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Tectonic uplift driving climatic aridification in the late Miocene on the northeastern Tibetan Plateau

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The paleoenvironment and paleoclimate of Asia dramatically changed during the late Cenozoic, such as enhanced Central Asian aridification and East Asian monsoon development. The uplift of the Tibetan Plateau in the late Cenozoic is considered one of the major drivers forcing the Asian paleoenvironmental changes. However, the complex interaction between tectonic and climate change is still unclear. This is largely due to 1) the combined effect of aridification of the continent by global cooling, oceanic closure and uplift of the plateau, and 2) the lack of temporally and spatially matching tectonic and climatic records in a critical zone. The Xining Basin lies in the transitional zone between the arid Asian interior and the East Asian monsoon region. Here, we present detailed paleomagnetic analysis of a fluvial-lacustrine sequence in the Xining Basin and the first record of clay mineralogy and elemental geochemistry. High-resolution paleomagnetism revealed 16 normal and 16 reversed zones that correlate well with chrons 3n to 5Ar.1r of the Geomagnetic Polarity Time Scale, constraining the section to $\sim$12.7–4.8 Ma. The changes in lithofacies from floodplain to braided river at $\sim$8.6 Ma with predominantly southerly paleocurrent directions occur simultaneously with an increase in the sedimentation rates, representing a rapid uplift in the eastern Qilian Shan to the north. Geochemical provenance proxies (Th/Sc, Zr/Sc and Cr/Zr) in the <2 μm fraction show a significant provenance change at $\sim$8.8 Ma. Silicate-based weathering indexes (CIA, CIW and PIA) displayed coeval changes with provenance but discrepant changes with regional climate. Since the clay mineralogy exhibit significant change at $\sim$7.8 Ma uncorrelated with modifications in provenance, it can be employed to reveal regional climate change. The rise in illite, and associated decrease in the sum of smectite and illite/smectite mixed-layers reflect gradual and slow aridification since $\sim$12.7 Ma with intensified drying since $\sim$7.8 Ma until approaching the modern climate status. Our results, together with other regional climatic and tectonic records, clearly illustrate that accelerated uplift of the northeastern TP since $\sim$8-9 Ma has mainly modulated the regional erosion, weathering, transportation and sedimentation, and amplified the global cooling and drying trend towards the regional climate of modern conditions. Our study suggests that in the tectonically active northeastern TP, a comprehensive mineralogical and geochemical investigation of the fine-grained fraction of the basin sediments could retrieve the interactions between tectonics and climate behind the complex change in exhumed lithology and sedimentary routing systems.