EPSC Abstracts
Vol. 12, EPSC2018-936, 2018
European Planetary Science Congress 2018

Analytical investigations of Laser-Produced Impact Melts of Basaltic Rocks

Iris Weber (1), Andreas Morlok (1), Christopher Hamann (2), Dayl J. P. Martin (3), Katherine H. Joy (3), Roy Wogelius (3), Aleksandra Stojic (1), Harald Hiesinger (1), Jörn Helbert (4)
(1) Institut für Planetologie, Wilhelm-Klemm-Strasse 10, 48149, Münster, Germany (2) Museum für Naturkunde, Invalidenstrasse 43, 10115 Berlin, Germany (3) School of Earth and Environmental Sciences, University of Manchester, Oxford Road, Manchester M13 9PL, UK (4) Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany (sonderm@uni-muenster.de)

1. Introduction

The Infrared and Raman for Interplanetary Spectroscopy (IRIS) laboratory at the Institute für Planetologie in Münster produces, among others, spectra for a database for the mid-infrared spectrometer MERTIS (Mercury Radiometer and Thermal Infrared Spectrometer) onboard of the ESA/JAXA BepiColombo mission to Mercury. MERTIS will be able to map spectral features of the surface in the 7-14 µm range, with an average spatial resolution of ~500 m [1-4]. Thus, the mineralogical composition of the planetary surface can be determined via remote sensing.
Mercury has been exposed to heavy impact cratering [4]. Therefore, impact products like glass are an important component of its surface. We thus are studying a series of mid-IR spectroscopy of shocked, i.e., basaltic material in the laboratory environment, in order to interpret future MERTIS measurements [5-8].

2. Samples and Techniques

In this work, the impact melting of basaltic materials was simulated by using a pulsed Nd:YAG laser at the Technische Universität Berlin [9]. The sample was irradiated along 15 mm long and 1 mm wide lines. To optimize the melt production the laser settings were: 0.9 kW for emitted power over 15 s at a wavelength of 1064 nm, a pulse frequency of 25 Hz, and a pulse duration of 2.5 ms. Afterwards the sample runs were collected, embedded in resin, sectioned, and polished. Hoffelder basalt (Hoffeld, Germany) was used as starting material. This sample is a basanitic, porphyritic rock consisting of 200–800µm size olivine ($Fo_{79\pm4}$) phenocrysts set in an aphanitic groundmass (≤100µm) of labradorite ($An_{62}Ab_{36}$), salite ($En_{39\pm3}Wo_{49\pm2}$), Fe,Ti oxides, and feldspathoids.
Detailed quantitative analyses were made with a JEOL JXA-8530F Hyperprobe electron probe micro analyser (EPMA) equipped with four wavelength dispersive spectrometers and operating at an excitation voltage of 15 kV and a beam current of 15 nA. Measurements were carried out with a spot size of 2 µm.
For IR analyses, we used a Perkin-Elmer Spotlight-400 FTIR spectrometer at the University of Manchester. Spot analyses (25×25 µm) were made in a wavelength range from 2.5–15.4 µm in the reflectance mode, using a cooled mercury-cadmium-telluride (MCT) detector. For mapping an adjoining micro spectroscopy mapping unit was used.

3. Results

EMPA analyses of one area of the Hoffelder basalt confirm the mineralogy of the sample. Large grain olivines show a Fo content between 87 and 77. In the fine-grained matrix labradorite ($An_{60-53}Ab_{43-38}$), olivine (Fo_{73}), pyroxene ($En_{36}Wo_{50}$), and Fe,Ti-oxides are present. The analyses of the laser-generated glass are in good agreement with the bulk composition of the sample. A summary of the measurements are given in Table 1. The BSE (backscattered electron image, Fig. 1) shows the appearance of the investigated area.
Basaltic glass shows a very simple IR spectra (Fig. 2), dominated by one broad Reststrahlen band (RB) between 10.1 and 10.5 µm, and a Christiansen feature (CF) from 8.3 to 8.5 µm. Fine-grained parts of the basalt show more variation; here the dominating RB (9.7–10.1 µm) is accompanied by additional bands from 8.9–9.4 µm and 10.2–10.4 µm. The CF is between 7.9 and 8.3 µm. Minor bands are located at longer wavelengths from 13.1 to 16.7 µm (in the bulk spectrum). Larger crystals show a wider distribution of features, in part due to crystal orientation effects. The CF is between 8.2 and 9.1 µm, various major RB are at 9.3–9.5 µm, 9.6–10 µm, 10.2– 10.4µm, 10.6–10.9 µm, 11–11.2 µm, and 11.9–12 µm, with additional minor features between 13 and 16.2 µm.

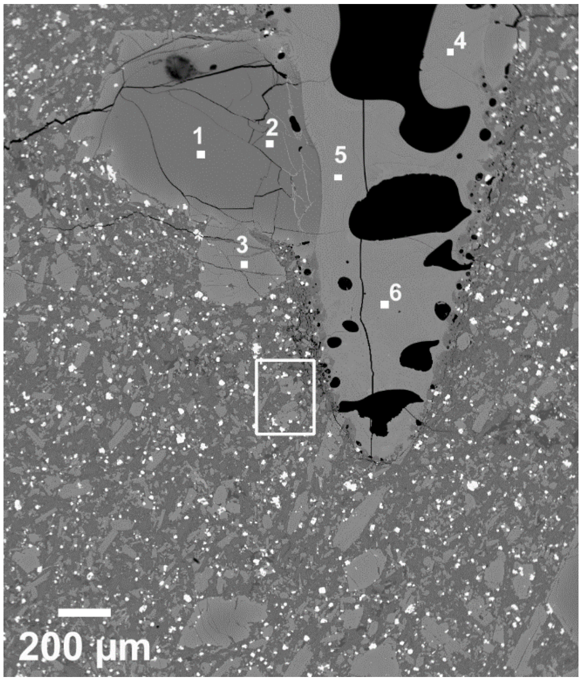

Fig. 1: BSE image of the investigated area of the treated Hoffelder basalt. Points 1–3 are the large grain olivines. Points 4–6 are in the glass. Framed is the analyzed fine-grained matrix.

Table 1: EMPA analyses of the marked areas in the BSE image of Fig. 1.

	Olivine 1,2 (Fo_{87})	Olivine 3 (Fo_{77})	Glass (4-6)	Olivine Fine grained	Feldspar Fine grained
Na_2O	0.02	0.01	2.52	0.02	4.6
MgO	46.3	39.7	12.7	36.8	0.04
SiO_2	40.0	38.5	42.4	38.1	53.5
Al_2O_3	0.05	0.03	14.5	0.02	28.7
K_2O	n.d.	n.d.	1.13	0.01	0.42
CaO	0.16	0.28	10.6	0.42	11.7
FeO	12.7	20.6	11.2	23.7	0.70
TiO_2	0.05	0.04	2.65	0.09	0.14
Cr_2O_3	0.01	0.03	0.04	0.03	n.d.
MnO	0.17	0.42	0.18	0.57	0.03
Total	99.46	99.61	97.92	99.66	99.74

References

[1] Maturili A. (2006) Planetary and Space Science 54, 1057–1064 [2] Helbert J. and Maturilli A. (2009) Earth and Planetary Science Letters 285, 347-354 [3] Benkhoff, J. et al. (2010) Planetary and Space Science 58, 2-20 [4] Hiesinger H. et al. (2010) Planetary and Space Science 58, 144–165 [5] Morlok A. et al. (2017) Icarus 296, 123-138 [6] Morlok A. et al. (2016) Icarus 278, 162-179 [7] Martin, D.J.P. (2017) Meteoritics & Planetary Science 52, 1103-1124 [8] Pernet-Fisher, J.F. (2017) Scientific Reports 78 [9] Hamann C. et al. (2016) Journal of Geophysical Research 43, 10602-10610 [10] DuFresne C.D.M. et al. (2009) American Mineralogist 94, 1580-1590 [11] Weber I. et al. (2018) 49th LPSC Abstract #1430

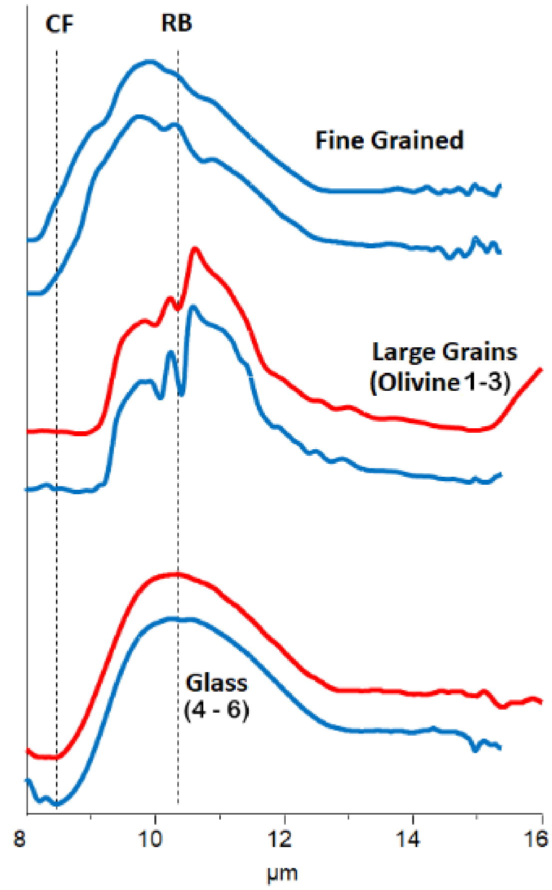

Fig. 2: Resulting micro-FTIR spectra from the pristine and melted parts of the basalt slab. Red = single point analyses (25 × 25 µm), blue = phases identified using PCS analyses.

4. Discussion and Conclusions

IR spectra of the melt glass are consistent with those of basaltic glass in earlier studies [5,10].

Mid-infrared investigations give distinctive signatures for the melted and un-melted components in the sample. This helps to discriminate impact-shocked lithologies in basalt from pristine igneous material. However, as glass will be only a part of the mineral mixture of the surface; further components will have to be taken into account.

Our results are available via a web-accessible database, which will be extended continuously [11].

Acknowledgements

This work is partly supported by the DLR (funding 50QW1702 in the framework of the BepiColombo mission) and the DFG (MEMIN Research Unit FOR 887).