

**PETROLOGY AND GEOCHEMISTRY OF NEW PAIRED MARTIAN METEORITES 12095 AND LAR 12240.** R.C.Funk<sup>1</sup>, A.D. Brandon<sup>1</sup>, and A. Peslier<sup>2</sup>, <sup>1</sup>University of Houston, 4800 Calhoun Road Houston, TX 77004 USA, rcomstock@uh.edu, abrandon@uh.edu, <sup>2</sup>Jacobs-NASA Johnson Space Center, Mail Code XI3 Houston, TX 77058 USA, anne.h.peslier@nasa.gov

**Introduction:** The meteorites LAR 12095 and LAR 12240 are believed to be paired Martian meteorites and were discovered during the Antarctic Search for Meteorites (ANSMET) 2012-2013 Season at Larkman Nunatak [1]. The purpose of this study is to characterize these olivine-phyric shergottites by analyzing all mineral phases for major, minor and trace elements and examining their textural relationships. The goal is to constrain their crystallization history and place these shergottites among other Martian meteorites in order to better understand Martian geological history.

**Methods:** Two polished, 100  $\mu\text{m}$  thick sections have been obtained for examination (1 from LAR 12095 and 1 from LAR 12240). A petrographic microscope has been used at University of Houston to take images of the paired meteorites in order for petrographic descriptions to be made. A JEOL JXA 7600F scanning electron microscope (SEM) was used at NASA-Johnson Space Center (JSC) to obtain elemental maps of both thick sections. Major and minor element analyses of all mineral phases have been obtained with a Cameca SX100 Electron microprobe (EMP) at JSC.

**Results:** Both LAR 12095 and 12240 have a fractured, porphyritic texture and LAR 12240 has a black/brown fusion crust (**Fig. 1**). They are typical olivine-phyric shergottites [2] with large mm size olivines in a matrix comprised of pyroxene, smaller more Fe-rich olivines ( $\sim 1$ -1mm in size) and maskelynite (**Fig. 2**). The large olivines are zoned from  $\sim\text{Fo}_{74}$  in the center of the grains to  $\sim\text{Fo}_{64}$  at the edges. These grains are angular and appear broken up. The Mg rich cores of the large olivine grains are in contact with the matrix in some instances. The small olivines found within the matrix have a homogeneous composition of  $\sim\text{Fo}_{60}$ . The pyroxenes have patchy zoning that ranges from  $\sim\text{En}_{44}\text{Fs}_{18}\text{Wo}_{38}$  (augite) to  $\sim\text{En}_{66}\text{Fs}_{26}\text{Wo}_8$  (pigeonite) (**Fig. 3**). The major elemental composition of maskelynite is relatively homogeneous and has an average composition of  $\sim\text{An}_{63}\text{Ab}_{37}$ .

Accessory minerals include sulfides, phosphates, Cr-rich spinels and ilmenite. The phosphates appear to be merrillite with 0-.02 weight % Cl. Of the 17 phosphate grains analyzed, only 2 contain F (in amounts of .06 and .07 weight %), 16 contain Cl and

only 1 contains no volatiles. Melt inclusions are present in the largest olivines and have a homogeneous pyroxene composition of  $\sim\text{En}_{72.2}\text{Fs}_{23.7}\text{Wo}_{4.1}$ . Cr-rich spinels are present both in the matrix and within the large olivines, where they are usually associated with melt inclusions (**Fig. 2**). The CrO wt % of the spinel ranges from  $\sim 20\%$  in the matrix up to  $\sim 55\%$  inside of the melt inclusions in the large olivines. The sulfides are typically associated with spinel. Phosphates are present interstitially within the matrix. Both samples contain shock melt veins.

The Mg#'s ( $\text{Mg}/(\text{Mg}+\sum\text{Fe}^{2+})$ ) of a pyroxene melt inclusion located inside of a  $\sim 3$  mm olivine and one inside of a medium olivine within the matrix are 75 and 72, respectively. The Mg#'s of a melt vein and of the fusion crust are  $65\pm 2.1$  and  $64\pm 1.2$  ( $2\sigma$ ), respectively (**Fig. 4**).

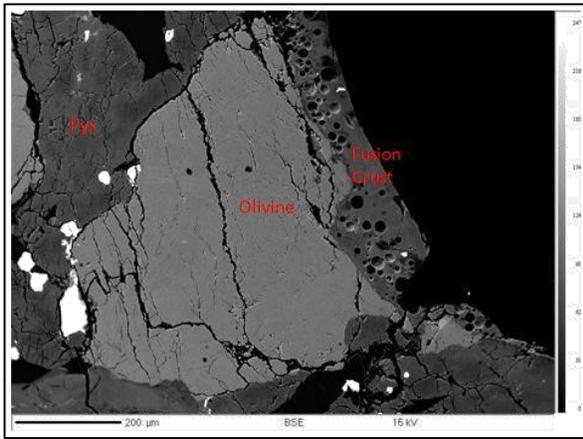
Olivine, orthopyroxene and spinel assemblages (all in contact) were used in order to calculate the oxygen fugacity in LAR 12240 [3]. The equilibration temperatures and the oxygen fugacities are  $1135^\circ\text{C}$  and  $-3.5 \Delta\text{FMQ}$  at a melt inclusion inside a large olivine and  $1002^\circ\text{C}$  and  $-3.4 \Delta\text{FMQ}$  in the matrix.

**Conclusions:** The olivines found in LAR 12240 and LAR 12095 are somewhat Mg-rich in comparison to olivines found in other olivine-phyric shergottites (summarized in [4]), but they are not as Mg-rich as the olivine-phyric shergottite Yamato 980459 ( $\text{Fo}_{85}$ ) [5]. The low oxygen fugacity of LAR 12095 and 12240 places them in the reduced shergottite group. The Mg#'s calculated from the melt vein and the fusion crust are within the bulk rock range of olivine-phyric shergottites (59-69) and may be representative of the bulk rock Mg# of LAR 12095 and 12240 [6]. The bulk composition of LAR 12095 and 12240 do not appear to represent a magma composition because the Mg# of their most Mg-rich olivines are too high relative to equilibrium values [7]. This observation combined with the broken texture of the large olivine suggests that they may be xenocrysts or antecrysts rather than phenocrysts.

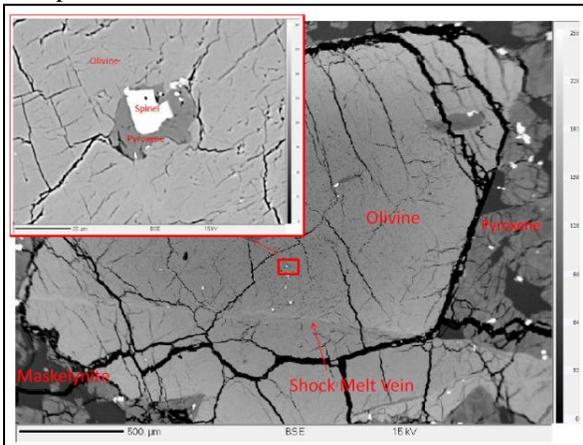
The crystallization history of LAR 12240 was modeled with MELTS using the fusion crust composition as the starting composition. Based upon the petrological features of both samples and MELTS modeling, their crystallization histories likely occurred in the following manner: First, the large olivines and

Cr-rich spinel crystallized at depth. These olivines would have become entrained in a magma that crystallized at or near the surface. The magma would have first crystallized the smaller matrix olivines and spinel. Pyroxene would begin to crystallize followed by plagioclase feldspar and interstitial phosphates. LAR 12095 and 12240 may represent a melt with a minor amount of olivine accumulation

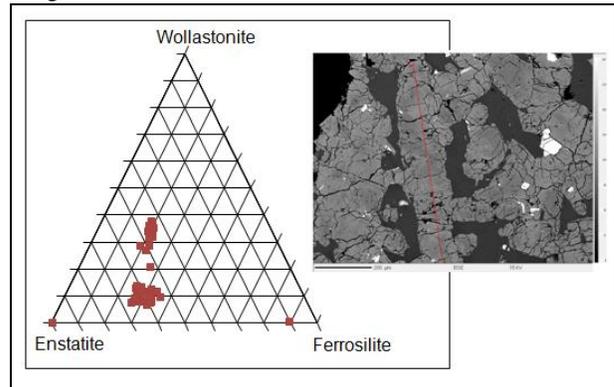
**Figure 1:** Back scattered electron (BSE) image of LAR 12240 showing fractures across a large olivine and patchy pyroxene. These fractures are likely related to shock processes. The fusion crust is also seen in this image.



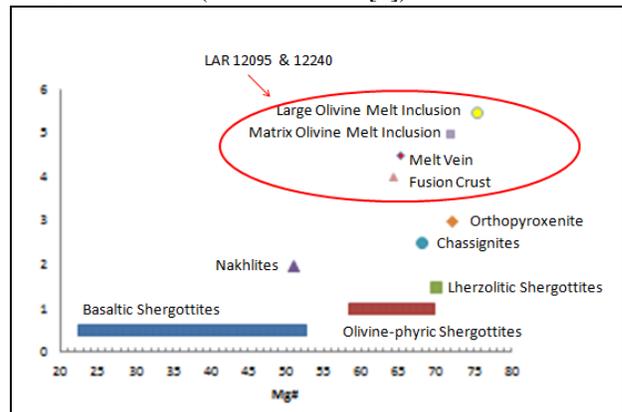
**Figure 2:** BSE image of LAR 12240 showing an olivine in a pyroxene/maskelynite matrix cross cut by a shock melt vein. The inset shows a melt inclusion in the olivine phenocryst that is comprised of pyroxene and spinel.



**Figure 3:** Composition of a 1 mm long pyroxene of LAR 12240 obtained with a 100 point line across the grain shown in inset



**Figure 4:** Figure 4 shows the bulk rock Mg#s of Martian meteorites in comparison to Mg#s of LAR 12095 and 12240 (modified from [6]).



**References:** [1] Satterwhite C. et al. (2013) *Ant. Meteorite Newsletter*, 36, 1–22. [2] Goodrich, C.A. (2002) *MAPS*, 37, B31-B34. [3] Sack R.O. and Ghiorso M.S. (1991) *Am Mineral*, 76, 827-847. [4] Peslier A. et al. (2010) *GCA*, 74, 4573-4576. [5] Usui T. et al. (2008) *GCA*, 72, 1711–1730. [6] Bridges, J.C. and Warren, P.H. (2006) *J. Soc. Lond.*, 163, 229-251. [7] Filiberto J. and Dasgupta R. (2011) *PSL*, 304, 527-537.