
The condensation sequence, which forms an indispensable basis for discussions of petrogenetic processes in the solar nebula, was calculated 17 years ago [1] by assuming P = 10^-3 atm and a system that consists of the cosmic abundances of the elements. More recently, astrophysical nebula models have pointed to lower pressures in what is now the asteroid belt [2], and evidence has appeared that chondritic components formed in systems of non-cosmic composition (e.g., O/H greater than cosmic) [3]. We have recalculated the condensation sequence under conditions that we consider more closely applicable to the region of chondrite formation. An example is shown in Fig. 1: this condensation sequence assumes P = 10^-5 atm, and a composition that would result if the condensable elements in the cosmic abundance pattern (all Si, Mg, Fe, Al, Ca, Na, Ni, Ti, plus CI proportions of H, C, N, O, and S) were increased by a factor of 100 relative to remaining H, C, N, O, and S. Net O/H in such a system is 41 x the cosmic ratio. Under these conditions we note that:

1. Though the lower pressure assumed should decrease condensation temperatures, this effect is more than offset by the increased relative abundances of condensable elements and O also assumed. Most condensation now occurs above 1400K, i.e., in the melting range for mafic rocks. In this system silicate melts would be stable, and could in principle condense from cooling vapors.

2. On the other hand, once most condensation has occurred (T < 1400K) the assumed enhancement of O and metallic element abundances in the gas phase is lost, and further reaction between condensates and gas does not differ from the case where a cosmic composition is assumed. The equilibrium Fa content of olivine remains very low through the range of igneous temperatures (0.04% at 1500K, 0.25% at 1400K). The higher Fa contents observed in chondrule olivines must, therefore, result either from (a) nonequilibrium chondrule melt compositions containing FeO from precursor solids, or (b) local O/H enhancement of the gas stemming from the concentration and vaporization not just of silicate dust, but of water ice (+dust), since O contributed to the gas by water ice would not recondense in the igneous temperature range.

3. The pattern of coexistence among earliest-condensed phases differs from that of the classic condensation sequence (CCS) [1]. In the case examined, melilitite and forsterite coexist stably between 1605 and 1531K, whereas in the CCS forsterite appears only after melilitite has disappeared. The observed coexistence of these phases in forsterite-rich inclusions [4] is more readily explained by the non-classic condensation sequence presented here than by the CCS, which has to invoke kinetic constraints to account for the forsterite/melilitite inclusions. The temperature range of coexistence of spinel and melilitite is also about twice as great in Fig. 1 as in the CCS (1675-1531K vs. 1513-1450K), consistent with the great frequency with which these two ubiquitous CAI minerals are seen to coexist.

4. Nepheline, a prominent reaction mineral in CAI's, is produced as a by-product of the formation of abundant fayalite. The SiO2 needed to form fayalite is withheld from plagioclase, causing the Si-poor phases nepheline and spinel to form instead.

Figure 1. Atomic fractions of elements Si, Mg, Fe, Al, Ca, Na, and Ti sited in various phases, under equilibrium conditions. System pressure, $10^{-5}$ atm; dust/gas enhanced to 100x cosmic (see text).