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A speleothem record of rapid climate shifts during the last deglaciation from northern Iberian Peninsula

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We present a high resolution speleothem record of the last deglaciation from NW Spain, which provides as an important link between the millennial climate variability well characterized in the North Atlantic and Greenland, and the correlative abrupt climate changes observed in high accumulation rate marine cores in the western Mediterranean. The nearly continuous record from stalagmite CANDELA, from 25.5 to 11.6 ky BP documents with high resolution and precise chronology the climate change in NW Iberia from the Late Glacial period through the end of the Younger Dryas. By combining trace element indicators of aridity with oxygen and carbon isotopic tracers sensitive to temperature and moisture-source, this record provides an integrated perspective on the climate changes experienced by the region. Carbon isotopic variations reflect temperature and humidity regulation of vegetation and soil respiration and dripwater degassing. Oxygen isotopic variations reflect a more complex array of processes including temperature-driven changes in isotopic fractionation during calcite precipitation, changes in sources of moisture in the hydrological cycle, and changes in seasonality of precipitation. Mg/Ca and Ba/Ca respond to the hydrological balance (P-E) through soil contact times and extent of prior calcite precipitation.
This location in NW Spain is particularly sensitive to climate disruptions caused by changes in the North Atlantic Meridional Overturning Circulation (MOC). Stalagmite growth ceases only during the 2 ky shutdown of the MOC known as the Mystery Interval, but not during the preceding glacial maximum or GS-3 stages which are colder in Greenland and are periods in which speleothem growth is absent farther north on the Atlantic or Mediterranean coasts of France. Thus, in NW Iberia this Mystery Interval is potentially the coldest and driest interval of the presented record. Cold interludes in the North Atlantic region, such as Heinrich event 2, were characterized by more arid and cold conditions in NW Iberian Peninsula. In contrast, warm Greenland interstadial 2 (GI-2) was characterized by more humid conditions.
The major glacial-interglacial transition is not synchronous among all climate indicators in the stalagmite. In oxygen isotopes, the main transition occurs during the hiatus between 18.2 and 15.4 ky BP; values after the hiatus are Ĩ %■ lighter than before and may reflect changes in precipitation source regions with the northward retreat of the polar front. In contrast, the other indicators (Mg/Ca, Ba/Ca and carbon isotopes) suggest that the major shift in humidity between dry glacial conditions and more humid interglacial conditions occurred between 15.4 to 13.4 ky BP. The increase in humidity is gradual and reaches its peak at 13.4 ky BP. This gradual change is consistent with that of speleothems from the Atlantic coast of France and lakes in the Pre-Pyrenees, but contrasts with the more abrupt change in temperature in Greenland and in the hydrological cycle in the Mediterranean which occurred at the onset of the Bølling about 14.7 ky BP. Carbon isotopes and Ba/Ca ratios indicate that the Younger Dryas represented a return to more arid conditions analogous to glacial times. Although both this site in NW Spain and the Mediterranean show a generally similar response of greater aridity during cold periods in Greenland, the different rates of response during deglaciation are suggestive of a different climate threshold for Mediterranean vs. Atlantic margin precipitation.