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Copper Bio-Enrichment: Results from Isotopic Analysis at the Las Cruces Deposit, Spain

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The Las Cruces is a volcanogenic massive sulfide deposit located in the easternmost part of the Iberian Pyrite Belt. The primary stratabound massive sulfides of late Devonian- Early Carboniferous age have been affected by a pervasive supergene alteration, giving rise to a unique secondary mineralization. The secondary rocks include the widespread reduction of the former gossan and the formation of a cementation zone dominated by massive chalcocite and covellite. The formation of the supergene mineralization is probably due to the reaction, from ca. 7 My to Present, of different types of fluids that circulated through fault-controlled and unconformity-related confined aquifers below a thick (>200 m) sequence of Messinian marl. The key feature of the deposit is the existence of a complex microbial ecosystem that dramatically modified the pre-Alpine assemblages.

The ore grade at the cementation zone has made Las Cruces one of the richest copper deposits worldwide. For this study, rock samples from fresh outcrops and water samples from the aquifers in and outside the mine have been analysed in an Isoprobe multicollector ICP-MS at the University of Arizona. $\delta^{65}Cu$ values for ore samples range from -9.2 to +4.3‰, while water values range between -0.01 ‰ to +4.5‰.

The extremely low $\delta^{65}Cu$ values and their distribution are consistent with a microbial control on the precipitation of the secondary copper sulfides. Our best interpretation of the $\delta^{65}Cu$ values are that the Las Cruces had a small cementation zone below a gossan cap and previous to the burial at 7 My; later on, sulfate and copper reducers coexisting with other microbes in the deep anoxic environment were able to trap copper transported as Cu^{2+} by the water, lowering the originally high $\delta^{65}Cu$ values. The likely source of copper is the dismantling, oxidation, and dissolution of massive sulfides located upstream.