PETROLOGY AND MINERAL CHEMISTRY OF NEW OLIVINE-PHYRIC SHERGOTTITE RBT04262.

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Introduction: RBT04262 was found by the 2004-2005 ANSMET team at the Roberts Massif in Antarctica. It is paired with RBT04261 and is classified as an olivine-phyric shergottite. RBT04261 is 4.0 x 3.5 x 2.5 cm and 78.8 g, and RBT04262 is 6.5 x 5.5 x 3.5 cm and 204.6 g. Both were partially covered by a fusion crust [1]. Chemical analysis and mapping of this meteorite was performed using the Cameca SX100 electron microprobe at NASA Johnson Space Center.

Overview: RBT0426 is composed primarily of pyroxene, olivine, and maskelynite with minor chromite spinel, Ca phosphate, ilmenite, Fe sulfide crystals, and glass with a K feldspar composition. There are two main lithologies present in the section examined: a coarse pyroxene (px) zone, characterized by large low-Ca pyroxene crystals, and a maskelynite-rich zone, in which most of the crystals are finer-grained. A calcium chemical map illustrates the two zones (Figure 1). The coarse px zone is located in the bottom right portion of the section, while the maskelynite-rich zone composes the rest of the section. There is a large reaction zone, shown in yellow (higher Ca concentration) in Figure 1, between the coarse px zone and the maskelynite-rich zone. Figure 2 shows the different pyroxene compositions of the three zones.

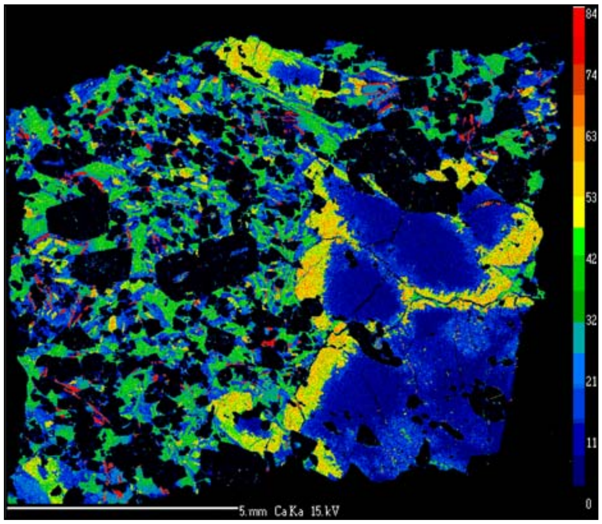

Figure 1. Ca chemical map of RBT04262 thick section. Scale bar is 5mm. Color bar indicates wt% Ca. Red areas are Ca phosphates; yellow, green, and blue areas are pyroxenes and maskelynite; black areas are oxides, sulfides, and olivine crystals.

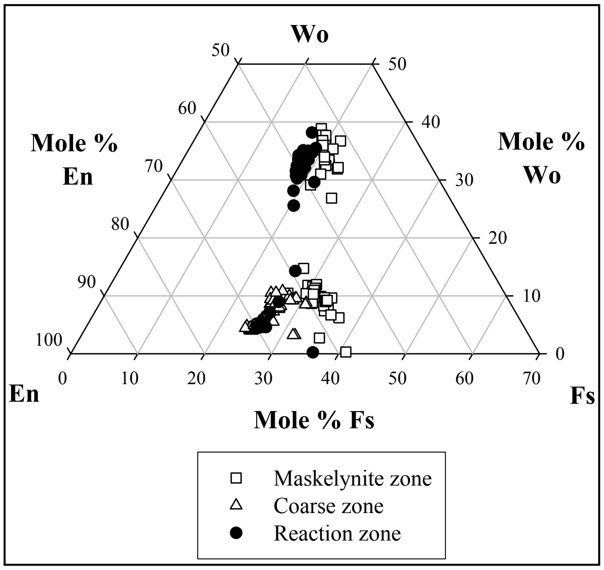

Figure 2. Pyroxene compositions of RBT04262.

Maskelynite-rich zone: Figure 3 is an iron chemical map of a portion of the maskelynite zone. Pyroxenes in this zone are smaller on average than in the coarse zone and are anhedral to subhedral. Pyroxene compositions fall into two distinct groups: pigeonite ($En_{57}Fs_{37}Wo_{6}$ to $En_{57}Fs_{31}Wo_{12}$) and augite ($En_{50}Fs_{21}Wo_{29}$ to $En_{43}Fs_{18}Wo_{39}$). Rare orthopyroxene (CaO <2 wt%) is also present. There are no pyroxene compositions between $En_{57}Fs_{31}Wo_{12}$ and $En_{50}Fs_{21}Wo_{29}$. Mg#s vary with size: 63-68 in small crystals and 58-74 in large crystals. The Ca-rich pyroxenes have higher Mg#s than Ca-poor pyroxenes. The Ca-rich pyroxenes exist in the centers of some pyroxene crystals, as well as along the edges of others. There is a distinct contact with no gradation between the low-Ca and high-Ca pyroxene, as can be seen in the green and blue areas of Figure 3. Olivine crystals range greatly in size (<50 µm to 2 mm), and many are larger here than in the coarse zone. They are homogeneous with no zoning. Their Mg content ranges from Fo_{56-57} in small crystals (<50 µm), to Fo_{57-59} in medium-sized crystals (<50 µm – 1 mm), to Fo_{59-61} in large crystals (2 mm). Feldspar has been completely converted to maskelynite glass with no crystal structure remaining. The majority of the maskelynite compositions range from $An_{70.1}$ to $An_{63.1}$, but there are a few areas with compositions of $An_{40.9}$ to $An_{59.5}$. K-feldspar-like glass (7-10 wt% K_2O) is present in the center of a few of the olivine crystals in this zone, with chromite, Fe sulfide, and high-Ca pyroxene. Ca phosphates in this zone are bladed in shape and are approximately 50 µm wide and between 200 and 750 µm long. The phosphates are severely fractured, probably as a result of shock from impact and ejection. These crystals cross-cut other minerals, indicating they were one of the first minerals to crystallize and did not result from impact melting. Ilmenite crystals are either anhedral or bladed, and some occur with Ca phosphates along maskelynite grain boundaries, indicating they formed concurrently. They contain 40.1 to 52.6 wt% TiO_2, 38.2 to 41.1 wt% FeO, and small amounts (<5 wt%) of MgO and Cr_2O_3. Anhedral ilmenite crystals are generally small (<50µm), but the bladed crystals range between 100 and 250 µm in length. Chromites vary in Cr_2O_3 content from 14.9 to 56.8 wt% coincidentally with FeO content (57.2 to 30.1 wt%). Most of the chromites have more than 1 wt% TiO_2, with some having up to 17 wt% (ulvospinel). Small amounts of MgO and Al_2O_3, along with trace amounts of CaO, MnO, SiO_2, and ZnO are also present. Chromite crystals are anhedral to euhedral and range in size from 20 to 200 µm. Fe sulfides are generally anhedral and small (<100 µm), though a few are between 100 and 200 µm in size. Many have extensive fracturing, similar to the phosphates. The sulfides do not vary much in composition, with 56.1 to 60.2 wt% Fe and 36.4 to 38.5 wt% S. Trace amounts of Cu and Ni also exist in the sulfides.

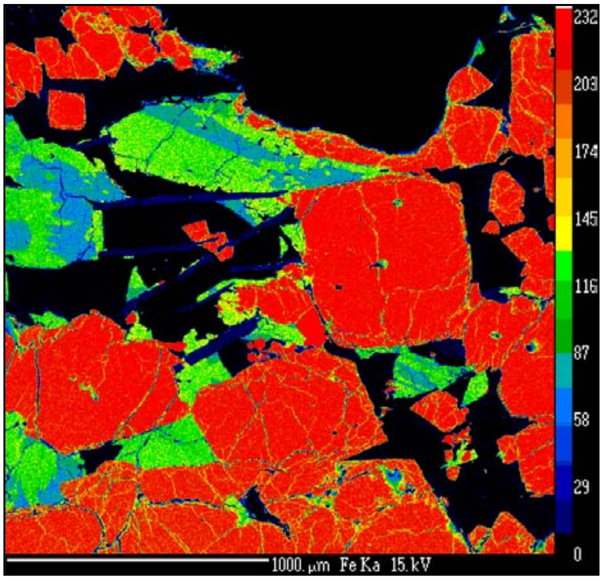

Figure 3. Fe chemical map of RBT04262 thick section. Scale bar is 1000µm. Color bar shows X-ray counts. Red areas are olivines; green areas are maskelynite and low-Ca pyroxene; blue areas are high-Ca pyroxene; dark blue areas are Ca phosphates, and black areas are maskelynite.

Coarse px zone: Large (1-5 mm) pigeonite crystals dominate this region. They are zoned with $En_{65}Fs_{32}Wo_3$ to $En_{64}Fs_{25}Wo_{11}$ and Mg#s between 68 and 74 from center to edge. The pyroxene crystals in the coarse zone have higher Mg#s than the smaller crystals in the maskelynite zone. Olivine crystals range in size from 100 to 300 µm with one 750-µm megacryst. They are chemically homogeneous and Mg content varies according to crystal size. Smaller olivines are Fo_{66-67}, while the megacryst is Fo_{70}. The megacryst also contains K-feldspar glass in its center, but the glass does not coexist with chromite, sulfides, and pyroxene as the glass in the maskelynite-rich zone does. Small chromites are common and are scattered throughout both pyroxene and olivine crystals; ilmenite and Fe sulfide minerals are rare. Chromite, ilmenite, and Fe sulfide compositions do not vary between the coarse and maskelynite zones.

Reaction Zone: The reaction zone is a region of high-Ca pyroxene that exists between the coarse px zone and the maskelynite-rich zone. The pyroxene is augite with compositions ranging between $En_{52}Fs_{20}Wo_{28}$ and $En_{45}Fs_{17}Wo_{38}$.

Crystallization History: This meteorite may have had a similar crystallization history to Zagami [2]. The magma that formed this meteorite first crystallized the coarse px zone, allowing the relatively large, Mg-rich pigeonite crystals to form. The large crystal size may indicate a relatively slow cooling time, perhaps deep in the lithosphere. Fractional crystallization allowed formation of the maskelynite-rich zone and reaction with the previously-crystallized coarse zone. On average, the crystals in this zone are smaller, indicating a faster cooling time, and perhaps a shallower crystallization depth. The more Mg-poor crystals and late-crystallizing phases such as maskelynite and Ca phosphate likely indicate crystallization from a more evolved liquid than that which formed the pyroxene megacrysts. Because of the placement of Ca phosphates along grain boundaries of the maskelynite, they could have formed around the plagioclase crystals after the plagioclase had already crystallized. The presence of K-feldspar-like glass within olivine crystals might be significant for pinpointing the depth of crystallization. Alkali-rich glasses can coexist with olivine and pyroxene at high pressures [3,4], indicating this rock may have formed deep in the Martian lithosphere.

References: [1] Satterwhite C. and Righter K. (2007) *Antarctic Meteor. Newsletter, 30:1,* 1-20. [2] McCoy T. J. et al. (1999) *Geochim. Cosmochim. Acta 62,* 1249–1262. [3] Hirschmann M. M. et al. (1998) *Geochim. Cosmochim. Acta 63,* 883-902. [4] Draper D. S. and Green T. H. (1999) *Earth & Planet. Sci. Letters, 170* , 255-268.