Long-term history of Asian desertification in the past 22 Myr as recorded in the eolian deposits in China

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In northern China, the loess-soil sequence of the last 2.6 Myr, the *Hipparion Red-Earth* of eolian origin and the recently reported Miocene loess-soil sequences provide a near continuous continental record of Asian desertification history for the past 22 Myr. The onset of loess deposition by 22 Myr ago indicates the existence of sizeable deserts in the interior of Asia and of a energetic winter monsoon by that time. The alternations of loess and soils indicate cyclical changes in the intensity of winter and summer monsoons. The Himalayan-Tibetan complex was extended enough and sufficiently elevated by 22 Myr ago to cause desert formation and to produce winds strong enough to carry eolian particles. Loess accumulation rate during the Miocene was much lower than for Quaternary, suggesting moderate levels of aridity and winter monsoon strength. Higher accumulation rates are observed at 15-13 Myr and 8-7 Myr, which may represent temporary instabilities of climate or land-surface conditions in the source region.

Desert lands and winter monsoon must have been constantly maintained since then, as evidenced by the *Hipparion Red-Earth* and Quaternary loess-soil sequences. The inland aridity was stronger from ~6.2 to ~5 Ma BP and weaker from ~5 to ~3.6 Ma BP. Two major drying steps are observed at ~3.6 and ~2.6 Ma BP, respectively. The enhanced aridity at ~3.6 Ma BP is synchronous with a suggested uplift of portions of the Tibetan Plateau. The general aridification history is also highly consistent with the ongoing high-latitude cooling and the consequent expansion of Arctic sea-ice/ice sheets since 6.2 Myr BP. These suggest that both Tibetan uplift and ice-building processes in the northern hemisphere were two prominent driving forces behind the long-term desertification in the interior of Asia.