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Large discrepancies between garnet Lu–Hf and Sm–Nd isochron ages: the problem of inherited Hf

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A commonly observed phenomenon in garnet geochronology is that Lu–Hf isochron ages are consistently older than Sm–Nd ages from the same sample, a relationship explained by differences in closure temperature and REE zoning that are then used as the basis for constraining mineral growth and/or cooling rates. We report Lu–Hf and Sm–Nd age discrepancies of up to 40 Myr from three samples of garnet–chlorite–magnetite schist from the Walter-Outalpa Shear Zone, Curnamona Province, South Australia. Lu–Hf and Sm–Nd isochron ages vary between 531–515 Ma and 500–479 Ma, respectively, spanning the entire duration of the 514–490 Ma Delamerian Orogeny. U–Pb monazite ages from matrix-hosted grains are within error of the youngest Sm–Nd ages (c. 480 Ma), whereas monazite inclusions in garnet return age estimates coeval with the oldest Sm–Nd age (c. 500 Ma). LA-ICP-MS trace element mapping reveals that Nd is strongly partitioned into garnet rims for samples with the youngest ages, suggesting that REE zoning biases these estimates towards the latter stages of garnet growth. Conversely, Lu–Hf ages largely reflect Hf distributions that are strongly concentrated in core domains, most likely representing the earlier timing of garnet nucleation in prograde zoned grains.

However, all samples contain zircon present either as a matrix accessory phase or as inclusions in garnet, often as micron-scale grains difficult to detect without detailed SEM/LA-ICP-MS imaging. This calls into question the implicit assumption that the Lu–Hf isochron has an initial gradient of zero, i.e. that the ^{176}Hf/^{177}Hf ratio of newly grown garnet is in equilibrium with the whole rock composition. We demonstrate that this assumption is invalid in circumstances where the whole-rock Hf budget is dominated by minerals that do not enter diffusional exchange with garnet, a common occurrence in metapelitic and felsic rocks that contain significant amounts of inherited zircon. Such problems are exacerbated by mineral separation and dissolution techniques that preferentially reduce zircon contamination in garnet relative to the untreated whole rock fraction, systematically skewing the Lu–Hf isochron to an apparent age older than the 'true' age. Furthermore, the moderate metamorphic grade of the Walter-Outalpa samples (530 ºC; 5 kbar) prevents an appeal to diffusion to explain the large Lu–Hf vs. Sm–Nd age discrepancy. As such, it is concluded that the problem of inherited Hf can produce spuriously old ages that falsely suggest a high closure temperature for the Lu–Hf isotopic system and/or an early onset of garnet nucleation. This should urge caution in the interpretation of Lu–Hf data without consideration of potential inheritance effects.