CONSTRAINING THE MATERIAL THAT FORMED THE MOON: THE ORIGIN OF LUNAR V, CR, AND MN DEPLETIONS.

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The mantles of the Earth and Moon are similarly depleted in V, Cr, and Mn relative to chondritic values [1, 2]. Core formation deep within the Earth was suggested by [1] as the origin of the depletions. Following Earth's core formation, the Moon was proposed to have inherited its mantle from the depleted mantle of the Earth by a giant impact event [3, 4]. This theory implied the Moon was primarily composed of material from the Earth's mantle.

Recent systematic metal-silicate experiments of V, Cr, and Mn evaluated the behavior of these elements during different core formation scenarios [5]. The study found that the V, Cr, and Mn depletions in the Earth could indeed be explained by core formation. The conditions of core formation necessary to deplete V, Cr, and Mn in the Earth's mantle were consistent with the deep magma ocean proposed to account for the Earth's mantle abundances of Ni and Co [6, 7].

Using the parameterizations of [5] for the metal-silicate partition coefficients (D) of V, Cr, and Mn, we investigate here the conditions needed to match the depletions in the silicate Moon and determine if such conditions could have been present on the giant impactor. Using a silicate composition consistent with the Moon and assuming a metallic core about 30% of the body with 6 wt% S and 3 wt% C, different core formation scenarios for the impactor were modeled. Figure 1 shows the modeling results, which indicate a high temperature (>3300 K) and reducing conditions (ΔIW<-2) can match the lunar depletions of V and Cr, and nearly match the lunar depletion of Mn. The partitioning behavior of all three elements was not found to be significantly dependent on pressure [5], and thus, the core formation conditions from V, Cr, and Mn do not constrain the size of the planetary body.

These modeling results imply that the depletions of V, Cr, and Mn in the Moon are not necessarily inherited from the Earth but could have been inherited from the impacting body. Current estimates of the mass of the impactor place it at about two-thirds of an Earth mass [8], large enough to have formed a core at the hot and reducing conditions required in Fig. 1. Further, this result is consistent with recent modeling of the giant impact event, which suggests the majority of the material which formed the Moon was from the impacting body, not the proto-Earth [8].

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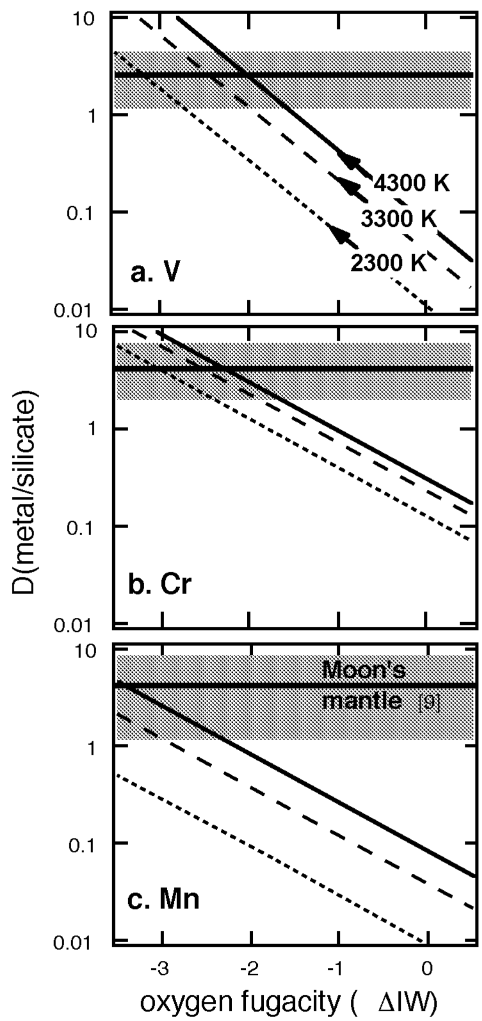

Fig. 1. The partition coefficients that are necessary to explain the depletions of **a)** V, **b)** Cr, and **c)** Mn in the silicate portion of the Moon are shown as shaded gray regions [9], with the preferred partitioning value shown as a thick black line. Each diagonal line indicates the modeled partition coefficients at different oxygen fugacities, expressed as log units below the iron-wüstite buffer (ΔIW), and a constant temperature of either 2300, 3300, or 4300 K. The model lines cross into the gray areas at high temperatures and low oxygen fugacities, suggesting such conditions during core formation can explain the lunar V, Cr, and Mn depletions.