Is the bulk Earth Nb/Ta chondritic?

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The accessible silicate Earth is characterized by a Nb deficit of ca. 30% relative to most groups of chondrites [1]. This Nb deficit has been attributed to a slightly siderophile affinity of Nb during high-pressure formation of the Earth’s core [1,2]. The finding of low Nb/Ta ratios in CV chondrites (ca. 17 [1]), however, has challenged this model, as CV chondrites closely resemble the Earth’s composition in their relative abundances of volatile and refractory elements. If the bulk Earth indeed had a CV-chondritic or even lower Nb/Ta ratio, the Nb deficit in the silicate Earth would be much less pronounced, and models using Nb/Ta ratios to assess conditions during core formation [e.g., 3,4] would need some revision.

In order to investigate the cause for the low Nb/Ta in CV chondrites, we analyzed small ca. 0.6 g slices taken from a single piece of Allende [5], together with an aliquot of the Smithsonian powder that is representative for bulk Allende. Ratios of HFSE were determined at high precision using isotopic dilution and the Neptune MC-ICPMS at Cologne-Bonn [6] and are compared to high precision data for REE previously determined at ETH Zürich and RSES Canberra [5, unpublished]. The Smithsonian Allende powder yielded a Nb/Ta of 19.1±0.8 (2σ), within error of values for other chondrite groups (19.9±0.6, [1]). Conversely, the Nb/Ta measured for the small Allende slices span a wide range from 14.2 to 22.0. Ratios of Zr/Nb are correlated with Nb contents and range towards values as low as 10, much lower than the chondritic value (13.5, [3]).

The Nb/Ta systematics found for Allende indicate that in contrast to Zr-Hf, Nb and Ta are not distributed homogeneously in CV chondrites. However, the data for the large Smithsonian powder aliquot suggest that the bulk Allende parent body had a Nb/Ta indistinguishable from other types of chondrites. Notably, the Nb/Ta in the small Allende slices are negatively correlated with Tm/Er ratios (0.16 to 0.26). At near-chondritic Tm/Er (ca. 0.16 [7]), the measured Nb/Ta in the Allende splits scatter around a value of 20, typical of the chondrite average. It has previously been argued that the elevated Tm/Er in many CV chondrites can be attributed to the presence of type II CAIs [5]. Low Nb/Ta ratios occasionally found in CV chondrites may reflect selective enrichment group II CAI.

The co-variation between Nb/Ta and Tm/Er could imply that the bulk Earth Nb/Ta chondritic?

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The co-variation between Nb/Ta and Tm/Er could imply that the bulk Earth exhibits a superchondritic Tm/Er, if it had a low Nb/Ta. This is clearly not the case, as the silicate Earth displays a Tm/Er that is not resolvable from that of CI-chondrites [7]. The Nb/Ta of the bulk Earth should therefore overlap the chondritic value and the Nb deficit in the Earth’s mantle reflects its siderophile behaviour.