V, CR AND MN PARTITION COEFFICIENTS BETWEEN MANTLE MINERALS AND SILICATE MELT; Elisabeth A. McFarlane*, Michael J. Drake* and David C. Rubie#. *Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona 85721, U.S.A; #Bayerisches Geoinstitut, Universität Bayreuth, D-95440 Bayreuth, GERMANY.

Introduction: The abundances of V, Cr, and Mn in the mantles of the Earth and Moon are very similar to each other, and differ from all other sampled differentiated planetary bodies (e.g. Drake *et al.*, 1989). The origin of this similarity is currently unknown, but is not attributable to metal/silicate fractionation at pressures from 1 bar to 165 kbars, or to differential volatility (Drake *et al.*, 1989; Ringwood *et al.*, 1991; Hillgren *et al.*, 1994, this volume). Mg-perovskite and magnesiowüstite are the dominant phases in the lower mantle of the Earth. The present work examines whether the V, Cr and Mn abundance pattern for the mantle of the Earth (and Moon) can be explained through high pressure and temperature fractionation of Mg-perovskite and magnesiowüstite from a silicate melt during a postulated magma ocean phase (e.g., Agee and Walker, 1988). Also investigated is the effect of fractionation of these two phases on some refractory and moderately lithophile elements (Ca/Ti, Mg/Si, Si/Ca, Si/Al) which are inferred to be approximately chondritic in the upper mantle of the Earth (e.g. Jagoutz *et al.*, 1979; see also Kato *et al.*, 1988a,b; McFarlane *et al.*, 1990,91a,91b; Drake *et al.*, 1993).

Experimental: An experiment using a mantle composition (KLB-1) was doped with V, Cr and Mn and was run using a 1200 ton multianvil apparatus at the Bayerisches Geoinstitut. A 7 mm MgO (+5 wt. % Cr_2O_3) octahedron was used together with 3 mm truncation edge lengths on the WC anvils. The sample was contained in a Re capsule, and high temperature was generated using a cylindrical $LaCrO_3$ resistance heater. Experiment UHP.723 was run at a hotspot temperature of 2650 (±100)°C and 24.5 (±0.5) GPa for 13 minutes, within the stability field of Mg-perovskite. Partition coefficients between quenched liquid and crystalline phases were measured in the vicinity of the liquidus which is estimated to have been at a temperature of 2400 (± 100)°C. Analysis was by CAMECA SX-50 electron microprobe. The structural identity of the Mg-perovskite was confirmed using X-ray microdiffractometry.

Results: Mg-perovskite/melt partition coefficients and 2 sigma uncertainty estimates are: Na=0.2(±0.1), Mg=1.0(±0.2), Al=1.3(±0.1), Si=1.18(±0.04), Ca=0.5(±0.1), Ti=1.4(±0.3), V=1.14(±0.06), Cr=1.1(±0.1), Mn=0.62(±0.08), Fe=0.6(±0.05), Ni=0.3(±0.1). Magnesiowüstite/melt partition coefficients and 2 sigma uncertainty estimates are: Na=0.8±0.2, Mg=2.3±0.1, Al=0.38±0.01, Si=0.01±0.001, Ca=0.017±0.004, V=0.45±0.01, Cr=1.27±0.03, Mn=0.77±0.06, Fe=1.43±0.05, Ni=4.1±0.4. The results of several subsequent experiments, performed at 25 GPa and 2700°C to investigate the partitioning of Ni, Co, Ga, Mo, Cr, Ge, La, Sm, Eu, Lu, Hf, Rb, Cs, Na, and K, will also be presented.

Discussion: The abundances of V, Cr and Mn in the upper mantle of the Earth decrease in the order V>Cr>Mn (Drake *et al.*, 1989). Figure 1 shows the relative abundance pattern that would result in the upper mantle of the Earth with the fractionation of Mg-perovskite from a melt. Manganese would be most abundant and V and Cr would be present in lesser and approximately equal abundances. Figure 2 shows the relative abundance pattern that would result in the upper mantle of the Earth with the fractionation of magnesiowüstite from a melt. The resulting relative abundance pattern would be V>Mn>Cr. These results show that the V, Cr and Mn abundance pattern of the mantle of the Earth (and Moon) do not result from high pressure and temperature fractionation of Mg-perovskite and/or magnesiowüstite at conditions relevant to the uppermost lower mantle of the Earth.

The ratios of partition coefficients for some refractory and moderately refractory lithophile elements deviate significantly from one. If Mg-perovskite and/or magnesiowüstite segregated from a terrestrial magma ocean, nonchondritic ratios of some refractory and moderately refractory lithophile elements (Ca/Ti, Mg/Si, Si/Ca, Si/Al) would be imparted upon the primitive upper mantle of the Earth, contrary to inference based on analyses of naturally occurring samples. Olivine addition into the upper mantle can be invoked to eliminate this constraint for some elements (e.g., Mg/Si), but will exacerbate the problem for other elements (e.g., Si/Ca, Si/Al). There is no surviving evidence of mineral fractionation implying that either (a) the Earth was never substantially molten at the end of accretion; (b) segregation of minerals from magma was suppressed by some mechanism; (c) some other mechanism masked evidence of fractionation; or (d) partition coefficients change significantly at pressures above 25GPa.

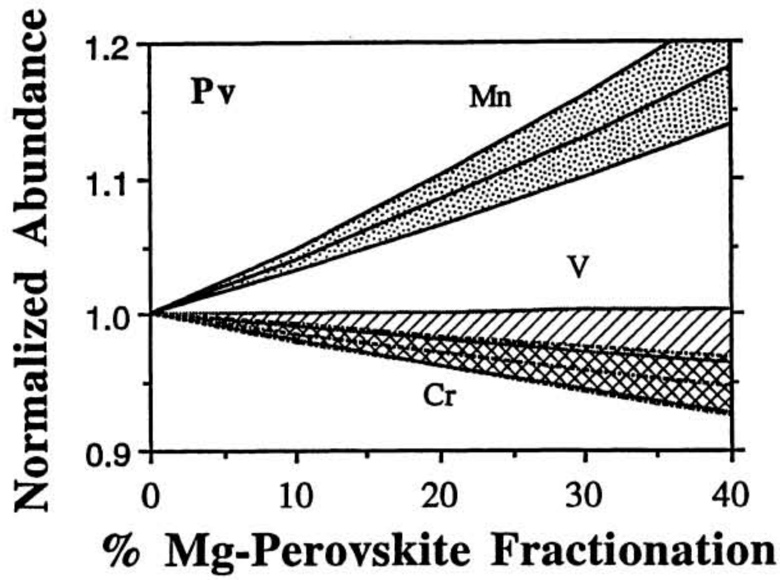

Figure 1. The pattern of V, Cr, Mn abundances that would be observed in the upper mantle of the Earth with the fractionation of Mg-perovskite from a melt, such as might have occurred during a postulated magma ocean stage. Initial abundances are defined to equal 1.0. Most likely estimates leave Cr more depleted than V, although their uncertainty envelopes overlap. Partition coefficient values used are those given in this abstract. Mg-perovskite segregation is not responsible for the pattern of V, Cr, and Mn abundances which are inferred for the primitive upper mantle of the Earth.

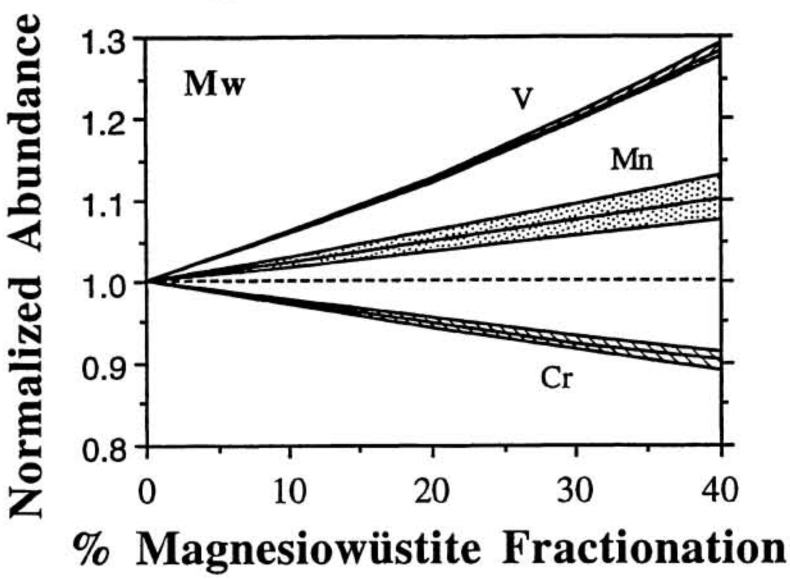

Figure 2. The pattern of V, Cr, Mn abundances that would be observed in the upper mantle of the Earth with the fractionation of magnesiowüstite from a melt, such as might have occurred during a postulated magma ocean stage. Initial abundances are defined to equal 1.0. Partition coefficient values used are those given in this abstract. Magnesiowüstite segregation is not responsible for the pattern of V, Cr, and Mn abundances which are inferred for the primitive upper mantle of the Earth.

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