Preliminary Calibration of Stalagmite Oxygen Isotopes from Eastern Monsoon China with Northern Hemisphere Temperatures

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Changes in stalagmite oxygen isotope ratios that are related to the India Monsoon during the Holocene have been widely discussed (e.g., Neff et al., 2001, Fleitmann et al., 2003). The number of stalagmite oxygen isotope series from the Holocene in China that have been reported is limited but increasing (Hou et al., 2003, Zhang et al., 2003, 2004, Wang et al., 2005). However, the relationships between the oxygen isotope ratios of stalagmites from northeastern and southeastern China have not been discussed. In this preliminary report, we compare the stalagmite oxygen isotope records from the Eastern Monsoon China (East of 108°E), and focus on two questions:

1. What is the range in values and the time series pattern for stalagmite oxygen isotope ratios from Eastern Monsoon China?
2. What is the signature represented by the change in stalagmite oxygen isotope records from Eastern Monsoon China within the entire Holocene?

Data and Methods

Here, we present and compare four stalagmite oxygen isotope records from Water Cave (unpublished), Shihua Cave (Hou et al., 2003), Dongge Cave (Wang et al., 2005) and Xiangshui Cave (Zhang et al., 2003, 2004), respectively (see Table 1 for details).

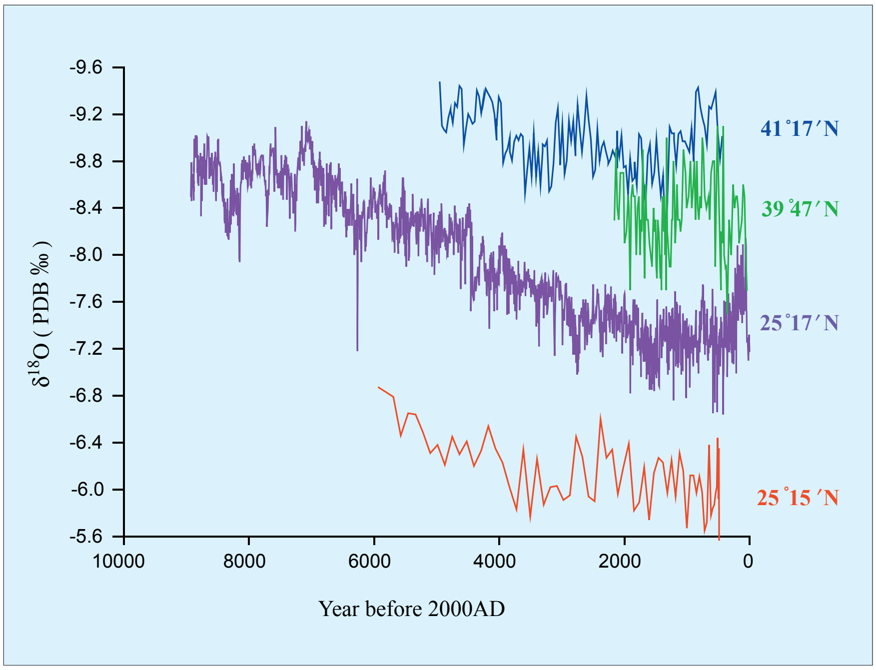

Fig. 1: Comparison of stalagmite oxygen isotope record from Water Cave (blue) with that from Shihua Cave (green), Dongge Cave (purple) and Xiangshui Cave (red).

The timescale of the stalagmite from Water Cave was derived by fitting the uranium dates (511±80, 2081±73, 3845±45, 5227±83 years before AD 2000) with the distance of the dated site (2.09, 49.63, 96.96, 157.23 mm) from the top of the stalagmite. The fit function is:

$$Y = -0.0011X^3 + 0.2155X^2 + 24.829X + 458.22$$

(where Y is age, X distance from the top; $r^2 = 1$).

For the stalagmite from Shihua Cave, we used counting chronology to recalibrate the oxygen isotope time series. Since the age of the top layer is known, we can measure the distance of each isotope sub-sample site from the top and calculate an age by summing annual layer thicknesses to match the distance measured. Finally, we can accurately use the layers counted as the age of each site.

For the stalagmite from Xiangshui Cave, we recalibrated the timescale for the oxygen isotope series by fitting the four uranium dates to the distances of each sample site dated from the top, based on data in Zhang et al. (2003, 2004). The fit function is:

$$Y = -0.0095X^3 + 1.8735X^2 + 5.1317X + 489.89$$

(where Y is age, X distance from the top; $r^2 = 1$).

The four stalagmite oxygen isotope records are compared in Figure 1.

Table 1: Sample-specific details

Cave location	Latitude and longitude	Oxygen isotope ratio range (per mill PDB)	Time interval covered	Availability of data
Water Cave: Benxi, Liaoning Province	41° 17′N, 124° 04′E	−8.2 to −9.5	About 5000 years (from about 3000 BC to 300 years before present)	unpublished
Shihua Cave: Beijing	39° 47′N, 115° 56′E	−7.5 to −9.1	About 2200 years (from about 200BC to present)	Tan et al., 2003
Dongge Cave: Libo, Guizhou Province	25° 17′N, 108° 05′E	−6.64 to −9.14	About 9000 years (from 6930BC to 2000AD)	Wang et al., 2005
Xiangshui Cave: Guanyang, Guangxi Province	25° 15′N, 110° 55′E	−5.6 to −6.5	About 6000 years (from about 4000BC to 500 years ago)	Zhang et al., 2004

Results

As shown in Figure 1, the oxygen isotope ratios become lighter from south to north. This pattern matches the observed pattern of the summer monsoon. Starting from the South China Sea and going northward, the summer

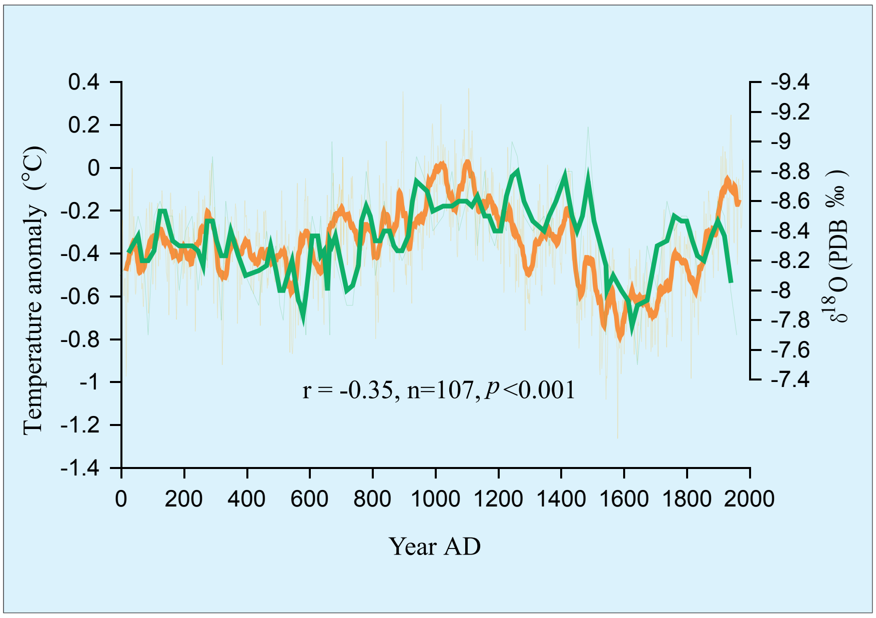

Fig. 2: Oxygen isotope of the stalagmite from Beijing Shihua Cave (green, thick line: 3-point running mean) and the northern hemisphere temperature over the last 2,000 years (yellow, thick line: 31-year running mean, Moberg et al., 2005).

monsoon supplies rainfall from the south to the north, and oxygen isotope ratios become lighter with precipitation. Our comparison of oxygen isotope ratios reveals that in Eastern China, stalagmite oxygen isotope records show similar fluctuation patterns on centennial-to-millennial scales. All of them contain a multi-millennial trend towards heaver ratios since 9000 Yr BP, responding to a reduced insolation of the Northern Hemisphere (Berger, 1978, 1991). This suggests that the change in patterns recorded in these ratios in Eastern China results from a single water source (i.e., the summer monsoon just travels northward from the South China Sea, isotopic ratios become lighter, and there is no, or limited, mixing with water with a different oxygen isotopic signature).

To understand what these oxygen isotope time series datasets represent, we compared the record from Shihua Cave, which has ready been age-controlled by counting chronology, to regional- and large-scale quantitatively reconstructed annual proxy records (e.g., Tan et al., 2003; Mann et al., 2003; Moberg et al., 2005). Data is available at: http://wdc.cricyt.edu.ar/paleo/data.html). We find that our re-dated oxygen isotope series has a statistically significant relationship (r = -0.35, n = 107, p <0.001) with the recently reported 2,000-year-long Northern Hemisphere temperature series developed by Moberg et al. (2005). This indicates that the lighter oxygen isotope ratios in the stalagmite from Beijing Shihua Cave correspond to higher temperatures (Fig. 2). Based on this comparison, the stalagmite oxygen isotope ratios from Eastern Monsoon China may be responding to large-scale temperature changes. What should be mentioned is that the stalagmite from Beijing Shihua Cave and its isotope and layer thickness data used here are independent and different (i.e., unique) from another stalagmite from the same cave (Tan et al., 2003) that is included in the Moberg et al. series. Therefore, the relationship shown in Figure 2 is not a circular argument.

Conclusion and Discussion

It is difficult to obtain long temperature proxy records with annual resolution, such as from tree rings, stalagmite layers, etc. The calibration of the oxygen isotope ratios of cave deposits with millennial-long annually resolved temperature records has great potential to semi-quantitatively establish long-term temperature records (e.g. oxygen isotope based themperature reconstructions of the Northern Hemisphere for the entire Holocene).

The oxygen isotope records from stalagmites before and within the Holocene in Eastern Monsoon China have been interpreted as a signature of the strength of the East Asia Summer Monsoon (Wang et al., 2001, Yuan et al., 2004, Wang et al., 2005). Do our findings contradict this interpretation? No. In fact, the observed temperature record of Beijing has a statistically significant relation (-0.33 from AD 1881 to 1995) with the East Asia Summer Monsoon Index (Shi et al., 1998. Here, the lower the index, the stronger the East Asia Summer Monsoon).

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For full references please consult:
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