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Anti-phase variation of long eccentricity and precipitation in inland Asia during the middle Miocene Climatic Optimum (MMCO)

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The mechanisms and pace of orbital forcing on precipitation in inland Asia during the Cenozoic remain poorly understood. Many previous studies have shown a consistent signal of long eccentricity (405 kyr) on precipitation records of central China that are younger than ~11 Ma. These studies suggest that variations of rainfall amount were controlled by Northern Hemisphere summer insolation, with peak of precipitation associated with eccentricity maxima. We report here multiple records dating back to the middle Miocene Climatic Optimum (MMCO, ~14-17 Ma ago) that show the exact opposite, including a detailed record from a new section in the Qaidam Basin, dated by a combination of magnetostratigraphy, U-Pb geochronology and apatite low-temperature thermochronology. Our records display dominant 405 kyr wet-dry cycles, but the wetter intervals correspond to eccentricity minima and ice-volume maxima during the MMCO. These results question the origin (monsoonal or westerly-derived?) of the precipitation reaching central China during Greenhouse episodes and the mechanisms enhancing monsoonal penetration inland Asia; they indicate that higher atmospheric pCO_2 significantly impacts East Asian monsoonal circulation and its response to orbital forcing.

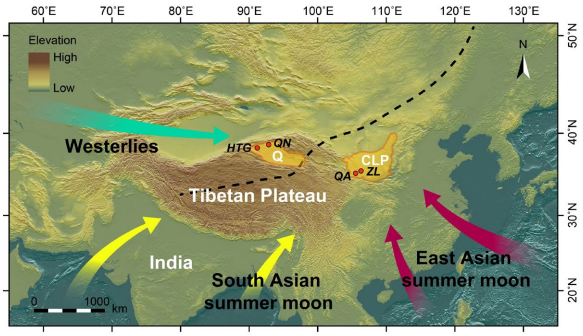

Figure 1. Overview map of the study sites and the dominant circulation systems. Black dashed line depicts the modern Asian summer monsoon limit (Chen et al., 2010). Q, Qaidam Basin; CLP, Chinese Loess Plateau; HTG, Huatugou; QA, Qin'an; ZL, Zhuanglang

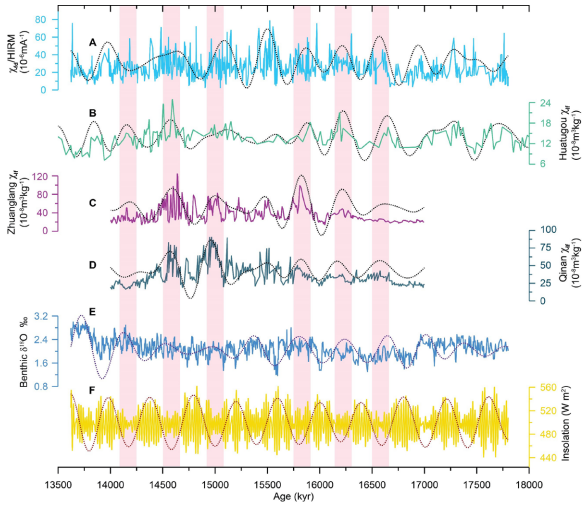

Figure 2. Paleoenvironmental variations of QN section during the middle Mioence and comparison with other records. (A) χ_{lf}/HIRM records from QN section. (B) χ_{lf} records from Huatugou section. (C) χ_{lf} records from Zhuanglang section. (D) χ_{lf} records from Qin'an section. (A, B) are located in the Qaidam Basin and (C, D) are located in the Chinese Loess Plateau. (E) Benthic $\delta^{18}O$ stack (Westerhold et al., 2020). (F) 21 June insolation at 35° N (Laskar et al., 2004). The dashed lines in A, B, C, D, E and F are their 400 kyr components.