

Noble gas incorporation into the deep Earth

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The present state of the Earth evolved from energetic events that were determined early in the history of the solar system. A key process in reconciling this state and the observable mantle composition with models of the original formation relies on understanding the planetary processing that has taken place over the past 4.5Ga and the range of most relevant P-T conditions governing primary segregation and mixing. Recent developments with the laser-heated diamond anvil cell have made possible extension of the conventional pressure limit for solubility and partitioning experiments as well as the direct study of volatile trace elements. In particular, selected results of liquid-liquid, metal-silicate (M-Sil) partitioning are presented for several noble gas and molecular elements in a synthetic chondritic mixture, spanning a wide range of atomic number - helium to iodine. The application of these methods is new and allows extension of geochemical studies performed in larger-volume apparatus. Not only is the attainment of uniform and equilibrium mixing important in this small-sample environment (perhaps 10-100 micrometers in linear dimension depending on the pressure), but also the microanalysis of quenched samples to determine the distribution of minor and trace elements. Systematic results on the solubility of He, Ne and Ar suggests that their incompatibility in solid silicate and metallic phases may not have been as great as previously thought -- and hence are candidates for storage in the deep Earth. Helium solubility in the metal phase relative to that of the silicate suggests the core should be considered a deep Earth reservoir for example. If the core is a reservoir, then the mechanisms for interaction with the lower mantle become important requiring examination of the processes of material exchange at the core-mantle boundary. The interpretation of the results depended on precise microanalysis of LHDAC samples, and the application of UV laser ablation, mass-spectrometric techniques that provided for the first time a spatially resolved depth profile in samples. Attention needs to be paid to the likely mode of solubility - entrapment versus bonded and non-bonded host environments for example - and we attempt to consider the real implications for the Earth in either case.

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