**REHOMOGENIZED INTERSTITIAL AND INCLUSION MELTS IN LHERZOLITIC SHERGOTTITE ALH77005: PETROLOGIC SIGNIFICANCE.** C. Calvin[1*] and M. Rutherford[1], [1]Brown University 324 Brook Street, Box 1846, Providence, RI 02912.*Christina_Calvin@brown.edu.

**Introduction:** Melt inclusions may be used to help decipher the magmatic history of an igneous rock because they provide a record of the magma composition at the time of the mineral formation. Therefore, melt inclusions are of particular importance in analyzing Martian meteorites in an effort to understand their petrogenetic history. Among the many still unanswered questions regarding shergottites is their relationship to each other and the composition of their parental melt. One previous study proposes that olivine-phyric shergottites may be parent magmas to the lherzolitic and basaltic shergottites [1]. An alternate model suggests that the composition of lherzolitic and basaltic shergottites can be explained through mixing [2], but the major element composition of the end members are not well constrained.

The SNC meteorites are complicated in that most cooled very slowly resulting in partially to completely crystallized melt inclusions. In addition, most samples have experienced significant shock effects. Several prior investigators have analyzed melt inclusions in minerals from ALH77005, a lherzolitic shergottite and have reported different compositions. [3] analyzed the glass matrix and daughter grains found in melt inclusions in olivine. They found the glass matrix to have major element wt % of 56-73% $SiO_2$, 0.6-11% FeO, 0.2-13% MgO. [2] also analyzed olivine melt inclusions and found $SiO_2$ of 59.27 wt %. The high $SiO_2$ likely reflects the presence of daughter minerals in the melt inclusion, which changes the major element composition of the trapped melt. [4] also analyzed melt inclusions in olivines from ALH77005, however they attempted to rehomogenize the inclusions prior to analysis. They analyzed two melt inclusions, but daughter phases remained in the inclusion and led to an incomplete interpretation of the overall composition of the melt inclusion. They found the glass contained 54.6 wt % $SiO_2$.

Our study is based on analysis of melt inclusions in chips of ALH77005 experimentally re-equilibrated at liquidus temperatures and 1kbar pressure. This data allows a more detailed analysis of volatiles that might otherwise escape during reheating at atmospheric conditions. In addition, reheating and melting of these samples to various degrees will enable us to compare the interstitial melt at various stages of the rock formation. It is our hope that this will answer some of the remaining questions about the magmatic origins and relationships of the shergottite meteorites. In particular, we hope to be able to detect differences in melt inclusions trapped in early crystallized phases (olivine) and later crystallized phases that will determine where the proposed assimilation of REE and incompatible element rich SNC melt took place [5].

**Experiments:** Experiments were performed using TZM pressure vessels. Samples were surrounded with graphite to prevent oxidation of the samples and subsequently sealed in platinum tubing. The graphite also prevents sample tube reaction (Fe-loss). The tubes were sealed and brought to 1kbar. The temperature of the samples was then raised to 1185ºC. The first sample was held at this pressure and temperature for 3 hours. The second sample was held for 6 hours. After completion of the experiment, the samples were immediately quenched. Thick sections were made for analysis by electron microprobe.

**Results:** The sample that was held at 1185ºC and 1 kbar for 3 hours showed small pools of melt at triple junctions and along phenocryst grain boundaries in addition to phenocrysts containing rehomogenized melt inclusions. The results of analyses of 4 of these regions are presented in Table 1.

**Table 1:** Composition of melt pools and rehomogenized melt inclusions (MI) in ALH77005 from sample held at 1185ºC and 1kbar for 3 hours.

| Location | Melt Pool 1 | MI 3 | MI 4 | MI 8 |
|---|---|---|---|---|
| **Host Mineral** | Ortho-pryoxene | Olivine/ Clino-Pyroxene Boundary | Clino-pyroxene | Olivine |
| **$SiO_2$** | 51.65 | 46.57 | 47.99 | 51.32 |
| **FeO** | 16.33 | 20.83 | 19.64 | 14.02 |
| **MgO** | 6.09 | 4.78 | 4.24 | 5.99 |
| **$Al_2O_3$** | 10.31 | 8.70 | 10.36 | 11.30 |
| **$Na_2O$** | 2.16 | 1.69 | 2.31 | 2.24 |
| **MnO** | 0.52 | 0.55 | 0.52 | 0.40 |
| **$TiO_2$** | 0.96 | 1.40 | 1.34 | 1.27 |
| **$Cr_2O_3$** | 0.00 | 0.09 | 0.05 | 0.04 |
| **CaO** | 11.46 | 12.47 | 11.01 | 10.84 |
| **$P_2O_5$** | 1.15 | 2.04 | 1.89 | 1.87 |
| **$K_2O$** | 0.07 | 0.32 | 0.73 | 0.30 |
| **Total** | 100.70 | 99.45 | 100.07 | 99.60 |

Four melt inclusions, all inside olivine phenocrysts, contain $Al_2O_3$ ranging from 10.8 to 12.7 wt % and an average MgO of 6.0 wt %. MI 8 is typical of these inclusions except that it also contains a residual spherule of Fe-S melt that is not found in the other 3 melt inclusions. The sulfur content of MI8 is 1900 ppm while the other three MIs range from 1800 to 2500 ppm.

Melt pool 1 and MI 3 are interpreted to be melts at crystal boundaries. MI 3 is formed at the boundary between an olivine and a Ca-rich pyroxene. Melts along grain boundaries contained olivine, low-Ca pyroxene and Ca-rich pyroxene phenocrysts. Melt inclusion 4 (MI 4) is completely contained within a Ca-pyroxene phenocryst. The compositions of adjacent phenocrysts for MI3, MI4, and MI8 are displayed in Table 2.

**Table 2:** Composition of olivine and clinopyroxene grains surrounding Melt inclusion 3 and clinopyroxene crystal surrounding melt inclusion 4.

| Location | Olivine (MI3) | Pyroxene (MI3) | Pyroxene (MI4) | Olivine (MI8) |
|---|---|---|---|---|
| $SiO_2$ | 38.2 | 52.3 | 52.3 | 37.69 |
| FeO | 23.8 | 8.6 | 7.9 | 25.12 |
| MgO | 37.4 | 16.9 | 17.0 | 36.52 |
| $Al_2O_3$ | 0.0 | 2.8 | 2.1 | 0.00 |
| $Na_2O$ | 0.0 | 0.2 | 0.2 | 0.01 |
| MnO | 0.5 | 0.4 | 0.4 | 0.54 |
| $TiO_2$ | 0.0 | 0.6 | 0.4 | 0.01 |
| $Cr_2O_3$ | 0.3 | 1.0 | 0.9 | 0.02 |
| CaO | 0.3 | 18.17 | 18.2 | 0.24 |
| $P_2O_5$ | 0.0 | 0.2 | | |
| Total | 100.5 | 101.3 | 99.5 | 100.15 |

The second sample, held for 6 hours at the same temperature and pressure, showed considerably more intergranular melt. The compositions of two regions of melt are presented in Table 3. Due to the relatively large degree of melting, no melt volumes could be conclusively identified as melt inclusions in the two slices studied in this chip.

**Table 3:** Composition of melt pools in ALH77005 from sample held at 1185ºC and 1kbar for 6 hours.

| Location | Melt Pool 1 | Melt Pool 2 |
|---|---|---|
| $SiO_2$ | 48.24 | 47.63 |
| FeO | 16.28 | 15.68 |
| MgO | 6.60 | 6.92 |
| $Al_2O_3$ | 13.31 | 13.83 |
| $Na_2O$ | 2.39 | 2.49 |
| MnO | 0.42 | 0.44 |
| $TiO_2$ | 1.38 | 1.35 |
| $Cr_2O_3$ | | 0.24 |
| CaO | 9.47 | 9.77 |
| $P_2O_5$ | 1.36 | 1.58 |
| $K_2O$ | 0.16 | 0.16 |
| Total | 99.60 | 100.10 |

**Discussion:** In our first experiment, the wt % $SiO_2$ obtained for the melt pools and melt inclusions are considerably lower then the values obtained for melt inclusions in [2], [3], and [4] which were 56-73, 59.27 and 54.6 wt % respectively. Furthermore, the melt inclusions in our study show lower $SiO_2$ and MgO and higher FeO contents than the melt pools. Previous studies on the melt inclusions of LEW88516, another lherzolitic shergottite, that has been interpreted to be a twin of ALH77005, have led to the interpretation that the inclusions represent mixing of two magmas, one of which had intermediate to felsic composition [7]. The melt inclusions found in this sample of ALH77005 are clearly more mafic in composition then those found in the study of LEW88516.

Another interesting aspect of our analysis is the $Al_2O_3$ content of the melt inclusions. The melt inclusions found in olivine have $Al_2O_3$ values that range from 10.8 to 12.7. This is in contrast to values reported for LEW88516, which were estimated to be between 6.06 and 9.27 [7]. Our $Al_2O_3$ values are also higher than values reported for other SNC meteorites. [8] reported Chassigny $Al_2O_3$ content for melt inclusions at 8.72 wt %. Proposed parental magma values for Nakhla range from 5.73-8.6 wt % $Al_2O_3$ [6].

The significance of the high-Al basaltic melt inclusions we have rehomogenized in ALH77005 is still under investigation. However, the inclusions do not contain identifiable plagioclase and they have MgO/FeO suggesting the melt is in equilibrium with the host olivine. The presence of simultaneously high Al interstitial melt pools suggests these MI values are real. We note that these MIs are also high in $P_2O_5$ and sulfur when compared with the results of other ALH77005 melt inclusion studies (0.7 % from [3]) and Nakhla (1.0 % and 0.7 % from [3] and [6] respectively), however [3] reported $P_2O_5$ weight % as high as 6.0 in impact melts in ALH77005. The existence of high-$Al_2O_3$ and high-$P_2O_5$ glass in the rehomogenized melt inclusions could be the result of interactions between 2 magmas [5] early in the history of ALH77005 that also produced a magma enriched in incompatible elements and possibly enriched in $H_2O$ when compared with the primitive end member.

**References:** [1] Goodrich, C. (2003) GCA, 67, 3735-3771. [2] Ikeda, Y (1998) MAPS, 33, 803-812. [3] Edmunson, J. et al. (2002) LPSC XXXIII, #1844. [4] Stockstill, K. R. et al. (2002) LPSC XXXIII, #1644. [5] Borg, L. E. et al. (2003) GCA, 67, 2037-2053. [6] Treiman, A. H. and Goodrich, C. A. (2001) LPSC XXXII, #1107. [7] Harvey, R. P. et al. (1993) GCA, 57, 3519-3536. [8] Johnson, M. C et al. (1991) GCA, 55, 349-366.

**Acknowledgements:** We would like to thank Joe Devine for his time and expertise with microprobe analysis.