**HALOGENS IN MARTIAN SHERGOTTITE RBT 04262.** J. A. Cartwright, J. D. Gilmour and R. Burgess. School of Earth, Atmospheric and Environmental Sciences, Williamson Building, Oxford Road, University of Manchester, M13 9Pl, UK. (julia.cartwright@postgrad.manchester.ac.uk)

**Introduction:** Halogens (Cl, Br, I) are incompatible elements in anhydrous silicate phases. In Martian meteorites they are concentrated in OH-rich phases such as phosphates or more rarely in amphiboles, and in secondary alteration products. They may also occur in melt inclusions found within olivine and pyroxene crystals, which can be analysed to determine the halogen composition of the magma source. Some secondary aqueous alteration products have a terrestrial origin, whilst others formed by weathering on the Martian surface (e.g. [1-2]). Analysis of the halogens in meteorites therefore has potential for identifying the primary halogen content of the Martian interior, and the composition of brines acting on the Martian surface. Ultimately, the halogens may be a useful inorganic biomarker for life on Mars, as living organisms on Earth produce significant amounts of organohalogen compounds [3-4]. We report preliminary results of the first halogen data for mineral separates from the Martian meteorite Roberts Massif 04262 (RBT 04262).

**Sample description:** RBT 04262 is an olivine-phyric shergottite recovered from Antarctica in 2004 [5-9]. It is composed of 53 % pyroxene, 20 % olivine, 25 % maskelynite and 2 % opaque phases (including chromite spinel) and has a Lu-Hf age of 225 ± 21 Ma [6-7, 9-10]. RBT 04262 has two distinct igneous lithologies, one coarse grained, containing low Ca pyroxene oikocrysts surrounding olivines and sulphide phases, whilst the second is fine grained, and consists of mainly high and low Ca pyroxene, olivine, maskelynite, small crystals of ilmenite, chromite and Fe sulphides [6, 10]. Our sample of RBT 04262 is from the fine grained lithology. A number of alteration and weathering products are present, in particular pyrhottite and apatite have been altered to gypsum, jarosite and iron phosphate [11]. Numerous melt inclusions occur within olivine and pyroxene crystals in both lithologies, including secondary inclusion trails formed by the healing of cracks. The melt inclusions are partially recrystallized and rich in late-stage fractionates such as K-rich feldspathic glass, phosphates and opaque oxides [12].

**Methodology:** A chip of RBT 04262 was crushed and minerals hand-picked under a binocular microscope in a clean laboratory. Using this procedure, mineral separates of olivine/pyroxene (Olpx1, Olpx2), maskelynite (Mask1) and opaque (Opq1) phases were obtained. Distinguishing between olivine and pyroxene was not possible due to their small size, and similarity in colour. The samples were neutron-irradiated to convert halogens into noble gas isotopes. Noble gases can be released by laser stepped heating over a range of temperatures, helping to distinguish different halogen-bearing phases and to discriminate terrestrial halogen contamination. The noble gas isotopes were measured by mass spectrometry. All halogen ratios quoted are molar and errors are 1σ.

**Results:** Results are summarised in Table 1, and step-release plots are shown in Figure 1.

*Concentrations*: The opaque phases released the highest concentration of halogens (Cl = 175 ± 52 ppm), followed by maskelynite (Cl = 47 ± 1 ppm) and olivine/pyroxene (Cl ~14 ± 2 ppm). The identity of the halogen-rich phase in the opaque fraction is unknown at present. The relatively high concentration of halogens in maskelynite may be a primary feature. However, halogens may also have been introduced from the surrounding Martian crust during shock-conversion of feldspar. The halogen concentrations from the olivine/pyroxene aliquots, being relatively low, may have been released from melt inclusions within the minerals, and thus represent a Martian interior halogen component. Potassium is also present in all four samples, with maskelynite showing the highest concentration of ~0.18 wt%. The high K (~0.11 wt%) in the opaque fraction suggests the presence of a K-rich phase, although again the identity of this phases is yet to be determined. The high K concentrations observed in the olivine/pyroxene samples may be related to a K-rich melt inclusion composition.

*Release patterns:* The halogen-derived noble gases were released at different temperatures during the experiments. The low temperature heating steps for samples Olpx1, Olpx 2 and Mask 1 released a high amount of iodine (12-50% of total), with I/Cl ratios of ~0.15 – 0.2 (Fig. 1). These early releases may represent release from low temperature alteration products or terrestrial contamination which is a known problem for Antarctic meteorites (e.g. 11). With increasing temperature, there is an overall trend of decreasing I/Cl in the olivine/pyroxene aliquots to <0.002, whilst the maskelynite plateaus at ~ 0.005 (Fig. 1).

Br/Cl ratios are reasonably consistent over the entire Cl release with the maskelynite averaging ~0.004, and olivine/pyroxene averaging ~0.003. There is a slight peak in the mid-range temperatures, and decrease at higher temperatures (Fig. 1). The K/Cl release pattern shows increasing K/Cl with temperature for the maskelynite sample, and decreasing for the olivine/pyroxene samples (e.g. Fig. 1). The first heating steps for the Olpx release relatively high amounts of K, which again may be related to a release from alteration products such as jarosite. The opaque sample was heated in a single step and yielded Br/Cl = 0.003 and I/Cl = 0.002.

**Discussion:** Analysis of separated mineral phases reveals considerable variation in halogen abundances and ratios within RBT 04262 (Table 1). This range may represent mixtures of different Martian components including an interior component from melt inclusions in olivine and pyroxene (I/Cl <0.002, Br/Cl = 0.003), shock implanted mars crustal halogens in maskelynite (Br/Cl = 0.004, I/Cl = 0.005), and alteration products (low temperature release from olivine). However, it is not possible to distinguish halogens from Martian and terrestrial alteration products based on the current data-set. The identity of the halogen and K-rich phase(s) in the opaque fraction is currently being investigated. The halogen composition of all the minerals in RBT 04262 are within the ranges obtained for bulk Martian meteorites: I/Cl = 2.4 x $10^{-6}$ (Nakhla [13]) - 3.4 x $10^{-2}$ (ALHA 7705 [14] and Br/Cl of 3.51 x $10^{-4}$ (Y-000593 [13]) - 3.1 x $10^{-2}$ (Nakhla, [15]).

**Acknowledgments:** Thanks to the ANSMET team for supplying RBT 04262.

**References:** [1] Rao M. N., Nyquist, L. E., Wentworth S. J., Sutton S. R., and Garrison, D. H. (2008) *JGR*, 113, (E06002). [2] Treiman A. H., and Lindstrom D. J. (1997) *JGR* 102, 9153-9161. [3] Gribble G. W. (2003) *Chemosphere*, 52(2), 287-297. [4] Gilmour J.D, Whitby J. A. and Turner G. (1999) *LPSC XXX*. [5] Satterwhite C. and Righter K. (2007) *AMN*, 30, 1-20. [6] Dalton H. A., Peslier A. H., Brandon A. D., Lee C.-T. A., and Lapen T. J. (2008) *LPSC XXXIX*. [7] Lapen T. J., Brandon A. D., Beard B. L., Peslier A. H., Lee C.-T. A., and Dalton H. A. (2008) *LPSC XXXIX*. [8] McCoy T. and Reynolds V. (2007) *AMN*, 30, 16. [9] Cartwright J., Burgess R., Crowther S. A., and Gilmour J. D. (2008) *LPSC XXXIX*. [10] Mikouchi T., Kuirhara T., and Miyamtot M. (2008) *LPSC XXXIX*. [11] Greenwood J. P. (2008) *LPSC XXXIX*. [12] Anand M., James S., Greenwood R. C., Johnson D., Franchi I. A., and Grady M. M. (2008) *LPSC XXXIX*. [13] Dreibus, G., Huisl W., Spettel B., and Haubold R. (2006) *LPSC XXXVII*. [14] Dreibus G., and Wänke H. (1987) *Icarus*, 71(2), 225-240. [15] Burgess R. (Unpublished).

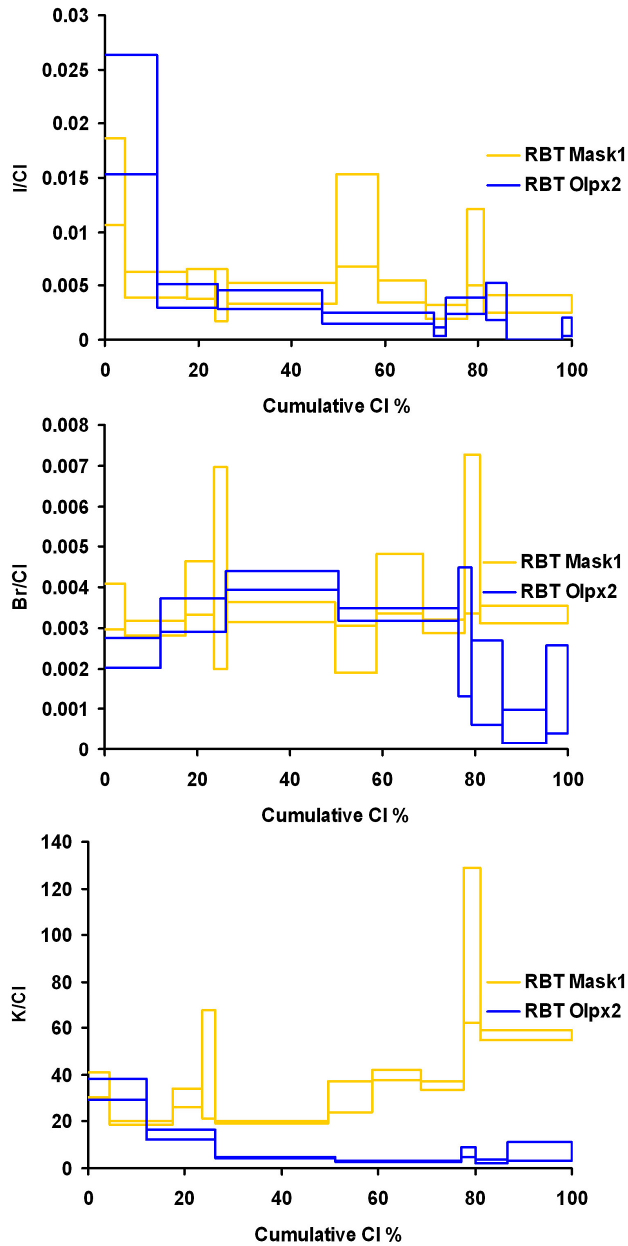


**Figure 1: Step release plots of molar ratios of Br/Cl, I/Cl and K/Cl vs. cumulative Cl (%) for aliquots Mask1 and Olpx2.**

**Table 1: Results for RBT 04262. Olpx = olivine/ pyroxene, mask = maskelynite, opq = opaque phases.**

| Sample | Cl (ppm) | Br (ppb) | I (ppb) | K (ppm) |
|---|---|---|---|---|
| Olpyx1 | 10 ± 2 | 68 ± 10 | 283 ± 32 | 138 ± 8 |
| Olpyx2 | 18 ± 1 | 106 ± 4 | 283 ± 36 | 160 ± 8 |
| Mask 1 | 47 ± 1 | 359 ± 11 | 888 ± 82 | 1837 ± 13 |
| Opq 1 | 175 ± 52 | 1121 ± 35 | 1505 ± 352 | 1111 ± 58 |