

5504

**NANOGLOBULE ABUNDANCES IN IOM EXTRACTS: CORRELATION WITH PARENT BODY PROCESSING**

H. G. Changela<sup>1,2</sup>, R. M. Stroud<sup>2</sup>, B. T. De Gregorio<sup>3</sup>, L. R. Nittler<sup>4</sup>, C. M. O'D. Alexander<sup>4</sup> and G. D. Cody<sup>4</sup>. <sup>1</sup>George Washington University, Department of Physics, Washington, District of Columbia 20052, USA. <sup>2</sup>Naval Research Laboratory, 4555 Overlook Ave. SW, Washington, District of Columbia 20375, USA. E-mail: changela@anvil.nrl.navy.mil. <sup>3</sup>Johnson Space Center, Houston, Texas 77058, USA. <sup>4</sup>Carnegie Institution of Washington, Washington, District of Columbia 20015, USA.

**Introduction:** Nanoglobules are a form of Insoluble Organic Matter (IOM) found in chondrites [1], IDPs [2] and Comet 81P/Wild2 [3]. Some nanoglobules exhibit large <sup>15</sup>N and D enrichments relative to solar values, indicating that they likely originated in the ISM or the outskirts of the protoplanetary disk [4]. Recent studies of samples from the Tagish Lake meteorite with varying levels of hydrothermal alteration suggest that nanoglobule abundance decreases with increasing hydrothermal alteration [5]. The aim of the present study is to further constrain the morphologies of IOM from a range of primitive chondrites in order to determine any correlation between morphology and petrographic grade and chondrite class.

**Methods:** We are performing a comprehensive scanning transmission electron microscopy (STEM) survey of IOM residues prepared by methods described in [3]. STEM annular dark-field (ADF) imaging surveys were performed with NRL's JEOL 2200FS on residues from Murchison (CM2), EET 92042 (CR2) and QUE 97008 (L3). IOM textures were classified as either having a 'globular' morphology, i.e. spherical, non-porous regions approximately 50–1000 nm in size; 'fluffy', i.e. porous material with fine scale heterogeneity below 50 nm; and 'dense-irregular', i.e. uniformly dense, non-spherical material > 50 nm. ADF images were taken of each chondrite, sampling approximately 100  $\mu\text{m}^2$  of IOM. The different morphologies were manually identified from the images and masked using Adobe Photoshop. Area fractions were then obtained using Image J software. Because some small globules (< 100 nm) are difficult to distinguish from the background of fluffy IOM, our results reflect a lower limit on globular abundances.

**Results and Discussion:** Globular to fluffy and dense irregular to fluffy IOM fractions in these chondrites show distinctive variations. Murchison contains the highest abundance of nanoglobules (approximately 7%), followed by EET 92042 (approximately 5%) and then QUE 97008 (approximately 1%). The abundances of dense irregular IOM fractions are similar for Murchison and EET 92042, but have much higher abundance (approximately 20% of measured IOM) in QUE 97008. We will also present new analyses of residues from types 1, 2 and 3 CR and other chondrites to identify any links between nanoglobule abundances and petrographic grade. It has been shown that isotopic enrichment within the IOM is not just localized to globular species, but to some 'fluffy' components as well [6]. It is not clear whether some of the 'dense irregular' morphologies of IOM contain similar enrichments. Coordinated analyses of these extracts and in situ IOM studies will enable us to further constrain the nature of these morphologically distinct components and how they vary with petrographic grade or chondrite class.

**References:** [1] Nakamura-Messenger K. et al. 2006. *Science* 314:1439–1442. [2] Flynn G. J. et al. 2003. *Geochimica et Cosmochimica Acta* 4791–4806. [3] De Gregorio B. T. et al. 2010. *Geochimica et Cosmochimica Acta* 74:4454–4470. [4] Alexander C. M. O'D. et al. 2007. *Geochimica et Cosmochimica Acta* 71:4380–4403. [5] Herd C. D. K. et al. 2011. *Science*, in press. [6] De Gregorio et al. 2010. Abstract #2108. 41st Lunar and Planetary Science Conference.

5401

**ABUNDANCES OF Cl, F, H, AND S IN APATITES FROM SNC METEORITES**

M. B. Channon, J. W. Boyce, E. M. Stolper and J. M. Eiler. California Institute of Technology, Pasadena, CA 91125, USA. E-mail: mchannon@gps.caltech.edu.

**Introduction:** Magmatic volatiles influence igneous phase equilibria, eruptive behavior, atmospheric composition, and climate. Several lines of evidence suggest that Mars is rich in halogens and S relative to Earth. However, magmatic volatile abundances and their effects on magmatic processes on Mars are controversial. Here we examine igneous apatites in SNC meteorites as indicators of magmatic volatile abundances.

**Methods:** We measured Cl, F, H (reported as wt% H<sub>2</sub>O), and S in 25 apatites from 3 basaltic shergottites (JaH 479, NWA 856, and NWA 2986), 1 lherzolitic shergottite (NWA 1950), and 1 nakhlite (NWA 998) using Caltech's 7f SIMS. We compared our data to literature data for volatiles in SNC apatites [1–8].

**Results:** Our measurements of Cl, F, and H in SNC apatites are similar to previous data, but the increased size of the collective data set sheds light on systematic variations. Our 3 basaltic shergottites have 0.33–0.95 wt% H<sub>2</sub>O (literature data: 0.18–0.64 wt% [1–2]), those from the lherzolitic shergottite have 0.07–0.27 wt% (the only previously measured apatite from such a sample has 0.43 wt% [3]); and those from the nakhlite have 0.07–0.11 wt%. Data are also available for apatites from Chassigny (0.21 wt% [4]) and ALH 84001 (0.08 wt% [2] and 0.22 wt% [4]). Apatites from basaltic shergottites appear to be on average H<sub>2</sub>O-rich relative to apatites from other lithologies. S contents are variable (< 0.01–0.82 wt%); previous measurements are < 0.01–0.08 wt% [5–8]). As with H<sub>2</sub>O, S contents are lower in the nakhlite (< 0.01 wt%) and lherzolitic shergottite (0.02–0.04 wt%) than in the basaltic shergottites (0.05–0.82 wt%).

**Discussion:** The H in apatites from basaltic shergottites spans a range similar to apatites from terrestrial mafic igneous rocks. The higher H and S contents of basaltic shergottites relative to other SNC rock types may indicate higher initial volatile contents or lower extents of degassing prior to apatite crystallization.

Based on our results, apatites in SNCs, particularly basaltic shergottites, are significantly richer in S (by approximately 2 $\times$ ) than those in mafic terrestrial igneous rocks. S is typically incorporated into apatite as SO<sub>4</sub><sup>2-</sup>, and thus is expected to be more strongly partitioned into igneous apatite at higher  $f\text{O}_2$  (i.e., where sulfate dominates over sulfide in basaltic melts). As expected, terrestrial S-rich apatites are found in lavas that are oxidized ( $\Delta\text{QFM} + 2$  to  $+6$  log units). Estimates of  $f\text{O}_2$  in shergottite parent magmas ( $\Delta\text{QFM} - 4$  to  $+0.5$  log units) would indicate that S<sup>2-</sup> was the primary sulfur species. The high S contents of SNC apatite despite low  $f\text{O}_2$  could reflect (1) high total magmatic S contents; (2) apatite crystallized late when  $f\text{O}_2$  levels rose above estimates; or (3) some S in SNC apatites is present as sulfide in the halogen site.

**References:** [1] Leshin L. A. 2000. *Geophysical Research Letters* 27:2017–2020. [2] Greenwood J. P. et al. 2008. *Geophysical Research Letters* 35:L05203. [3] Guan Y. et al. 2003. Abstract #1830. 34th Lunar and Planetary Science Conference. [4] Boctor N. Z. et al. 2003. *Geochimica et Cosmochimica Acta* 67:3971–3989. [5] Harvey R. P. et al. 1993. *Geochimica et Cosmochimica Acta* 57:4769–4783. [6] Xirouchakis D. et al. 2002. *Geochimica et Cosmochimica Acta* 66:1867–1880. [7] Greenwood J. P. et al. 2003. *Geochimica et Cosmochimica Acta* 67:2289–2298. [8] Treiman A. H. and Irving A. J. 2008. *Meteoritics & Planetary Science* 43:829–854.