EPSC Abstracts
Vol. 12, EPSC2018-333, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Analysis of reflectance spectra of enstatite-oldhamite mixtures for comparison with 2867 Šteins

Kathrin Markus (1), Gabriele Arnold (2), Lyuba Moroz (3,2), Daniela Henckel (2,4), and Harald Hiesinger (1)
(1) Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Germany (kathrin.markus@uni-muenster.de), (2) DLR, Institut für Planetenforschung, Berlin, Germany, (3) Institut für Erd- und Umweltwissenschaften, Universität Potsdam, Germany, (4) Institut für Geologische Wissenschaften, Freie Universität Berlin, Germany.

Abstract

We present 0.3-17 µm reflectance spectra of synthetic orthoenstatite ($Mg_2Si_2O_6$), synthetic oldhamite (CaS), and their mixtures that can be used as analogue materials for comparison with E[II]-type asteroids like 2867 Šteins. We investigate the spectral behavior of the mixtures in regard to their oldhamite content and especially the changes in band depth in the VIS.

1. Introduction

2867 Šteins is a main belt asteroid and was discovered in 1969 [1]. It was a fly-by target of ESA's Rosetta mission in 2008 [2] and was previously studied with ground-based observations (e.g., [3,4,5,6,7,8]). It was classified as an E[II]-type asteroid [3]. E-type asteroids are characterized by high geometric albedos and flat or slightly reddish and featureless VIS and NIR reflectance spectra and are generally linked to the enstatite achondrites aubrites [9]. The E[II]-subtype asteroids show a strong absorption band at ~0.49 µm, and sometimes a weaker band at ~0.96 µm [10]. These absorption bands are attributed to oldhamite [11]. However, oldhamite usually only occurs as an accessory mineral in aubrites [12] while the required abundance of oldhamite needed to reproduce the absorption band in mathematical model mixtures is much higher (>40%) [4,5]. As a member of the E[II]-type asteroids, Šteins shows these absorptions bands. The depth of the absorption band at 0.49 µm is reported to be 9-13 % [4,6,7,8]. We present laboratory reflectance spectra of mixtures between synthetic orthoenstatite [13] and synthetic oldhamite for the comparison with reflectance spectra of Šteins and discuss the changes in the strength of the visible absorption band in relation to the oldhamite content of the mixtures.

2. Laboratory measurements

We collected biconical reflectance spectra from 0.3 to 17 µm of mixtures of synthetic orthoenstatite and oldhamite. All spectra were measured in vacuum using a Bruker Vertex VERTEX 80v FTIR-spectrometer at the Planetary Spectroscopy Laboratory (PSL) of the Institute of Planetary Research at DLR, Berlin. The same setup as in [13] was used. The orthoenstatite sample was synthesized and characterized in [13]. The composition of the sample is $En_{99.9}Fs_{0.03}Wo_{0.0}$ [13]. The oldhamite sample was obtained as synthetic calcium sulfide (99.95 %, CAS #20548-54-3) from abcr GmbH. We verified our CaS sample being crystalline oldhamite by using XRPD at the Institute for Mineralogy at the University Münster. Mixtures of the two endmembers were produced in 10 vol% steps with additional mixtures with 5, 3, and 1 vol% oldhamite. The weighted sample materials for each mixture were mechanically mixed for at least 30 minutes.

3. Reflectance spectra

The oldhamite spectrum shows a major absorption band at 0.41 µm. The depth of the absorption band is 6.0 % relative to a fitted linear continuum and calculated as the difference between the reflectance of the continuum and the spectrum at the band minimum. The spectrum is characterized by the red continuum slope throughout the near UV and visible ranges. Spectra from 0.3-1 µm of the endmembers and the mixtures are shown in Figure 1. The depth of the absorption band decreases with decreasing amount of oldhamite in the mixtures (Fig. 2). At oldhamite contents <20 vol% the depth of the absorption bands changes rapidly while the change is much slower at oldhamite contents between 20 and 100 vol%.

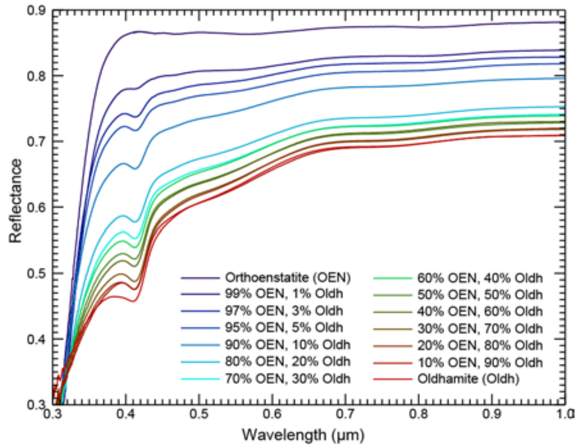

Figure 1: Reflectance spectra of orthoenstatite, oldhamite, and their mixtures from 0.3 to1 µm. Composition of mixtures is given in vol%.

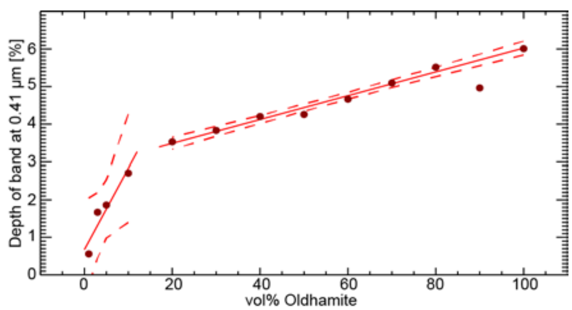

Figure 2: Depth of the absorption band at 0.41 µm. Linear fits are displayed as a continuous line. 2σ uncertainties of the fits are shown as dashed lines. The value at 90 vol% oldhamite has been excluded from the fit as an outlier.

In the MIR the oldhamite spectrum shows a much higher overall reflectance than the orthoenstatite and several broad absorption bands (e.g., between 6 µm and 7.4 µm and at 8.9 µm and 10.5 µm). A very narrow absorption band is visible at 6.59 µm. The detailed description of the orthoenstatite spectral features is provided in [13]. The spectra of the mixtures with 1, 2, 5, and 10 vol% of oldhamite are almost identical to the orthoenstatite spectrum, especially in the Reststrahlen bands. The spectra of mixtures with ≥20 vol% oldhamite show a significant increase in overall reflectance. The absorption band at 6.59 µm is clearly visible in all spectra of mixtures with ≥20 vol% oldhamite. In the spectra of the mixtures with 10 vol%, 5 vol%, and 3 vol% oldhamite it is only visible as a weak feature.

4. Conclusion

Our laboratory measurements of synthetic oldhamite does not show the absorption band at 0.49 µm observed in E[II]-type asteroids and oldhamite picked from the aubrite Norton County [11]. Instead, our spectra show an absorption band at 0.41 µm, which was previously also reported in [14]. Therefore, the spectra of our mixtures do not enable us to constrain the oldhamite abundance needed to reproduce the absorption band observed in Šteins' spectra. However, our data on the depth of the absorption band at 0.41 µm shows, that the depths does not follow a simple linear trend. [4] and [5] used areal (linear) mixing models for their estimates of the composition of Šteins. A linear trend would overestimate the required abundance of oldhamite for a given band depth. In the MIR our spectra show that oldhamite contents <20 vol% do not alter the spectral features typical for enstatite.

References

[1] IAU Minor Planet Center: www.minorplanetcenter.net/iau/lists/NumberedMPs000001.html, Last updated: 04.05.2018

[2] Keller, H.U. et al.: Science 327, 190-193, 2010.

[3] Barucci, M.A. et al.: Astronomy & Astrophysics 430, 313-317, 2005.

[4] Nedelcu, D.A. et al.: Astronomy & Astrophysics 473, L33-L36, 2007.

[5] Dotto, E. et al.: Astronomy & Astrophysics 494, L29-L32, 2009.

[6] Fornasier, S. et al.: Astronomy & Astrophysics 474, L29-L32, 2007.

[7] Fornasier, S. et al.: Icarus 196, 119-134, 2008.

[8] Weissman, P.R et al.: Meteoritics & Planetary Science 43, 905-914, 2008.

[9] Gaffey, M.J. et al.: Meteoritics 28, 161-187, 1993.

[10] Gaffey, M.J., Kelley, M.S.: Lunar and Planetary Science Conference XXXV #1812, 2004.

[11] Burbine, T.H. et al.: Meteoritics & Planetary Science 37, 1233-1244, 2002.

[12] Keil, K.: Chemie der Erde - Geochemistry 70, 295-317, 2010.

[13] Markus, K. et al.: Planetary and Space Science, In Press, 2018.

[14] Izawa, M.R.M. et al.: Icarus, 226, 1612-1617, 2013.