# HIGH RESOLUTION SPELEOTHEM PALEOCLIMATOLOGY OF NORTHERN VENEZUELA: A PROGRESS REPORT

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## ABSTRACT

Stalagmites from four caves of northern Venezuela were collected for paleoclimatology studies. Preliminary age determinations and carbon and oxygen isotope data from a stalagmite, show a major stable isotope shift from approximately 11,500 to 10,000 years ago similar to the Sajama ice core record and the Cariaco basin foraminifera *G. rubber* record. The enriched $\delta^{13}C$ and $\delta^{18}O$ data at this period (relative to the Holocene data) suggest dryer conditions with either greater contribution of C4 plants or less recycling of soil $CO_2$ and colder conditions.

*Key words:* Geochronology, speleology, El Niño Southern Oscillation, Inter Tropical Convergence Zone, stable isotopes.

## RESUMEN

*Paleoclimatología de alta resolución en espeleotemas del norte de Venezuela: Informe de progreso.*

En cuatro cuevas del norte de Venezuela fueron colectadas estalagmitas para estudios paleoclimáticos. Datos preliminares de edades y de isótopos de oxígeno y carbono de una de las estalagmitas, muestran un cambio brusco e importante de los isótopos estables aproximadamente entre 11.500 y 10.000 años, muy similar a los registros obtenidos en el núcleo de hielo de Sajama y en los foraminíferos *G. ruber* de Cariaco. El enriquecimiento de $\delta^{13}C$ y $\delta^{18}O$ en éste período relativo a los datos de Holoceno, sugiere condiciones más secas con, ya sea una mayor contribución de plantas C4, o un menor reciclaje del $CO_2$ del suelo y condiciones más frías.

*Palabras claves:* Geocronología, espeleología, oscilación sur de El Niño, zona de convergencia intertropical, isótopos estables.

## INTRODUCTION

The climate of Central America, the Caribbean islands (Antilles), and the northern part of South America is largely controlled by the position of the Inter Tropical Convergence Zone (ITCZ) and its interactions with the tropical Atlantic and Pacific Oceans (ENFIELD & ALFARO 1999). In this region anomalous rainfall patterns and the flooding and droughts that result from them, have been linked with El Niño Southern Oscillation (ENSO) and the North Atlantic Oscillation (e.g., HASTENRATH 1984, ENFIELD & ALFARO 1999, GIANNINI *et al.* 2000, 2001, CHEN & TAYLOR 2002). Climatic change during the last 20,000 years in Central America, the Caribbean, South America, and even changes in the intensity of the North American monsoon have bee attributed to long-term changes in the position and/or intensity of the ITCZ over South America, and changes in ENSO and NAO intensity (LIN *et al.* 1997, CURTIS *et al.* 1999, HAUG *et al.* 2001, BAKER *et al.* 2001, LEDRU *et al.* 2002 and many others).

Because during the northern hemisphere summer the ITCZ resides over northern Venezuela, it is the best region to study the history of changes in the ITCZ over the last 20,000 years. Few paleoclimatic studies have been conducted in northern Venezuela as the marine sediments and fossils in the Cariaco basin (e.g., HAUG *et al.* 2001, LIN *et al.* 1997), and sediments and pollen from Lake Valencia (e.g., CURTIS *et al.* 1999), the Venezuelan Andes (e.g., RULL *et al.* 1987) and the Guayana Highlands (e.g., SCHUBERT *et al*. 1994). Thus, we have begun a study to provide a broader longitudinal and temporal coverage using stalagmite growth histories and the stable isotope compositions (carbon and oxygen isotopes) of the carbonate.

## METHODS

During January 2002 and with the assistance of the Venezuelan Speleological Society (SVE) members, we sampled

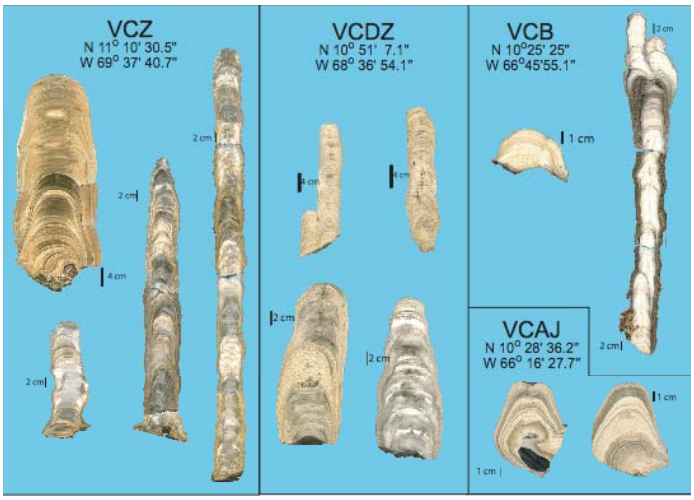


**Fig. 1.** Samples collected from caves along the northernmost reach of the ITCZ. All stalagmites were active at time of collection.

four different caves in northern Venezuela (Fig 1).

Two of the sampled caves lie in the state of Falcón west of Caracas, Cueva Zárraga (Fa.55) (VCZ) south of the city of Coro, near the town of Curimagua; and Cueva del Zumbador (Fa.116) (VCDZ) west of the coastal city of Tucacas and north the town of Yumare. One cave lies on the eastern side of the city of Caracas, Cueva de la Brújula (Mi.1) (VCB). The fourth cave, Cueva Alfredo Jahn (Mi.35) (VCAJ) is east of Caracas near the town of Higuerote. The stalagmites from Zárraga, Zumbador, and Alfredo Jahn caves are nicely banded and well shaped, and ideal for paleoclimatic studies. Brújula samples are still usable but not ideal samples for paleoclimatology, but may help to unravel the paleoseismical history of the region as suggested by URBANI (2002).

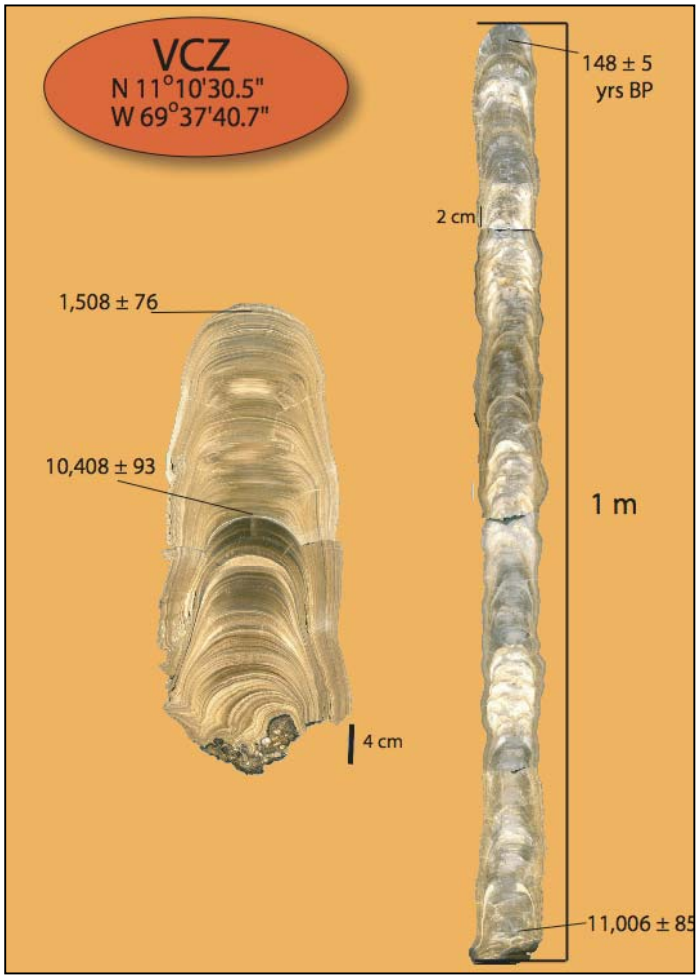


**Fig. 2.** Dated samples from Cueva Zárraga (sample VCZ-1 at left; VCZ-2 on the right).

## RESULTS AND DISCUSSION

We have preliminary dates on two of the stalagmites from Cueva Zárraga (Fig. 2). Stalagmite VCZ-1 is about half a meter long and has been near the top (1,500 years BP) and middle (10,400 years BP). Sample VCZ-1 is about a meter long and has grown over the last 11,000 years dating at 145 years BP near the top and to 11,000 years BP at the base.

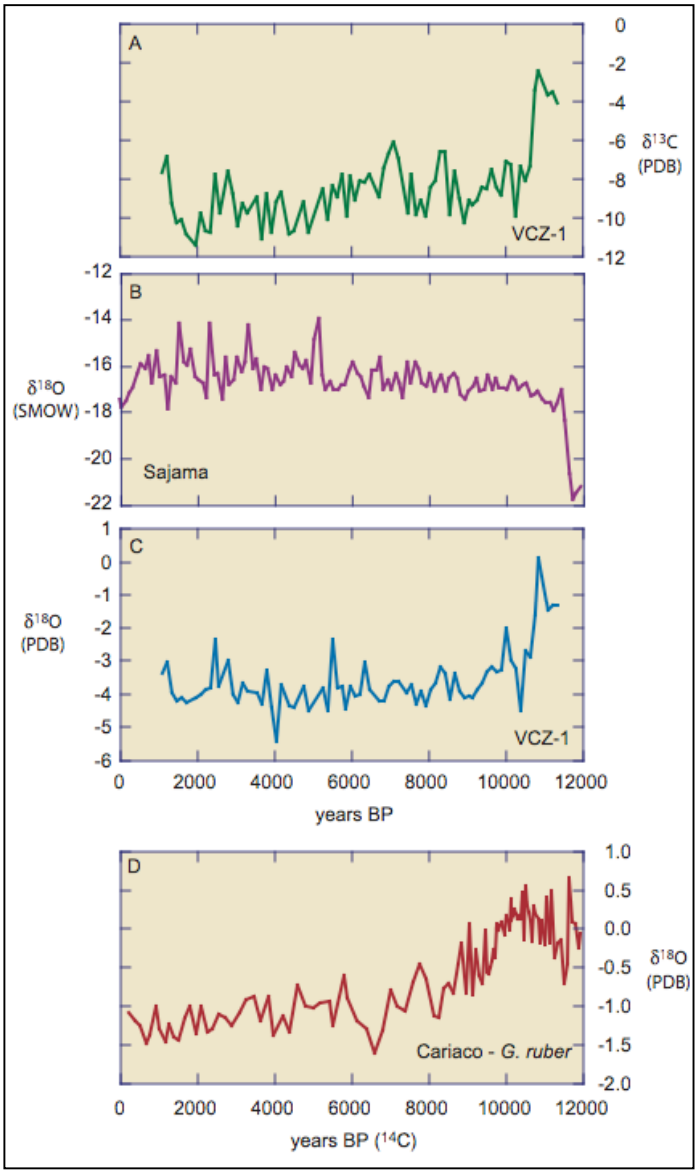


**Fig. 3.** Plots A and C are the preliminary stable isotope data for stalagmite VCZ-1, Cueva Zárraga. The chronology for VCZ-1 is considered tentative since only two U series dates bracket the data. The resolution of the VCZ-1 isotopic record is approximately 125 years. B. Sajama ice core isotope record (THOMPSON *et al.* 1998, THOMPSON 2001). D. Cariaco basin *G. ruber* oxygen isotope record (LIN *et al.* 1997, 2001), note that the Cariaco basin ages are radiocarbon dates.

In addition we have preliminary carbon and oxygen isotope data for Cueva Zárraga stalagmite VCZ-1 (Fig. 3). The stable isotope data shows a major shift from approximately 11,500 to 10,000 years ago and bears striking similarity to the Sajama record (Thompson *et al.* 1998) and the Cariaco basin foraminifera G. rubber record (Lin *et al.* 1997). The enriched $\delta^{13}C$ and $\delta^{18}O$ data at this period (relative to the Holocene data) suggest dryer conditions with either greater contribution of C4 plants or less recycling of soil CO2 and colder conditions. The $\delta^{13}C$ record suggests that moisture was possibly higher from about 7000 to 2000 years ago, while there is a slight

| Sample Number | $^{238}U$ (ppb) | $^{232}Th$ (ppt) | $^{230}Th/^{232}Th$ (atomic x$10^{-6}$) | $\delta^{234}U$* (measured) | $^{230}Th/^{238}U$ (activity) | $^{230}Th$ Age (years) (uncorrected) | $\delta^{234}U_{Initial}$** (corrected) | $^{230}Th$ Age (years) (corrected) |
|---|---|---|---|---|---|---|---|---|
| **C1mA** | 51.8 ±0.1 | 3210 ±20 | 199 ±2 | 838 ±7 | 0.7435 ±0.0066 | 54210 ±660 | 974 ±8 | **53300 ±800** |
| **S1mA** | 71.8 ±0.2 | 4820 ±20 | 150 ±1 | 1634 ±6 | 0.6097 ±0.0041 | 27970 ±220 | 1765 ±7 | **27260 ±420** |

The error is 2σ error.
$\lambda_{230} = 9.1577 \times 10^{-6}\ y^{-1}$, $\lambda_{234} = 2.8263 \times 10^{-6}\ y^{-1}$, $\lambda_{238} = 1.55125 \times 10^{-10}\ y^{-1}$.
*$\lambda^{234}U = ([^{234}U/^{238}U]_{activity} - 1)x1000$.
** $\delta^{234}U_{initial}$ was calculated based on $^{230}Th$ age (T), i.e., $\delta^{234}U_{initial} = \delta^{234}U_{measured} \times e^{\lambda 234 \times T}$.
Corrected $^{230}Th$ ages assume the initial $^{230}Th/^{232}Th$ atomic ratio of 4.4 ±2.2 x $10^{-6}$. Those are the values for a material at secular equilibrium, with the crustal $^{232}Th/^{238}U$ value of 3.8. The errors are arbitrarily assumed to be 50%.

**Table 1.** $^{230}Th$ dating results of an opal stalactite from Sima de la Lluvia de Sarisariñama (Bo.3).

decrease in □18O, hinting either warmer conditions or an enhanced amount effect of the precipitation.

The preliminary data acquired so far indicates that the Venezuela cave stalagmites clearly grew during the period of interest. Furthermore, the stable isotope data of the stalagmites seems to be preserving the climatic fluctuations recorded in other records in the region. The sampled caves along the east-west transect in northern Venezuela and other caves in the region, to be sampled in the near future, will mostly likely yield the most comprehensive paleoclimatic reconstruction for northern South America and the Caribbean region.

From the SVE collection we were also given an opal stalactite collected in 1976 in Sima de la Lluvia de Sarisariñama (Bo.3) to ascertain the potentiality of this mineral in paleoclimatology studies. They are the only speleothems available from caves developed in the Precambrian Guayana Shield rocks of southern Venezuela. Two ages were obtained by R. Lawrence Edwards and Hai Cheng, yielding a Pleistocene age (Table 1).

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