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Identifying the drivers of vegetation change on the western Chinese Loess Plateau over the last 70,000 years

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The Chinese Loess Plateau (CLP) is regarded as an excellent continental paleoclimate archive, as cycles of warm, wet interglacials and cool, dry glacials have been recorded in a sequence of alternating layers of loess and paleosols. Vegetation on the CLP is thought to have shifted between C_3 and C_4 plants in the past. Although increased temperatures generally lead to an expansion of C_4 vegetation, increased humidity has an opposite effect, as does pCO_2.

To identify the drivers of past vegetation change we generated a 70,000-year vegetation record based on the average chain length (ACL, indicating plant functional type; higher meaning more grasses, lower, more trees) and carbon isotopic composition of plant leaf waxes ($\delta^{13}C_{wax}$, separating C_3 and C_4 taxa) at Yuanbao, located on the western edge of the CLP. Records of air temperature and precipitation-induced changes in soil pH derived from soil microbial membrane lipids (brGDGTs) in the same material and the hydrogen isotopic composition of plant waxes ($\delta^{2}H_{wax}$) allow for a direct comparison with our vegetation record.

The $\delta^{13}C_{wax}$ record reflects predominantly C_3 vegetation, which may be attributed to the elevation of our site (>2100 masl), resulting in air temperatures that largely remain below the threshold for C_4 vegetation to thrive (~15°C) and implies that vegetation likely primarily responded to changes in hydroclimate. Indeed, the gradual increase in ACL from 70 ka towards the last glacial maximum suggests an adaptation to more arid conditions, as reflected by the brGDGT-based precipitation record. Similarly, a sudden decrease in ACL during the Holocene is coupled with a shift towards heavier $\delta^{2}H_{wax}$ indicating that the site fell within the reach of the East Asian summer monsoon, leading to the increase in precipitation seen in the brGDGTs record. Despite the warmer and wetter conditions during the Holocene, the $\delta^{13}C_{wax}$ record shows a shift towards only C_3 vegetation at this time, possibly resulting from a change in precipitation seasonality coupled to the shift in moisture source. Hence, although our multi-proxy records provide more insight into the drivers of past vegetation change, they also reveal the complexity of the vegetation responses to changes in precipitation dynamics.