Redox control on Nb/Ta fractionation during planetary accretion

C. CARTIER[12], T. HAMMOUDA[2], A. BOUHIFD[2], M. BOYET [2], J.L. DEVIDAL[2]

[1] c.cartier@opgc.univ-bpclermont.fr

[2] Laboratoire Magmas et Volcans, UBP, CNRS UMR 6524, 5 rue Kessler, 63038 Clermont-Ferrand, France.

During the segregation of the Earth's core, the refractory lithophile elements such as Ca, Al and the rare earth elements are known to remain in the same proportions in the silicate part of the Earth as in the chondritic meteorites[1]. However, even though Nb and Ta are both classified as refractory lithophile elements and share similar degree of incompatibility[2] the Nb/Ta ratio of the bulk silicate Earth (BSE) is subchondritic[3]. To explain this behavior, Wade and Wood[4] suggested that at the high pressure of Earth's core formation Nb become siderophile, thus being depleted from the silicate Earth. Recent Earth's core formation models[5,6] as well as simulations of the dynamical aspects of planetary accretion[7] suggest however that the nature of the primitive building material has evolved as well as the oxygen fugacity (fO_2) of the proto-Earth. Yet, the impact of the evolution of fO_2 during Earth's core formation from reducing to more oxidizing conditions has not been investigated. Here we show that the behavior of Nb and Ta is mainly controlled by the oxygen fugacity, while pressure has only a negligible impact on Nb/Ta ratio. By using our new metal-silicate partitioning data we reproduce the Nb/Ta ratios of the BSE, Mars and 4-Vesta. Because Nb/Ta displays little dependence to any other parameter than fO_2, it is a unique tool to trace oxygen fugacities prevailing during planetary body accretion.

1. Kargel, J.S. & Lewis, J.S. The composition and early evolution of Earth. *Icarus* **105**, 1-25 (1993).
2. Hofmann A.W. Chemical differentiation on the Earth: the relationship between mantle, continental crust, and oceanic crust . *Earth Planet. Sc. Lett*. **90**, 297-314 (1988).
3. Münker, C. *et al.* Evolution of planetary cores and the Earth-Moon system from Nb/Ta systematics. *Science* **301**, 84–7 (2003).
4. Wade, J. & Wood, B. J. The Earth's "missing" niobium may be in the core. *Nature* **409**, 75–8 (2001).
5. Wade, J. & Wood, B. J. Core formation and the oxidation state of the Earth. *Earth Planet. Sc. Lett*. **236**, 78–95 (2005).
6. Rubie, D. C. *et al*. Heterogeneous accretion, composition and core–mantle differentiation of the Earth. *Earth Planet. Sc. Lett*. **301**, 31–42 (2011).
7. Morbidelli, A., Lunine, J.I., O'Brien, D.P., Raymond, S.N. & Walsh, K.J. Building terrestrial planets. *Annu. Rev. Earth Pl. Sc*. **40**, 251-275 (2012).