FINAL REPORT

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Experimental and Analytical Studies of Solar System Chemistry.

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The cosmochemistry research funded by this grant resulted in the publications given in the attached Publication List.

The research focused in three areas: (1) Experimental studies of trace element partitioning. (2) Studies of the minor element chemistry and O isotopic compositions of $MgAl_2O_4$ spinels from Ca-Al-Rich Inclusions in carbonaceous chondrite meteorites, and (3) The abundances and chemical fractionations of Th and U in chondritic meteorites.

(1) (a) Studies were made of Mg and Ti partitioning in anorthitic plagioclase. These showed strong control of the partitioning of these elements by crystallographic sector zoning in the synthetic crystals. The sector zoning closely matched that measured in natural anorthite crystals from Ca-Al-Rich Inclusions showing that these had remained thermally unaffected since the time of initial crystallization of these materials. A graduate student thesis has been started as a follow-up to this work.

(b) Studies of partitioning of Si, Ca, Ti , V, and Cr in $MgAl_2O_4$ spinel from liquids of Ca-Al-Rich Inclusion composition. Experiments involving crystals grown at slow cooling rates gave estimates of equilibrium partition coefficients. Isothermal experiments initially produced inhomogeneous minor element distributions in spinel, but when considered as a function of run duration, significant homogenization of Ti and V were observed, but not for the other elements. This showed that the times of initial melting of Ca-Al-Rich Inclusions were comparable to the time scales of our laboratory experiments (less than 100 hours).

(2) These analytical studies showed that spinels in Ca-Al-Rich Inclusions show remarkable compositional groupings in terms of physical location in the inclusion and in terms of the host phase in which the spinels were present as inclusions. The distributions are best interpreted in terms of (at least) two stages of melting, accompanied by subsolidus re-equilibration of the inclusions that were present in clinopyroxene. The re-equilibration was complete for Ti, but only partial for V. The O isotope data showed that the previously-well-documented exchange event in Ca-Al-Rich Inclusions happened after the remelting event(s).

(3) This work was the basis of a graduate student PhD thesis. An apparent bimodal distribution in literature data of Th/U in ordinary chondritic meteorites was shown not to be real, but instead a continuous variation explained the inhomogeneous distribution of the mineral apatite which has a very high U concentration and a low Th/U ratio. This showed that simple averaging of high accuracy isotopic dilution data for Th and U would give a significantly improved value for this chronologically important ratio. A related study of the distribution of Th and U in carbonaceous chondrites has been completed and a manuscript written. Before submission, w e await confirmation by colleagues in Japan by an independent technique of our most striking result that the P in CM chondrites is concentrated in reduced phases (probably sulfides) rather than as phosphates.

Publication List from NASA/Goddard Grant No. NAG5-4319

Minor element partitioning and sector zoning in synthetic and meteoritic anorthite.
I.M. Steele, M.T. Peters, E.E. Shaffer, and D.S. Burnett
Geochemica, Cosmochemica, Acta, 61, 415-423, 1997.

Three-color resonance ionization spectroscopy of Zr in Si.
C.S. Hansen, W.F. Calaway, M.J. Pellin, R.C. Wiens, and D.S. Burnett. AIP Laser Symposium, 215-218, 1997.

Minor element distributions in and among spinels from type B CAIs
H.C. Connolly Jr and D.S. Burnett Lunar, Planet. Sci. Conf 29, 1998.

* The solar O isotopic composition: Predictions and implications for nebula processes.
R.C. Wiens, G.R. Huss, and D.S. Burnett. Meteoritics and Planet. Sci. 34, 99-107, 1999.

Th/U variations in chondritic meteorites. A ubiquitous U-rich component?
J.S. Goreva and D.S. Burnett. Lunar, Planet. Sci. Conf, 30, #1467, 1999.

Minor element distributions in spinels from type B CAIs: an experimental study.
H.C. Connolly Jr. and D.S. Burnett. Lunar. Planet. XXX, #1459, 1999

* A study of the minor element concentrations of spinels from two type B calcium-aluminum-rich inclusions: An investigation into potential formation conditions of calcium-aluminum-rich inclusions.
H.C. Connolly Jr. and D.S. Burnett. Meteoritics and Planet. Sci. 34, 829-848 1999

Phosphate control on Th/U in ordinary chondrites.
J. Goreva and D.S. Burnett. Lunar, Planet. Sci. Conf, 31, 2000 #1512.

The remelting of type B CAIs: relationship between the minor element concentrations in spinel to their host silicate.
H.C. Connolly Jr. and D.S. Burnett. Lunar. Planet. XXXI #1440, 2000.

Experimental constraints on type B CAI formation: spinel minor elements.
H.C. Connolly Jr. and D.S. Burnett. Lunar Planet. Sci. Conf. 32, #1149 , 2001

* Phosphate control on the Th/U variations in ordinary chondrites: Improving solar system abundances.
J.S. Goreva and D.S. Burnett. Meteoritics and Planet. Sci. 36, 63-74, 2001

The Petrogenesis of Type B1 Ca-Al-rich inclusions: The spinel connection.
Connolly H.C. Jr, Burnett D.S., and McKeegan, K.D. in press, Meteoritics and

Planet. Sci..

On Type B CAI Formation: Experimental Constraints on fO2 Variations in Spinel Minor element Partitioning and Sub-solidus Re-equilibration Effects. Submitted to *Geochim. Cosmochim. Acta*