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Raman Measurements of a Fine-Grained Labradorite Sample Heated to Typical Mercury Dayside Temperatures.

U. Böttger, J. Helbert, A. Maturilli and H.-W. Hübers

Institute of Planetary Research, DLR, Rutherfordstr.2, 12489 Berlin-Adlershof, Germany, (ute.boettger@dlr.de)

Abstract

Labradorite is considered as a Mercury surface analogue and is investigated for a better understanding of the processes on the surface of Mercury. For this purpose mid-infrared and Raman measurements of labradorite were performed in the Institute of Planetary Research at DLR in Berlin. The measurements indicate significant changes of the spectral features in the mid-infrared region at high temperatures and some of these changes were still observable after cooling the sample to room temperature. This led Helbert et al. [1] to the assumption that labradorite during the heating process undergoes an irreversible structural change. Here we present the Raman spectra of labradorite. The results are complementary to the mid-infrared measurements. As for the mid-infrared spectra the Raman spectra show differences for the heated and unheated samples.

Introduction

Analyzing the surface composition of Mercury's regolith from remote sensing measurements is a challenging task. To support the interpretation of data of recent missions like MESSENGER (NASA) and to prepare future missions like BepiColombo (ESA) to Mercury measurements of surface material analogues must be performed on Earth.

Labradorite is considered as a Mercury surface analogue and is investigated for a better understanding of the processes on the surface of Mercury. For this purpose mid - infrared and Raman measurements of labradorite were performed in the Institute of Planetary Research at DLR in Berlin. The mid-infrared-measurements were first presented by Helbert et al. [1]. These spectra indicate significant changes of the spectral features in the mid-infrared region at high temperatures and some of these changes were still observable after cooling the sample to room temperature. This led Helbert et al. [1] to the assumption that labradorite undergoes an irreversible structural change during the heating process. Here we present Raman spectra of the same samples of labradorite which are complementary to the mid-infrared measurements. The Raman spectra show differences for the heated and unheated samples.

The experimental setup and samples

Two samples of labradorite were investigated. The samples were powder like with a grain size less than 25 μm. The first sample was measured without any prior treatment. The second sample was heated in air for three days at a temperature of 420°C which corresponds to temperature on the dayside of Mercury. After heating it was cooled to room temperature and than analyzed.

The measurements were performed with a Raman microscope alpha300 system from Witec [2]. The spectral range covered 0 - 3800 cm^{-1} with a spectral resolution of 3 cm^{-1}. The sample was excited with a Nd:Yag laser of 532 nm wavelength and a maximum power of 15 mW on the sample. A 10x objective was used with a numerical aperture of 0.25 and a working distance of 12.5 mm. For 22 measurement the acquisition time was 40 s. For three measurements 250 spectra each taken within 1 s were averaged. This was done to consider the influence of the measurement procedure.

The diameter of the laser spot is 4 μm. However, due to the small grain size multiple reflections and refractions at grain boundaries broaden the region illuminated by the excitation laser beam [3]. The observed point on the sample hit by the laser beam is assumed to be representative for the considered sample. To take into account possible inhomogeneities of the sample the measurements were taken at different randomly chosen locations on the sample.

Results

The spectrum of labradorite is shown in figure 1. The change of ratio of the two peaks of the spectrum around 511 cm^{-1} and 283 cm^{-1} was analyzed. The two samples of labradorite (unheated and heated with subsequent cooling) were investigated: 10 single spectra and one averaged spectrum were analyzed for the not heated sample. 12 single spectra and two averaged spectra were analyzed for the heated sample.

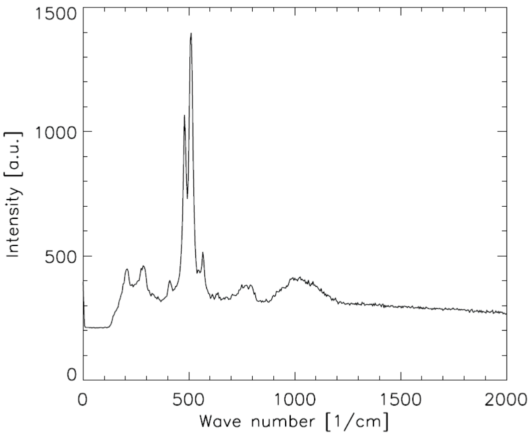

Figure 1: Raman spectrum of labradorite.

For each spectrum the following simplified procedure was applied to retrieve the height of the peaks at Raman shifts of 284 cm^{-1} and 511 cm^{-1}:

- The value of the minimum around 360 cm^{-1} was used as the reference level and was subtracted from the spectrum.
- The height of the peaks at 284 cm^{-1} and 511 cm^{-1} were determined relative to this reference level.
- Measurements with high fluorescence were excluded from the analysis, because this simplified procedure for calculating the height of the main peaks is not applicable to these spectra.

In figure 2 the values of the peak height at 511 cm^{-1} and 284 cm^{-1} (black-green) and 410 cm^{-1} (blue) are drawn versus each other.

From figure 2 it can be seen that the samples differ in the ratio of the height of the two main peaks. For the unheated sample the value at 284 cm^{-1} is larger than for the heated sample for similar values at 511 cm^{-1}. This effect is more obvious for higher intensities. Other Raman peaks e.g. at 410 cm^{-1} do not show such a relation, probably due to lower line intensities.

Thermal analysis of Raman spectra of albite and corresponding lattice dynamics calculations performed by McKeown [4] show that environments including larger atom clusters, such as bond angles between tetrahedra, differ significantly when crystalline albite and albite glass are compared. However, the temperatures reached in our experiment were far below the melting temperature. Thus, to confirm a structural alteration further analysis will be performed.

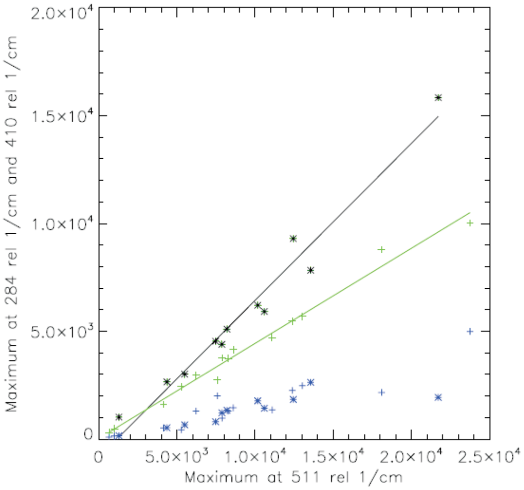

Figure 2: Peak height at 511 cm^{-1} drawn as a function of peak height at 284 cm^{-1} (black and green) and 410 cm^{-1} (blue) of not heated (*) and heated (+) samples.

Since the sample was heated in air, a chemical reaction with the atmosphere cannot be excluded. An oxidation or reduction of an iron-bearing component of the sample was considered as a less likely explanation, because the chemical analysis showed an FeO content below the detection limit.

In summary it can be said that the ratio between the line strengths at Raman shifts of 284 cm^{-1} and 511 cm^{-1} indicates an irreversible change in the heated and cooled down sample. To confirm a structural change X-ray diffraction measurements will be performed.

References

[1] Helbert J. and Maturilli, A.(2009) *EPSL)*, in press.

[2] ”WITec focus innovations” (2008) ”alpha300”, http://www.witec.de/en/products/raman/alpha300r/

[3] Huskin L.A. et al. (1997) *JGR*, 102 (E8), 19293–19306

[4] McKeown D.A. (2005), *American Mineralogist)*, 1506–1517.