

INFRA-RED SPECTROSCOPY ON SYNTHETIC LUNAR GLASSES – AN EXTENSION OF THE DATABASE TOWARDS HIGH TiO₂ BASALT COMPOSITIONS. C. P. Haupt¹, C. J. Renggli¹, A. N. Stojic², A. Morlok², S. Klemme¹, I. Weber², and H. Hiesinger², ¹Institut für Mineralogie, Universität Münster, Corrensstr. 24, 48149 Muenster, Germany ²Institut für Planetologie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Muenster, Germany. (chaupt1@uni-muenster.de)

Introduction: Our understanding of planetary surface composition and surface modifying processes (e.g., space weathering and high-velocity impacts) has improved considerably with the first space missions that included spectrometers as scientific payload. For surfaces of which no laboratory samples are available (e.g., Mercury) or only limited locations have been sampled (Moon), remote sensing techniques are the only way to obtain additional information on mineralogy and chemistry of the distant surfaces. OSIRIS-Rex [1] and BepiColombo [2] are current space missions that will provide data in the thermal infrared (IR) range. In this range most rock-forming minerals show Reststrahlenbands (RBs: i.e., intensity maxima in reflectance and minima in emission spectroscopy [3]). The mineral-characteristic RBs occur due to silicon/aluminum-oxygen bond oscillations.

The interpretation of remotely acquired IR data is augmented by laboratory-generated data-sets of natural and synthetic material analogues. Important features, apart from the RBs, that can be related to the molecular structure of materials are: The Christiansen Feature (CF), a composition-related reflectance minimum [3], and the transparency feature (TF), linked to the grain size of the material [3–5].

On the surface of the Moon and Mercury, high-velocity impacts, space weathering, and volcanic activity (e.g., pyroclastic glasses) have formed glasses and amorphous material. Studying spectra of glasses designed after mission-inferred chemical compositions of the lunar/hermean surface in the laboratory can help to identify these components within remote sensing data [6].

Here, we present new micro-FTIR spectroscopic data of experimental lunar glass analogues with varying chemical compositions, covering a wide range of TiO₂ contents (0.9–18 wt.%). This data set expands the existing data base of lunar material analogues towards more mafic compositions and includes recent Change5 mission bulk compositions [7].

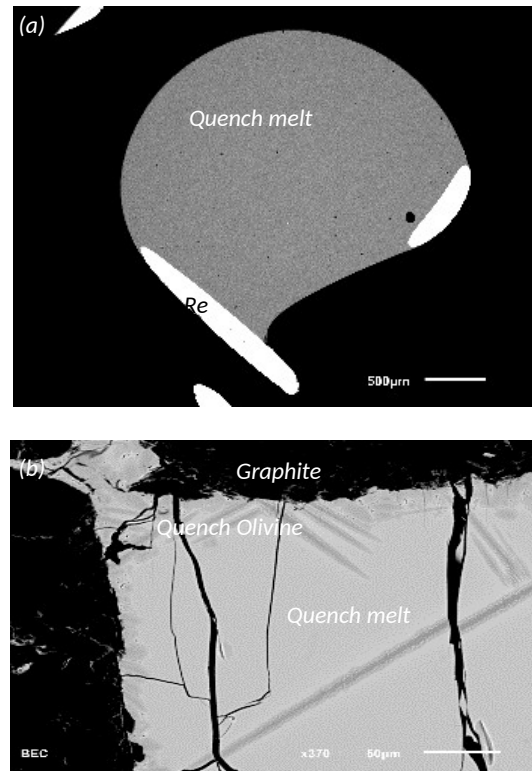


Figure 1 Back-scattered electron images of analyzed experimental glasses of (a) run product 236 a basaltic glass bead from 1-atm gas mixing experiment attached to Re-wire (b) GPC 771 picritic glass in graphite capsule with large homogeneous glass areas and quench olivine

Methodology:

Glass synthesis. Starting material compositions where synthesized in the in-house high-pressure and high-temperature laboratory from pure reagent oxides and carbonates. Powders where decarbonated, homogenized under acetone with mortar and pestle, vitrified, reground, and dried, before glass synthesis. Glass synthesis of 20 glass samples was done in a 1-atm gas-mixing furnaces (Figure 1a), 7 experimental glasses were synthesized in piston cylinder runs in Pt-graphite double capsules (Figure 1b). Samples were recovered from the runs after quench, embedded in epoxy and polished for further electron beam characterization

Determination of chemical compositions. For characterization, the mounts were carbon-coated,

examined in-house with a JEOL JSM 6510-LV scanning electron microscope and analyzed quantitatively with an electron probe microanalyzer (EPMA; JEOL JXA 8530 F 119 Hyperprobe).

Micro-FTIR spectral characterization. Regions of interest (ROIs) were identified with an optical microscope. IR measurements were performed with a dry air purged Hyperion 3000 FTIR microscope attached to a Bruker Vertex 80v spectrometer at the IRIS laboratory of the Institut für Planetologie, Universität Münster. A knife edge aperture (60 μm x 60 μm) was used to obtain specular reflectance spectra from ROIs only, and an MCT detector provided spectral information in the range between 3900 cm^{-1} and 600 cm^{-1} . All spectra were integrated over 128 scans to improve the signal-to-noise ratio and were measured against a commercial flat gold standard. All measurements were performed in dry air to eliminate atmospheric interferences.

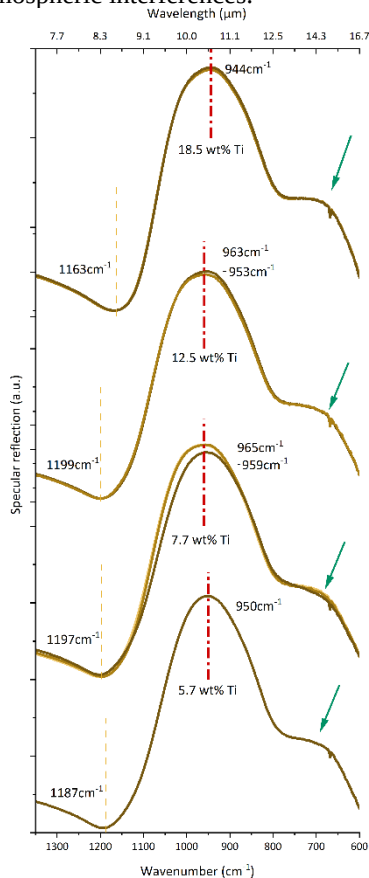


Figure 2 Glass IR-spectra of experimental samples containing different TiO_2 concentrations. Yellow dotted line = CF, red line = MB, green arrow = flank.

Results: Analyzed ROIs were spectrally free from small crystals and are optically smooth and homogeneous. The glass aliquots show a typical glass

spectrum, i.e., a nearly Gaussian shaped main band, an attached flank, and a CF. The exact locations of CF and mainband (MB) scatter across a relatively wide range between 1163 cm^{-1} (8.6 μm) and 1224 cm^{-1} (8.17 μm), and between 960 cm^{-1} (10.42 μm) and 991 cm^{-1} (10.09 μm) for CF and MB, respectively. The location of the CF reflects the distinct chemical composition of each aliquot, however the less scattering MB agrees with the silicate groundmass of each sample aliquot, as silicon/aluminium-oxygen bond oscillations are the source of this spectral feature (Figure 2).

Discussion and Outlook: Our preliminary data on high- TiO_2 basaltic glasses reveal a weak correlation between the increasing Ti-abundance in the glasses and the CF position. The MB is less sensitive to changes in TiO_2 than the CF. However, a small shift towards longer wavelength can be observed. This might be attributed to other oxide components that vary together with TiO_2 . There is a notable variation in the slope of the flank, which is attached to the MB (Figure 2). Dudko et al. [8] and references therein proposed a dependency of the slope on the concentration of e.g., sodium and non-bridging oxygen in the sample. Our aim is to understand the cation-interaction in order to deduce which chemical parameters besides the TiO_2 influence the spectra collected in this study.

We will compare the spectral laboratory data with planetary and terrestrial materials to evaluate if chemical fingerprinting of planetary materials (e.g., [9]) can be applied to high-Ti samples from the Moon [6].

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References: [1] Laurretta D.S. et al. (2017) *Space Sci Rev*, 212, 925–984. [2] Hiesinger H. et al. (2020) *Meteoritics & Planet Sci*, 32, A74. [3] King P. et al. (2004). [4] Mustard J.F. & Hays J.E. (1997) *Icarus*, 125(1), 145–163. [5] Cooper B.L. et al. (2002) *J Geophys Res Planets*, 107.E4: 1-1. [6] Gaddis L.R. et al. (2003) *Icarus*, 161, 262–280. [7] Che X. et al. (2021) *Sci*, 374(6569), 887–890. [8] Dudko Y.V. et al., *J Non Cryst Solids* 188(1–2), 87-92. [9] Pisello A. et al. (2022) *Icarus* (338).

Additional Information: Data will be made available in the planetary database IRIS (<http://bc-mertis-pi.uni-muenster.de/>).