Why does speleothem δ 18 O differ from groundwater δ 18 O in the late Pleistocene? Insight from modern precipitation with their recharge dynamics in the northern margin of the East Asian summer monsoon region

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Abstract

Both δ ^{18}O in groundwater and speleothem are inherited from precipitation δ ^{18}O, however, stalagmite δ ^{18}O and groundwater δ ^{18}O do not simultaneously agree with each other in the monsoon regions, especially in the late Pleistocene. The reason remains unclear due to the complex stable isotope systematics in the monsoon affected regions with their controlling factors as well as the possible different recharge dynamics of groundwater and drip water. In this study, we have collected 539 daily precipitation samples throughout 2015 from seven monitoring stations in Beijing, in the northern margin of the East Asian summer monsoon region. Stable isotopes (δ ^{18}O and δ ^{2}H) of these precipitation samples are investigated for the controlling factors of precipitation isotopes, e.g., moisture source, temperature (T), and precipitation amount (P) effects. The δ ^{18}O values in the precipitation decrease from the south to the northwest, which is controlled by the monsoon from the south and continental moisture from the northwest. Consistently, the precipitation exhibits an apparent seasonal variation in δ ^{18}O values. The P effect is significant during the monsoon season, especially when the precipitation events are greater than 5 mm and single moisture source is considered. In contrast, the T effect is significant, with a gradient of 0.4non-monsoon season. A Rayleigh distillation model indicates that the moisture source and residual vapor fraction are the two most important factors controlling the δ ^{18}O precipitation patterns in a monsoon region, independent of temperature. Isotopes in groundwater in the late Pleistocene exhibit a significant T effect, implying that the monsoon might not reach Beijing when the groundwater was formed at that time. Furthermore, we highlighted the different recharge mechanisms of groundwater and drip water: lateral flow and direct vertical infiltration make diverse contributions of non-monsoon precipitations to the groundwater and drip water respectively, resulting in that speleothem δ ^{18}O differ from groundwater δ ^{18}O in the late Pleistocene.

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