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Deep-time paleoclimate studies are crucial to develop a comprehensive understanding of climate variability and dynamics. The Late Miocene to Early Pliocene, when Greenland was mostly free from ice, was characterized by a global cooling trend and massive Antarctic ice sheet expansion, which ultimately led to the onset of major northern hemisphere glaciation in the Late Pliocene. This period is of great interest because it holds important information about climate developments that shaped modern terrestrial environments, ecosystems, fauna and hominoids. Yet, Late Miocene–Early Pliocene climate variability and dynamics remain poorly constrained, especially in terrestrial settings. The continuous eolian Red Clay sequence underlying the well-known Quaternary loess-paleosol sequence on the Chinese Loess Plateau (CLP), North China, provides an important opportunity to study Miocene–Pliocene terrestrial climate variability in East Asia.

Here, we present new mineral magnetic records of the Shilou Red Clay succession from the eastern CLP, and demonstrate a marked East Asian climate shift across the Miocene–Pliocene boundary (MPB). Pedogenic fine-grained magnetite populations (ranging from superparamagnetic (SP)/single domain (SD) up to small pseudo-single-domain (PSD) sizes, i.e. from <30 nm up to $\sim$1000 nm) dominate the magnetic properties. Importantly, our mineral magnetic results indicate that both pedogenic formation of SP grains and transformation of SP grains to SD and small PSD grains accelerated across the MPB in the Shilou Red Clay, which are indicative of enhanced pedogenesis. We relate this enhanced pedogenesis to increased soil moisture availability on the CLP, associated with stronger Asian Summer Monsoon precipitation during an overall period of global cooling. This notable environmental change across the MPB in East Asia may have resulted from growth of Asian mountain ranges (Tibetan Plateau, Pamir, Tianshan, Mongolian Plateau), which significantly affected ASM precipitation by changing land-ocean thermal contrasts and oceanic/atmospheric temperature gradients. Our study, thus, develops new insights into the Miocene–Pliocene climate transition in East Asia and associated dynamic controls due to regional tectonic uplift.