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Uranium-Lead dating of speleothems >500 kyr: examples from the early Hominid bearing caves of South Africa

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Speleothems have become well established archives for palaeoenvironmental information. Accurate and precise dating by Uranium-series methods greatly enhances their usefulness as archives. However, Uranium-Thorium dating can only be applied to material younger than 500 kyr. Older speleothems can be dated by Uranium-Lead dating, and this has been successfully applied to material as young as 200 kyr [1] and to a range of older samples [2, 3]. Uranium-Lead dating of speleothems is more complicated than Uranium-Thorium, as more isotopes are invloved and ages need to be calculated using isochrons, increasing the number of measurements required to produce an age. Problems with initial 234/238U ratios and common lead contamination are considerable. There are numerous intreguing potential applications of Uranium-Lead dating. In this study, we attempt to provide the first set of direct, absolute age determinations for the South African early hominid bearing caves. The absolute dating of these deposits and the fossils within them remains an outstanding issue in Palaeoanthropology. Traditionally, the sites are given biostratigraphic ages based on faunal comparisons with the better dated fluvial-lacustrine sites of East Africa. Recently both cosmogenic isotope burial and Uranium-Lead dating have been applied to deposits at Sterkfontein Cave, but with mixed results. Here we have adapted the method of the pioneering work of [2] on sample material from Sterkfontein, Swartkrans and Coopers, arguably the three most important hominid bearing sites in this area. Without modelled or measured initial 234/238 ratios only maxium ages can be obtained. We model initial conditions, i.e. excess initial 234U and depleted 230Th. Samples are pre-screened using β-scanner imaging to identify U rich layers. Initial MC-ICP-MS results indicate that relatively U-rich layers can exist near the base of flowstones, with U concentrations of between 0.1 and 2.4 ppm. Strong inital (234U/238U) disequilibrium is found for samples younger than 2.5 Ma. Both high U and large initial 234U excess may result from slow weathering of bedrock, without leaching, in the arid phase preceeding conditions conducive to flowstone formation. [Pb] ranges between 20 - 200 ppb and is highly heterogeneous. Small scale (˜cm spaced) sampling of U rich speleothem layers provides a range of U-Pb ratios. Using MC-ICP-MS in static mode, with 204Pb in an electron multiplier, gives relative precision on 206/204 better than 0.13 %. Thus 204Pb can be used as a reference for isochrons. A number of problems remain: discrepancies between ages obtained by different dating methods, poor stratigraphic control of the clastic deposits the sites and estimates of initial 234U/238U values for samples $>$ 3 Ma. Efforts to contrain the latter using O and C isotopes as proxies are underway.

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