Accretion, volatile-addition and Earth's connections to the moon-forming impact

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This talk will address several interrelated questions: (a)What (if any) are the effects of "light" element contents of the core on silicate Earth composition? (b) Do these effects have implications for the oxidised or reduced nature of conditions during accretion? (c) How can we explain the "spiky" pattern of depletion of moderately volatile (Cu, Ag, Pb, Cd etc) elements in silicate Earth when compared to carbonaceous chondrites? (d) When during accretion were these elements added to the Earth? (e) How can we explain the profound chemical and isotopic connections between Earth and Moon? We approach these questions from several different directions. Firstly, we have supplemented available data with new determinations of the metal-silicate partitioning of a number of volatile and refractory elements (Mo, W, Cu, Ag, Mn, Cr, Tl, Cd) at high pressures and temperatures. Secondly, we have determined the effects of S and C on metal-silicate partitioning of these and other refractory elements (notably Ni, Co and V) in order to be able to model silicate Earth composition during core growth. Thirdly, we have made simple models of accretion, volatile addition and moon formation.

We find that S and C have profound effects on metal-silicate partitioning of Mo and W and the chalcophile elements Pb,Tl,Cd, and that these effects are less important for Ni, Co and V. The Mo/W ratio of silicate Earth and the pattern of depletion of moderately volatile elements can be generated by addition of metal rich in S and elements of similar volatility during the last 10-20% of accretion. This would give an overall S content of the core of ~2%. The current silicate Earth contents of weak siderophiles such as V, Cr and Nb is consistent with growth being under reducing conditions until the last ~20% of accretion. Accretion of the Earth and generation of a moon dominated by material from Earth's mantle (as seems likely from isotopic evidence) requires post-impact addition of a small amount (~5%) of chondritic material to both bodies. Post-impact removal of FeO from Earth's mantle and generation of similar Hf/W in Earth and Moon and $(Nb/Ta)_{Moon} > (Nb/Ta)_{Earth}$ requires a secondary high pressure re-equilibration of Earth's mantle with metal added during the impact (Wade and Wood, this meeting).