Earth's volatile element contents and volatilities during partial melting

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Depletions, relative to CI chondrites, of the silicate Earth in moderately volatile elements may qualitatively be explained by accretion of 10-20% of a CI chondritic body to a reduced volatile-free protoEarth[1] followed by partial extraction of some elements to the core. Several anomalies remain, however, notably the apparent overabundance of Indium in silicate Earth relative to elements of similar volatility such as Tl. Our study was aimed at investigating volatility during the melting processes which attended accretion on Earth and precursor bodies. To do this we performed vaporisation experiments under conditions of fixed temperature and oxygen partial pressure and determined relative volatilities of Ag, Bi, Cd, Cr, Cu, Ga, Ge In, Pb, Sb, Sn, Tl and Zn.

Experiments were performed in a one-atmosphere gas-mixing stirring furnace. The furnace design incorporates a crucible and stirring element made of nickel, and allows the experiment to be rapidly quenched via ejection into a water bath. By stirring we eliminate diffusion in the melt as an important process, enabling relative loss rates from a homogeneous melt to be established. At 1573K and oxygen fugacity about 2 log units below the Fe-FeO buffer we find relative volatilites are: Sb>Bi>Ge>Cd>Sn>Tl>Pb~Zn>Cu~In >Ga>Cr. We find that this order of volatility is much more consistent with the abundance pattern of these elements in Earth than relative volatilities based on condensation temperature which are[2]: Tl~In>Cd>Sn>Zn~Pb>Bi> Ge>Ga>Sb>Ag>Cu>Cr. We suggest that melting and vaporisation on precursor bodies and during the giant moon-forming impact was largely responsible for establishing the observed abundances of these moderately volatile elements in the Earth.

[1] O'Neill, H.S.C (1991) Geochim. Cosmochim. Acta v55, 1159-1172

[2] Lodders, K. (2003) Astrophys. J. v591, 1220-1247