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The Decay Constant of ^{176}Lu Determined by Calibration Against the U-Pb System in the Phalaborwa Carbonatite

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Currently, there is no consensus on which ^{176}Lu decay constant should be used in Lu-Hf geochronology or for determining the initial Hf isotope compositions of rocks. Recent (i.e., post-1980) counting experiments have yielded systematically lower decay constants than the commonly used value of 1.94 x 10^{-11} yr^{-1} that was defined by the slope of a eucrite isochron of known age (Patchett and Tatsumoto 1980; Tatsumoto et al., 1981). Ideally, a consensus value for the decay constant would be supported by both counting experiments and calibration against the relatively well-known U decay constants by analysis of geologic samples. To calibrate λ^{176}Lu against the U-Pb system, we have obtained a baddeleyite-apatite Lu-Hf isochron and U-Pb baddeleyite ages for a carbonatite from the Phalaborwa Igneous Complex, South Africa.

Two baddeleyite fractions that were analyzed by TIMS yield an upper U-Pb concordia intercept age of 2061.9±6.3 Ma (error includes U decay constant uncertainties), which is in excellent agreement with other recently published baddeleyite ages for the Phalaborwa carbonatite: Heaman and LeCheminant (1993): 2059.8±0.8 Ma; Reischmann (1995): 2060.6±0.5 Ma; Horn et al. (2000): 2058 ±11. Multiple-collector ICP-MS Lu-Hf analyses of the baddeleyites and apatites are summarized in the table below.

Assuming that the carbonatite cooled rapidly after intrusion, and that these minerals have remained closed systems with respect to Lu, Hf, U, and all U decay-chain products since carbonatite crystallization, the slope of the baddeleyite-apatite isochron and the U-Pb age of the baddeleyite may be used to calculate the decay constant of ^{176}Lu relative to those of ^{235}U and ^{238}U. This yields a λ^{176}Lu of (1.855±0.008) x 10^{-11} yr^{-1}, which corresponds to a half-life of (3.738±0.017) x 10^{10} yr. These values agree very well with the suggested values of Nir-El and Lavi (1998), i.e., λ^{176}Lu = 1.86 x 10^{-11} yr^{-1}, and $T_{1/2}$ = 3.73±0.01 x 10^{10}. If correct, these λ^{176}Lu values will result in ages that are about 4% older than those determined using the commonly used λ^{176}Lu of 1.94 x 10^{-11} yr^{-1}. However, if the baddeleyite-apatite isochron was partially reset by a later heating event, the true λ^{176}Lu would be greater than our observed λ^{176}Lu.

While the agreement between our preliminary U-Pb-calibrated decay constant and those of recent counting experiments is promising, we are investigating additional samples to evaluate whether our assumptions (i.e., rapid cooling and no subsequent disturbance of the Lu-Hf or U-Pb systems) are valid. Close agreement among several samples from different localities would suggest that these assumptions are correct and that the decay constant is robust.

MC-ICP-MS Lu-Hf analyses of Phalaborwa carbonatite minerals.

sample	ppm Lu	ppm Hf	^{176}Lu/^{177}Hf	^{176}Hf/^{177}Hf	ε_{Hf}
baddeleyite-1 IC	---	---	---	0.281163	-56.9
baddeleyite-1	0.5114	13,980.	0.00000519	0.281161	-57.0
apatite-2	0.3519	0.02495	2.030	0.360224	+2739.0
apatite-3	0.4188	0.02838	2.126	0.364110	+2876.5

Table 1: MC-ICP-MS Lu-Hf analyses of Phalaborwa carbonatite minerals.

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