

EXPERIMENTAL TECHNIQUES APPLICABLE TO PROCESSING AND REPROCESSING OF PRIMITIVE SOLAR NEBULAR MATERIALS. J. R. Beckett¹,

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Introduction: From an experimental perspective, the salient features associated with study of primitive nebular materials are the tremendous range of conditions for relevant processes and the broad spectrum of elements at high concentrations in the phases upon which these environments operated. Redox conditions, for example, ranged from environments that would be viewed as fairly oxidizing in terrestrial settings to some as reducing or even more reducing than a gas of solar composition. Similarly, relevant bulk compositions range from compositionally complex refractory alloys and oxides to chondrules whose bulk compositions approach those of peridotites. This work considers some basic experimental techniques that have been used or could be used to constrain the properties of cosmochemically interesting phases and the nature of the processes that produced them.

Direct Techniques: One common approach to constraining conditions during the formation and/or evolution of a natural material is to construct a synthetic analog and subject it to a variety of experimental conditions thought to be relevant. Usually temperature, fO_2 , and exposure time are controlled directly. A comparison between the run products and targeted materials is then used to constrain the formation conditions. This approach yields valuable information on phase equilibria, redox conditions, and volatilization/diffusion processes. Isothermal equilibration, volatilization, reduction, oxidation, and dynamic crystallization experiments all fall into this category as do some uses of Knudsen cell techniques and vacuum systems with or without controlled leaks.

Limited Approaches: Given the thermodynamic or reactive properties of a

phase or set of phases, it is often possible to use the now existing phase(s) to constrain the nature of now absent phases, such as gases or solids lost through fractionation, or on the original state of an existing phase assemblage modified through secondary processes or exsolution. If the phases of interest are compositionally complex and/or little studied, however, experimental approaches need to focus on specific components within the complex solutions. Meteoritic refractory alloys and the less common but equally important Zr-rich oxides, for example, can have 8-9 components at easily measured levels, each of which offers an opportunity to constrain environment. The compositional complexity, however, means that the potential is poorly realized. Experimentally determining specific activities of interest within the complex solutions provides a path to understanding more about the environments in which multicomponent phases formed. Many experimental techniques such as classical phase equilibria, oxide equilibration with alloys, transpiration, Knudsen and galvanic cell measurements can be used.

Some Additional Possibilities: A number of experimental techniques that may potentially yield useful information on the nature of primitive meteoritic materials have been little used by the cosmochemical community. For example, solid-state electrolytes such as yttria-doped zirconia are commonly employed in the form of oxygen sensors but sulfur sensors and galvanic cells, in which thermodynamic information is elicited through a suitable selection of paired phase assemblages, have not. Opportunities also exist for the application of other techniques including thermopower and thermogravimetric measurements.