasing humidity in Unit 1. (Gagosian and Peltzer, 1986; Gauvrit and Gaillardon, 1991; Shepherd and Wynne Griffiths, 2006). Conversely, increasing ACL and *n*-alkane amount in lignites in Unit 2 may reflect higher temperature and aridity (Figure 1). Additionally, evapotranspiration was estimated from the isotopic difference between δD values of the C_{23} and the C_{27} *n*-alkanes, noted $\Delta D_{ter.-aq}$ (Sachse et al., 2006). Maximal $\Delta D_{ter.-aq}$ is recorded during the coolest/most humid interval, suggesting a contrasted seasonality with a warm/humid growing season. Difference close to zero was recorded in drier/warmer intervals (e.g. Unit 2) pointing to preponderant evaporative conditions in the aquatic environment during most of the year leading to a D-enrichment of this pool.

In some parts of the section, the δD and the $\delta^{15}N_{org}$ suggest different environmental conditions. This may point to different spatial integration of those proxies: δD being under regional influence (precipitation regimes, air mass temperatures) and $\delta^{15}N_{org}$ being more sensitive to local environmental parameters (Amundson et al., 2003; Sachse et al., 2012). Local environmental variations are also suggested by the $\delta^{13}C_{org}$, which is highly variable within a lignite bed (Figure 1). Thus, the combination of *n*-alkane δD values and $\delta^{15}N_{org}$ values shed new light on the continental paleoclimatic changes during the Early Jurassic. It also underlines the potential of these parameters to reconstruct paleoclimatic changes at different spatial and time scales. A higher accuracy in biostratigraphy is needed to correlate those changes with global paleoclimatic pattern identified in the Early Jurassic.

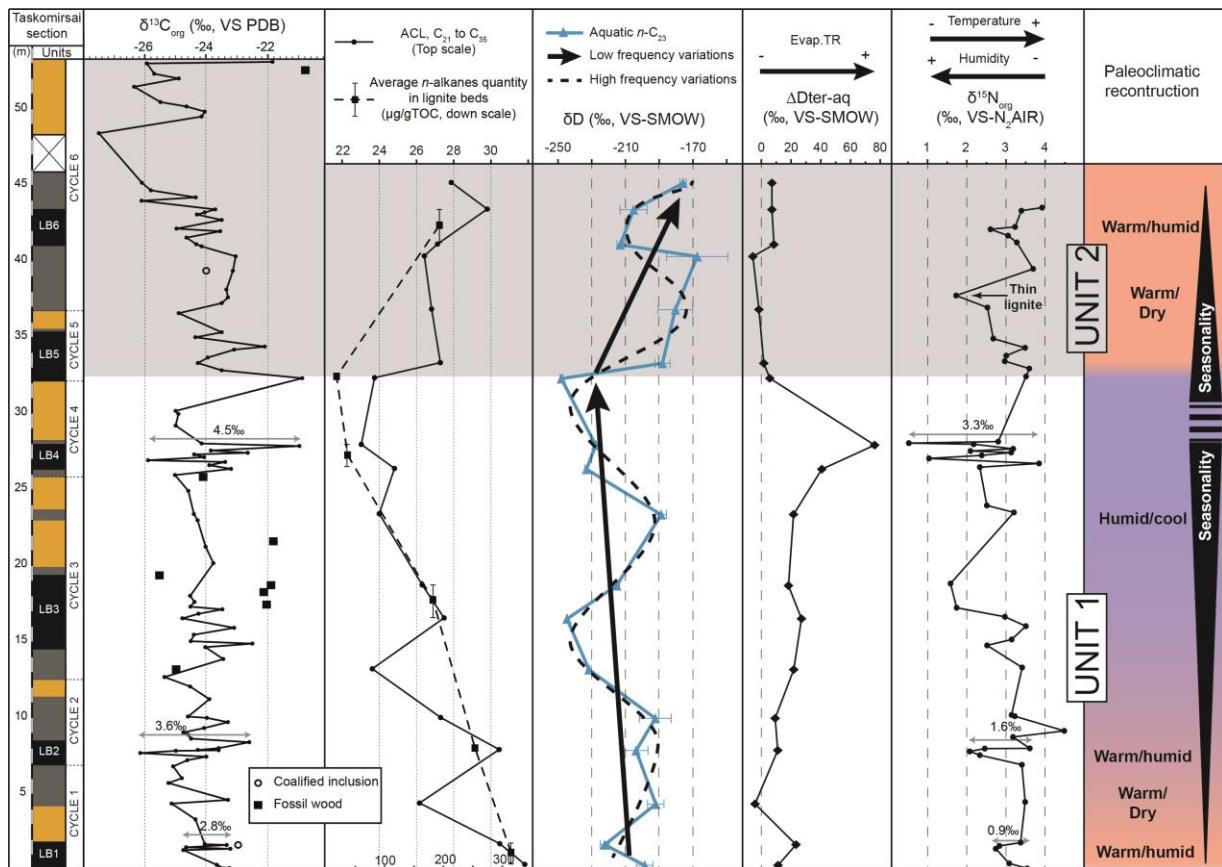


Fig. 1. Taskomirsai section and organic parameters ($\delta^{13}\text{C}_{\text{org}}$, ACL, δD , $\Delta\text{D}_{\text{ter-aq}}$ and $\delta^{15}\text{N}_{\text{org}}$). Stratigraphic units: black for lignites, grey for clayey layers, orange for silty-sandstones. LB: Lignite Bed.

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