Tracing the terrestrial Nb-Ta paradox at high analytical resolution

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If measured at sufficient precision and accuracy, Nb/Ta ratios allow unprecedented insight into the geochemical cycle of both elements that are critical to many geochemical mass balance approaches [e.g., 1]. Here, a high precision Nb-Ta dataset for different terrestrial and planetary reservoirs is reviewed, involving partially unpublished data, which, for internal consistency, were all measured by isotope dilution.

At a planetary scale, there is now clear evidence that Nb is selectively depleted in the silicate Earth by ca. 20% relative to different classes of chondrites that display a uniform value (Nb/Ta ca. 19). Only in CV chondrites Nb/Ta is significantly lower (ca. 17), due to the large portion of refractory materials with low Nb/Ta. In the mantles of Mars and oxidised asteroids Nb/Ta also overlap the chondritic value, whereas in the mantles of reduced asteroids, Nb can be selectively depleted by sulfide segregation. Experimental evidence now can show that segregation of a late Hadean sulfide matte has likely not affected the Nb budget of the silicate Earth.

The Nb/Ta of the lunar mantle is intermediate between the terrestrial mantle and the chondritic value. The selective depletion of Nb in the silicate Earth and the Moon is best explained by core formation at high pressures and reducing conditions or, alternatively, by early disequilibrium accretion of differentiated, reduced asteroids with extermely low Nb/Ta in their silicate portions and high Nb/Ta in their cores.

Internal differentiation of the silicate Earth can now be regarded unlikely to explain its Nb deficit. This is because compositions of early Archean basalts and komatiites tightly overlap compositions of Phanerozoic MORBs and OIBs (12-17). Although mantle peridotites can display substantial Nb/Ta fractionation, this is not mirrored in the Nb/Ta found in most basalts. Due to the presence of residual phases like rutile or amphibole, however, there is substantial Nb/Ta fractionation in subduction related magmas and Archean TTGs (Nb/Ta from 5 to ca. 30). This, in turn, may lead to fractionated Nb/Ta in intra-continental magmas that tap the lithospheric mantle. New Nb/Ta data for sediments only indicate a slightly lower Nb/Ta composition of the upper continental crust (12-16). Irrespective of the timing and the different mechanisms controlling crustal growth, crust-mantle differentiation and recycling processes in the silicate Earth can therefore not have significantly affected its Nb/Ta budget.

[1] Hofmann et al. (1986) *EPSL* **79**, 33-45.