

GAS-DUST FRACTIONATION AND THE ORIGIN OF CHONDRITIC METEORITES

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The differences in elemental ratios observed among the various groups of chondrites (Mg/Si, Fe/Si, etc.) are usually interpreted in terms of a gas-dust fractionation process that occurred prior to accretion. Other differences exist, oxidation state, oxygen-isotope composition, etc., but it has not been clear whether these differences are in any way related to the gas-dust fractionation required to explain the elemental abundance ratios. Here, we would like to explore the possibility that there is some relation between many of these characteristic differences among chondrite groups. Our approach departs from most previous work in two ways: 1) The gas-dust fractionation is assumed to occur very early, prior to heating, partial to complete evaporation and recondensation. This obviously is only a first approximation, later fractionation cannot be ruled out and, in fact, seems to be required. 2) Recent estimates of solar system abundances are used (1, 2) in which the proportion of C, O, etc., have decreased relative to Fe, Mg, Si, etc., by about 30%. This is a subtle but significant change because it means that the dust carries a greater proportion of the total oxygen.

If the solar system originated from the gas and dust in an interstellar cloud as is generally believed then local enrichments or depletion of dust to gas are plausible, and perhaps probable. Based on the observed elemental distributions in interstellar clouds, we have assumed the dust to consist of the more refractory elements (Al, Ca, Fe, Mg, Si, etc.) plus their associated oxygen while all the more volatile elements were present as gases. Other possibilities, addition of oxygen to the dust in the form of FeO or Fe₂O₃ and/or water of hydration, remain to be explored. Letting α = fractionation factor of the dust, we performed chemical equilibrium calculations over a range of P-T conditions at $0.01 \leq \alpha \leq 100$.

The effect of varying the concentration of dust is similar to, but not identical with, varying P_T owing to the fact that the composition of the system changes. Thus, the stability of solid metal is much more weakly dependent on variations in α than is the stability fields of oxides and silicates. This results in a number of interesting consequences, only a few of which will be mentioned here. At dust enrichment factors of about 20 to 25, the first condensate will be an Al-Ca-Ti-rich silicate melt @ $P_T = 10^{-3}$ at m, $T \approx 2050^\circ\text{K}$. Once formed, such a melt is likely to remain stable down to temperatures of 1500-1600°K. The FeO content could range from 0.01 to 0.5 or so depending on the value of α and P_T . Using the best available thermodynamic data on hibonite (3), Al₂O₃ is predicted to be the first major solid condensate when $\alpha < 10$ while CaAl₆O₁₉ will be the first at $10 < \alpha \leq 25$. Modest variation in dust concentration thus provides a simple way of producing differences in mineralogy among CAIs as well as a large stability field for silicate melts, removing the problem of finding special conditions for melts with compositions resembling CAIs and chondrules.

Of equal importance are the mineral stability relations in dust depleted regions. Using the recent estimates of solar abundances, at dust depletion factors of ($\alpha \leq$) 0.5 the loss of oxygen results in stabilizing CaS, TiN, etc. the minerals characteristic of enstatite chondrites. It is significant that these depletion factors are very similar to those required to explain the fractionation of Al, Ca, Mg, etc., relative to Si in enstatite chondrites (4).

References: (1) Anders, E. and Ebihara (1982) *GCA*, 46, 2363; (2) Cameron, A.G.W. (1982) In *Essays in Nuclear Astrophysics*. Cambridge Univ. Press; (3) Fegley, M. B. (1981) *Proc. Lunar Planet. Sci. Conf.* 12th., p. 211-212; (4) Larimer, J.W. (1979) *Icarus* 40, 446.