Do some shergottite impact melts contain jarosite-type phases in their precursor mineral-assemblages?

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Introduction

Detailed experimental studies on gas -rich impact melts (GRIMs) in shergottites [1-7] provide evidence for the occurrence of altered Martian soil components in their precursor-assemblages based on the results obtained from vestigial records of shock-molten mineral constituents trapped in voids of these meteorites prior to shock. During impact ejection of shergottites from Mars, these void spaces became preferential sites for shock-melting of the porous mineral phases. Manifestation of the characteristic features of the GRIM precursors depends on the nature and abundance of the Martian soil grains trapped in the collapsed void spaces [2,6].

Experimental

We determined elemental abundances in several gas-rich impact-melts (GRIMs) in shergottites (PTS No. #507 in EET79001, Lith B, Shergotty (# DBS1& 2), Zagami (#H1, #992 and #994), Los Angeles #748 and QUE 94201 belonging to pyroxene-phyric type using EPMA and FE SEM techniques [1-3].

Discussion

In the polished thin sections (PTS) of EET79001, 507; Shergotty DBS 1&2; Zagami H1 & # 992; Los Angeles 748 and QUE 94201 (pyroxene-phyric type), we notice that micron-size S-bearing bleb-clusters occur adjacent to the magmatic pyrrhotite grains. Typical examples of this feature observed in GRIMs from EET79001,507 and Los Angeles, LA748 are shown in Figs.1 and 2. A similar feature of S-bleb clusters is also present in Shergotty impact-melt (PTS #30, Fig.10) given by [8]. The juxtaposition of these two S-bearing species in the shocked samples could result from either incipient melting of Fe-sulfide (pyrrhotite) during shock or due to some other process. If the S-bearing blebs in the GRIMs are produced by the incipient melting of igneous pyrrhotite $Fe_{(1-x)}S$, they are expected to yield Fe/S (atomic) ratios of ~0.92 [9]. But, the Fe/S (atomic) ratios measured in S- bearing blebs in GRIMs are much greater than this value (range: 1.02 to 1.4) indicating that these S-blebs are not related to pyrrhotite [2,5]. Moreover, if these S-blebs are produced from igneous pyrrhotite, they should yield $Fe_{(1-x)}S$ characteristic S K-XANES spectra having two peaks at 2470 eV and 2478 eV with a peak-height- ratio of ~1.1 [2]. But, S K-XANES spectra recorded in S-blebs in PTS of EET79001, 507 and Tissint black glasses yield very different peak-height patterns which are typical of "sulfites" but not pyrrhotite [2]. Further, if sulfide is shocked to high pressures and temperatures, it will be reduced to Fe-metal.

Alternatively, we look for other processes that produced the micron-size S-bleb clusters in GRIMs on shock-heating. For this purpose, the results obtained by [10-12] regarding the occurrence of jarosite and hematite in MIL 03346 are relevant. For the formation of this type of mineral assemblage in MIL 03346, highly acidic oxidized S- and Fe-rich brines are required on Mars [13,14]. Jarosite is likely produced as liquid water infiltrates through rocks and soil on Mars and interacts with Fe-sulfides at low pH and low water/ rock ratios [10,13,14,19]. Moreover, there is ample evidence based on D/H ratios determined in impact-melts in EET 79001 and Shergotty [15,16], Tissint [5, 17], Los Angeles 748 and QUE 94201 [3] that liquid water likely infiltrated and interreacted with GRIM precursor mineral assemblages (presumably at shergottite provenance) as these samples yield D/H ratios of ~ 4000 ‰ characteristic of Martian surface water. These results provide the context for explaining the juxtaposition of S-bleb clusters and igneous sulfides in our PTS samples: The igneous Fe-sulfide grains at the shergottite provenance interacted with acidic water infiltrating through rocks and soil resulting in the production of jarosite-like sulfate phases. These S-assemblages were later mobilized into void spaces of shergottite source rocks (prior to impact) presumably by aeolian activity. During impact, the porous sulfate mineral phases became the preferential sites of shock-focusing leading to melting at high temperatures & pressures. The sulfates thus decomposed into sulfites and were concomitantly reduced to sulfides by isentropic cooling [2]. The crystalline sulfides, however, remained unaltered. Note that, although the above findings are relevant to the GRIMS from pyroxene phyric shergottites, However, it may be noted that Tissint GRIMs display anomalies.

Conclusions. The vestigial records of shock-melted decomposition-products retrieved in GRIMs from pyroxene-phyric shergottites suggest the possible occurrence of jarosite- & alunite-type mineral mixes in their GRIM-precursors (prior to shock).

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Figure Captions

Fig.1. Back-scattered electron image mosaic of the large impact melt in Los Angeles LA 748 (provided by Paul Warren). The EPMA data are collected along the line traverses 1 to 5. Line 6 shows Fe-sulfides.

Fig.2. BSE image of the area in EET79001, 507 PTS where the S K-XANES spectra are recorded (blue and black arrows) by the APS Cyclotron facility at ANL, Argonne. IL.[2]. All white rounded micron-size spherules are shock-produced S-bearing blebs whereas the large white chunky irregular objects (bottom right and top left) are magmatic pyrrhotite grains as in the case of Fig.1. The bleb-clusters represent "sulfites" partially reduced to "sulfides" on isentropic cooling [2]. The elemental correlation plot for these bleb-clusters in #507 is shown in Fig.3 of [2] and it is similar to the LA748 plot.

Fig.3. The data collected along the lines drawn in Fig.1 are plotted here. Green points represent FeO vs SO3 which show positive correlation whereas red points represent Al2O3 vs SO3 that shows negative correlation. Note, as FeO increases, Al2O3 decreases at every point which suggests substitutive deposition [2]. Similar features were found in EET 79001, 507 (PTS) [2].

Fig.4. Electron micrographs of altered secondary minerals trapped in a interior vug from QUE 94201,38. C, F, J, I, H, K, L are Fe, K-sulfates (presumably altered jarosite that escaped melting?), G- Ca-sulfate [18].

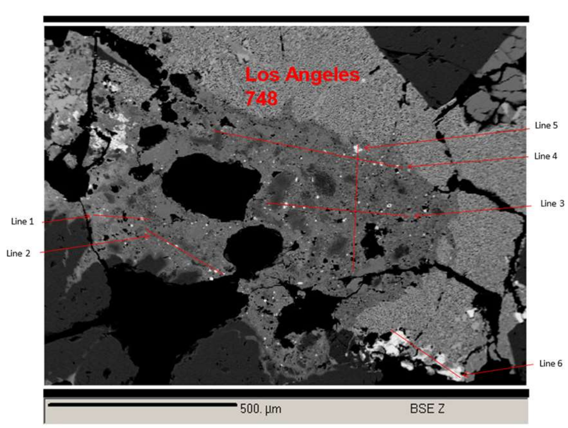

Fig. 1. See Figure Captions in text for details.

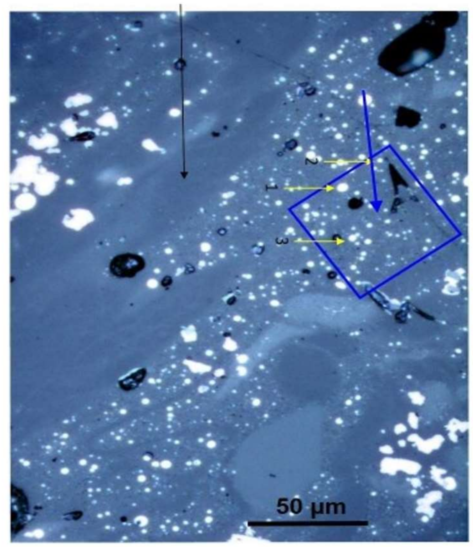

Fig. 2. See Figure Captions in text for details

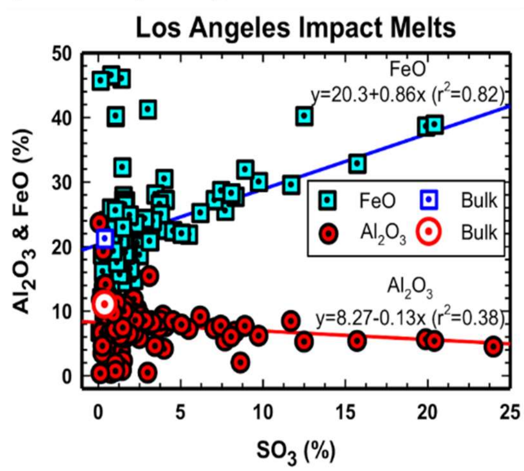

Fig. 3. See Figure Captions in text for details

QUE 94201 vug

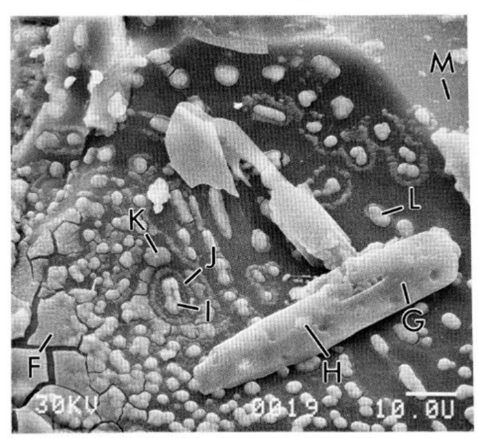

Fig.4. See Figure Captions in text for the details