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Seasonal and inter-annual variability in drip water and environmental parameters of Kaite Cave, N Spain: implications for paleoclimate reconstructions

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Kaite Cave, which belongs to the Ojo Guareña Karst Complex in northern inland Spain, has been monitored during the last 12 years for calibrating paleoclimate studies based in speleothems, as well as for using it as a natural observatory in the aim of controlling the key environmental variables of the karst system. These variables provide insights to inorganic geochemical processes occurring today in both systems, and to factors that may alter the physicochemical equilibrium of the karst.

The cave is quite small (~350 m of maximum length) and relatively shallow (12-20 m below the surface), and is topographically isolated from the main levels of the Ojo Guareña Karst Complex. The cave is 860 m above sea level and the climate is warm-temperate, with annual precipitation averaging ~720mm and mean temperatures in the range of 10-11 ºC, although these vary notably with the seasons. The region is located in the transition between the two main climatic zones of Western Europe: the Atlantic and the Mediterranean. The soil above the cave is shallow (essentially a lithosol) with scarce argillaceous material and organic matter. However, it allows the development of a quite dense vegetal cover of small *Quercus* and *Juniperus*. The cave is developed on lightly dipping carbonate unit of Upper Cretaceous (Coniacian) age, which consists of shallow marine, partially dolomitized limestone.

The monitoring site is characterized by a stable cave climate: the temperature is 10.40 ± 0.04 ºC and reflects the mean annual temperature outside the cave, the relative humidity exceeds always 99 % and there are no significant air currents. The seepage water is frequent, with permanent but inhomogeneous variable dripping during the year with a definite seasonal effect, and the speleothems are abundant, some of which are growing at the present time. The total volume of dripping water collected seasonally is consistent with an advective flow through the surrounding rock. This study is based on a continuous seasonal multi-parametric monitoring of the cave, which has yielded a multi-year record of stable isotopes and trace elements in rainfall, drip water and present calcite, as well as of CO_2 and $\delta^{13}C$-CO_2 signals in the atmosphere and cave air.

This work focuses on the relationships between rainfall, drip rates, and drip-water isotopic and elemental composition, as indicators of hydrologic processes defining the karst system and controlling speleothem growth and composition patterns. Interannual and seasonal changes in rainfall mean variable water for recharging the system and differential intensity of the occurring water-rock interaction processes. Prior calcite precipitation in the epikarst and/or unsaturated zone is invoked for Kaite Cave as the dominant process causing interannual changes in variables such as Ca concentration, $\delta^{13}C$, and Mg/Ca ratios. At seasonal scale lower rainfall during spring, summer and autumn lead to lower

recharge and increase of the effect of prior calcite precipitation, being the general inter-annual trend superimposed to that seasonal trend.

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