Interpreting Climatic Fluctuations Using the Isotope Geochemistry of Tibetan Hot Spring Travertine Deposits

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Abstract

δ18O and δ13C values of consecutive laminations in travertine can indicate changes in spring flow and/or climate ranging from daily to centennial in scale. In meteoric hot spring CO2, δ13C is controlled by vegetation (Desouky et al., 2014). In warmer/wetter periods, plant life flourishes, leading to lower δ13C values. The δ18O value is controlled by atmospheric and water temperatures (Desouky et al., 2014). As spring water cools the CO2 is preferentially evaporated; warmer temperatures and greater energy levels lead to more evaporation of 18O. Thus, warmer, wetter climates give lower δ18O and δ13C values. Laminations from a vein in Tibet, an area affected by monsoons and cold rains (Fig. 1), should show a pattern of high isotope values corresponding to cold rains and lower values corresponding to monsoons.

Methods and Results (cont.)

- A 1 m wide carbonate vein in a fault-associated fossil hot spring system in Tibet was sampled in 2012 (Fig. 2) (Newell et. al, 2008).
- Laminations were subsampled with a Dremel tool from vein wall to vein center (interpreted as oldest to youngest).
- δ13C and δ18O values in each lamination were measured using the H2PO4 method and a ThermoScientific Delta V Advantage isotope ratio mass spectrometer (Fig. 3).
- A subset of laminations are currently being dated using 238U-230Th disequilibrium methods.
- δ12C values =4.6 to 7.6‰ vs PDB
- δ18O values = -27.9 to -20.1‰ vs PDB
- The isotope values have a general positive correlation (Fig. 4), indicating that a similar process has impacted both the δ13C and δ18O values.

Methods and Results (cont.)

- δ18O values vs SMOW of the spring water, δ18O(CaCO3) = δ18Owater (SMOW) - 2.9‰ (O’Neil et al., 1969) using the temperature of a spring located 100km west (Zentmyer et. al, 2008). Values are close to modern meteoric water, lighter values could correspond to higher spring tans.
- Calculated variation in δ18O value (Zentmyer et. al, 2008) averaged for meteoric water of the area.

Conclusions

- Variations in vein δ18O could be due to a combination of water temperature and meteoric source (Fig. 6).
- Correlation of δ13C and δ18O indicates open system degassing and CaCO3 precipitation.
- Sawtooth pattern suggests cyclical nature of fluid flow and mineralization.
- Variation of fluid flow may be related to climatic fluctuations (Kampman et al 2012).

- Glacial/ Interglacial
- Monsoon intensity variability.

Future directions: Infer deposition rates from 238U-230Th data, carry out trace metal analysis in samples 27-33 (Fig. 3).

References


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Fig. 1- Annual climatic variation of the Tibetan plateau. Location of measurements in 29°40N, 92°E, 3650 m; approximately 460km east of the sample area. Image taken from http://www.tibet.climatemps.com/

Fig. 2- a) Regional structural map of the Himalaya and Tibetan Plateau containing the sampled vein, shown by a red star. Location of spring water used for calculations shown by yellow star (Zentmyer et. at, 2008). Faults and contacts are: MBT, Main Boundary Thrust; MCT, Main Central Thrust; STDS, South Tibetan Detachment System; ITS2, Indus Tsango Suture Zone. (Figure modified from Newell et. al, 2008)

b) Image showing the location of sampled vein and nearby landmarks. Vein is 445.7m in elevation (Figure modified from Google Earth).

c) Photograph of vein sample 1, corresponding to data points 1-10 (see Fig. 3), black arrow indicates the direction to the center of the vein.

d) Annotated photograph showing approximate sample location in the original vein. Numbers continue to the center of the vein.

Fig. 3- Stable isotope values from each successive lamination, age decreases with increasing position. Notice the general correlation of the oxygen and carbon values and the sawtooth pattern of alternating high and low values, as well as the general decreasing trend.

Fig. 4- Vein laminations show a positive correlation. See Fig. 6 for possible explanations for the positive correlation.

Fig. 5- Photograph of sampled vein, looking to the north. Vein is approximately 1.5m across

Fig. 6- a) Calculated variation in δ18O values vs SMOW of the spring water, δ18O(CaCO3) = δ18Owater (SMOW) - 2.9‰ (O’Neil et al., 1969) using the temperature of a spring located 100km west (Zentmyer et. al, 2008). Values are close to modern meteoric water, lighter values could correspond to higher spring temp.

b) Calculated variation in spring temperature given a constant δ18O value (Zentmyer et. al, 2008) averaged for meteoric water of the area.

Objective

Determine the presence of significant fluctuations in the stable isotope values of Tibetan sub-surface hot spring travertines and connect any fluctuations to climatic or tectonic factors.

Methods and Results


Fig. 3

Fig. 4

Fig. 5

Fig. 6