Changes of eolian dust provenance in East Asia and their linkage with uplift of northern Tibet and Tien Shan during late Cenozoic

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http://www-sys.eps.s.u-tokyo.ac.jp/~paleo/

Loess-paleosol sequence and red clay formation of Chinese Loess Plateau [CLP] hold a continuous eolian record that covers the last 7.2 Ma. Recent study by Sun et al. (2004) revealed that these eolian sediments are composed of two different grain size populations, one is characterized by modal size of 4 to 8 um (finer population) and the other by modal size of 20 to 80 um (coarser population), respectively. They interpreted that the finer population was transported by high-altitude westerly jet whereas coarser population was transported by near-surface wind of winter monsoon. However, their interpretation is based solely on the characteristic of the modal grain sizes and present dust transport wind for each grain-size populations, and no direct evidence to specify the transportation wind system was presented.

It is generally accepted that provenance of eolian dust in loess-paleosol sequence and red clay formation records long-term history of dry land development as well as changes in nature, intensity, and route of dust transport wind in East Asia since the Late Miocene. However, until present, no well-established method exists to extract such information from these eolian sediments in CLP. We recently developed the method to characterize eolian dust provenance by utilizing electron spin resonance [ESR] signal intensity of E center of quartz, which reflects ages of its mother rocks, together with crystallinity index of quartz, which reflects temperatures and/or speed of crystallization. We applied the method to the two different size fractions (+30 um and -30 um) of loess, paleosol, and red clay samples from Lingtai Section in south central part of CLP. We compared the extracted provenance characteristics with those of the present surface samples obtained from dry areas all over China, Mongolia, and southeastern part of Russia. The result suggests 1) provenance of the finer and coarser populations are different, 2) provenance of all samples for both grain size populations can be explained by mixtures of the dust from Taklimakan Desert, Jungger Desert (north of Tien Shan Mts.) plus northwestern deserts, and probable Siberia areas, and 3) provenance of both populations changes with time. In general, source area of the finer population changed from Jungger Desert, northwestern deserts plus probable Siberia to Taklimakan Desert from 7.2 Ma to 0.3 Ma with slight reversals from 2.3 to 1.9 and 1.8 to 1.5 Ma. A drastic switch in source area occurred at 0.3 Ma when the dominant source changed from Taklimakan Desert to Jungger Desert plus northwestern deserts. Source area of the coarser population was dominantly from probable Siberia at 7.2 Ma which gradually changed to Taklimakan Desert (with possible contribution from Jungger Desert plus northwestern deserts) with slight reversals from 2.3 to 1.9 and 1.8 to 1.5 Ma.

Generally increasing trend of fine dust contribution from Taklimakan Desert from 7.2 Ma to 0.3 Ma could be attributed either to i) formation and gradual expansion of Taklimakan Desert (the source area), ii) increasing supply of fine material to Taklimakan Desert, or iii) increasing intensity of westerly jet during this period. Since coarse dust contribution from Taklimakan Desert also shows similar trend, third explanation is less likely. There is evidence that Taklimakan Desert was already present at least by 4.6 Ma (Zheng et al., 2006), which tends to argue against the first possibility although not conclusive.

Increasing evidence suggests that Kunlun and Tien Shan Mountains, which bounded southern and northern margin of Taklimakan Desert respectively, uplifted since 4 to 3 Ma. This is consistent with increasing contribution of dust from Taklimakan Desert especially since around 5 Ma. Temporal decrease in contribution from Taklimakan Desert between 2.3 and 1.5 Ma may imply temporal decrease in uplift rate during this period.