

The Lu-Hf isotopic composition of CHUR and BSE: Tighter constraints from unequilibrated chondrites

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The Lu-Hf isotopic system has been used increasingly in geochemistry as a chronometer and tracer of mantle and crust processes since the development of MC-ICPMS techniques [1]. Although a consensus has emerged on the value of the ¹⁷⁶Lu decay constant, in contrast, the Lu and Hf isotopic compositions of the Chondrite Uniform Reservoir (CHUR) and Bulk Silicate Earth (BSE) have not been as well constrained. Lu-Hf isotopic compositions vary dramatically between the chondrite classes and petrologic types of the specimens that have been analyzed [1-3], which hampers a choice of Lu-Hf CHUR parameters. Chondrites are classified in three main petrologic groups: carbonaceous (CC), ordinary (OC) and enstatite chondrites (EC). They represent distinct chemical and isotopic compositions, which can be associated with reservoirs in the protoplanetary disk where the respective parent bodies have formed. They also have been subjected to various degrees of aqueous alteration (types 1 and 2) or thermal metamorphism (types 3-6) that has potentially affected their initial chemical and mineralogical characteristics. Despite the fact that numerous OCs (~50) have been analyzed for their Lu-Hf isotopic composition, nearly all of these have been equilibrated types 4-6; only 5 finds of types 3.6-3.8 unequilibrated OC have been analyzed. We have analyzed 20 new chondrites for Lu-Hf and Sm-Nd isotope systematics including (i) 13 H, L, and LL OC of types 3.0- 3.8, where their low degree of metamorphism limits the growth of phosphate (main carrier of REE) compared to the equilibrated OC; and (ii) 7 CC of types 1-3 (CI, CV, CO and CK groups). We obtained mean values (2σSE) of ¹⁷⁶Lu/¹⁷⁷Hf = 0.0337 ± 3, ¹⁷⁶Hf/¹⁷⁷Hf = 0.282802 ± 23, ¹⁴⁷Sm/¹⁴³Nd = 0.1961 ± 6, and ¹⁴³Nd/¹⁴⁴Nd = 0.512629 ± 16 from the types 1-3 OC and CC from this study and [3]. Our Lu-Hf values are higher than the previous estimates of [1] and are our best estimates for CHUR. The CC alone give higher mean values of ¹⁷⁶Lu/¹⁷⁷Hf = 0.0339 ± 4, ¹⁷⁶Hf/¹⁷⁷Hf = 0.282816 ± 32, ¹⁴⁷Sm/¹⁴⁴Nd = 0.1966 ± 10, and ¹⁴³Nd/¹⁴⁴Nd = 0.512639 ± 28. These last values are concordant with the Sm-Nd CHUR and BSE parameters that are currently widely used [4].

Lu-Hf and Sm-Nd isotopic systems involve refractory and lithophile elements, so that the composition of BSE should coincide with that of the CHUR. The Lu/Hf chondrite range in unequilibrated OC and CC is now constrained by ~7%, equivalent to what is found for the paired Sm-Nd system. To refine the Lu-Hf BSE estimate, we need to determine which chondrites are the best representative of BSE. For Sm-Nd isotope systematics, there is wide overlap between the chondrite groups. In contrast, CC have significantly higher Lu/Hf than OC. If we compare with other refractory and lithophile elements, CV, CK, CM and CO chondrites represent the closest composition with Earth's mantle [5]. From O and Cr isotope constraints [6], EC share a common reservoir of formation with the Earth. We will refine the BSE composition based on these observations and also present supplementary data on CI, CR and unequilibrated EC.

[1] Blichert-Toft and Albarède, 1997. *EPSL*, 148 243-258. [2] Bizzarro et al., 2003. *Nature*. 421 931-933. [3] Patchett et al., 2004. *EPSL*, 222 29-41. [4] Jacobsen, and Wasserburg, 1980. *EPSL*, 50 139-155. [5] Palme, 2001. *Phil. Trans. R. Soc. Lond.* 359 2061-2075. [6] Trinquier et al., 2007. *APJ*, 655 1179-1185.