Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18365

The distribution of highly volatile elements during rocky planet formation

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The distribution of highly volatile elements (HVEs; H, C, N and S) in rocky planets plays a key role in the thermochemical and dynamical evolution of their interiors and has a direct effect on the conditions necessary for the origins and support of life through long-term impact on climate and surface geochemistry [1, 2]. Core segregation and atmosphere formation are two of the major processes that re-distribute volatile elements in and around rocky planets during their formation. HVEs are siderophiles, meaning they concentrate in core-forming metal, but they are also, by their definition, elements that tend to accumulate in gaseous reservoirs and form atmospheres [3]. Current models of core formation suggest that metal-silicate reactions occurred over a wide range of pressure, temperature, and composition (P-T-fO_2-X) conditions to ultimately impose the chemistry of the core and silicate portion of rocky planets [4]. The solubilities of HVEs in magmas determine their transfer between the interior and atmosphere, which has recently come into sharper focus in the context of highly irradiated, potentially molten exoplanets. H, C, N and S species are expected to dominate the gaseous envelopes of extrasolar rocky planets [5]. On an experimental basis, there has been a significant recent focus on investigating the effects of pressure, temperature, and composition on the metal-silicate and magma-gas exchange coefficients for the HVEs. We review the laboratory measurements of these quantities and how they inform the equilibrium distribution of HVEs in planets undergoing accretion, ranging from smaller bodies that formed early to larger bodies that formed late. The qualitative potential for disequilibria affecting distribution is also discussed.

References:

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