Refining the paleosol-CO_2 proxy and the reconstruction of early-Pleistocene CO_2 levels

JIAWEI DA[1*], YI GE ZHANG[2], GEN LI[3], XIANQIANG MENG[1,4], JUNFENG JI[1]

[1]Nanjing Univerisity, Nanjing 210000, China (*correspondence: jiawei_da@smail.nju.edu.cn)
[2]Texas A&M University, College Station, TX 77843, USA
[3]California Institute of Technology, Pasadena, CA 91125, USA
[4]Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing 210000, China

Finely disseminated calcites and MS-S(z) model

The paleosol-CO_2 proxy suffers from the largely unconstrained S(z) (soil-respired CO_2 concentration at depth z during the formation time of pedogenic carbonate). Here, based on both modern soil observations and paleosol analyses from the Chinese Loess Plateau (CLP), we propose two refinements to this method, which could significantly reduce the uncertainty of the paleosol-CO_2 estimates.

First, we target finely disseminated calcites (FDC) in bulk paleosols, which are mainly composed of nm-µm scale needle fiber calcites. Unlike calcite nodules traditionally used for pCO_2 reconstruction, the near-in-situ formation and the successive distribution of FDC provide the opportunity to build continous, high-resolution pCO_2 records.

Moreover, we identified a significant correlation between the degree of soil respiration and rainfall intensity based on modern soil observation data, which are further confirmed by the positive relatioship between paleosol-S(z) estimates and bulk soil magnetic susceptibility (MS)—a classic indicator of monsoonal rainfall. Through the application of a MS-S(z) model, we were able to provide specific S(z) estimate for each paleosol sample.

Early-Pleistocene pCO_2 reconstruction

Using these refinements and paleosols from the CLP, we reconstructed interglacial pCO_2 during 2.6-0.9 Ma. The results show overall low CO_2 levels similar to ice core records, indicating the Earth system has operated under low CO_2 levels for an extended period. Moreover, statistical analysis shows no apparent differences in pCO_2 before and after the mid-Pleistocene Transition (1.2-0.8 Ma), suggesting that CO_2 is unlikely the driver of this climate change event.