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(U-Th)-He dating of $CaCO_3$ speleothems: a new perspective for dating fossil-bearing cave deposits

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Cave mapping and geological studies in the Cradle of Humankind (CoH) site have revealed that 81 caves contain evidence of macrofossils and 15 are known to contain hominin or archaeological remains from a variety of ages between 0 and 3 Ma [1]. Deposits of the CoH have been traditionally dated on the basis of biostratigraphic correlation [2], and in spite of recent advances particularly in U-Pb dating, dating many fossil-bearing deposits older than the c. 0.5 Ma limit for U-Th dating remains a challenge [3,4]. (U,Th)-He dating of fossil aragonites was first carried out in 1965 [5]. Although the method is used routinely for apatite thermochronology, retention of He in calcite was first demonstrated in 2007 [6] and the first successful dating of a fault-filling calcite in 2014 [6]. Given retention of He, the (U,Th)-He dating offers some potential advantages over (U,Th)-Pb. First sensitivity, because many more nuclides are produced in the course of decay (8 for ^{238}U, 7 for ^{235}U and 6 for ^{232}Th), and second, absence of initially built-in He in samples. In this study we have explored the dating of calcium carbonate flowstones, interbedded with fossil-bearing breccia deposits at the CoH, using this dating technique. Sample powder or grains, wrapped in copper foil, is heated using a laser or a miniature furnace to analyze helium using a ^{3}He spike, after which the sample is removed from the vacuum chamber, dissolved and analysed for U and Th by isotope dilution. For laser heating, a continuous 1064 nm Nd-YAG laser is used which necessitates carbon coating of the foil package. Challenges are the large release of CO_2 (captured on cold traps) and sometimes hydrocarbons that impede He ionization, as well as quantitative recovery of samples after degassing. The method was tested on well-dated flowstone samples from Swartkrans, where we have reproduced within error an age of 1.8 Ma for a sample dated to 1.816 ± 0.041 Ma using U-Pb [8] and which relates to clastic sediments in member 1 for which a similar age (1.80 ± 0.09 Ma) has been obtained using cosmogenic nuclides burial dating [9]. This and other preliminary results show that the method is promising as a technique that might help radiometrically date fossil-bearing cave deposits of the CoH.

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