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Nebular condensation of different stellar compositions and its influence on planetary chemistry

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The volatility of an element is defined by its 50% condensation temperature (T_c^{50}) from a canonical nebular gas of Solar composition at 10^{-4} bar [1, 2]. However, the variability in metallicity and metal/oxygen ratios of extrasolar systems inferred from the spectroscopic measurements of their parent stars [3, 4] implies that the identity, abundance and sequence of condensation may deviate from that of our solar system. As such, planets formed at similar heliocentric distances may be expected to have distinct compositions from those of the terrestrial planets in our solar system. Here we investigate the degree to which nebular composition influences the condensation process by taking nine sets of stellar compositions with variable metallicities that span the range from -0.4 to +0.4 dex and performing Gibbs free energy minimisation calculations with FactSage, including treatment of mineral solid-solutions, over the temperature range 1723 K to 473 K. We find that, although the general order of condensation is similar, absolute values of T_c^{50} are shifted to higher temperatures at higher dex, where $T_c^{50}(S)$, in particular, increases relative to those of other elements. Condensing nebulae with high metallicities (and also high metal/oxygen ratios) also exhibit the following features: (i) the appearance of reduced assemblages (e.g. CaS oldhamite, forsterite-rich olivine and graphite) in the condensates, (ii) increased fractions of oxygen (relative to its total abundance) locked in the silicate condensates, and (iii) lower fO_2 in the gas phase. As a result, these characteristics will lead to significant differences in the chemistry of planetary building blocks, which are then accreted to form telluric planetary bodies.

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