140,000 years of precipitation dynamics on the Western Chinese Loess Plateau

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Introduction

Paleorecords of East Asian Monsoon (EAM) climate variability indicate large changes on (sub)orbital timescales, but often represent a mixed signal of temperature and precipitation, thereby limiting our understanding of the response of EAM climate dynamics to global warming. The Chinese Loess Plateau (CLP) is one of the best continuous paleoclimate archives on land, and its sediments host a long record of EAM climate variability in the alternating layers of loess and paleosols reflecting glacial and interglacial period, respectively. Here we reconstruct a continuous, high-resolution record of the precipitation dynamics for continental China over the past 140,000 years.

Study site. Yuanbao loess paleosol sequence (LPS) is located at 2177 m on the western CLP (with a mean annual temperature of 4 ºC), and mean annual precipitation of 500 mm, under the influence of the East Asian Summer Monsoon (EASM) and the East Asian Winter Monsoon (EAWM). The red circles also show the location of Kesang, Hulu and Sanbao caves, used for Speleothem δ18O (Fig. 1a, f).

Methods

BrGDGTs (branched Glycerol Dialkyl Glycerol Tetrather lipids) are pH-sensitive soil microbial membrane lipids. BrGDGT-based soil pH represents the net moisture (precipitation-evaporation) balance.

Plant wax n-alkanes are resistant to degradation. Hydrogen isotopic values of plant waxes (δD_wax) reflect the isotopic composition of moisture used for lipid synthesis.

Results and discussion

• Yuanbao, Kesang and Hulu/Sanbao records show same trend and timing despite their large geographic distance and different modern hydrometeor.
• Precession is the main driver of the Yuanbao δ¹⁸O record. Yuanbao δ¹⁸O and GS show half-precession cycles during MIS 5 (Fig. 2).
• Yuanbao δ¹⁸O has a stronger summer monsoon during MIS 5a than 5c and 5e, different from MagSus and speleothem δ¹⁸O. Seasonality / growing season / precipitation source?
• δ¹⁸O_wax is not influenced by vegetation change (flat δ¹⁸O_wax).
• δ¹⁸O at Yuanbao and pH are similar during the LGM.
• Large pH increase during MIS 4.
• δ¹⁸O_wax is less depleted during the Holocene than in MIS 5.
• δ¹⁸O_wax is relatively stable during MIS 3, different from GS and MagSus.

Conclusions

• The half-precession cycles during MIS 5 suggest that Yuanbao responds to Southern Hemisphere forcing, possibly due to its close position to the Tibetan Plateau (TP).
• Yuanbao also responds to North Atlantic cooling events (Heinrich events).
• North Atlantic processes could explain the lag between δ²H_max and GS/MagSus, as they could lead the Westerlies North or South of the TP, influencing the precipitation.

Figure 1. Comparison among proxy records for the Yuanbao LPS. a) Composite speleothem δ¹⁸O record from the Kesang cave (central Asia), b) Magnetic susceptibility (MagSus) at Yuanbao, c) Mean grain size (GS; μm) at Yuanbao, d) pH (inferred from brGDGTs) and δ¹⁸O at Yuanbao. Error bars indicate mean standard deviation based on at least duplicate analysis. VSMOW = Vienna standard mean ocean water, e) δ¹⁴C_wax at Yuanbao. Error bars indicate mean standard deviation based on at least duplicate analysis. VPDB = Vienna Pee dee belemnite, f) Composite speleothem δ¹⁸O record from the Hulu3 and Sanbao2 caves (red), and precipitation (grey).

Figure 2. Wavelet power spectrum for δ¹⁸O_wax.

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