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# Novel method for determining $^{234}U$-$^{238}U$ ages of Devils Hole 2 cave calcite (Nevada)

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Uranium-uranium ($^{234}U$-$^{238}U$) disequilibrium dating can determine the age of secondary carbonates over greater time intervals than the well-established $^{230}Th$-$^{234}U$ dating method. Yet it is rarely applied due to unknowns in the initial $d^{234}U$ ($d^{234}U_i$) value, which result in significant age uncertainties. In order to understand the $d^{234}U_i$ in Devils Hole 2 cave, Nevada, we have determined 110 $d^{234}U_i$ values from phreatic calcite using $^{230}Th$-$^{234}U$ disequilibrium dating. The sampled calcite was deposited in Devils Hole 2 between 4 and 590 ka, providing a long-term look at $d^{234}U_i$ variability over time. We then performed multi-linear regression among the $d^{234}U_i$ values and correlative $d^{18}O$ and $d^{13}C$ values. The regression can be used to estimate the $d^{234}U_i$ value of Devils Hole calcite based upon its measured $d^{18}O$ and $d^{13}C$ values. Using this approach and the measured present-day $d^{234}U$ values of Devils Hole 2 calcite, we calculated 110 independent $^{234}U$-$^{238}U$ ages. In addition, we used newly measured $d^{18}O$, $d^{13}C$, and present-day $d^{234}U$ values to calculate 10 $^{234}U$-$^{238}U$ ages that range between 676 and 731 ka, thus allowing us to extend the Devils Hole chronology beyond the $^{230}Th$-$^{234}U$-dated chronology while maintaining an age precision of ~2 %. Our results indicate that calcite deposition at Devils Hole 2 cave began no later than 736 ± 11 kyr ago. The novel method presented here may be applied to future speleothem studies in similar hydrogeological settings, given appropriate calibration studies.