HIGH PRECISION MEASUREMENTS OF Nb/Ta AND Zr/Hf IN CHONDRITES: IMPLICATIONS FOR THE MASS BALANCE OF Nb-Ta IN SOLID PLANETS. C. Münker[1] and K. Mezger[1], ZLG, Institut für Mineralogie, Correnssstr. 24, 48149 Münster, Germany, muenker@nwz.uni-muenster.de

Introduction: Mass balance calculations of the major and trace element inventory in solid planets hinge on the precise knowledge of the chondritic compositions as reference values. Recent measurements of Nb/Ta and Zr/Hf in a variety of terrestrial and extraterrestrial materials indicate that Nb is depleted in the silicate Earth, where all major silicate reservoirs have subchondritic Nb/Ta [1, 2]. In stark contrast to Earth, Nb/Ta of the silicate mantles of Mars and the HED parent body appear to be close to the chondritic value [2]. The chondritic Nb/Ta and Zr/Hf values were long assumed to be ~17.6 and ~36.5, respectively [3]. Here we report revised chondritic values for Nb/Ta and Zr/Hf based on the analyses of 17 ordinary, enstatite and carbonaceous chondrites.

Analytical Methods and results: Nb/Ta and Zr/Hf were analyzed by MC-ICPMS using a mixed ^{180}Ta-^{180}Hf-^{94}Zr tracer. Niobium was analyzed as Zr/Nb relative to a 99.9% AMES metal solution. External reproducibilities are ±4% for Nb/Ta and ±0.6% for Zr/Hf (all 2σ). Nb/Ta and Zr/Hf in all analyzed ordinary and enstatite, and most carbonaceous chondrites yield well defined average values of 19.8±0.6 and 34.2±0.3, respectively. In contrast to all other analyzed groups of carbonaceous chondrites (CI, CM, CK), four CV3 chondrites (Allende, Bali, Arch, Axtell) have significantly lower Nb/Ta between 16 and 18. However, Zr/Hf in these CV3 chondrites overlaps with those of the other chondrite groups.

Discussion: The new data indicate that the distribution of Nb-Ta and Zr-Hf in all major chondrite groups (except CV3) is homogeneous to within ±5%. While the variations in Nb/Ta are nearly within analytical error, the variations in Zr/Hf are clearly outside analytical error, possibly reflecting sample heterogeneities. The lower Nb/Ta in the CV3 chondrites are most likely caused by an enrichment of refractory components in this group, as suggested by the higher abundance of other highly refractory elements [4]. Nb is probably more volatile than Ta, Zr, and Hf, consistent with experimental evidence [5]. Since CV chondrites are clearly more depleted in moderately volatile elements than Earth and Mars, this meteorite group can be ruled out as a major component in these two planets. Based on the results for the other chondrite groups, there is clear evidence that the bulk Earth and Mars have Nb/Ta of ~20 and Zr/Hf of ~34. The Nb deficit in the silicate Earth can therefore be ascribed to slighly siderophile properties of Nb at high pressures (>20GPa) that prevailed in the magma ocean when Earth's core formed. In the silicate portion of Mars, Nb is not depleted due to lower core formation pressures (~1 GPa). The Nb/Ta of the Moon (17.0±0.8) lies between the values of the bulk silicate Earth and chondrites and can therefore be used to estimate the mass fraction of the material in the Moon that is derived from the Mars-sized impactor (chondritic Nb/Ta). Depending on the Nb/Ta of the silicate proto-Earth, the mass fraction of impactor material in the Moon can be constrained to ~50%.

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