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Terrestrial climate and carbon cycle of East Asia in the Late Cretaceous: Records from the Continental Scientific Drilling of the Songliao Basin

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The Late Cretaceous climate was characterized by a general cooling trend from a “hot greenhouse” to a “cool greenhouse”, with evidence for rapid cooling and warming events. Although marine sediments record abundant climate signals in the Late Cretaceous, our knowledge of the terrestrial climate change is limited and the reason for such climate changes is not well resolved. The Continental Scientific Drilling of Cretaceous Songliao Basin (the SK-1 drilling project) provides a continuous terrestrial record of the Late Cretaceous. A multidiscipline research on SK-1 provides important information on the terrestrial climate change and carbon cycle in the Late Cretaceous.

Detailed stable isotopic and organic geochemical analyses on SK-1 core indicate strong correlation between organic carbon deposition and Milankovich cycles. Stable carbon isotopes of ostracod shells show that the largest perturbation of carbonate $\delta^{13}C$ occurred at long eccentricity maximums. In the hundred-meter thick, dark colour, lacustrine shale deposits, the highest TOC values and heaviest TOC $\delta^{13}C$ occurred at maximums of the short eccentricity that likely acted as a modulation to the precession cycles. These records suggest that terrestrial climate rhythms in the Songliao Basin were significantly influenced by orbital forcing in the Late Cretaceous greenhouse world.

Besides, multiple proxies from scientific cores and outcrops in East Asia reveal terrestrial climate change and carbon cycling in the Late Cretaceous. Atmospheric pCO_2 concentrations were more precisely constrained by a comparison of different methods and from different localities, and were synthesized to show a generally declining trend with several rapid changes. Organic carbon burial rate in lake basins, the Songliao Basin in northeast China as an example, was calculated to be much higher than that in marine basins suggesting that giant lakes may serve as important carbon sinks to cause atmospheric pCO_2 perturbation. Paleotemperatures measured from stable oxygen isotopes and clumped isotopes of biogenic and pedogenic carbonates revealed rapid terrestrial climate changes in the Late Cretaceous, probably in response to changes of carbon cycling.

In summary, combined with paleoclimatic and paleoenvironmental datasets from scientific cores and outcrops of the Late Cretaceous age in East Asia, the SK-1 records may help us to better understand the terrestrial climate change and carbon cycling in a greenhouse world.