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Comparison of two comtemporary stalagmite records from the Villars Cave (SW-France) : a test for the significance of δ^{13}C and for the accuracy of U-Th ages, and a means for the reconstruction of the millenial climate variability between 50 and 30 kyrs

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Because speleothems can be dated thanks to uranium-series methods, great hopes are expected from them in order to construct robust chronologies that other palaeoclimatic records can rely on. However, despite the great improvement they have brought to ice core chronologies, the most recent examples (the Dansgaard-Oeschger events that have been observed in four speleothem records), still display discrepancies that impede full confidence in these records; this raises questions about the significance of U-Th errors and isotope signals. We present here a speleothem isotopic record (δ^{13}C and δ^{18}O) of the 50-30 kyr period that has been double-checked thanks to the study of two contemporary stalagmites from the Villars Cave (SW-France). Great similarities between these two records (this study and .....[1]) in their growth rate curves (constructed thanks to 50 TIMS U-Th ages) and in their isotope signals gives confidence, at least, in the chronology and in the isotopic signal. Considering that the main δ^{13}C variation is driven by change in vegetation and soil activity, the interpretation of the isotopic profiles shows that, in SW-France, the period between 50-30 ka is marked by : 1) an exceptionally warm event that reached, in the δ^{13}C signal, the present day level about 45.3 $\pm$0.4 kyr and which is characterized by a very fast growth rate suggesting high humidity; this event, related to DO #12, occurred between 46 and 43 $\pm$0.5 kyr (mid-transition points); 2) extreme rapid δ^{13}C variations of 3-5 $\%$¸ reached a positive maximum that can be linked to H5 and H4 events; these cold phases appear much

shorter than the warm DO phases, i.e. less than the U-Th 2σ error bars ($<$700 to $<$400 years); 3) from the DO12 maximum 45.3 $\pm$0.4 kyrs ago, to the simultaneous halt of both stalagmites at 31.7 $\pm$0.5 kyrs, a global δ^{13}C trend indicates a general climatic cooling trend which is very slightly marked in the ice core records; 4) just before the DO 12 warm event, the δ^{13}C started to decrease, in both stalagmites, at 46.7 $\pm$0.4 kyrs and 46.7 $\pm$0.8 kyrs respectively; this suggests that the climate improvement started at this time which is in agreement with the GISP2 chronology (δ^{18}O minima at 46.2 kyrs); .....[2]) but in contradiction, for this period, with the new NGRIP chronology (48.7 kyrs; .[3]), the Sokotra (47.7 kyrs; .....[4] .....[5]) and Hulu Cave (48.2 kyrs; .....[6]) δ^{18}O records. The Autrian Alps SPA 49 stalagmite record ...[7] does not entirely cover this period and thus can not be fully compared but could be in agreement with the Villars record provide that its δ^{18}O signal is discussed.

An explanation for the observed differences among the N. hemisphere speleothem records would be a possible time delay for the δ^{13}C in response to climate change, because of its dependency on vegetation activity, compared to rainfall δ^{18}O. However, this is not coherent with, first, the fact that the Villars δ^{18}O also displays changes at the same time (especially for pronounced events such as the DO12), and, secondly, the fact that during the last deglaciation there is no significant time delay between the δ^{13}C Villars records and the ice cores δ^{18}O, especially for the YD onset. Consequently, other hypotheses must be done, and, for example, the fact that there was actually a time delay between the monsoon changes that have influenced the Sokotra and Hulu Cave δ^{18}O records, and the climate changes that have influenced the δ^{13}C variations in Villars stalagmites at a higher latitude; but more measurements are needed. As a conclusion it appears that any progress in a more confident significance of speleothem records requires, first, a better understanding of the isotopic signal calcite δ^{13}C and δ^{18}O and, second, a reduction in the dating uncertainties error in order to reduce ambiguities on periods where the DO durations are close to the U-Th error bars, and, third, a quasi-continuous dating sampling along the growth axis in order to better define the growth rate changes.

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