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Volatile element behaviour during melting on Earth, Mars and smaller bodies

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During accretion the Earth, Mars and many asteroidal bodies, underwent periods of partial melting, vaporisation and re-condensation. This resulted in complex patterns of volatile element depletion in the terrestrial planets relative to CI chondrite. The behavior of moderately volatile elements (Pb, Cd, Zn,Cu, etc) during melting, vaporisation and re-condensation processes is usually approximated by condensation temperature from a reduced solar gas. There is, however, no reason why this should be appropriate for the more oxidised conditions which pertained on molten asteroids and protoplanets. We therefore directly determined the vaporisation behavior of 13 elements (Ag,Bi,Cd,Cr,Cu,Ga,Ge,In,Pb,Sb,Sn,Tl,Zn) from molten basalt at 1 atm pressure and oxygen fugacities between Ni-NiO (NNO) and 2 log units below the iron-wüstite buffer Fe-FeO (IW). The relative volatilities of the elements turn out to be only weakly correlated with condensation temperature, indicating that the latter is a poor proxy for volatility on molten bodies. In contrast, we find that there is an excellent correlation between our measured volatilities from silicate melt under oxygen fugacities close to IW and the abundances of the 13 elements in silicate Earth. This indicates that these moderately volatile elements were added to Earth in bodies which had undergone episodes of melting and vaporisation. Surprisingly their abundances in silicate Earth appear not to have been greatly affected by core formation. In contrast, abundances in silicate Mars do not correlate as well with volatility with siderophile and chalcophile elements being the most depleted. This indicates that the moderately volatile elements were added to Mars while core segregation was ongoing.