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Atmospheric circulation system during the Cretaceous "greenhouse" world: New insights from the desert deposits in Asian interior

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Understanding of the process and interaction of various components of the Earth System during the Cretaceous "greenhouse" world is one of the major targets of paleoclimatology. During the Cretaceous period, the equator-to-pole temperature gradient was estimated to have been much lower than the present, implying larger meridional heat transport either by atmospheric or by oceanic circulation. If true, the circulation system during the Cretaceous "greenhouse" world might have been quite different from today. However, a reconstruction of the atmospheric circulation pattern during the Cretaceous has been retarded due to the lack of appropriate indicators.

Deserts are mostly developed in subtropical arid zone, and westerlies and northeast trade winds are prevailed in northern and southern part of the desert area in case of the Northern Hemisphere. Thus, deserts are direct product of general atmospheric circulation, and their distributions and prevailing surface wind patterns preserved in their deposits are direct indicators of the past atmospheric circulation system. Hence, we examined the Cretaceous desert deposits from low- to middle-latitude non-marine sedimentary basins in Asian interior (Gobi basin of Mongolia; Ordos, Subei, Jianguan, Sichuan, Simao basins of China; Khorat basin of Thailand), in order to reconstruct the spatio-temporal changes of desert distributions and prevailing surface wind patterns in Asia during the Cretaceous.

The result suggests that northward expansion of the subtropical arid zone in Asia during the early and late Cretaceous (Berriasian-Barremian and Coniacian-Maastrichtian), whereas southward shrinkage of the arid zone during the mid-Cretaceous (Aptian-Turonian) “supergreenhouse” period. Reconstructed prevailing surface-wind pattern also reveals the drastic latitudinal shift of the subtropical high pressure zone. Namely, subtropical high was shifted poleward (much higher latitude compared to today) during the early and late Cretaceous. On the other hand, it was shifted equatorward during the mid-Cretaceous time. Therefore, it is suggested that Hadley Cell was expanded poleward than the present during the early and late Cretaceous “greenhouse” period, in response to the globally warmer climatic condition, whereas it was shrunk equatorward during the mid-Cretaceous “supergreenhouse” period. These results indicate that the atmospheric circulation system could be significantly different from the present during the greenhouse world.