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Difficulty and complexity interpreting cosmogenic nuclide data in cave settings – a case study in multilevel karst system in Atapuerca, northern Spain

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In this paper we revisit cosmogenic nuclide analysis from multilevel karst system in Atapuerca mountain range to discuss difficulty and complexity in interpretating cosmogenic data not only for chronology but also for sediment dynamics, i.e., provenance, transport pathway and depositional processes. Atapuerca is situated in the western end of Europe, and is among the key sites in the study of early human evolution. The site consists of a multilevel karst system developed within the Cretaceous limestones that make the "Sierra de Atapuerca" mountain range, where several cave infills have been exposed by a railway cutting in early 1900s. Since 1980s, excavation of the sites has revealed rich records of archaeological and paleontological remains, including one of the earliest human fossils outside Africa dated ˜1.2 Ma, as well as a new homo species, *Homo antecessor*, dated ˜0.8-0.9 Ma. Efforts to constrain chronological framework have paralleled. Paleomagnetism identified B/M boundary indicating the sites extend from Early to Middle Pleistocene. Several early attempts by U-series, OSL and ESR have been successful at certain degree, with some unresolved discrepancies. Recent advancement in OSL and ESR provided better chronological constraints in key sites including Gran Dolina. In this study, we revisited previously measured 10Be-26Al data together with some new data from Gran Dolina, Cueva del Silo and associated river terraces proximity to the sites, to discuss analytical feasibility and difficulty applying quartz 10Be-26Al method to largely karstic environment, and complexity interpretating such data not only for burial ages but also for sediment dynamics from its origin, to potential prior-burial and reworking, and to accumulation rate. Nevertheless, approaching the problems with multiple geochronological methods (e.g., paleomagnetism, ESR, OSL) and comparing with paleontological and archaeological evidence provide invaluable opportunities to test and validate assumptions and model for burial age calculations based on cosmogenic nuclides.

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