

THE AGE OF ZAGAMI AND OTHER SHERGOTTITES

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We report new Sm-Nd, Lu-Hf, and Pb-Pb mineral and whole-rock isotope data for the basaltic shergottite Zagami, as well as Pb-Pb whole-rock isotope data for the basaltic shergottite Los Angeles, the therszolic shergottite Dar-al-Gani 476 (DaG 476), and the clinopyroxenite Nakhla.

The internal Lu-Hf isochron age on Zagami is 190 ± 11 Ma. Although not concordant within error bars with the Sm-Nd age obtained on the same mineral and whole-rock aliquots (155 ± 6 Ma), it overlaps with previous age estimates on Zagami and Shergotty [1-3] as well as Los Angeles [4]. Whole-rock and residual fractions left after leaching of pyroxene and maskelynite of Zagami form an essentially perfect alignment in $^{207}\text{Pb}/^{206}\text{Pb}$ - $^{204}\text{Pb}/^{206}\text{Pb}$ space, which, if interpreted as an isochron, indicates an age of 4044 ± 1 Ma (MSWD = 0.018). The Los Angeles residue falls on this isochron as well. Pb from the DaG 476 residue left after leaching is particularly unradiogenic, a characteristic shared by the Nakhla residue. These rocks and their mantle sources must have evolved in an environment with an extremely low μ value.

The young Lu-Hf and Sm-Nd ages strengthen the claim based on literature data that this age range represents the time of crystallization. In contrast, our new Pb isotope results are not consistent with a young age and must either represent an age of great antiquity or a mixing line between two separate Pb reservoirs. An important consideration, however, is that phosphates are common phases in Zagami [5], as in all the shergottites, and explains why most of the rare earth elements, Th, and U and a substantial fraction of Pb can be removed by leaching [3, 6]. Maskelynite and pyroxene therefore do not add up to the whole-rock and the alignment should not be assigned to closure. The shergottite array of [3] is indistinguishable from our internal Zagami and Los Angeles residue Pb isotope array and cannot be coincidental. We propose that the young isochron ages date the last isotopic resetting of phosphate-hosted chronometers by acid solutions percolating through the volcanic rocks exposed on the Martian surface. The young ages are also in conflict with the presence of ^{142}Nd and ^{182}W anomalies observed in SNCs [7], which must be inherited from their mantle sources, thus implying the Martian mantle was only poorly stirred between 4.5 Gy and 180 My ago. A young age for shergottites paradoxically calls for recent volcanic activity on a planet with slow or even no mantle convection at all, a scenario that necessitates stable density layering and pure heat loss by conduction. This paradox is eliminated if the shergottites are ~ 4.0 Ga old, in which case the modern mantle can be fully convective, but then a reassessment of the extinct radioactivity anomalies becomes necessary.

References: [1] Nyquist L.E. et al. 1979. *Geochimica et Cosmochimica Acta* 43:1057-1074. [2] Shih C.Y. et al. 1982. *Geochimica et Cosmochimica Acta* 46:2323-2344. [3] Chen J.H. and Wasserburg G.J. 1986. *Geochimica et Cosmochimica Acta* 50:955-968. [4] Nyquist L.E. et al. 2000. *Meteoritics & Planetary Science*. vol. 35:A121. [5] McCoy T.J. et al. 1999. *Geochimica et Cosmochimica Acta* 63:1249-1262. [6] Jagoutz E. and Wänke H. 1986. *Geochimica et Cosmochimica Acta* 50:939-953. [7] Foley C.N. et al. 2005. *Geochimica et Cosmochimica Acta*, in press.