Final Report: NAG5-9789

"Isotopic investigations of Nebular and Parent Body Processes with a High Sensitivity Ion Microprobe"

NASA NAGW-9789 supported the development of the CAMECA ims 1270 ion microprobe at UCLA for applications in cosmochemistry. The primary investigations centered on measuring the microscopic distributions of key isotopic abundances in primitive meteoritic materials as a means of constraining the nature of important thermal and chemical processes in the solar nebula and the timescales associated with those processes. Our prior work on oxygen isotope anomalies in a wide variety of meteoritic materials had led us to a view of a spatially heterogeneous nebula, and in particular, a restricted region for CAI formation that is characterized by $^{16}$O-rich gas [e.g., McKeegan, 1998 #420; Fagan, 2001 #915; Guan, 2000 #914; Krot, 2002 #1279]. Because of its production of CAIs in the energetic local environment near the protosun, the existence of a natural transport mechanism via bipolar outflows, and a general astrophysical plausibility, we were attracted to the fluctuating X-wind model which had been put forward by Frank Shu, Typhoon Lee, and colleagues [Shu, 1996 #176; Shu, 1997 #378; Shu, 2001 #1326]. With our collaborators, we undertook a series of investigations to test the viability of this hypothesis; this work led directly to the discovery of live $^{10}$Be in CAIs (McKeegan et al., 2000) and a clear demonstration of the existence of $^{16}$O-rich condensates, which necessarily implies an $^{16}$O-rich gaseous reservoir in the nebula [Simon, 2002 #1321; Krot, 2002 #1279]. Both of these observations fit well within the context of X-wind type models, i.e. formation of CAIs (or condensation of their precursors) in the reconnection ring sunward of the inner edge of the accretion disk, however much work remains to be done to test whether the physical parameters of the model can quantitatively predict not only the thermal histories of CAIs but also their radioactivity [Lee, 1998 #802; Gounelle, 2001 #1327].

The issue of spatial heterogeneity in the nebula, central to the X-wind model, is also at the heart of any chronology based on short-lived radioisotopes. In this work, we followed up on strong hints for presence of extremely (53 day) short-lived $^{7}$Be, and have prepared a manuscript (in revision). We also measured Al-Mg systematics by a combined approach of high-precision multiple-collector SIMS analyses, traditional analyses on the UCLA ims 1270, and high-spatial resolution analyses using a NanoSIMS instrument. The data help to deconvolve effects due to partial resetting of the Al-Mg system by multiple thermal events. Finally, we initiated investigations related to nebular heterogeneity with a new initiative of in situ high-precision sulfur isotope analyses of sulfides from a wide variety of components of chondrites. The ultimate goal of all this work is to help develop a better understanding of the relationships between CAIs and chondrules, the astrophysical environments in which they formed, and the timescales of nebular processes.

As detailed in Table 1, for the project period, 14 manuscripts were published and 17 abstracts were presented describing the work supported by NAG5-9789.
Table 1. Manuscripts supported by NAG 5-9789 during the project period 7/15/00 – 7/14/04


Abstracts:


**Personnel supported by NAG 5-9789**

At the beginning of the project period, postdoc Dr. Jerome Aléon was supported by NAG5-9789. He then left UCLA for a permanent research position with the CNRS in his native France. Dr. Marianna Cosarinsky (Ph.D. Arizona State University, 2004) replaced him as the postdoctoral researcher on this grant. an H1 visa). Additionally, Dr. Haibo Zou, UCLA research geochemist, worked part time with the PI on projects related to this grant. Dr. Zou is an expert in U-series isotope chemistry and clean-room techniques; he helped to develop novel applications for the ion probe and ICPMS laboratories. The research group also grew during the grant period by the addition of two new Ph.D. candidates, Dianne Taylor and Ming-Chang Liu. Both students are continuing under current NASA support.