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The ^{176}Lu decay constant revisited

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The initial Hf isotope compositions (ε_{Hf}[t]) of Early Archean and Hadean rocks and zircons are increasingly being utilized to constrain early Earth's crust-mantle evolution. Such samples crystallized from melts derived from either mantle or (proto)crust sources. Using ε_{Hf}[t] values to determine the extent of depletion or enrichment in these sources requires accurate values for the Lu/Hf and ^{176}Hf/^{177}Hf of the bulk silicate Earth (BSE) and the ^{176}Lu decay constant (λ^{176}Lu). BSE parameters alone may account for a ca. 2.5 ε-unit systematic uncertainty for 3.4-4.56 Ga samples. However, a greater source of uncertainty for ε_{Hf}[t] values arises from the choice of λ^{176}Lu used. Recent determinations of λ^{176}Lu by age comparison against the U-Pb system in *terrestrial* samples were performed independently by two labs, yielding identical results of $1.869 \pm 0.016 \times 10^{-11} yr^{-1}$ 2σ, n = 7 samples [1,2], and $1.866 \pm 0.009 \times 10^{-11} yr^{-1}$, n=2 [3]. In contrast, the mean of λ^{176}Lu values based on Lu-Hf whole rock isochrons [2, 4-7] of *meteorites* (chondrites and eucrites) is higher: $1.96 \pm 0.04 \times 10^{-11} yr^{-1}$. This 5% discrepancy translates to a 4-5 ε-unit difference in εHf[t] for Hadean zircons, preventing robust conclusions regarding depleted or enriched melt source regions. The "terrestrial" λ^{176}Lu values were based on individual rocks (*internal* Lu-Hf isochrons, U-Pb accessory phase ages) or single crystals (Lu-Hf *and* U-Pb ages), enhancing the chances that initial isotopic equilibrium occurred and that the Lu-Hf and U-Pb ages apply to the same material. Furthermore, only rapidly-cooled igneous samples were used, minimizing the effects of closure temperature differences between U-Pb and Lu-Hf or among different minerals. Based on the excellent agreement among terrestrial λ^{176}Lu values from 9 different (0.9-2.8 Ga) samples, we suggest that similar strategies (simple samples, independently dating the same material used for internal Lu-Hf isochrons) applied to meteorites may help resolve the discrepancy between "terrestrial" and "meteorite" λ^{176}Lu values.

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6.2.31

3.9Ga to 4.3Ga zircons in lunar breccia 14321: Evidence for a complex source for ejecta from the Imbrium impact

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Lunar breccia sample 14321 from the Apollo 14 mission contains a wide variety of rock types and is thought to be ejecta from the giant Imbrium impact at about 3.85 Ga. Zircons from "sawdust" from multiple sawcuts of the breccia carry information on the ages and chemistry of felsic components of breccia source material and the extent of mixing of materials forming the breccia. We report results of SHRIMP U-Pb analyses made at the ANU and Curtin University, and Raman spectroscopy, and CL imagery at Curtin for 15 zircons from this "sawdust" sample. The zircons are angular fragments of relatively large crystals and show a network of fractures. Curved and planar banded internal structures are revealed by CL imagery in a few grains but most grains appear relatively homogeneous. The age distribution of the 15 zircons ranges from 3.90 Ga to 4.37Ga. This is an exceptional age range. It is identical to the total age range of zircons from lunar samples reported by Meyer et al. [1] and is also similar to the total age range of the oldest terrestrial detrital zircon population from conglomerates and quartzites from the Jack Hills and Mt Narryer [2]. The U-Pb ages are essentially concordant and are interpreted as dating original zircon crystallisation. The ages show no indication they have been affected by the Imbrium impact at ca 3.85Ga. The age range could indicate extreme inhomogeneity of the ages of felsic rocks within the area of the Imbrium impact or it could reflect wider sampling due to multiple mixing events prior to the Imbrium event.The variation in uranium and thorium contents together with the age spectrum, suggests that zircons from the breccia derive from a number of rock types. Also, a comparison of U and Th contents, grain size and internal structures between the lunar and the >3.9Ga terrestrial zircons suggest significant differences in the source rocks of these zircon populations.

References

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