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Reassessing decay constants through U-Pb ID-TIMS geochronology

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A goal of the EARTHTIME initiative is to establish a robust high-resolution record of Earth history at the 0.1% level (or better) using multiple radionuclide decay schemes. Achieving this goal is dependent on the accuracy and precision of the decay constants of the long-lived radionuclides, most importantly U and 40K. Several studies have demonstrated broadly systematic biases between 40Ar/39Ar and U-Pb dates, as well as between the two U-Pb dates, requiring a reevaluation of the decay constants and open system behavior in dated minerals. Intercalibration of the 238U-206Pb and 235U-207Pb schemes is necessary to fully exploit the benefits of dual U decay and to intercalibrate with 40K derived datasets. High-precision ID-TIMS geochronology at the single- and sub-grain scale on zircon and xenotime from rock samples ranging from 0.1 to 3.3 Ga has allowed us to test the accuracy of the U decay constants quantitatively. High-n statistically equivalent datasets on samples that are arguably unaffected by open-system behavior give 207Pb/206Pb dates that are systematically older than 206Pb/238U dates by ca. 0.15% in Precambrian samples and up to several percent in Mesozoic samples. Evaluation of the tracer calibration and mass discrimination suggest these factors are not the cause of the discordance, indicating that inaccuracies in the mean values of one or both of the U decay constants are responsible. We calculate a ratio of the U decay constants that is different from the accepted ratio by 0.09% and is a factor of six more precise. These samples augment a database in which U-Pb and 40Ar/39Ar dates were obtained from the same rock, such that systematic and non-systematic biases can be evaluated. As noted by several studies, U-Pb and 207Pb/206Pb dates are older than 40Ar/39Ar dates by 1% or less. However, review of the data shows significant scatter in the amount of offset as a function of age, suggesting that the bias is not entirely systematic and may incorporate interlabo-

ratory biases and/or geologic complexities. In particular, the possibility of up to 200 kyr of pre-eruptive residence time of zircons in magma chambers and incorporation of partially degassed xenocrysts in pyroclastic eruptions may complicate comparisons. Understanding the sources of these discrepancies and their relative contribution can partially be accomplished through distribution of the EARTHTIME U-Pb tracer solution that will effectively eliminate interlaboratory bias and ensure accuracy of U-Pb dates (through calibration against multiple gravimetric solutions). Further U-Pb and 40Ar/39Ar dating of mineral standards in multiple laboratories is also essential for high-precision comparative geochronology. Although the 40K and 235U decay constants may be calibrated against the 238U-206Pb system to improve the precision of these schemes, the accuracy of this approach should be tested by redetermination of the decay constants.