CONDENSATION IN SOLAR AND STELLAR SYSTEMS

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The condensation sequence of elements from gas of solar composition has been widely applied in the early solar system particularly with regard to mineralogy of refractory inclusions. The oxidising nature of solar system gas results in a sequence of major elemental oxides Al, Ca, and Ti, through to Mg and Si and hence a mineralogical sequence of corundum, hibonite, perovskite, spinel, melilite, forsterite. In the context of the solar system, a near equilibrium condition can be applied whereby the solids continue to react with the gas. In this way, more refractory elements can continue to appear in lower temperature phases in the sequence. The lanthanoids are particularly noteworthy in this respect since their condensation temperatures cover the full range from Al to Si condensation. However, despite fundamental differences in bulk element compositions, the lanthanoids frequently show little correlation. This is particularly noteworthy for the ultrarefractory-depleted Group II pattern which can have similar major element chemistry to ultrarefractory-enriched inclusions (see for example [1]). Such systematics suggest at least a partial decoupling between refractory trace-elements and the major elements within an inclusion. It would appear that the lanthanoids and potentially other trace elements are carried in multiple phases that are amalgamated into the refractory inclusions.

Condensation is envisaged to occur around stellar systems during accretion, but also during mass ejection events such as occurring in Asymptotic Giant Branch (AGB) stars where 10^{-7} to 10^{-4} solar masses of material may be shed. Observation and mineralogical identification of such stars allows a window into the formation mechanisms and chemical context of grain formation and this may be relevant to condensation occurring in the early solar system. Through radiative transfer modelling of the ISO spectrum of IRAS 22036+5306 we have found that its unusual 11 µm band can be suitably modelled with an Al2O3-MgFeSiO4 mixture substantially dominated by the former [2]. This suggests that condensation does follow a mineralogical sequence, but we cannot identify melilite in the spectrum or other Ca, Mg silicates that would normally appear before forsterite. This star therefore suggests a fractional condensation sequence may occur as a response to outflow where condensation close to the star follows the expected early corundum condensation but the later condensates are subdued through kinetics and nucleation with only forsterite being in sufficient abundance to appear in the spectrum.

References: [1] Ireland T. R. and Fegley B. 2000, *Int. Geol. Rev.* **42**, 865-894. [2] Maldoni M. et al. 2008, *Mon. Not. Roy. Astron. Soc*. **386**, 2290-2296.