Comparisons between RBT 04262 and lherzolitic shergottites (ALHA 77005 and LEW 88516). C.K. Shearer[1], P.V. Burger[1], J.J. Papike[1] and J. Karner[1], [1]Institute of Meteoritics and Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131 (cshearer@unm.edu),

Introduction: RBT 04262 (paired with RBT 04261) is a rather unique remnant of Martian basaltic magmatism consisting of three distinct lithologies [1,2]. Lithology A consists of pyroxene oikocrysts commonly enclosing anhedral olivine and chromite that is immersed in a pyroxene, olivine, maskelynite groundmass in a texture reminiscent of the lherzolitic shergottites. Lithology B consists of coarse-grained low-Ca pyroxene, and lithology C is a high-Ca pyroxene assemblage that appears to represent a reaction zone between A and B [1,2]. The intent of this abstract is to compare lithology A in RBT 04262 to two other lherzolitic shergottites (ALHA 77005 and LEW 88516) to gain a better understanding of the petrogenesis of RBT 04262 and the lherzolitic shergottites, and their relationship to the basalts that produced the complete suite of shergottites.

Comparisons between RBT 04262 and lherzolitic shergottites:

Textures. Generally, the textures exhibited by RBT 04262 (RBT), ALHA 77005 (ALH) and LEW 88516 (LEW) are very similar (Figure 1). In the poikilitic areas of these basalts, the texture is defined by anhedral olivine that is surrounded by pyroxene oikocrysts. The non-poikilitic areas consist of larger anhedral olivine and finer-grained pyroxene and plagioclase (maskelynite). The plagioclase component in the lherzolitic shergottites (7-13%) is often less than observed in well-crystallized basaltic shergottites.
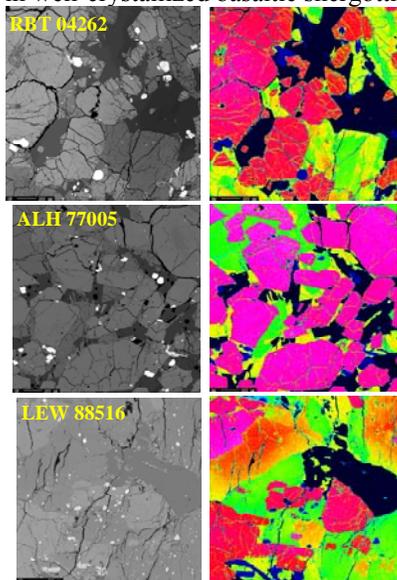

Figure 1. BSE images (left) and Mg x-ray maps (right) of lherzolitic shergottites compared in this study. Red-pink=olivine, green-yellow=pyroxene, black=plagioclase.

Olivine. The morphology of the olivine in these three lithologies is very similar: anhedral and often in a poikilitic relationship with pyroxene. In RBT, the large olivine megacrysts range in composition from Fo_{63-59} and are generally less magnesian than either ALH (Fo_{73-69}) or LEW (Fo_{70-64}). Although there are subtle differences in the Fo content in these three lithologies, there appears to be a clear difference in the Ni and Co content. The olivine in RBT has both a higher Ni concentration and unique Ni/Co compared to ALH and LEW. These trace element characteristics suggest that RBT is closer in petrogenetic heritage to the "enriched" basaltic shergottites (i.e. NWA1110, NWA1068) than the depleted shergotites (i.e. Y 98).

Pyroxene. A comparison of pyroxene compositions within the pyroxene quadrilateral is illustrated in
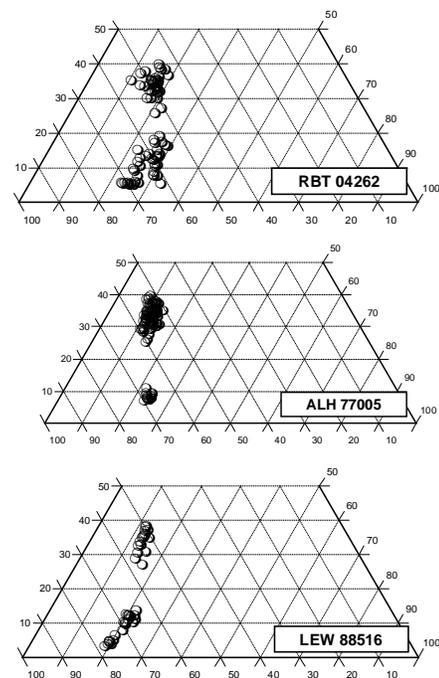

Figure 2. Comparison of pyroxene compositions for RBT, ALH, and LEW.

Figure 2. The differences in "QUAD" components are not dramatic and may be more closely related to thermal history. The dominant "OTHERS" substitution in all of these pyroxenes is $Si(IV)+X^{2+}(M1) \leftrightarrow Al(IV)+Fe^{3+}(M1)$ and $Ca(M2)+X^{2+}(M1) \leftrightarrow Na(M2)+Fe^{3+}(M1)$. There are differences among the lithologies in the extent of these "OTHERS" substitution that results in

differences in ferric iron concentrations. The extent of this substitution is closely tied to pyroxene composition (i.e. Wo content). For example, in LEW, both the Na (afu) and (Fe^{3+}/total Fe) increase with Wo. Based on pyroxene stoichiometry, at pyroxene compositions with a Wo=30-40, the percent ferric iron (Fe^{3+}/total Fe) in RBT= 7% compared to 19% for LEW and 18% for ALH. This may be partially tied to the oxygen fugacity during crystallization. Goodrich et al [5] suggested that the f_{O2} for ALH is QFM-2.6. If (Fe^{3+}/total Fe) in pyroxene is only a function of f_{O2}, this would suggest that LEW and ALH crystallized at similar f_{O2}, whereas RBT crystallized at somewhat more reducing conditions. Both LEW and ALH have similar Na (in pyroxenes with Wo>30) at 0.014 afu, whereas the Na in RBT is somewhat higher at 0.018 afu.

Oxides. A comparison of oxide compositions (chromite-spinel-ulvöspinel) among the three different lithologies is illustrated in Figure 3. Overall trajectories from the chromite apex toward ulvöspinel are approximately the same. However, the variation in the earliest chromites is dependent upon host silicate (pyroxene versus olivine) and the extent of subsolidus reequilibration between the oxide and host. The extent of the magnetite (100 x $Fe^{3+}/(Fe^{3+}+Fe^{2+}+Al+2Ti)$) component was calculated from select analyses of early oxides based on "spinel" stoichiometry. The magnetite component in RBT is approximately 4.4% whereas the magnetite component in LEW and ALH is somewhat lower (3.0% and 3.9%, respectively). This is contrary to the observations made with regards to the pyroxene and suggests that RBT is somewhat more oxidized than LEW or ALH.
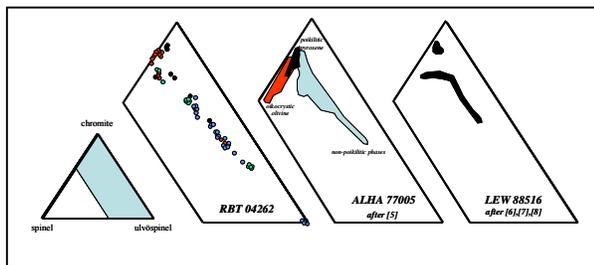

Figure 3. Comparison among oxides in RBT, ALH, and LEW within the components chromite-spinel-ulvöspinel. In RBT, red data points represent oxides included in olivine, blue data points represent oxides in pyroxene, green data points represent oxides in "plagioclase", and black data points represent oxides need grain boundaries. References to data for ALH and LEW given in the figure.

Feldspar. Plagioclase compositions among the three meteorites are fairly similar ranging from approximately An_{58} to An_{24}. RBT has a slightly higher Or component (Or_{2-8}) in the plagioclase and has K-rich feldspar [1-4].

Discussion:

Ferric iron in minerals and oxygen fugacity. Pyroxene and "spinel" appear to give two contradictory indications of f_{O2} crystallization conditions for these three meteorites. The ferric iron in high-Ca-pyroxene implies RBT crystallized under more reducing conditions, whereas the magnetite component in the earliest "spinel" implies RBT crystallized under more oxidizing conditions. Assuming an early crystallization assemblage of "spinel"+olivine+pyroxene, estimates of f_{O2} for the three lherzolitic shergottites suggest RBT and ALH crystallized under the most oxidizing conditions (QFM-2.1 and QFM-2.5, respectively) with LEW slightly more reducing (QFM-3). Some care must be taken in interpreting these calculations. As pointed out by Goodrich et al. (2003), estimating f_{O2} in the lherzolitic shergottites is notoriously difficult because the phases have reequilibrated at subsolidus temperatures and the assumption that early "spinel"+olivine+pyroxene assemblages were in equilibrium with one another may not be entirely correct. Furthermore, estimates of ferric iron are based on stoichiometic assumptions.

Nevertheless, an interesting observation is that it appears that the lherzolitic shergottite that crystallized under the most oxidizing conditions has pyroxene with the lowest abundances of Fe^{3+}. This observation demonstrates that Fe^{3+} in pyroxene is not only a function of f_{O2}, but is also related to the coupled substitutions needed to accommodate it in the pyroxene structure.

Petrologic relationships among the lherzolitic shergottites. Differences in f_{O2} and incompatible-compatible element enrichments observed in individual mineral phases (i.e. Ni-Co in olivine, Na in pyroxene, REE in phosphates, K in plagioclase) and whole rock REE patterns [9] among the lherzolitic shergottites indicate that RBT was derived from the crystallization of an "enriched" basalt similar to the basalt represented by NWA1110-1068. This indicates that the basalt from which RBT crystallized was derived from a Martian mantle source distinct from the sources that produced the basalts represented by LEW and ALH.

References: [1] Dalton et al. (2008) LPSC XXXIX, abst.# 2308. [2] Mikouchi et al. (2008) LPSC XXXIX, abst.# 2403. [3] Papike et al. (2009) GCA, in review. [4] Karner et al. (2009) *LPS XXXX, in press.* [5] Goodrich et al. (2003) MAPS 38, 1773-1792. [6] Harvey et al. (1993) GCA 57, 4769-4783. [7] Treiman et al. (1994) MAPS 29, 581-592. [8] Gleason et al. (1997) GCA 61, 4007-4014. [9] Usui et al. (2008) 71st annual METSOC Meeting abst. #5052.