Short communication

Reply to Comment by Domínguez-Villar on "Land surface temperature changes in Northern Iberia since 4000 yr BP, based in $\delta^{13}C$ of speleothems" (Martín-Chivelet et al., 2011)

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a b s t r a c t

We have considered the additional data that Domínguez-Villar (this issue) has provided, as well as his crit-icisms of the interpretations of Martín-Chivelet et al. (2011). We argue that with or without the additional data, our original interpretations are the most likely interpretations, on the basis of Ockham's Razor. Those of Domínguez-Villar violate Ockham's Razor, and in the final analysis do not offer an alternative explanation for the Martín-Chivelet et al. (2011) and Domínguez-Villar (this issue) data. In particular, all of the ^{230}Th ages (reported by both Martín-Chivelet et al. (2011) and Domínguez-Villar (this issue)) are in stratigraphic order, within quoted errors, so that our original chronology is robust, with no reason to invoke diagenetic processes. Given this chronology, the empirical relationship between $\delta^{13}C$ and temperature also hold. Finally, our orig-inal mechanism for the cause of this relationship (prior calcite precipitation) has been invoked in a number of other studies to explain carbon isotopic variations and remains a perfectly plausible explanation for the ob-servations at the studied caves.

Keywords: climate change; speleothem; paleoclimate; stable isotopes; Holocene; Iberia

We thank Domínguez-Villar (this issue) for providing two addition-al ^{230}Th dates for one of the studied stalagmites (SLX1) and several ad-ditional stable isotope data from Kaite Cave. Below we consider our original interpretations (Martín-Chivelet et al., 2011) of the Kaite Cave record with this new data and in light of Domínguez-Villar's criticisms, starting with the age model by Martín-Chivelet et al. (2011).

The original age model (Martín-Chivelet et al., 2011) was precise and robust. It was based in 43 ^{230}Th ages covering the last four millennia, all in stratigraphic order within quoted errors, all performed following the standard procedures by Edwards et al. (1986) and Dorale et al. (2004) and supported by detailed geomorphologic, micro-stratigraphic and petrologic analyses (e.g., Martín-Chivelet et al., 2006; Muñoz-García et al., 2006, 2011, 2012; Muñoz-García, 2007; Ortega, 2009; Ortega et al., 2012). Domínguez-Villar (this issue) ques-tions the age-models of two stalagmites: SLX1 and LV5.

The argument against the SLX1 chronology is based upon two ad-ditional ^{230}Th dates (Domínguez-Villar, this issue). As both are in stratigraphic order, within error, with the original Martín-Chivelet dates for this stalagmite, there is no reason to alter the original age model. Furthermore, there is no reason to invoke a set of diagenetic processes to explain the sequence of ages. Although diagenesis is a process that can never be unequivocally ruled out, in this case, invok-ing diagenesis is a violation of Ockham's Razor.

For LV5, Domínguez-Villar (this issue) argues that the Martín-Chivelet et al. (2011) age-model is worse than a previous age-model that Domínguez-Villar and some of the authors of the Martín-Chivelet et al. (2011) paper published together (Domínguez-Villar et al., 2008). The 2011 age-model is essentially identical to the former, as it is based on the original Domínguez-Villar et al. (2008) dates, plus new dates (Martín-Chivelet et al., 2011) added to improve temporal resolution. As this additional data improves the precision and accuracy of the age model, we do not understand the Domínguez-Villar (this issue) ar-guments about the LV5 age model of Martín-Chivelet et al. (2011).

Given that the Martín-Chivelet et al. (2011) a g e m o d e l s a r e t h e m o s t likely models given all available data, our correlations among the $\delta^{13}C$ data of our three stalagmites hold. We agree with Domínguez-Villar (this issue) that it would be great to have a single stalagmite that covers the full time range of interest; however, so far, that ideal sample has not been identified at the studied caves. Until that sample is identified, we will need to settle for the current situation where we, at least, can piece together a composite record from a few stalagmites (Martín-Chivelet et al., 2011).

Also, given that our age models are the most likely models, the re-lationships that we observe between temperature and $\delta^{13}C$ also hold. This interpretation is supported by comparison of the speleothem

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records with the available climate instrumental record and also with regional and supra-regional paleoclimate reconstructions. Although our knowledge of the precise mechanisms that determine the rela-tionship between the $\delta^{13}C$ of our speleothems and the average tem-perature outside the caves is still poorly understood, we propose the most plausible hypothesis for the link between $\delta^{13}C$ and temper-ature in our case studies. This mechanism involves the enrichment of water $\delta^{13}C$ in the soil and through the host rock, during intervals of higher temperature. Factors such as soil evaporation, soil biological activity, and prior calcite precipitation are proposed to conjointly ex-plain it. All these factors occur in the area during summer, and are strongly dependent on surface temperature. All this is supported by long-term cave monitoring that we have been performing in two of the three caves since 2002.

In sum, the additional data provided by Domínguez-Villar (this issue) support the original interpretations of Martín-Chivelet et al.(2011). The alternate interpretations proposed by Domínguez-Villar (this issue) violate Ockham's Razor. We conclude that the original interpretations and conclusions of Martín-Chivelet et al. (2011) re-main the most likely ones given the available data at this time.

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