

## Extended range of U-series dating by combining $^{230}\text{Th}/\text{U}$ disequilibrium and $^{234}\text{U}$ excess dating

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Since the early work on U-series disequilibrium by  $\alpha$  spectrometry during the 1960s and '70s, the development of spectrometric (TIMS and MC-ICP-MS) determinations of U and Th isotopes, which are more precise and accurate, have opened new applications for U-series. This analytical progress, allowing the use of smaller samples, increases the dating limit from 350-400 ka by  $\alpha$  spectrometry to ~600 ka by MC-ICP-MS. Here we present U-series data, obtained by the analytical methods mentioned above, from pure  $\text{CaCO}_3$  hydrothermal travertine deposits from southeast Morocco. The results from outcrop sections and a 12 m core show that calculated  $^{230}\text{Th}/^{234}\text{U}/^{238}\text{U}$  for all outcrop sections, as well samples from the upper 5.5 m of the core, yield  $^{230}\text{Th}/\text{U}$  ages between 10 to 500 ka, depending on their stratigraphic positions. In addition, the calculated initial  $(^{234}\text{U}/^{238}\text{U})_0$  activity ratio for all these samples indicate a relatively high (~5) and constant initial excess of  $^{234}\text{U}$ . Below 5.5 m all samples show  $^{230}\text{Th}/\text{U}$  at radioactive equilibrium, when taking into account the analytical errors, while  $^{234}\text{U}/^{238}\text{U}$  indicates disequilibrium and thus the  $^{234}\text{U}$  excess decay method can be applied. For these samples, an age based on the decay of  $^{234}\text{U}$  excess can be calculated assuming that the initial  $(^{234}\text{U}/^{238}\text{U})_0$  activity ratio prevailed for the period older than 500 ka. Using this approach we calculate ages up to 1000 ka in the lower part of the core. A paleomagnetic inclinations record of the core can be used to validate these calculated ages. The results show a transitional change from about  $-50^\circ$  at 8m depth to  $+50^\circ$  at 10 m depth. This change to a reverse polarity was attributed to the B/M transition. Ages of samples at these depths varies from  $724\pm 48$  to  $784\pm 48$  ka, this is in good agreement with the age of the B/M transition. In conclusion, the combination of  $^{230}\text{Th}/\text{U}$  dating with the decay of initial  $^{234}\text{U}$  excess allow, in our case, to extend the range of applicability of U-series dating.