Paleoenvironmental reconstruction of the Late Cretaceous Songliao Paleo-lake by molecular biomarkers

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The Late Cretaceous was characterized by a variable greenhouse climate, with evidence for cooling and/or glaciation and warming, with humid and arid events. However, most of these climatic and environmental signals are derived from marine records, and knowledge of the terrestrial climate and environment, especially in the mid-latitudes, is limited due to fragmented geological records on continents. The Songliao Basin (SLB) located in northeastern China is one of the largest Cretaceous continental rift basins in the world. Well-preserved Cretaceous lacustrine deposits in this basin provide a unique record for the paleoenvironmental reconstruction of the non-marine Cretaceous. Here, we reconstruct the paleoenvironment of the Late Cretaceous by the lacustrine sedimentary strata (lower Nenjiang Formation) in the eastern SLB. Biomarkers, including aliphatic and aromatic hydrocarbons and, steranes, as well as stable carbon and hydrogen isotopic compositions of *n*-alkanes extracted in outcrop samples from the Houjingou section, corresponding to the Late Santonian, are analysed. The distribution of the biomarkers and the stable carbon isotope ($\delta^{13}C$) of the TOC indicate that the organic matter (OM) in the uppermost of the first member of the Nenjiang Formation (K_2n^1) was mainly originated from the input of aquatic macrophytes and land plants. The compositions of the biomarkers and the $\delta^{13}C$ of the TOC and *n*-alkanes indicate that the OM in the lower of the second member of the Nenjiang Formation (K_2n^2) was a mixture of algae, bacteria, and higher plants. Marine transgression indicated by 24-*n*-propyl- and 24-*iso*-propyl-cholestanes episodically occurred in the lower K_2n^2. The hydrogen isotopic compositions (δD) of short chain *n*-alkanes in the lower K_2n^2 indicate the corresponding environment was extremely humid and large-scale flooding might have occurred in the Songliao Paleo-lake. High-resolution biomarker and stable isotope records from the Houjingou section demonstrate that the paleoenvironment in the Songliao Paleo-lake experienced abrupt changes after seawater incursion.