Speleothems from the Balkan Peninsula (Serbia & Montenegro)

Late-Quaternary Records of Atmospheric Circulation and Changing Seasonality since the Last Interglacial

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EGU General Assembly 2011
Poster Board: A506
EGU2011 - 864

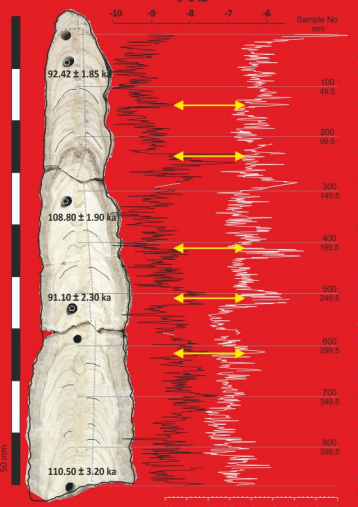
① — Potential and Objectives

Figure 1: Greater study area (red rectangle) and first investigated study site in Eastern Serbia (small white rectangle). (Compilation based on an image from NASA WorldWind)

Figure 2: 3D-View of the Lazareva Canyon where the karstic cave Vernjikica is located at. (Compilation based on an image from GoogleEarth)

In the course of this PhD project speleothems from the Western Balkan Peninsula (Figure 1) are investigated to study Late Quaternary climate variability. Our main objective is the regional differentiation of the climatic and environmental variability during the Holocene and late Pleistocene, starting with the maritime influenced regions in the West to the continental-temperate regions of the Carpatho-Balkans. Here results and conclusions are presented for the first studied stalagmite from Vernjikica Cave (Figure 2).

② — The Record: Stalagmite Vernjikica 4.2



Technical details

A proxy record has been established based on more than 900 stable isotope analyses at a sampling resolution of 0.5 mm, including 14 Hendy tests:

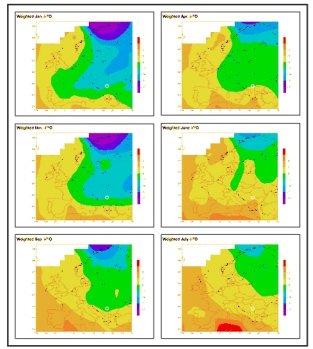
From bottom to top, oxygen isotopic values decrease from averagely -8.5 ‰ (PDB) to about -9.4 ‰; carbon isotopic values increase from lower values (-8.8 ‰) towards higher values (-6.0 ‰).

While oxygen and carbon stable isotope data show opposing trends along the growth axis, simultaneous shifts occur towards positive values that coincide with pronounced accumulations of denser and darker laminae (⟷).

Eight out of eleven Hendy tests show a correlation between the isotopic records, suggesting that kinetic effects might be important. As variation of δ18O and δ13C along the growth axis is not coeval, however, the isotopic record is not entirely superposed by kinetic fractionation and useful for paleoenvironmental reconstructions.

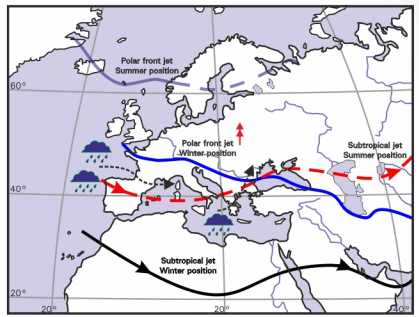
The construction of a $^{234}U/^{230}Th$ based chronology at the University of Minnesota is still underway. Four preliminary derived ages (•) measured on a TIMS MAT 262 RPQ at the LIAG, Hannover, show some considerable dating uncertainty likely caused by problems with the filament that was used at that time. However, all four ages constrain the period of growth of Vernjikica 4.2 to the last interglacial period, MIS 5 (sensu lato).

③ — Assessing the Proxy Record and its Paleoclimatic Signature



Consideration B: Hypothesis A is further corroborated by the modern-day precipitation pattern in the study area. Rainfall is isotopically enriched during the warm summer season and depleted during the cold winter season* reflecting seasonally alternating conditions at the source regions of vapor, transport patterns of vapor in the atmosphere and average rain-out history.

Consideration C: Seasonal precipitation patterns result from the latitudinal migration of the Subtropical jet and Polar front jet. On decadal to millennial time-scales, changes and fluctuations in the position and permanency of these atmospheric circulation features (cf. Wigley and Farmer, 1982)** are likely to influence the isotope signature in rainfall and ultimately in cave drip waters and related speleothems.



Consideration A: The isotopic composition of precipitation at remote sites is explained by the progressive depletion of vapor with increasing number of rain-out events and distance to the major parent vapor source.

As fractionation of D/H and $^{18}O/^{16}O$ in precipitation is a function of temperature, and given that the oxygen isotopic composition of precipitation and drip water is the dominant control of precipitated calcite ($\delta^{18}O_{ca}$), the relationship between $\delta^{18}O_{ca}$ and temperature is positive.

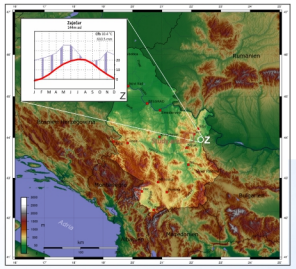
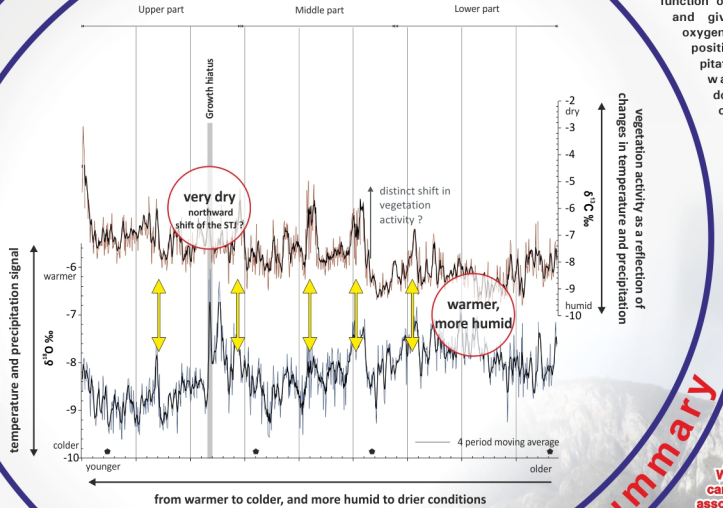


Figure 3: Present local climate of the study site is determined by its leeward position at the eastern fringes of the Carpatho-Balkan; precipitation maxima occur in May/June and November.



* GNIP (Global network of isotopes in precipitation data from IAEA, 2001

** Wigley, T. M. L., and G. Farmer (1982): Climate of the eastern Mediterranean and Near East. In: Palaeoclimates, Palaeoenvironments and Human Communities in the Eastern Mediterranean Region in Later Prehistory, Part i. Edited by J. L. Bintliff and W. van Zeist, pp. 3-37, British Archaeological Reports, Oxford.

Acknowledgments: Funding for this study derives from the Elsa Neumann fellowship program of Berlin, and the DAAD doctoral fellowship program. I. John is very grateful to Paul Königer (LIAG, Hannover) for his help and numerous stable isotope measurements.

Summary

Speleothem growth commenced at a time of warm and humid environmental conditions that gradually changed to drier and colder conditions during the growth period.

The oxygen and carbon isotopic variations likely reflect alternating contributions of precipitation regimes and processes effective in the study area (Consideration A & B), most likely connected to long-term shifts of the relative position of the Subtropical jet (STJ) and its seasonal duration (Consideration C).

When the STJ was shifted northwards, the study area presumably came in closer proximity to the subtropical high pressure ridge, associated with hot and dry summers and a reduction of vegetation and soil activity, leading to enhanced δ18O and δ13C levels, further amplified by kinetic fractionation* (⟷).

Once the chronology of the Vernjikica 4.2 record is improved, the precise timing and duration of described events in the proxy record, including the observed shorter-termed increases in δ18O as well as δ13C, will be fully explored.

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