Paleo-climate reconstruction of the Gran Dolina site (Sierra de Atapuerca, Spain) using Hydrogen stable isotope of authigenic clay minerals

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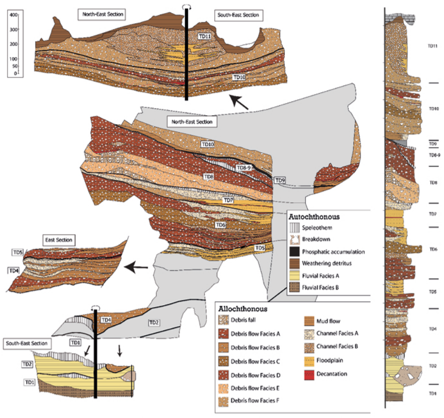
INTRODUCTION

Gran Dolina is a key site to understand Early and Middle Pleistocene human evolution in Europe (Rodríguez et al., 2011). The archaeo-paleontological remains of Gran Dolina have provided many works about Early and Middle Pleistocene that have enriched the knowledge about human linage in Europe (Carbonell et al., 1999; Bermúdez de Castro et al., 2015). Due to its fossil remains, the paleoclimatic reconstruction of this site is very important to understand human evolution.

The isotopic composition of authigenic minerals constitutes a valuable proxy for paleoenvironmental reconstruction. Hydrogen isotopes in the hydrous phyllosilicates are conditioned by the environment condition that prevailed during their formation and they were used as reliable paleothermometers of the water system at the time the mineral was formed (Savin & Epstein, 1970; Vitali et al., 2002).



Figures 1 & 2: Gran Dolina site in 1994 (M. A. Martín), sedimentary facies distribution in the section cut by the railway trench and synthetic sedimentary facies column of the site (Campaña et al., 2017).

The **aim** of this work is to complement paleoenvironmental information based on current knowledge of Gran Dolina site, adding information from the hydrogen isotopic composition of clay minerals.

METHODOLOGY

43 samples were collected from Gran Dolina site. Before the analyses, the samples were treated by H_2O_2 and HCl to remove organic matter and carbonates .

The samples were analyzed following the procedures described by Sharp et al. (2001) and Vandelvelde et al. (2013). Two milligrams of each sample was introduced into folded silver capsules. Previous to the analysis, all samples were heated at 200°C during 4 hours under vacuum conditions to remove adsorbed and interlayer water. The samples were heated during four hours and then moved to the autosampler attached to a ThermoFinnigan thermal conversion elemental analyzer (TC-EA) which is linked to ThermoFinnigan Delta V + isotope ratio mass spectrometer (IRMS). The standards used for analysis were USGS 57 (δ^2H value of -91.50 ‰ VSMOW) and USGS 58 (δ^2H value of -28.40 ‰ VSMOW). The results of the isotope analyses are reported relative to Vienna Standard Mean Oceanic Water (VSMOW). These analyses were performed in the Stable Isotope Lab of University of South Florida (Tampa, Florida, USA).

Figure 3: ThermoFinnigan thermal conversion elemental analyzer.

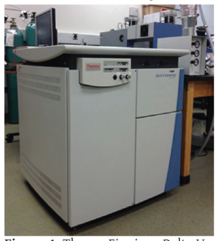
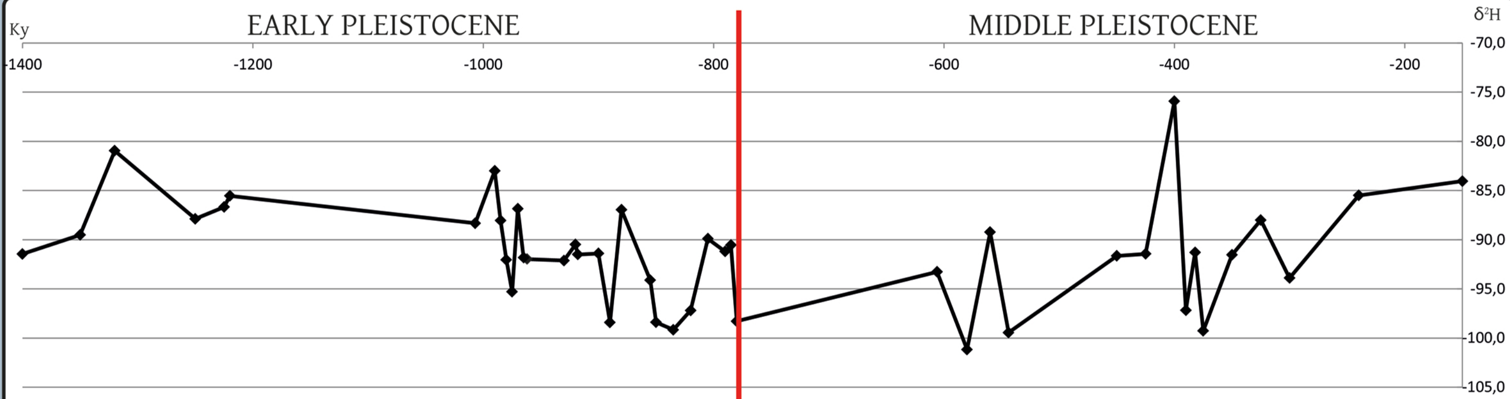


Figure 4: ThermoFinnigan Delta V + isotope ratio mass spectrometer.



During the Early Pleistocene, the δ^2H values show different variations with a progressive decrease, indicating a possible change to wetter conditions. The sedimentation of Gran Dolina cave during the period between 1000 – 780 ky shows an alternation of sediment gravity flow facies subunits and fluvial facies subunits. This difference is noted in the δ^2H results, which sediment gravity flow subunits show higher values than fluvial subunits. This could suggest that sediment gravity flows were deposited in drier conditions than fluvial flows, as the sedimentology also suggests. The final of the Early Pleistocene sedimentation is formed by fluvial flows. Although this may suggest an increase in humidity, the δ^2H data indicates a drier environment than previous facies. An increase in humidity to the top is observed.

During the Middle Pleistocene, the δ^2H results show important variations, with the highest and lowest values. The Gran Dolina sediments, in this period, are mainly formed by sediment gravity flows facies. Notwithstanding, low δ^2H values are registered, suggesting that the lack of fluvial facies is not caused by climate change. The highest value of δ^2H is observed in TD10.2 subunit that is formed by sediment gravity flow. Then, δ^2H decreased until a clayed level interpreted as fluvial facies. The rest of the sequence shows higher δ^2H values towards the top. This is interpreted as a change to dry environment.

FLUVIAL / GRAVITY FLOW

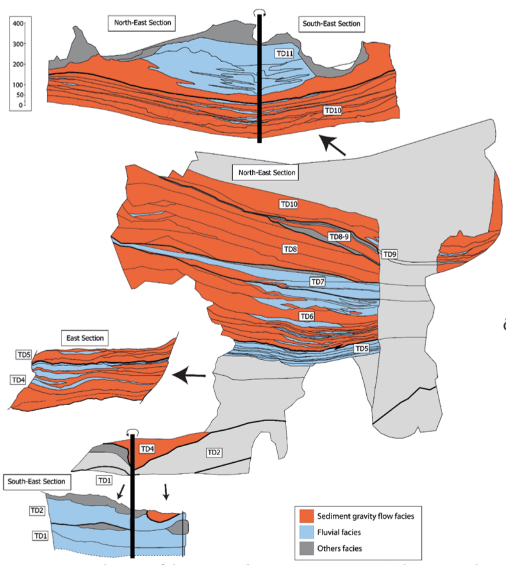


Figure 5: Distribution of the main sedimentary processes in the Gran Dolina site. The site has been separated into each excavation section observable (Campaña et al., 2017).

The sedimentary facies of Gran Dolina have been separated in two main groups: fluvial facies and sediment gravity flow facies (Fig. 5) (Campaña et al., 2017). In this work, the hypothesis that the fluvial facies periods were more humid climate than sediment gravity flow was postulated. Evaporation processes causes the fractionation of the hydrogen isotope of water. In a humid climate, less evaporation occurs. So, following this hypothesis, more negative values in fluvial facies than in sediment gravity flow facies is expected. The figure 6 shows that the values of sediment gravity flows facies are slightly greater than the values of fluvial facies. Although this is in agreement with the hypothesis, the difference is not enough to demonstrate it.

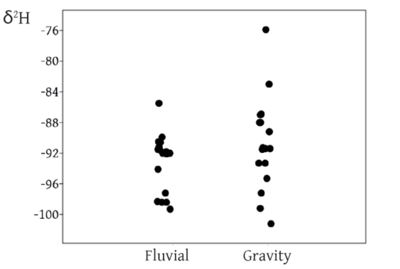


Figure 6: Jitter boxplot of fluvial facies samples and sediment gravity flow samples.

CONCLUSIONS

The use of hydrogen isotopic composition of the authigenic minerals in Gran Dolina has allowed making a paleoenvironmental proposal of the site. The results indicate that different humid-dry climate cycles happened during the deposit of Gran Dolina sediments. During the Early Pleistocene, a progressive increase of humid environment is evident, with at least three humid-dry cycles. The results in the Middle Pleistocene show greater variations with the driest registered event in TD10.2. In some cases, the environment interpretation of the isotopes composition and the sediments are not in agreement.

ACKNOWLEDGEMENTS

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