

The PhotoNebula: photochemical effects on the mineralogy and petrology of Solar System bodies and meteorites.

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Introduction: The influence of the intense and variable radiation fields associated with the growth of the early sun are being recognized as a major control on isotopic systems (Theimens, 1994, 1999). The magnitude of these isotopic effects in oxygen and sulfur are large and provide a framework that suggests that several thermal/photochemical regimes existed within the early nebula. The effectiveness of photochemical processes that modify mineral and rock chemistry, in addition to the isotopic composition, needs to be assessed critically.

Photochemistry in the Solar Nebula: Correlations between mass independent fractionation signatures in oxygen and Fe/Mn/Mg ratios in chondrules and among some meteorite groups are known, but have not been explored in depth.

Selective photochemical excitation of gaseous elements such as H₂ and O₂ as well as gaseous compounds such as CO, CO₂, H₂O, CH₄, CH₃OH, SO₂, SO_x and others, provides mechanisms that account for the observed isotopic signatures. However, these modified gases cannot be isolated from the solid and liquid components of the nebula. Similarly, photochemical reactions on the surfaces and near-surface volumes of nebular grains may result in isotopically distinct interiors and exteriors of grains.

A major unknown is the extent to which photochemical reactions will modify the mineralogical and bulk compositional signatures of solar system material. Can such effects be recognized in meteorite chemical compositional data in addition to the dramatic results seen in isotopic space. "Clayton-Mayeda space" – the three isotope oxygen system, has long provided the definitive example of such a systematic and dramatic influence, although not recognized for its true significance immediately. (Clayton and Mayeda, 1976)

The recognition of photochemical influences is perhaps most likely in gas sensitive reactions, such as reduction–oxidation, hydrogenation, sulfidation, hydro-carbon exchanges. Of these, redox reactions are probably the most accessible and are certainly the most widely studied. Petrogenetic grids for oxygen, sulfur, hydrogen and carbon sensitive reactions between gas phase species and solid nebular minerals can be constructed to define P-T-X regions within the nebula that reflect specific photochemical interactions.

The system Fe-Ni-Mn-Mg-O-S provides a suitable target for such studies (Delaney, Jeremy S., 1991; De-

laney, J. S., 1993; Delaney, J. S. *et al.*, 1994; Goodrich and Delaney, 2000). The subsystem Fe-Mn-Mg-O provides transition metals with variable chemical states and has been used to demonstrate links among chondritic groups that reflect oxygen fugacity directly. Expanding such studies to S and H bearing systems offers great promise for future studies of nebula redox processes. The involvement of photochemically excited O and S provides the opportunity to link chemical compositional studies of macroscopic meteorite samples with gas phase and nanophase assemblages that were probably of fundamental significance in transferring the effects of photo-excitation in the gaseous nebula to the solid objects we sample today.

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