Geochemical and Mineralogical Characteristics of Zagami Impact Melts. Z.X. Peng[1], M. N. Rao[2], L. E. Nyquist[3] and D. K. Ross[4]. [1]California State University, Northridge CA, 91330 USA (zhan.peng@csun.edu), [2]SCI, Johnson Space Center, Houston TX. [3]XI/NASA Johnson Space Center, Houston TX, USA. [4]deceased.

Introduction: The geochemical composition of Zagami is similar to that of basaltic shergottites according to the studies conducted by several authors [1, 2, 3]. [3] suggested fractional crystallization of a single magma source from Mars for the Zagami meteorite. The black shock-melt veins in Zagami suggest rapid shock melting followed by fast cooling without complete crystallization [4, 5, 6, 7,8]. However, the geological and petrological evolution of Zagami impact melts have unanswered questions which need more studies.

This study is focus on a Zagami thin section (#H1). A combination of different analytical techniques is used to investigate the geochemical aspects of mineral constituents of Zagami. EDS and EBSD methods are used to analyze elements and mineral phases; and LA-ICPMS method is used for trace elements and REE analysis. The purpose is to check geochemical and petrological variations of impact melts to examine the partial melting/fractional crystallization processes relevant to Zagami.

EDS/EBSD: FEI Quanta 6000 SEM, equipped with energy-dispersive X-ray spectroscopy (EDS) and electron backscatter diffraction detector (EBSD) is used in our study. EDS method is used for major element compositions and elemental maps (Fig.1 and 2), The EBSD method is for mineral phases, boundary and orientation of the crystals. (Fig 3). A smaller map has been selected for more detail EDS/EBSD and LA-ICPMS analysis. The EDS layer map (Figure 1) shows that most of the pyroxenes in Zagami are around 0.5 to 1.0 mm long indicated in the map by green or yellowish–green color, pigeonite and augite are believed to be the major pyroxene phases here; the other abundant mineral is feldspar (mostly plagioclase/maskelynite). It appears to be less then pyroxene as indicated by blue-color. Most of them are albite and some may be K-bearing feldspar. Apatite and Fe-Ti oxides (ilmenite) are indicated by yellowish and reddish color respectively and can be seen sparkling around the whole section. Areas around the edge area to the left; the lower right corner; and a line along the middle in Figure 1 show some dark spaces that may be caused by impact melting. The minerals around these places are smaller in size compared to others which may be suggestive of shock comminution or fast recrystallization after impact.

Maps in Figure 3 and 4 represent smaller area composites that are re-analyzed after LA- ICPMS analysis. The EDS maps in Figure 4 show little changes but other EBSD maps display obvious laser ablation damage.

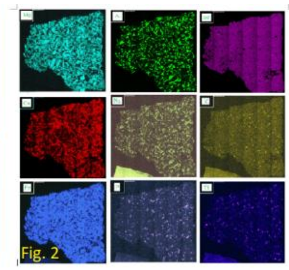
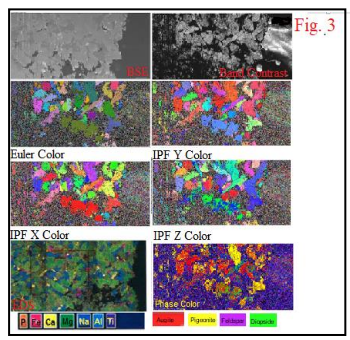


Fig. 1. EDS map: blue=feldspars/maskelynite, dark green = pigeonite; green=augite, yellow=P-Ca oxide/apatite; pink= Fe-Ti oxide

Fig. 2. EDS maps for Fe, Al, Mg, Ca. Na, K, Ti, P, and Sr.



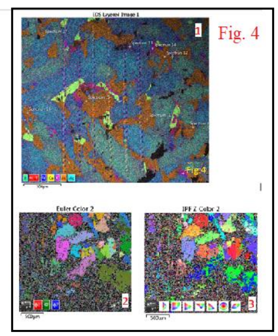


Fig. 3. EDS and EBSD analysis on selected area of the samples after laser ablation ICP-MS analysis on the very left section.

Fig. 4. EDS 1) Laser ablation spots and EDS layered map after laser ablation analysis. 2) Euler Color map from EBSD analysis after laser ablation. 3) IPF Z color map from EBSD after laser ablation.

The band-contrast shows the quality of the crystals: where a good crystal would have higher values and the deformed one would have lower values. In the band-contrast map of EBSD, boundaries of the larger gains are displayed clearly on the map. Most of them are pyroxenes, which are also indicated in EDS maps. Yet, areas for the plagioclase identified by EDS do not show up in the band contrast maps. Similarly, the Euler color map and IPF map show the same pattern, where areas of pyroxenes show up but not for that of plagioclase. Several laser-blasted spots lines in the very left show same laser blast damage as well. An interesting fact is that these laser-blasted areas show no crystal information by EBSD analysis for the plagioclase. The small EDS maps indicate that chemical composition of plagioclase is less affected by the laser-blast. It may imply that when melting occurs, the plagioclase crystals were destroyed though the melted but most of the solution remained in-place without much special movement. These maps suggest also that pyroxenes are not affected much by impact melting. Thus, the temperatures produced by the impact might not have reached to the melting temperature of the pyroxenes. There were reported shock melt veins in the similar areas in Zagami containing mostly pyroxenes [9] and such veins can be seen in our EBSD map along the grain boundaries around different pyroxenes crystals. The melted solution from plagioclase appears mostly trapped in place and cooled quickly too. Similarly, veins along the pyroxene grains could also be traps for the melted liquid which re-crystallized with tiny minerals [9, 10]. Previous studies in impact melts of Zagami [9] reported as "pseudotechylite -like melt veins and the feldspar occurs as diaplectic glass" which is consistent with our finding.

LA-ICPMS: Five lines with 31 spots each were analyzed for trace element compositions. These compositions, in combination with EDS/EBSD data obtained here, were used to identify mineral phases and crystal deformation, The chemical composition and possible mineral phases are listed in data tables separately (not shown here).

Laser ablation was performed by Teledyne Photon Machine Analytic G2 with spot of 40 um. BHVO-2G was served as primary standard. BCR2 and GSC1G were used for quality control. These standards were analyzed before and after each set of samples. CI normalized REE values for difference minerals are listed in Table 1. CI normalized REE patterns are displayed in Figure 5.

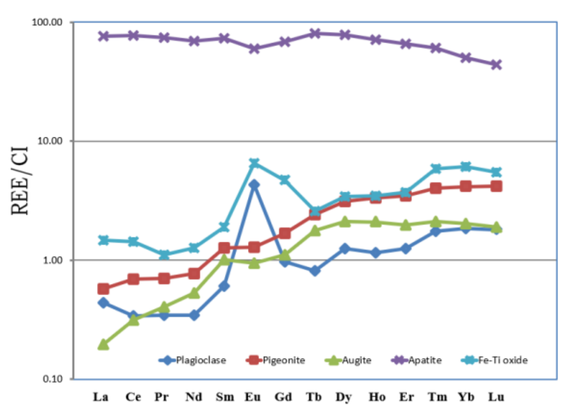


Figure 5. CI normalized REE patterns

Compared to CI [11], most minerals of Zagami have higher abundance of heavier REE than CI from Sm to Lu for pyroxenes; Eu, Dy to Lu for plagioclases, but low abundance for lighter REE. When considered with partition coefficients of these minerals, both REE patterns of pigeonite and augite appear normal but plagioclase shows a depleted LREE pattern. Similar REE patterns have been reported also in dark-mottled lithology and late-stage pockets in [3].

REE/CI	Plagioclase	Pigeonite	Augite	Apatite	Fe-Ti oxide
La	0.44	0.57	0.2	76.17	1.47
Ce	0.34	0.69	0.31	76.85	1.42
Pr	0.34	0.7	0.41	74.09	1.12
Nd	0.35	0.77	0.53	69.46	1.26
Sm	0.6	1.27	1.01	73.16	1.89
Eu	4.32	1.29	0.94	59.46	6.51
Gd	0.97	1.68	1.11	68.2	4.7
Tb	0.82	2.41	1.77	80.68	2.59
Dy	1.25	3.12	2.1	78.07	3.43
Ho	1.16	3.33	2.1	70.97	3.48
Er	1.25	3.48	1.99	65.43	3.71
Tm	1.76	4.04	2.12	60.45	5.87
Yb	1.84	4.16	2.03	50.1	6.15
Lu	1.81	4.2	1.9	43.75	5.48

Table 1 CI normalized LREE values for different mimerals

Summary: Combined EDS and EBSD methods used here indicate that plagioclase has melted and cooled down quickly on impact-melting and occurs as diaplectic glass but most of the melts were trapped in place. However, pyroxenes were less affected.

CI Normalized REE patterns of Zagami impact melts indicate depleted LREE, but enriched in HREE. Similar REE patterns have been reported also in dark-mottled lithology and late-stage pockets by McCoy et al. (1999) [3].

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