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Trace element condensation in dust-rich environments

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The relative proportions of dust and gas in protoplanetary disks or stellar environments can strongly influence the condensation of major elements, as has been shown by the study of Ebel and Grossman [1]. An enhancement in dust concentrations prior to the temperature elevation of the protoplanetary disk may lead to specific conditions that differ from the standard solar nebula commonly assumed to calculate the condensation temperatures of elements (Wood et al. [2]). These O-rich environments may correspond to the conditions of formation of chondrules as described Alexander et al. [3], or may be akin to the conditions following the Moon-forming impact [4].

In this study, we have calculated the condensation temperatures for a series of minor and trace elements used in cosmochemistry to determine the effect of a variable fO_2 and dust concentrations at various levels (100X and 1000X) relative to a CI chondrite composition. The activity coefficients of trace elements in silicate melts and minerals were taken from the literature or directly recalculated using metal-silicate or mineral-melt experiments. The results confirm the presence of a silicate melt at an early stage of condensation as in Ebel and Grossman [1]. The 50% condensation temperatures of trace elements are shiftted by several hundreds of kelvins to higher values. For example, for an dust enhancement by a factor of 1000, the condensation temperatures of Cr and Cu shifts by 400K and 280K, respectively at a pressure of 10^{-4} atm. Altogether, these results should be useful to better understand the formation conditions of chondrules.

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