VAPOR-CONDENSED PHASE PROCESSES IN THE EARLY SOLAR SYSTEM. L. Grossman. Department of the Geophysical Sciences and Enrico Fermi Institute, The University of Chicago, Chicago, IL 60637. E-mail: yosi@uchicago.edu.

Equilibrium thermodynamic calculations of the sequence of condensation of phases from a cooling gas of solar composition at total pressures thought to have prevailed in the inner part of the solar nebula successfully predict the primary mineral assemblage (spinel, melilite, perovskite, Ca-rich clinopyroxene, anorthite) of Types A and B refractory inclusions in CV3 chondrites. Textures of many of these objects indicate that they underwent melting after condensation, crystallizing into the same phase assemblage as their precursors. The Ti^{3+}/Ti^{4+} ratio of their pyroxene indicates that this process occurred in a gas whose oxygen fugacity (fO_2) was ~8.5 log units below that of the iron-wüstite buffer, making them the only objects in chondrites known to have formed in a system whose composition was close to that of the sun. Relative to C1 chondrites, these inclusions are uniformly enriched in a group of elements (*e.g.*, Ca, REE, Zr, Ta, Ir) that are chemically diverse except for their high condensation temperatures in a system of solar composition. The enrichment factor, 17.5, can be interpreted to mean that these objects represent either the first 5.7 wt% of the condensable matter to condense during nebular cooling or the residue after vaporization of 94.3% of a C1 chondrite precursor. The Mg and Si isotopic compositions of Types A and B inclusions are mass-fractionated by up to 10 and 4 ‰/amu, respectively. When interpreted in terms of Rayleigh fractionation during evaporation of Mg and Si from the inclusions while they were molten, the isotopic compositions imply that up to 60% of the Mg and up to 25% of the Si were evaporated, and that ~80% of the enrichment in refractory ($CaO+Al_2O_3$) relative to more volatile ($MgO+SiO_2$) in the average inclusion is due to initial condensation and ~20% due to subsequent evaporation. A remaining mystery is how sufficient Na remained in the liquid to produce Na zoning in the igneous melilite while extensive evaporation of Mg and Si was occurring. Many refractory inclusions in CM chondrites contain a less SiO_2-rich assemblage (spinel, hibonite, grossite, perovskite, corundum) that represents a higher-T stage of condensation than those above, and some may be pristine condensates that escaped later melting. Many contain no melilite, despite the presence of minerals with higher (hibonite) and lower (spinel) condensation Ts, possibly due to a higher rate of reaction of hibonite with the gas to form spinel than melilite. The FeO/(FeO+MgO) ratios of olivine in ordinary chondrites and Types I and II chondrules are too high to be made in a system of solar composition, requiring fO_2s only 1 or 2 log units below iron-wüstite, more than 10^5 times higher than that of a solar gas. Various ways have been devised to generate cosmic gases sufficiently oxidizing to stabilize significant FeO in olivine at Ts above those where Fe-Mg interdiffusion in olivine ceases. One is by vertical settling of dust toward the nebular midplane, enriching a region in dust relative to gas. Because dust is enriched in O compared to C and H relative to solar composition, a higher fO_2 results upon total vaporization of the region, but the factor by which theoretical models have so far enriched the dust is 10 times too low. Another is by transporting icy bodies from the outer part of the nebula into the hot, inner part where vaporization of water ice occurs. Not only does this method fail to make the needed fO_2 by a factor of 30-1000 but it also ignores simultaneous evaporation of C-bearing ices that would make the fO_2 even lower.