EPSC2018

LFI2 abstracts

13 Sep 2018 15:37:44

EPSC Abstracts
Vol. 12, EPSC2018-11, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Dust Loading and Pressure Drop of Fibrous Filters for Atmospheric In-Situ Resource Utilisation on Mars 2020

John B. McClean (1), Jonathan P. Merrison (2), J. Jacob Iversen (2), W. Thomas Pike (1), and the MOXIE science team
(1) Imperial College London, South Kensington Campus, SW7 2AZ, London, United Kingdom (j.mcclean15@imperial.ac.uk)
(2) Institute of Physics and Astronomy, Aarhus University, Ny Munkegade 120, Building 1520, Aarhus 8000 C, Denmark

Abstract

The Mars Oxygen In-Situ Resource Utilisation Experiment (MOXIE) on the Mars 2020 rover will produce oxygen from atmospheric carbon dioxide. Dust presents a risk to MOXIE as it may clog the inlet filter. We report the results of an experimental investigation into the dust loading and pressure drop of a MOXIE flight filter and several other filter configurations in simulated Mars conditions. Dust loadings of up to 44 g m^{-2} were achieved at which a doubling of pressure drop across the filter and ground support equipment was observed. This establishes a quantitative relationship between dust loading and pressure drop for the MOXIE flight filter media.

Introduction

In-Situ Resource Utilisation (ISRU) will be demonstrated by the Mars Oxygen ISRU Experiment (MOXIE) on NASA's Mars 2020 rover [1]. MOXIE will produce O_2 by solid oxide electrolysis of Mars' atmospheric CO_2. To protect MOXIE from dust, a High Efficiency Particulate Arrestance (HEPA) filter is fitted at the intake. As the filter dust loading (dust mass per unit filter media area) increases, the filter pressure drop also increases. HEPA filter performance in Mars conditions is poorly understood. Previous work [3] achieved a modest dust loading of 0.03 g m^{-2} and detected no increase in filter pressure drop, concluding that dust is unlikely to pose a problem during MOXIE's operational lifetime (~30 hr), but left open the question of filter performance over the longer term (1200 hr, extensibility goal). The current investigation addresses two objectives using simulated Mars atmospheric conditions (10 mbar CO_2): (1) determine the dust loading as a function of time for a range of dust particle sizes and filter configurations; and (2) determine the filter pressure drop as a function of dust loading.

Equipment

The Mars Simulation Laboratory at the University of Aarhus has several recirculating wind tunnels to study dust transport [2]. The first objective (dust loading vs. time) was addressed using the large wind tunnel (Fig. 1). Five filter configurations were tested: one pleated flight filter (in position 3), and four flat filters. To investigate the effect of pumping on dust loading, filters in positions 3, 4, and 5 were connected to a pump, whereas filters in positions 1 and 2 were not. Filters in positions 1, 3, and 5 were fitted with baffles to examine their effectiveness at reducing dust load.

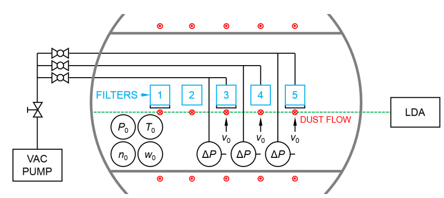

Figure 1: Experimental set-up, large wind tunnel.

The second objective (pressure drop vs. dust loading) was addressed using the small wind tunnel (Fig. 2). Three flat filters were tested: one using flight filter media (position 3), and two using an equivalent media (positions 2 and 4). Filters in positions 2 and 3 were connected to a pump. A calibration plate (position 1) was included to monitor dust loading.

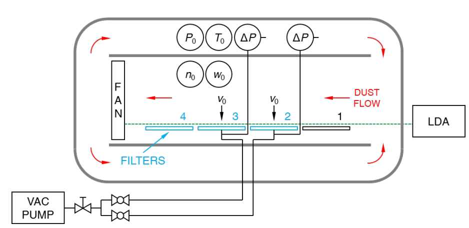

Figure 2: Experimental set-up, small wind tunnel.

Procedure

Clean filters were weighed and the pressure drops ΔP across them measured for inlet face velocities v_0 representative of MOXIE (0–8 cm s^{-1}) and above (up to 18 cm s^{-1}). Filters were then loaded with dust. Filters in the large wind tunnel were exposed to the equivalent of 1200 hours at an average dust particle number density n_0 of 4 cm^{-3} in CO_2 at a pressure P_0 of 10.3 mbar and horizontal wind speed w_0 of 3 m s^{-1}, for each dust Particle Size Distribution (PSD): the Martian dust analogue Salten Skov, mean diameter 2 µm [4], and soda-lime glass microspheres, mean diameters 4 µm and 10 µm. Filters in the small wind tunnel were loaded as rapidly as possible with Salten Skov only. The pressure drops ΔP across the loaded filters were measured, and the loaded filters weighed. All experiments were at room temperature T_0 (295 K).

Results

Dust loading rates for filters in the large wind tunnel are reported in Table 1. Pressure drops before and after dust exposure are plotted in Fig. 4. Images of filters are shown in Fig. 3 and Fig. 4.

Table 1: Dust loading rates, large wind tunnel. Passive filters (positions 1 and 2, not connected to a pump) saw negligible dust accumulation.

Filter position and type	Equivalent dust loading rate (mg m^{-2} hr^{-1})		
	Salten Skov simulant $d_p \approx 2$ µm	Soda-lime glass microspheres $d_p \approx 4$ µm	Soda-lime glass microspheres $d_p \approx 10$ µm
3: Flight, baffled	$(44 \pm 30)\times10^{-3}$	$(180 \pm 50)\times10^{-3}$	$(88 \pm 40)\times10^{-3}$
4: Flat, unbaffled	3.6 ± 0.4	2.3 ± 0.4	0.45 ± 0.4
5: Flat, baffled	2.7 ± 0.4	1.8 ± 0.4	0.45 ± 0.4

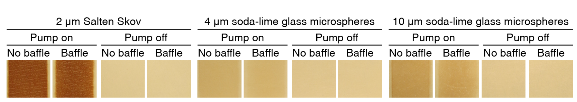

Figure 3: Colouration of filters after exposure to dust in the large wind tunnel.

Discussion

Dust loading rates for smaller dust particles were generally higher than for larger dust particles.

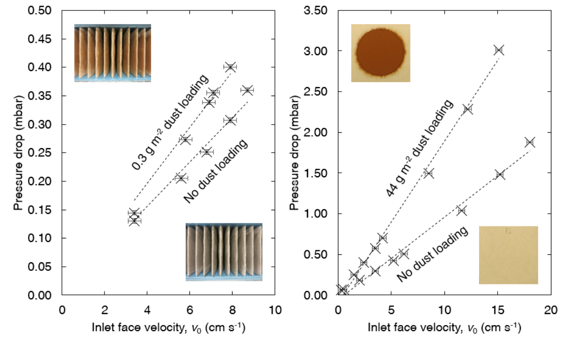

Figure 4: Pressure drop across filter and ground support equipment versus inlet face velocity, before and after dust loading, for the pleated flight filter (left, position 3, large wind tunnel) and flat flight filter media (right, position 3, small wind tunnel).

Passive filters saw negligible dust accumulation. The most heavily loaded flat filter (44 g m^{-2}) appeared caked and a doubling of pressure drop (including ground support equipment) was seen (Fig. 4). Future work has been proposed to examine dust loadings between 0 and 44 g m^{-2} to detect the onset of filter caking, the sizing case for atmospheric ISRU.

Acknowledgements

Funding provided by Europlanet, UK Space Agency, and the Val O’Donoghue scholarship. Europlanet 2020 RI has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 654208.

References

[1] Hecht, M. H. and Hoffman, J. A.: The Mars Oxygen ISRU Experiment (MOXIE) on the Mars 2020 Rover, 46th Lunar and Planetary Science Conference, 16-20 March 2015, The Woodlands, TX, 2015. Abstract #2774.

[2] Holstein-Rathlou, C. et al.: An Environmental Wind Tunnel Facility for Testing Meteorological Sensor Systems, J. Atm. Oceanic Tech., Vol. 31, No. 2, pp. 447–457, 2014.

[3] McClean, J. B. et al.: Testing the Mars 2020 Oxygen In-Situ Resource Utilization Experiment (MOXIE) HEPA Filter and Scroll Pump in Simulated Mars Conditions, 48th Lunar and Planetary Science Conference, 20-24 March 2017, The Woodlands, TX, 2017. Abstract #2410.

[4] Nørnberg, P. et al.: Salten Skov I: A Martian magnetic dust analogue, Planet. Space Sci., Vol. 57, Nos. 5-6, pp. 628–631, 2009.

EPSC Abstracts
Vol. 12, EPSC2018-58, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Research using a European Planetary Simulation Facility

J. P. Merrison, J.J. Iversen, K.R. Rasmussen
[1]Institute of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus C, Denmark
(merrison@phys.au.dk/ Fax: +45-86120740)

Abstract

This unique and recently improved planetary simulation facility is capable of re-creating extreme terrestrial, Martian and other planetary environments. It is supported by EU activities including **Europlanet 2020 RI** here the latest research and networking activities will be presented. This facility is also used as a test facility by ESA for the forthcoming ExoMars 2020 mission. Specifically it is capable of recreating the key physical parameters such as temperature, pressure (gas composition), wind flow and importantly the suspension/transport of dust or sand particulates. This facility is available both to the scientific and Industrial communities.

1. Europlanet Transnational Access

This environmental simulator facility is utilized for a broad range of research programs including; the study of other planets (such as Mars), for recreating extreme terrestrial environments, or in specific investigations involving aerosols and other forms of particulate transport. The facility is also involved in the Europlanet 2020 Research Infrastructure through which a trans-national access program is allowing numerous research groups access to this facility. Some selected recent projects are listed below;

- Polar CO_2 ice on Mars (G. Portyankina et al., Bern CH) [6]
- LIBS system on Mars2020 (N. Murdoch et al., ISAE France) [4]
- Volcanic ash transport (J. Taddeucci et al. INGV, Italy)
- Ice Jets on Enceladus (A. Davila, NASA USA)
- High speed Jets (J. Sesterhenn, TUB Germany)
- In-situ utilization on Mars2020 and dust loading (J. McClean Imperial UK)
- Passive acoustic wind sensor on Mars (R. Lorenz, John Hopkins University USA)

Other activities include the development, testing and calibration of sensor and planetary lander systems, both for ESA and NASA. Currently testing for missions ExoMars 2020 and Mars 2020 are being carried out.

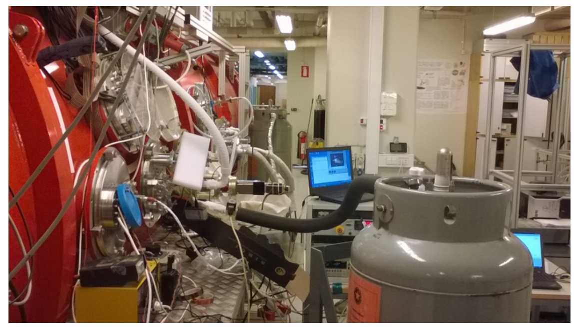

Figure 1 The main Planetary Simulation Facility during early use of the new liquid nitrogen atmospheric cooling system (for ExoMars 2020 testing).

2. Improved design and operation

The simulator consists of a 35m^3 environmental (thermal-vacuum) chamber within which a re-circulating wind tunnel is housed [1,2,6]. The wind is generated by a set of two fans which draw flow down the 2m×1m tunnel section and return it above and below. The test section can be fully removed for access. Wind speeds in the range 1-40 m/s have been demonstrated.
Cooling is achieved by a novel liquid nitrogen flow system which has achieved temperatures below -160ºC. The inner chamber is thermally isolated from the vacuum chamber.
Improved functionalities of this facility (funded by Europlanet 2020RI) include the implementation of;

- An atmospheric (gas) cooling system (fig 1) allowing independent control of the air temperature (tested to -50°C),
- A particle image velocimetry (PIV) system has been installed consisting of high speed imaging and laser illumination (fig 3).
- An LED based ultraviolet (UV) light source has been implemented capable of simulating the solar UV spectrum.

3. Atmospherics and Aerosols

A unique capability of this wind tunnel facility is the production and controlled study of suspended particulates (dust, ash, sand, etc.). The combination of low pressure, low temperature, composition and aerosol injection is ideal for recreating the environment of the upper atmosphere of terrestrial planets, gas giants or even moons). This type of experiment is a continuation of a large body of research performed over the past decade studying dust aerosols, specifically granular electrification, erosion and deposition processes [1-3]. This research has direct relevance to aerosol studies on Earth which impact air quality, the environment and climate. An advanced type of Laser aerosol and (2D) wind flow sensor is used for detailed study and control of these environmental parameters (fig 2).

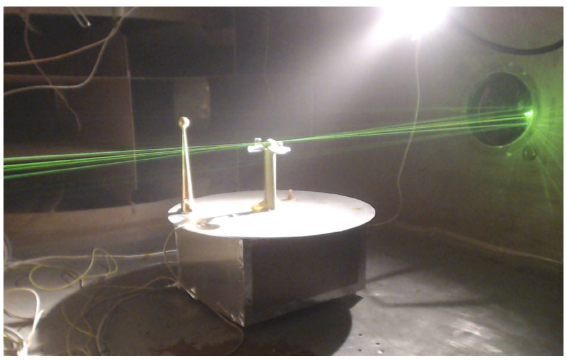

Figure 2 Europlanet funded testing of the DREAMS sensor systems on the ExoMars 2016 (Schiaparelli) lander showing the Laser based wind/dust sensor used for aerosol studies [5].

4. Planetary Surface Simulation

With control of wind flow at low pressure and temperature this facility is well suited for recreating the environment at the surfaces of terrestrial type planets such as Mars, Earth and Titan. The interaction of wind and the planetary surface, specifically the transport of sand and dust is fundamental to understanding the evolution of the planets' surface and atmosphere. Laboratory studies of the entrainment, flow, deposition and erosion are scarce and empirical in nature. The effects of low atmospheric pressure, composition, temperature and even gravity can now be studied in detail. For example detailed measurements of sand grain trajectories are now being made under Martian pressure and composition in wind tunnel studies. This has direct relevance to the recent and still poorly understood observations of active sand transport at the Martian surface.

Figure 3 Inside the simulator during pre-testing of SuperCam for NASAs Mars2020 mission, related projects also funded by Europlanet [4].

5. Conclusion

This planetary simulation facility has many unique and recently improved features which make it well suited for both planetary research applications and the development/testing of instrumentation. Details of some of the most recent collaborative research activities will be summarized. For information on access to this facility please contact the author.

Acknowledgements

This laboratory is a member of Europlanet 2020 RI which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

References

[1] J.P. Merrison, Aeolian Research. 4, 1–16 (2012)
[2] C. Holstein-Rathlou, et al., American Meteorological Society, 31, 447 (2014)
[3] S. Alois et al., Journal of Aerosol Science 106, 1–10, (2017)
[4] Murdoch, N., et al., Planetary and Space Science, Laser-Induced Breakdown Spectroscopy acoustic testing of the Mars 2020 Microphone, subm. (2018)
[5] Colombatti et al., 2018, MarsTEM sensor simulations in Martian dust environment, Measurement 122 (2018) 453–458
[6] G. Portyankina et al., ICARUS, Laboratory investigations of the physical state of CO2 ice in a simulated Martian environment, accpt. (2018)

EPSC Abstracts
Vol. 12, EPSC2018-92-1, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Emissivity and reflectance spectra of sulfide-bearing samples: new constraints for the hermean surface composition.

Giovanna Serventi (1), Cristian Carli (2), Alessandro Maturilli (3), Sabrina Ferrari (4), Maria Sgavetti (1), Arianna Secchiari (1), Alessandra Montanini (1) and Jorn Helbert (3)
(1) Department of Chemistry, Life Science and Environmental Sustainability, Parma University, Italy, (2) IAPS-Inaf, Tor Vergata, Rome, Italy (3) DLR, Berlin, Germany and (4) CISAS, University of Padova, Italy

Abstract

Mercury is an extreme planet with the largest temperature excursion in the Solar System that may affect spectral properties of the surface. Evidences suggest plagioclase, pyroxene, and olivine, with lesser amounts of quartz as possible mineralogy of Mercury's surface. Furthermore, the presence of abundant sulfide in hollows has been proposed. Here, we measure the emissivity and reflectance of mixtures composed of a silicate and a sulfide component at different temperatures.

1. Introduction

Mercury is an extreme planet, the smallest, the closest to the Sun, and the planet with the largest temperature excursion in the Solar System, from ca. -180°C to ca. 430°C. This high temperature range may affect spectral properties of the surface.
Recently, X-ray [1], and Gamma-ray and Neutron [2] spectrometers, onboard the MESSENGER mission, concluded that the hermean surface is Mg-richer and Al, Ca and Fe-poorer than Moon and Earth and enriched in volatiles and alkalis as [3].
Petrological models were proposed to infer the possible mineralogies exposed on the surface of Mercury. Generally, hypothesized SiO_2 values for the hermean surface is higher than those on Moon and more similar to terrestrial values, thus suggesting evolved compositions. [4] constrained the potential mineralogy of Mercury's surface as dominated by plagioclase, pyroxene, olivine, with lesser amounts of quartz, and with compositions varying from alkali-rich komatiites to boninites. Furthermore, some peculiar mineralogical assemblages were suggested, like the presence of abundant sulfides in hollows [5].
[6] already demonstrated how Visible and Near-Infrared (VNIR) spectral properties of sulfides are modified by the heating at hermean temperatures, and how the temperature acts differently on sulfides with variable chemistry. However, a detailed literature about the spectral behavior of mixtures composed with hermean-like minerals (e.g., sulfides) under different temperature conditions still lacks.
We, thus, propose to measure both the reflectance and the emissivity of mixtures composed of a silicate and a sulfide component in the VIS-MIR (Visible-Mid Infrared) and in the TIR (Thermal Infrared) ranges at PSL (Planetary Spectroscopy Laboratory) at DLR, Berlin.

2. Methodology

We measured the reflectance spectra in VIS_MIR range (0.4-16 μm) and the emissivity of size-intimate mixtures of different end-members. Considering the mineralogies proposed for the surface of Mercury, we select 2 end-members: 1) a Mg-rich gabbronorite sample [7] and 2) a Ca-sulfide, both at a fine grain size (<63 μm). Starting from these end-members, mixtures are prepared, with increasing sulfide abundances% (80, 60 and 40%, respectively). Emissivity spectra were acquired at four different temperature, 100°C, 200°C, 300°C and 400°C; reflectance spectra (i=13°; e=17°, 0.8mbar) were acquired from both fresh and heated samples.

3. Results

Here we present preliminary results for CaS measurements. Fig. 1 shows the reflectance spectra of CaS before and after the thermal process. The heating process (pink spectra) produces a reflectance increase and a spectral contrast decrease in the VIS range (Fig. 1a). Differences are evident also in the MIR, such as the appearance of new structures after the thermal process (see arrows in figure 1). Spectra will be deconvolved using different models (e.g., Modified Gaussian Model-MGM [8]) to evaluate possible variations (e.g., band center).

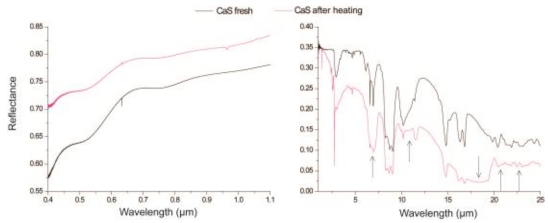

Figure 1 Reflectance spectra of CaS before (black spectra) and after heating at 400°C (pink spectra).

Fig. 2 reports the emissivity spectra of CaS at four different temperatures, showing how spectral features are affected by the sample temperature.

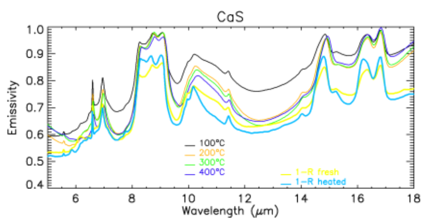

Figure 2 Emissivity spectra of CaS at surface temperature varying between 100°C (black spectrum) and 400°C (blue spectrum).

4. Conclusions

In this work we analyse in detail the spectroscopic behaviour of sulfide-bearing silicatic mixtures. These mixtures are important to understand the influences of different amounts of sulphide on spectra from hermean regolith. Furthermore, MESSENGER mission highlighted how a relatively short spectral range cannot be sufficient to understand the mineralogy and the composition of Mercury surface. The new mission Bepicolombo will work with image spectrometers both in the VNIR and in TIR. For this reason, we want to combine VNIR-MIR wavelengths with TIR range.

Our work will help to define indicators useful to analyze remote sensed data. Moreover, we will contribute to the creation of a spectral library to which compare results from orbit. Experience from laboratory analyses is fundamental to analyze data both from VIHI (Visible and Infrared Hyperspectral Imager) and MERTIS (Mercury Radiometer and Thermal Imaging Spectrometer).

Acknowledgements

Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

References

[1] Schlemm, C. E., II, et al., 2007. The X-Ray Spectrometer on the MESSENGER spacecraft, Space Sci. Rev., 131, 393–415, doi:10.1007/ s11214-007-9248-5.

[2] Goldsten, J.O., et al., 2007. The MESSENGER Gamma-ray and Neutron spectrometer. Spac. Sci. Rev., 131, 339-391.

[3] Braden, S.E., Robinson, M.S., 2013. Relative rates of optical maturation of regolith on Mercury and the Moon. JGR, 118, 1903-1914.

[4] E. Vander Kaaden, K., et al., 2017. Geochemistry, mineralogy, and petrology of boninitic and komatiitic rocks on the mercurian surface: Insights into the mercurian mantle. Icarus, 285: p. 155-168.

[5] Vilas, F., et al., 2016 Mineralogical indicators of Mercury's hollows composition in MESSENGER color observations. Geophysical Research Letters, 43(4): p. 1450-1456.

[6] Helbert, J., A. Maturilli, and M. D'Amore, 2013. Visible and near-infrared reflectance spectra of thermally processed synthetic sulfides as a potential analog for the hollow forming materials on Mercury, Earth Planet. Sci. Lett. 369, 233 – 238.

[6] Secchiari, A., Montanini, A., Bosch, D., Macera, P., Cluzel, D., submitted on Contributions to Mineralogy and Petrology. The constrasting geochemical message from the New Caledonia gabbronorties: insights on depletion and contamination processes of the sub-arc mantle in a nascent arc setting.

[7] Sunshine, J.M., et al., 1990. Deconvolution of mineral absorption bands: an improved approach. J. Geophys. Res., Vol. 95, 6955-6966.

EPSC Abstracts
Vol. 12, EPSC2018-239, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Emissivity and reflectance measurements of particulate mixtures for the interpretation of planetary remote sensing data

G. Alemanno(1), A. Maturilli(2), J. Helbert(2), A. Galiano(3,4)

(1) Institut d'Astrophysique Spatiale, CNRS, UMR-8617, Universite´ Paris-Sud, bâtiment 121, F-91405 Orsay Cedex, France, giulia.alemanno@ias.u-psud.fr
(2) Institute for Planetary Research, German Aerospace Center DLR, Rutherfordstr. 2, 12489 Berlin, Germany
(3) INAF-IAPS, Via Fosso del Cavaliere 100, 00133 Rome, Italy
(4) Università degli Studi di Roma Tor Vergata, Rome, Italy

Abstract

Without laboratory measurements, most of the planetary data are ambiguous and difficult to be interpreted. So far, many data collected in laboratory for several materials under various environmental conditions have been used to develop spectral libraries, analytical models, and databases for the interpretation of remote sensing data. But as planetary observations and instrumentation become more diverse and sophisticated many laboratory studies are needed to support the interpretation of these ever-expanding data sets. We are performing a systematic study on the spectral behavior of particulate mixtures of planetary analogues materials. This study is a key for a better interpretation of the planetary orbital data resulting in a careful detection of the materials present on a planetary surface.

1. Introduction

The fundamental question connected to the study of any Solar System object is: what is it made of? In addition, the composition of the surface of planetary objects records the history of their formation and the subsequent alteration over time. The mineralogy and chemistry of a planetary surface is also connected to other valuable information about the planet, ranging from its interiors to the potential habitability.

Spectroscopic data collected remotely using orbital instrument provide a powerful tool of investigation of a planetary surface mineralogy [1,2,3]. Many spectroscopic instruments are already in orbit around Mars, as for example: OMEGA (Observatoire pour la Mineralogie, l'Eau, le Glace e l'Activite, Mars Express spectrometer); CRISM (Compact Reconnaissance Imaging Spectrometer for Mars, Mars Reconnaissance Orbiter instrument); the most recent NOMAD spectrometer (Nadir and Occultation for MArs Discovery) and its ancestors TES (Thermal Emission Spectrometer, Mars Global Surveyor instrument) and PFS (Planetary Fourier Spectrometer, onboard Mars Express).

Other planetary bodies have been visited from orbital spectrometers: for example, the comet 67P/C-G (Visible and InfraRed Thermal Imaging Spectrometer VIRTIS, Rosetta instrument), the dwarf planet Ceres (Visual and Infrared Imaging Spectrometer VIR / Dawn instrument). In the next 5 years, new spectral instruments will be sent for orbital and in-situ analysis of planetary bodies: as for Mercury (MErcury Radiometer and Thermal infrared Imaging Spectrometer, MERTIS instrument payload of BepiColombo mission), the C-type asteroid (Hayabusa II mission), the Mars Phobos satellite (Mars Moons eXploration, MMX mission) and the upcoming Martian rovers that will perform in-situ IR spectroscopic instruments of the planet surface (ESA ExoMars and NASA Mars 2020 missions). However, while remote sensing and in situ data can allow us to address the surface composition of planetary surfaces, laboratory measurements are required to translate those data into knowledge. In fact, band shapes and depths are affected by composition and structures of the materials, but also by their physical/textural properties, including grain size distribution, surface roughness, packing density, crystallinity, and preferential orientation of crystals [4]. Detailed information is needed about wavelength positions, shapes and contrasts of absorption or emission bands of relevant materials.

Since any planetary surface is composed by mixtures of different materials and rocks, a good understanding of their spectral behavior, both in reflectance and in emissivity, is necessary for a good interpretation of orbital data. So far not many studies on the spectral behavior of particulate mixtures both in reflectance and/or emissivity for planetary analogues materials have been done [5, 6, 7, 8]. A systematic study of the spectral behavior of mixtures with different grain size, percentage of mixtures etc., is needed for a better interpretation of the high quantity remote sensing data continually obtained from the orbital instruments.

2. Data and methods

The main steps of our study are: - Emissivity and reflectance characterization of particulate mixtures; - Comparison between emission, bidirectional and hemispherical reflectance spectra of particulate samples; - Systematic study of parameters influencing the spectral behavior of laboratory mixtures; - Interpretation of remote sensing data of the planetary surfaces.

The samples were prepared starting from the bulk material and reducing it in powders with different grain size. To do that each material was sieved in several granulometric classes.

Materials considered as Martian analogues such as silicates, carbonates, oxides and sulfates have been selected for the first part of our work. We prepared samples of pure materials and mixtures of them. In particular: (1) mixtures of a phyllosilicate with two end-member of carbonates with different grain size, for granulometric and spectroscopic analysis; (2) mixtures of oxides with silicates to analyze the effect of oxides on silicates spectra.

We performed our emissivity and bi-directional measurements at the Planetary Spectroscopy Laboratory (PSL) facility at the DLR (Deutsches Zentrum für Luft- und Raumfahrt) in Berlin. The selected samples were measured in emissivity in two different configurations: in the vacuum chamber; in the air chamber. In the first case the sample was heated up to 200°C, and four different measurements were taken at the temperatures 50°C, 100°C, 150°C and 200°C. The progress of each experiment was monitored using an internal webcam and two temperature sensors: one located at the base of the sample holder and another at the sample surface. A picture of the sample was taken at each step.

Then the same sample was heated again but in air up to 150°C and measurements was performed at 50°C, 100°C and 150°C. Finally, all the heated samples were measured in reflectance to study any possible spectral change in the spectra after the heating process.

The hemispherical reflectance of our samples was measured at the Planetology Laboratory of Lecce by means of two spectrometers: one in UV-VIS and NIR range 0.2-2.5 µm and one in 2-25 µm.

3. Spectral parameters retrieved

We analyzed spectral parameters relative to absorption bands in reflectance spectra. Each absorption band was isolated by fitting and removing the spectral continuum. Spectral parameters as Band Center (BC), Band Depth (BD), Band Area (BA) and Full Width Half Maximum (FWHM) were measured. The BC is the wavelength corresponding to the minimum reflectance value in the isolated absorption bands and the BD is obtained as $1-R_b/R_c$, (R_b is the reflectance at the band center and R_c is the reflectance of the continuum) [9]. The BA was estimated as the sum of rectangles included in the absorption band, with a width corresponding to the spectral sampling. The FWHM is the width of absorption band estimated at a distance from the level of continuum that is half height of isolated absorption band. As preliminary results, a shift in the band center position is observed when samples are progressively heated and even band depth, band area and full width half maximum show interesting trends.

Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208

References

[1] Ehlmann B.L. and Edwards S.E.: 2014, Mineralogy of the Martian Surface, Ann. Rev. Earth Planet. Sci., 42, 291.

[2] Farmer V.C.: 1974, in The Infra-Red Spectra of Minerals, ed V.C. Farmer.

[3] Clark R.N.: 1995, in Rock Physics & Phase Relations: A Handbook of Physical Constants, ed. T.J. Ahrens.

[4] Maturilli, A., Helbert, J., D'Amore, M.: 2009, Phyllosilicates detection in Syrtis Major and Mawrth Vallis of Mars from PFS measured spectra, EPSC Conference, Abstract # EPSC2009-106.

[5] Roush T.L. and Orenberg J.B.: 1996, Estimated detectability limits of iron-substituted montmorillonite clay on Mars from thermal emission spectra of clay-palagonite physical mixtures. Jou. Geophys. Res., 101, 26111.

[6] Fonti S. et al.: 2010, Infrared reflectance spectra of particulate mixtures, Jou. Geophys. Res., 115, 1.

[7] Carli C. et al.: 2014, Spectral variability of plagioclase-mafic mixtures (2): Investigation of the optical constant and retrieved mineral abundance dependence on particle size distribution. Icarus, 235, 207.

[8] Roush T.L. et al.: 2015, Laboratory reflectance spectra of clay minerals mixed with Mars analog materials: Toward enabling quantitative clay abundances from Mars spectra. Icarus, 258, 454.

[9] Clark and Roush: 1984, Reflectance spectroscopy - Quantitative analysis techniques for remote sensing applications. Jou. Geophys. Res 89, Nr B7, pp.6329-6340

EPSC Abstracts
Vol. 12, EPSC2018-288, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Europlanet Distributed Planetary Simulation and Sample Analysis Facility: The Center for Microbial Life Detection

Christine Moissl-Eichinger and Kaisa Koskinen
Medical University of Graz, Austria (christine.moissl-eichinger@medunigraz.at)

Abstract

Within the Europlanet activity, the Center for microbial Life Detection at the Medical University of Graz in Austria offers expertise in detection of microbial signatures, analysis thereof and microbial cultivation.

1. Introduction

Our involved team members have large experience with microbial detection and quantification in samples from extreme environments and the growth of microbial specialists in (pure) cultures (e.g. anaerobes). Specifically we offer:

• Life detection in environmental and appropriate clinical samples (support in DNA extraction, selection of appropriate primers for bacteria, archaea and fungi, polymerase chain reaction (PCR), if desired in combination with propidium monoazide staining (detection of intact cells only), amplicon-sequencing and diversity data analysis, quantification of bacteria, archaea and fungi. If needed, -OMICS technologies can be applied.

• For the life detection workflow e.g. Next Generation Sequencing (Illumina MiSeq) for nucleic acid characterization, Gas Chromatography - Mass Spectrometry (GC-MS) for short fatty acids determination or scanning electron microscope SEM ZEISS DSM 950 for ultrastructure analysis.

• Detection of microbial cells: Domain to genus-specific fluorescence in situ hybridization, probe design and selection, visualization using confocal laser scanning microscopy (CLSM).

• Cultivation of specific microbial specialists, such as anaerobes or oligotrophs for use in laboratory experiments at the host's institution.

• Support in data analysis includes graphical display of e.g. microbial diversity and interpretation of results with respect to the metabolic capabilities of the microbiome and the possible impact on the habitat.

2. Our visitors and projects

To date, ten researcher teams from all over Europe have visited our facilities and processed a variety of different microorganisms and samples during their stay. Those included extreme cave, lake and volcano samples, Antarctic ice, samples from space-related indoor environments, such as the MARS500 mock-up spacecraft or samples from the HISEAS encapsulation experiment. We were successful to gain insights into the microbial diversity thriving in these samples, with potential impact on the ecology of the respective ecosystem or the human crew. In the following, two representative projects are presented in more detail.

a. Su Bentu limestone cave in Sardinia, Italy

This project was performed together mainly with researchers from DLR, Cologne, Germany and Italy. By the analyses in our laboratory, we could show human impact was confined to locations that are utilized as campsites and that exploration leaves only little microbial trails. Moreover, we uncovered a specialized microbiome, specifically adapted to survive in such an extreme environment with low nutrient availability [1].

b. The confined Mars500 habitat

This project was performed together with the University of Edinburgh and the DLR, Cologne. The Mars500 project was created to simulate a full duration crewed return flight to Mars. For 520 days, six crew members lived enclosed in the mock-up spacecraft and took 360 samples from 20 locations at 18 time-points. All samples were processed during the visitor's stay in our laboratory, and insights into the microbial dynamics during the Mars500 mission were obtained. Our results revealed that under confined conditions the community composition remains highly dynamic and microbes adapt quickly to environmental changes. The results serve as an important data collection for future risk estimations of crewed space flight and help to plan spacecraft missions with appropriate monitoring and countermeasures on board [2].

3. Summary and Conclusions

The Europlanet activity allowed us to create and accomplish projects together with researchers all over Europe. We are now aiming to increase our activities and our possibilities, as novel instruments have been installed. This includes digital PCR, optimized OMICS technologies, scanning electron microscopy and available hardware and software for improved data analysis.

Acknowledgements

We acknowledge the funding given to Europlanet 2020 RI by the European Union's Horizon 2020 research and innovation programme under grant agreement no 654208.

References

[1] Leuko, S., Koskinen, K., Sanna, L., D'Angeli, I.M., De Waele, J., Marcia, P., Moissl-Eichinger, C. and Rettberg, P., 2017. The influence of human exploration on the microbial community structure and ammonia oxidizing potential of the Su Bentu limestone cave in Sardinia, Italy. PLoS One, 12(7), p.e0180700.

[2] Schwendner, P., Mahnert, A., Koskinen, K., Moissl-Eichinger, C., Barczyk, S., Wirth, R., Berg, G. and Rettberg, P., 2017. Preparing for the crewed Mars journey: microbiota dynamics in the confined Mars500 habitat during simulated Mars flight and landing. Microbiome, 5(1), p.129.

EPSC Abstracts
Vol. 12, EPSC2018-323, 2018
European Planetary Science Congress 2018
© Author(s) 2018

The distributed planetary simulation and sample analysis facility

J. Helbert (1), G.R. Davies (2) for the EuroPlanet Research Infrastructure DPSF and DSAF teams

(1) Institute for Planetary Research, Berlin, Germany, (2) Faculty of Earth and Life Sciences (FALW), Vrije Universiteit, Amsterdam, Netherlands (joern.helbert@dlr.de)

Abstract

The Europlanet 2020 Research Infrastructure (EPN2020-RI) provides a pan-EU infrastructure that allows the multi-disciplinary European planetary science community to address the key scientific and technological challenges of modern planetary science by providing access to state-of-the-art research facilities across the European Research Area and a structure within which such research can be coordinated. Within the first two years almost 400 days of access have been provided to researchers.

The Distributed Planetary Simulation Facility makes laboratory facilities available capable of simulating the wide range of environments encountered on planetary bodies. The Distributed Planetary Simulation Facility provides the comprehensive capability to determine isotopic and elemental compositions of planetary samples, including analyses at high spatial resolution, high precision and high sensitivity.

1. Introduction

A central part of the Europlanet 2020 RI programme is to allow any European researcher interested in pursuing planetary science research access to a comprehensive set of laboratory facilities tailored to the needs of planetary research. Access is provided by a **Transnational Access (TA)** programme that supports travel and local accommodation costs of European researchers (and of researchers from Third Countries under certain conditions) at the facility for an approved period of time to conduct their own research programme. Applications are made in response to annual calls and are subject to peer review. It should be noted that applicants must apply to use facilities outside the country in which they are employed (i.e. it is a transnational access). Applications can be made for analytical time or access to planetary simulation laboratory ranging from single days up to several weeks and up to two researchers can be fully financed in each research visit.

2. Distributed Planetary Simulation Facility

The Distributed Planetary Simulation Facility (DPSF) joins seven of the leading laboratories for planetary science into a virtual facility. Three laboratory facilities that were already part of the EU Framework Program 7 research infrastructure have introduced new infrastructure and expanded their methodologies compared to the previous RI, allowing visitors to measure samples under analogue conditions for Mercury, Venus, Mars, the Moon and near-Earth asteroids. Among the four new additions to the DPSF, the low-temperature spectroscopy laboratory will extend this capacity to comets and the icy moons of the outer planets. The added life detection techniques will support the study of extremophiles and the range of potential habitable environments in the Solar System. The new high-temperature and pressure petrology laboratory will extend our knowledge from the planetary surface to the interior.

The DPSF consists of the following facilities:

- Planetary Spectroscopy Laboratory, Germany
- Planetary Environment Facilities at Aarhus University, Denmark
- Open University Mars Chamber, UK
- High-pressure laboratory at VUA, NL
- Cold Surfaces spectroscopy, Institut de Planétologie et Astrophysique de Grenoble (IPAG), France
- Center for microbial life detection at Medical University Graz, Austria
- Petrology-Mineralogy Characterisation Facility (PMCF), Mineral and Planetary Sciences Division, Natural History Museum, London, UK

2.1 Added capabilities in the DPSF

The two world-leading spectral facilities in the DPSF (DLR and IPAG Grenoble) currently have unique capabilities that attract large demand from international users. There was, however, a growing requirement from the community for more comprehensive spectral information. An upgrade program has take these two laboratories beyond the current state-of-the-art, adding new capabilities to both facilities that will maintain their premiere status and offer users unprecedented capabilities to perform experiments that are of direct relevance for the planning and implementation phases of forthcoming missions to Mercury and the outer ice moons of the giant outer planets. In addition, the upgrade program has expanded the current world-leading capabilities of the Aarhus University Planetary Simulator Facility and allows the development of new techniques for the study of planetary dust and sand transport, with a particular focus will be on Martian conditions that the ExoMars missions expect to encounter.

All upgrades have already been offered to the community during the third call for the EPN2020-RI.

3. Distributed Sample Analysis Facility

The new analytical capabilities offered in isotope geochemistry and cosmochemistry by "The Distributed Sample Analysis Facility" (DSAF) play a key role in understanding the complex feed-back mechanisms involved in the formation and evolution of planetary bodies and the (bio) geochemical cycles that operate within and between different parts of these bodies. The combined DSAF infrastructure provides the comprehensive capability to determine isotopic and elemental analyses at high spatial resolution, down to ~3 nanometres (nm), high precision (down to 5 part per 1,000,000 (ppm)) and high sensitivity (sub nanogram (ng) sample sizes). DSAF will allow scientists from across the ERA to access large, state-of-the-art infrastructure and to work under the guidance of scientists with expertise in sample handling and preparation. Visitors will be able to analyse terrestrial and extra-terrestrial samples (meteorites, returned samples) in order to (i) identify the nature of stellar sources that contributed material to the Solar System (ii) determine the rates and nature of the processes that controlled planetary accretion and differentiation and the subsequent evolution and interaction between the interior surface and atmosphere, (iii) constrain the nature of the Earth's building blocks, (iv) quantify biogeochemical cycles on Earth to determine proxies that can act for the detection of life elsewhere in the Solar System.

The DSAF consists of the following facilities:

- NanoSims and Stable Isotope Analytical Facilities. The OU, Milton Keynes, United Kingdom
- Radiogenic & non-traditional stable isotopes. IfP, University of Münster, Münster, Germany
- Radiogenic and non-traditional stable isotope facility, VU University, Amsterdam, NL
- Radiogenic, non-traditional stable & rare gas isotopes, CRPG, Nancy, France

3.1 New capabilities in the DSAF

Sample return missions have the potential to be truly ground-breaking as they provide scientifically unique material for detailed analysis. An upgrade focused on "Sample Handling Protocols and Ultra-Sensitive Isotopic Analysis", which includes two leading instrument manufacturers, will allow us to make measurements that will address two key goals of planetary scientists: i) to obtain 'ground truth' and calibrate remote sensing measurements; and ii) to place absolute constraints on the nature, timing and rates of processes that have operated within and on (proto-)planets. Such data will allow a critical assessment of existing models of planetary development, including the Earth, and provide indicators for the search for life elsewhere in the Solar System. Returned samples will also help to contextualise the interpretation of the diverse samples in existing meteorite collections.

4. Application and selection

European Science Foundation (ESF) coordinates the application and peer review process and no other members of the Europlanet 2020 RI consortium are involved in the evaluation procedure.

For more details go to our website:

http://www.europlanet-2020-ri.eu/

Europlanet 2020 RI is designed to support planetary science but applications in other research disciplines are also considered based on innovation and potential scientific and technological impact to the planetary sciences field.

EPSC Abstracts
Vol. 12, EPSC2018-548, 2018
European Planetary Science Congress 2018
© Author(s) 2018

CO_2 ice morphologies under Martian conditions

G. Portyankina (1), J. Merrison (2), J. J. Iversen (2), Z. Yoldi (3), C. J. Hansen (4), K.-M. Aye (1), A. Pommerol (3), N. Thomas (3)
(1) Laboratory for Atmospheric and Space Physics, University of Colorado, USA, (2) University of Aarhus, Denmark, (3) University of Bern, Switzerland, (4) Planetary Science Institute, Arizona, USA

Abstract

We have used the Aarhus Wind Tunnel Simulator II (or AWTSII [1]) in the framework of Trans-National Access opportunities within the EuroPlanet Research Infrastructure to experimentally study CO_2 ice deposition under conditions similar to those expected in the Martian polar areas. We have found that under Martian conditions, CO_2 ice most readily deposits as slab ice while under slightly lower temperatures (T <= 125 K), CO_2 ice deposited as crystals. The type of the substrate (machined aluminum or regolith) did not significantly alter the morphologies of the deposited ice.

1. Introduction

CO_2 is the main constituent of the Martian atmosphere and the main component of the seasonal polar caps on Mars. Martian climate is controlled by the state of CO_2. More specifically, the areas where the seasonal cap forms every fall and sublimes every spring are directly affected by the CO_2 ice and how it interacts with the surface and atmosphere. For understanding physics of these interactions and to adequately analyze remote-sensing data of CO_2-covered surfaces, knowledge of CO_2 ice properties is essential. However, important properties are unknown either completely or partially.

Among others, the crystalline structure and morphologies of CO_2 ice formed under Martian conditions are currently poorly investigated. CO_2 crystalline structure is known to be cubic, thus the possible range of morphologies of the CO_2 crystals can be hypothesized. However, which of these are to be realized on the Martian surface or in the atmosphere must be determined experimentally.

2. Experimental setup

AWTSII is a large cylindrical vacuum chamber (2.1 m inner diameter, 10 m length, volume 38 m^3) housing a recirculating wind tunnel. For this project we have developed and used a specialized cooling plate (35 × 50 cm) cooled by liquid nitrogen, separately from the chamber cooling system, for improved thermal uniformity and stable temperature of the upper surface.

We monitored temperatures inside the chamber and on and around the cooling plate by a set of thermoresistive temperature sensors. We used 2 USB microscopes inside the AWTSII to image the structure of CO_2 ice.

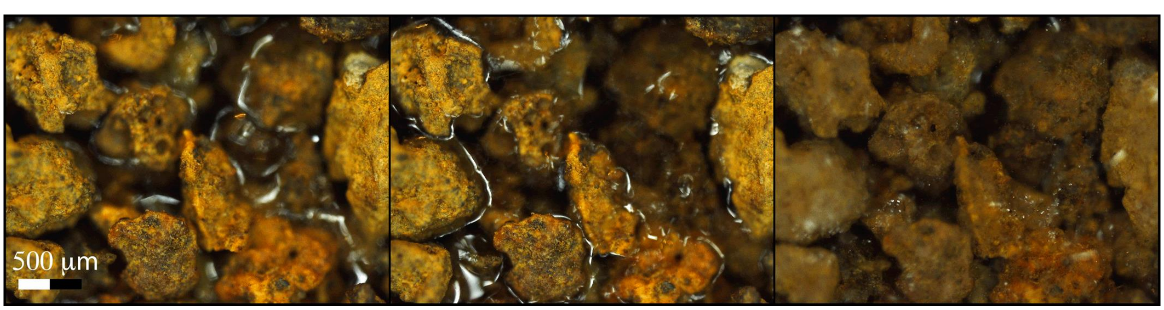

Figure 1: Sequence of microscopic images taken while CO_2 ice deposits in a form of slab ice under Martian conditions. From the left to middle frames CO_2 fills in the voids between the regolith particles. The right frame shows regolith completely covered by the ice.

During the experimental runs, AWTSII was first evacuated to below 0.5 mbar. Then the cooling plate was cooled to a selected target temperature, and then CO_2 gas was introduced into the chamber. We investigated ranges of temperatures and pressures similar to those in Martian polar areas and observed the physical state of the created CO_2 ice layer. Previously, we had reported on the results of experimental runs when CO_2 ice was deposited directly on the top surface of the cooling plate, i.e. on the machined aluminum substrate [2]. During the most recent campaign in April 2018, we aimed to investigate how (if at all) the substrate on which ice deposits influences the crystalline structure of CO_2 ice. We have used Martian regolith simulant (JSC Mars-1) as the surface to deposit CO_2 ice on instead of the surface of the cooling plate. We spread 2 monolayers of JSC on the top of the cooling plate and monitored deposition of CO_2 under the same conditions that were previously investigated and reported in [2].

3. Results

During our experimental runs we have observed several different textures of CO_2 ice. In previous tests, during the deposition directly on the brushed aluminum surface, we have identified that under Martian conditions the CO_2 ice deposited preferably as slab ice – continuous highly translucent polycrystalline form of the ice. In the most recent tests, we have confirmed that this stays true when CO_2 deposits on the regolith (Fig. 1). The ice starts depositing in-between regolith grains and fills in the pores in upward motion. The ice formed over the regolith layer is highly translucent and retains its translucency better than the ice formed on the aluminum surface because it is less prone to thermal cracking. We attribute this either to the decreased scale of thermal expansion and contraction of the regolith layer compared to the aluminum plate or to regolith acting as an insulating layer and reducing temperature variations that reach the ice layer from below.

Additionally, we have investigated P-T conditions slightly outside of typical Martian surface ranges. For example, at T = 120-125 K and P = 1 – 30 mbar we have previously observed unconventional "triangular" CO_2 crystals not previously reported in the literature. It is possible that we have observed preferential growth of one of the crystallographic planes of the more complex CO_2 crystalline structures, like hextetrahedral. Our most recent tests showed that the regolith substrate did not considerably alter the deposition pattern under these P-T. We have observed occasional cubic and octahedron crystals, but the most prevailing shape is shown in Fig. 2. These crystalline forms of CO_2 are thicker, i.e. less dense and opaque.

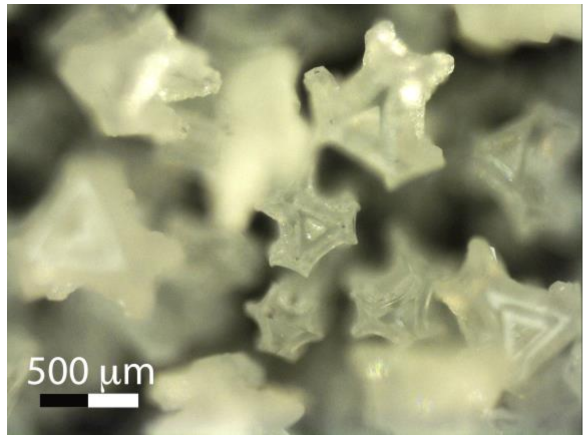

Figure 2: Microscopic view of CO_2 crystals shapes deposited at T = 120-125 K and P = 1 – 30 mbar.

4. Conclusions

The substrate did not considerably alter the deposition morphologies of CO_2 observed in our previous work. CO_2 deposits as a slab under Martian conditions. Under colder temperatures and lower pressures, CO_2 crystals assume shapes that we best can describe as hollow triangular prisms. These CO_2 crystalline morphologies require further investigation, because of their relevance to Martian CO_2 cloud formation.

Acknowledgements

This project is supported by the Trans-National Access opportunities within the EuroPlanet Research Infrastructure grant agreement No 654208. The team from the University of Bern is supported through the Swiss National Science Foundation and through the NCCR PlanetS.

References

[1] C. Holstein-Rathlou et al., 2014, An Environmental Wind Tunnel Facility for Testing Meteorological Sensor Systems, Journal of Atmospheric and Oceanic Technology 31 (2), pp. 447–457.

[2] G. Portyankina et al. (2018) Laboratory investigations of the physical state of CO_2 ice in a simulated Martian environment, Accepted for publication to Icarus.

EPSC Abstracts
Vol. 12, EPSC2018-550, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Temperature-dependent VNIR spectroscopy of thénardite and mirabilite

F. Tosi (1), S. De Angelis (1), C. Carli (1), P. Beck (2), S. Potin (2), O. Brissaud (2), B. Schmitt (2), G. Piccioni (1).

(1) INAF-IAPS, Via del Fosso del Cavaliere 100, I-00133 Rome, Italy, federico.tosi@iaps.inaf.it. (2) Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France.

Abstract

In the framework of the EuroPlanet 2020 Research Infrastructure (RI) programme, we took advantage of the CSS distributed planetary simulation facility at IPAG-Grenoble to perform a series of laboratory measurements aimed to acquire VIS-NIR spectra of anhydrous sodium sulfate (thénardite) and sodium sulfate decahydrate (mirabilite), in three different grain sizes and in a broad range of cryogenic temperatures, representative of real planetary surfaces. These measurements are key to correctly interpret data acquired by spectrometers carried onboard ongoing and future interplanetary space missions aimed at various planetary bodies, particularly the Jovian icy satellites (JUICE, Europa Clipper) and Mars (ExoMars 2020, Mars 2020).

1. Introduction

The surfaces of the icy Galilean satellites Europa, Ganymede and Callisto, dominated by water ice, also show substantial amounts of non-water-ice compounds both at regional scale and at local scale. These satellites will be the subject of close exploration by the ESA JUICE mission and the NASA Europa Clipper mission, which will focus on Ganymede and Europa, respectively.

Among non-water-ice compounds thought to exist on the surfaces of the Jovian icy satellites, hydrated salt minerals have been proposed to exist as a by-product of endogenic processes. In particular, Europa and Ganymede's non-ice material appears to be a complex mixture of sulfate hydrates and other materials [1]. Seasonal cycles of hydration-dehydration at Martian Polar Caps boundaries have also been suggested [2] for Na-sulfates compounds mirabilite and thénardite. Safe detection of these minerals shall rely on laboratory spectroscopic analysis of these materials carried out under appropriate environmental conditions.

2. Laboratory measurements

Following the third call of the Europlanet Transnational Access (TA) 2020 Research Infrastructure programme, our proposal was selected in June 2017. We focused on two sodium sulfates, namely anhydrous sodium sulfate or thénardite (Na_2SO_4) and sodium sulfate decahydrate or mirabilite ($Na_2SO_4 \cdot 10H_2O$). Visible to near-infrared spectral profiles of these compounds were obtained in April 2018 taking advantage of the Cold Surfaces Spectroscopy (CSS) facility at the Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), where such compounds can be measured under cryogenic conditions representative of real planetary surfaces.

These sulfates were first sieved so as to separate them in three different grain size ranges: <50 µm, 75-100 µm, and 125-150 µm. These grain sizes were chosen to: (1) be indicative of typical regoliths known or expected to exist on the surface of the icy satellites, and (2) avoid overlapping between ranges, therefore minimizing particles contamination among the dimensional classes. Each grain size was measured with the SHINE Spectro-Gonio-Radiometer facility [3] in the overall 0.5-5.0 µm spectral range, with spectral resolution increasing with increasing wavelength. For each sample, the overall 80-275 K temperature range was acquired in 12 steps varying from 10 K to 25 K, imposed by time constraints. In particular, at the uppermost temperature, 275 K, and at 140 K, we acquired the spectra both at the beginning (cooling) and during the ramp, to check for any macroscopic physico-chemical changes in the sample.

3. Preliminary results

In the case of anhydrous sodium sulfate (thénardite), our spectral profiles reveal absorption features at 1.9 and ~3-µm, due to an unavoidable hydration of the sample, although this has always been optimally preserved prior to the measurements. On the other hand, the main absorption of sodium sulfate in the considered spectral range is centered at about 4.5 µm, and shows a clear dependence on the grain size, whereas the dependence on temperature is weaker.

The spectral profiles of sodium sulfate decahydrate (mirabilite) are significantly different. Given the high level of hydration of this mineral, here the spectral signatures of the sulfate overlap with the combinations and overtones of the fundamental vibration modes of the water molecule, whose shape and intensity show a marked dependence both on the grain size and on the temperature, with the low temperatures that - similar to what we observed in the past for hydrated magnesium sulfates and hydrated sodium carbonates - reveal a finer structure.

We analyze the spectral behavior of the diagnostic signatures of these two hydrated minerals as a function of both grain size and temperature, deriving trends related to specific spectral parameters such as band center, band depth, band area, and bandwidth.

In Fig. 1, we show an example of spectral profiles of anhydrous sodium sulfate (thénardite), with an average grain size of 125-150 µm, measured in a total of 12 temperature values (coloured curves). Spectral profiles of the same mineral as found in the Reflectance Experiment LABoratory (RELAB) public database at Brown University (black curves) are displayed for comparison.

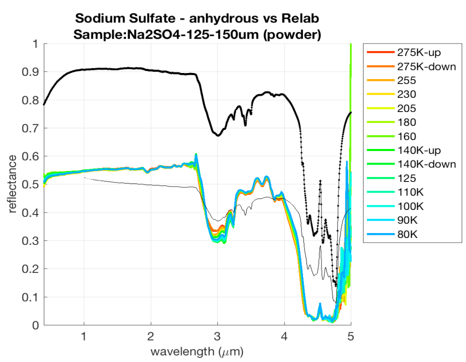

Figure 1: Example of spectral profiles of thénardite measured with the CSS facility at IPAG, in a ramp of cryogenic temperatures indicative of real planetary surfaces. The two black spectra are from Relab, for comparison (bkr1jb638a (thick line), bir1jb638a (thin line)).

Acknowledgements

The set of measurements described in this work is the outcome of the research project: "*Characterization of Na-sulfates at Cold Planetary Conditions*" (PI: Dr. Federico Tosi), selected and funded in June 2017 in the framework of the European Union's Horizon 2020 Research Infrastructure (RI) programme (http://www.europlanet-2020-ri.eu), under grant agreement No 654208. This work was partly supported by the Italian Space Agency (ASI), ASI-INAF grant 2013-056-R.O., and by the Centre National d'Etude Spatiale (CNES).

References

[1] McCord, T.B., et al., 1999. Hydrated salt minerals on Europa's surface from the Galileo Near-Infrared Mapping Spectrometer (NIMS) investigation. J. Geophys. Res. 104, 11827-11852.

[2] Kuzmin, R.O., et al., 2004. Global Mapping of Martian Bound Water at 6.1 Microns Based on TES Data: Seasonal Hydration-Dehydration of Surface Minerals. 35th Lunar and Planetary Science Conference, March 15-19, 2004, League City, Texas, abstract no.1810.

[3] Brissaud, O., et al., 2004. Spectrogonio Radiometer for the Study of the Bidirectional Reflectance and Polarization Functions of Planetary Surfaces. 1. Design and Tests. Applied Optics 43 (9), 1926-1937.

EPSC Abstracts
Vol. 12, EPSC2018-676, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Tracing metabolic pathways of Archean microbial community's

Sami Nabhan (1), Johanna Marin-Carbonne (2), and Christoph Heubeck (1)
(1) Institute of Geosciences, Friedrich-Schiller University, Jena, Germany, (sami.nabhan@uni-jena.de); (2) Univ Lyon, UJM Saint Etienne, Laboratoire Magma et Volcans, UBP, CNRS, IRD, St Etienne, France

Abstract

The ca. 3.22 Ga old Archean Moodies Group is the oldest, well preserved siliciclastic shoreline system. The excellent preservation allows to track a number of Archean habitats like microbially populated tidal plains, paleosols and shallow water BIFs that formed in anoxic, CO_2 rich environments possibly very similar to those of early Mars. Similar Ages and conditions under that Archean environments and potentially former habitable environments on Mars have been active allow us to use Moodies Group rocks as analogous for Mars. The challenging investigation of the Archean rock record allows us also to use approved methods in future missions. The complex behavior of Sulfur phases in the Archean, due to the lack of an ozone shield needs to be understood to apply investigations of the Sulfur cycle on Mars since the modern Earth has an efficient UV shield that prevents mass independent fractionation effects that are to be expected on Mars.

1. Introduction

The Moodies Group of the Barberton Greenstone Belt in southern Africa contains up to 1000 m of strata with fossilized microbial mats of excellent morphological preservation that are laterally about 15 km traceable [2]. However, metamorphic alteration under lower greenshist facies conditions (400-450°C) maturated the remaining carbonaceous matter to a degree that does not allow the extraction of biomarkers to determine former microbial pathways. Alternatively, variations of stable isotope ratios (e.g. C, S, N) can be used to track such pathways. A major target to trace such isotopic variations are early diagenetic and pedogenic minerals that most likely formed under the influence of microbial activity. Aridisols that formed in the same stratigraphic position adjacent to the microbial mats contain pedogenic nodules with remnants of sulfate partly connected to pedogenic pyrite formation [3]. The common occurrence of both minerals and the formation of gypsum in the Archean both are highly unusual and may already indicate a biogenic contribution to the pedogenic development.

2. Moodies biogenic involvement

The now silicified Moodies nodules still contain numerous inclusions of anhydrite and barite evident for their initial formation as gypsum nodules. Primary sulfates and especially gypsum are exceptional in the Archean rock record. The terrestrial environment in which they formed is more sensitive to changes than that of the otherwise marine sulfates of this age. Therefore, the Moodies nodules open a unique possibility to study the evolution of Sulfur based microbial pathways. The measured mass dependent fractionation between sulfate and sulfide of up to 34‰ is similarly high as in modern environment and clearly caused by microbial sulfate reduction while variations in the $\delta^{34}S$ composition and the recorded mass independent fractionation ($\Delta^{33}S$) of the sulfate inclusions are clearly caused by microbial sulfur oxidation which is in part photosynthetic. Therefore, the Moodies paleosols record one of the oldest microbial communities known to date. The consequences of MSO on the S-isotopic composition of the Moodies sulfate may thus explain the steady $\Delta^{33}S$ increase of Paleoarchean sulfates over a period of ca. 330 Ma. Indicating that MSO was an active microbial pathway since the formation of the oldest known sulfate deposits (3.55 Ga).

3. Moodies equivalents on Mars

The Sheepbed member of the Yellowknife Bay formation in Gale crater on Mars contains a number of diagenetic features, amongst which nodules are considered to be of early diagenetic origin. Sheepbed and Moodies both contain solid and hollow nodules with a macroscopically granular surface texture (Fig. 1). Solid nodules are simple round bodies that appear to lack zoning. Hollow nodules appear as spherical cemented bodies with a central void. Sheepbed and Moodies nodules differ significantly in mean size. Solid and hollow Sheepbed nodules have mean diameters of 0.8 mm and 1.35 mm, respectively [1,4]. Moodies nodules are about 10 times larger, so that the largest Sheepbed nodules (5-8 mm) roughly equal the smallest Moodies nodules that can reach up to 3 cm in diameter. The size of Sheepbed nodules decreases stratigraphically upward with smaller but more nodules in the upper part and slightly larger and fewer nodules in the lower part of the Member. Moodies nodules increase in size and number towards the top of each nodule containing paleosol bed.

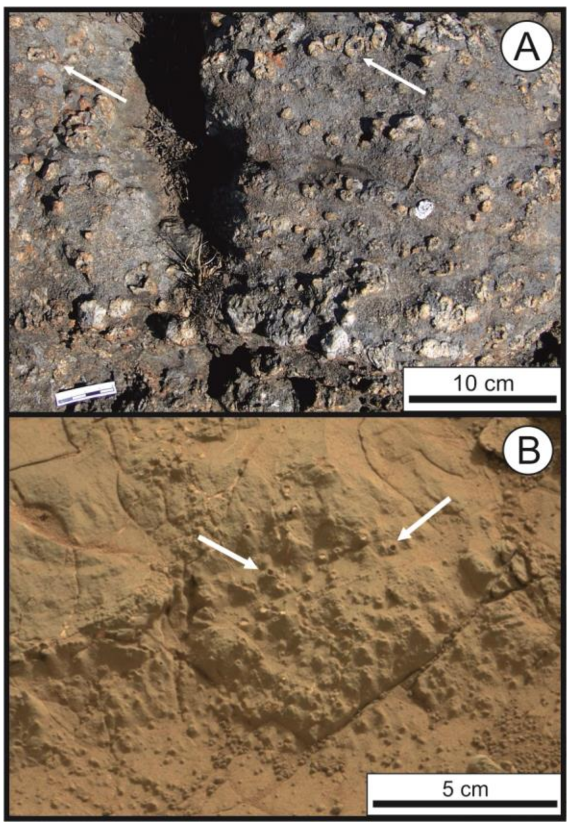

Figure 1: Solid and hollow (white arrows) nodules. A: In the Moodies paleosols the nodules are ca. 1 cm large and formed in sandstones of fluvial origin. B: The Sheepbed nodules are in average ~1 mm large and formed in a presumably lacustrine mudstone. Courtesy: NASA/JPL-Caltech.

4. Summary and Conclusions

Moodies nodules are a good analog to the nodules of the Sheepbed member. Both show solid and hollow morphologies and their formation processes may be similar with the hollow cores most probably resulting from preferential weathering of poorly cemented material. Sheepbed and Moodies nodules both formed at a similar time (~3.3-3.2 Ga) under similar conditions on planets that then resembled each other more than they do today. The involvement of a sulfur based microbial community in the formation of the Moodies nodules strengthen the case for an ancient habitable environment during the deposition of the Sheepbed mudstone and the subsequent formation of the Sheepbed nodules.

Acknowledgements

This research was funded by Europlanet 2020 grant number 17-EPN3-074. Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

References

[1] Grotzinger, J.P., et al.: A habitable fluvio-lacustrine environment at Yellowknife Bay, Gale crater, Mars. Science, Vol. 343, 1242777, 2014.

[2] Homann, M., Heubeck, C., Airo, A. and Tice, M.: Morphological adaptations of 3.22 Ga-old tufted microbial mats to Archean coastal habitats (Moodies Group, Barberton Greenstone Belt, South Africa). Precambrian Research, Vol. 266, pp. 47-64, 2015.

[3] Nabhan, S., Luber, T., Scheffler, F. and Heubeck, C.: Climatic and geochemical implications of Archean pedogenic gypsum of the Moodies Group (~3.2 Ga), Barberton Greenstone Belt, South Africa. Precambrian Research, Vol. 275, pp. 119-134, 2016.

[4] Stack, K.M., et al.: Diagenetic origin of nodules in the Sheepbed member, Yellowknife Bay formation, Gale crater, Mars. Journal of Geophysical Research, Planets, Vol. 119, pp. 1637-1664, 2014.

EPSC Abstracts
Vol. 12, EPSC2018-712, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Spectral Characterization of a Suite of Well-Characterized Bulk Lunar Soils from the Ultraviolet to the Far Infrared at the Planetary Emissivity Laboratory, DLR Berlin.

Kerri L. Donaldson Hanna (1), Neil E. Bowles (1), Benjamin T. Greenhagen (2), Jörn Helbert (3), Alessandro Maturilli (3)
(1) Department of Physics, University of Oxford, UK, (2) Johns Hopkins Applied Physics Laboratory, US, (3) DLR Institute of Planetary Research, Germany.

Abstract

Here we present a comprehensive set of laboratory measurements from the ultraviolet (UV) to the far infrared (FIR; 0.2 – 75 μm) on a suite of well-characterized lunar analogues. The objectives of the study included (a) characterize the reflectance of a suite of well-characterized samples across the UV to FIR under a controlled geometry and (b) comparing orbital UV, visible to near infrared (VNIR), thermal infrared (TIR), and FIR measurements of the Apollo landing sites with our laboratory reflectance and emissivity measurements to gain a better understanding of the difference between returned samples and undisturbed soils in their native setting.

1. Introduction

We utilized the facilities within the Planetary Spectroscopy Laboratory (PEL) at DLR, Berlin to characterize the reflectance from the UV through the FIR of a suite of lunar analogues in February 2018. These reflectance measurements, covering the entire spectral range, are the first of their kind. In addition, emissivity measurements were made across thermal infrared wavelengths to characterize differences between reflectance and emissivity across the TIR spectral range.

Our laboratory measurements will enable the analyses of past, current, and future remote sensing observations to constrain the surface compositions of airless bodies including the Moon, Mercury, and asteroids. These remote sensing observations included Mariner 10, Clementine, Smart-1, Chandrayaan-1, SELENE/Kaguya, MESSENGER, Diviner Lunar Radiometer, the Lunar Reconnaissance Orbiter Camera, Spitzer Space Telescope, BepiColombo, and James Webb Space Telescope.

2. Sample Suite

The analogue sample suite included well-characterized Apollo bulk soil samples and terrestrial minerals. Apollo bulk soils included samples from 5 of the 6 landing sites and with a range of compositions and maturities. The specific Apollo soils measured were 10084, 14259, 15071, 15201, 15411, 15601, 66031, 67701, 70181, 72501, and 79221. These soils have previously been characterized in reflectance by the Lunar Soil Characterization Consortium (LSCC) [e.g. 1-3] and in emissivity by Donaldson Hanna et al., [4].

Terrestrial mineral samples included a lunar-like anorthite (Miyake-jima anorthite with similar Ca- and Fe-contents as lunar anorthites), the same lunar-like anorthite that had been laser irradiated to simulate the effects of space weathering, San Carlos olivine (a well-characterized sample across most spectral ranges), a Mg-rich spinel, and a Mg-rich enstatite. All terrestrial mineral samples were fine particulates (< 75 μm). Several of these samples have been previously characterized in reflectance in RELAB and in emissivity by Donaldson Hanna et al., [4].

While most of these samples have been previously measured across specific spectral ranges, the new measurements made during this campaign filled necessary wavelength gaps (e.g. 0.2 – 0.4 μm, 2.6 – 7.0 μm, and 25-50 μm) and provide spectra across the entire UV to FIR spectral range from a single reflectance set-up and FTIR spectrometer.

3. Laboratory Measurements

Each of the samples was measured in the bi-directional reflectance set-up that sits in the sample compartment of the Bruker Vertex80V Fourier Transform Infrared (FTIR) spectrometer at the PEL. Samples were measured under vacuum conditions (pressures < 1hPa) across the 0.2 – 75 µm spectral range at a spectral resolution of 4 cm^{-1}. Each sample was measured with a fixed geometry of 30° phase angle (incidence 17° and emergence 13°).

As an inter-comparison check with other laboratories, San Carlos olivine was measured across all wavelengths. This olivine has been measured and characterized by most laboratory spectroscopy facilities in reflectance, emission, and transmission, thus its spectra are well known. Our initial analyses suggest that the reflectance measurements are comparable to previously measured San Carlos olivine reflectance spectra and that the signal to noise is sufficient to uniquely distinguish all spectral features from the noise.

In addition to the UV through FIR reflectance measurements of the lunar analogues, emissivity measurements were made of a select group of samples (e.g. samples where there was sufficient material to fill the emissivity sample cups). These samples included Apollo soil 10084, San Carlos olivine, Miyake-jima anorthite, Mg-rich spinel, and the Mg-rich enstatite. These measurements were made in an environment chamber that was backfilled with dry air, was cooled to 4C using a water chilling unit, and were heated from below to 80C. These calibrated emissivity spectra will be directly comparable to those that we make in the Planetary Spectroscopy Facility at the University of Oxford [e.g. 5].

4. Summary

Using the extensive spectroscopic facilities at the Planetary Emissivity Laboratory at DLR, Berlin, over 50 science quality spectra across a very wide (UV to FIR) spectral range were recorded for a suite of lunar samples, representing five out of the 6 landing sites. In addition, analogue samples including a San Carlos olivine, a Mg-rich enstatite, and a laser irradiated Miyake anorthite sample were measured across the same wide spectral range.

Analysis of the new laboratory data is ongoing and the spectra will provide a new measurements for the analysis of multispectral and hyperspectral lunar and other Solar System airless bodies remote sensing data for past, present, and future missions.

Acknowledgements

The authors wish to thank Europlanet TA programme for providing access to the laboratory facilities at PEL. K. L. Donaldson Hanna thanks the UKSA for their support through an Aurora Research Fellowship.

References

[1] Pieters, C. M., et al.: Space weathering on airless bodies: Resolving a mystery with lunar samples, MaPS, Vol. 35, pp. 1101-1107, 2000.

[2] Taylor, L. A., et al.: Lunar Mare Soils: Space weathering and the major effects of surface-correlated nanophase Fe, JGR, Vol. 106, pp. 27985-27999, 2001.

[3] Taylor, L. A., et al.: Mineralogical and chemical characterization of lunar highland soils: Insights into the space weathering of soils on airless bodies, JGR, Vol. 115, doi:10.1029/2009JE003427, 2010.

[4] Donaldson Hanna, K. L., et al.: Effects of varying environmental conditions on emissivity spectra of bulk lunar soils: Application to Diviner thermal infrared observations of the Moon, Icarus, Vol. 283, pp. 326-342, 2017.

[5] Thomas, I. R., et al.: A new experimental setup for making thermal emission measurements in a simulated lunar environment, Rev. Sci. Instrum., Vol. 83, 124502 2012.

EPSC Abstracts
Vol. 12, EPSC2018-714, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Experimental and modelled mid-infrared spectra of olivine: simulations of extreme temperature conditions

C. Stangarone (1), A. Maturilli (1), J. Helbert (1)

(1) Institute of Planetary Research, Deutschen Zentrums für Luft- und Raumfahrt, Berlin, Germany (claudia.stangarone@gmail.com)

Abstract

The effects of temperature, composition and grain sizes on emissivity bands have been investigated experimentally on natural samples of olivine. The measurements have been carried out at the Institute of Planetary Research, Deutschen Zentrums für Luft und Raumfahrt (DLR), at the Planetary Spectroscopy Laboratory (PSL), where 11 different olivine samples within the forsterite-fayalite series have been studied, measuring their thermal emissivity up to 900 K and IR reflectance.
The outcomes implement the modelling of emissivity spectra with *ab initio* modelling, which, at the present state, successfully foresee the bands shift due to temperature and composition [1], but do not take into accounts the bands shape due to grain sizes. Moreover, we point out the main spectral features due to the composition and temperature, since the spectra features due to the iron content in the samples overlap with the effects due to temperature [2].

1. Introduction

Planetary bodies may be influenced by extreme temperature conditions (e.g. Mercury), thus data interpretation must take into account changes in spectral characteristics induced by temperatures effects [3]. Recently we modelled high-temperature mid-IR spectra, by means of *ab initio* methods to predict the changes in spectral features due to the increase of temperature, with promising results [1]. However, some discrepancies between calculated and experimental spectra are evident.
In this study we take into account the effects on spectral features due to the composition and the grain size of different olivine samples, in order to better constrain future modelling.

2. Preliminary results

The approach was first tested on the modelling of forsterite. The results were compared with the experiments on a natural olivine (Fo_{89}). The outcomes are shown in Figure 1.
This first attempt reveals that the computational approach employed can reliably be used to predict band shifts due to temperature: a significant good agreement between measurements and simulated data is shown, especially within the spectral range of 1200-600 cm^{-1}, where the agreement with the experiments is found to exceptionally good.

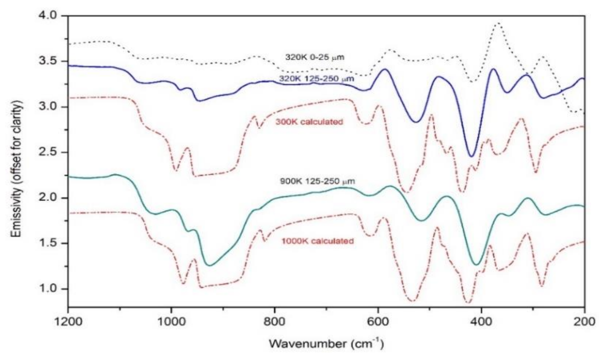

Figure 1: Comparison between calculated 1-R mid IR spectra and experimental emissivity measurements. Solid line: experimental thermal emissivity spectra of an Mg-rich olivine (Fo_{89}) measured at 320K and 900K.

3. Methodology

In this study, 11 samples of olivine with different compositions, within the series forsterite-fayalite have been measured. On these 11 samples, 5 of them have been measured on two different grain sizes (4 samples 125-250 µm and 0-25 µm, 1 sample 300-500 µm and 38-68 µm), according to the availability of sample. The thermal emissivity measurements have been performed at different temperatures, from 320K up to 900K, with intermediate temperature steps at 500K and 700K, in order to simulate the typical diurnal equatorial temperature variation of the

Mercury surface. The IR reflectance measurements have been performed for each sample (and when available on each grain size) on the fresh and on the heated sample. The spectral region detected for both emissivity and reflectance measurements are between 50 and 1400 cm^{-1}, which is the fundamental range for distinguish spectral absorption features of silicate [4]. To do so we employed two detectors: a liquid nitrogen cooled HgCdTe detector plus a KBr beamsplitter to cover the 1 to 16 µm spectral range, and a DTGS detector plus a Mylar multilayer beamsplitter from 16 to 200 µm.

4. Summary and Conclusions

Preliminary results show a consistent good agreement with calculations; by means of this approach we calculate and foresee with a good level of accuracy band minima shift as a function of temperature and, consequently, it is possible to reliably predict which modes are particularly sensitive to temperature variations. The post processing of data is still ongoing, and it will be focused on overcoming the volume scattering issues due to the grain size.

Acknowledgements

The measurements at Institute of Planetary Research, Deutschen Zentrums für Luft und Raumfahrt (DLR), Planetary Spectroscopy Laboratory (PSL), have been possible within the project Europlanet 2020 RI-TA.

Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

References

[1] Stangarone, C., Helbert, J., Maturilli, A., Tribaudino, M., Prencipe, M., Modelling of thermal-IR spectra of forsterite: application on remote sensing, , European Planetary Science Congress 2017, Vol. 11, EPSC2017-841, 2017

[2] Helbert, J., Nestola, F., Ferrari, S., Maturilli, A., Massironi, M., Redhammer, G. J., Capria M. T., Carli C., Bruno, M.: Olivine thermal emissivity under extreme temperature ranges: Implication for Mercury surface, Earth and Planetary Science Letters, Vol. 371, pp. 252-257, 2013

[3] Koike, C., Mutschke, H., Suto, H., Naoi, T., Chihara, H., Henning, T., Jäger, C., Tsuchiyama, A., Dorschner, J., Okuda, H., 2006. Temperature effects on the mid-and far-infrared spectra of olivine particles. Astron. Astrophys. 449, 583–596.

[4] Hamilton, V.E., 2010. Thermal infrared (vibrational) spectroscopy of Mg-Fe olivines: A review and applications to determining the composition of planetary surfaces. Chemie der Erde - Geochemistry 70, 7–33.

EPSC Abstracts
Vol. 12, EPSC2018-753, 2018
European Planetary Science Congress 2018
© Author(s) 2018

The Planetary Spectroscopy Laboratory (PSL)

A. Maturilli, J. Helbert, I. Varatharajan, Y Rosas Ortiz, and M. D'Amore
Institute of Planetary Research, German Aerospace Center DLR, Rutherfordstr. 2, 12489 Berlin, Germany – alessandro.maturilli@dlr.de

Abstract

The Planetary Spectroscopy Laboratory (PSL, formerly known as the Planetary Emissivity Laboratory-PEL) of DLR in Berlin is a well established facility providing spectroscopic measurements of planetary analogue materials. Spectral measurements of planetary analogues from the visible to the far-infrared range are routinely measured for comparison with remote sensing spacecraft/telescopic observations of planetary surfaces [1-5]. Bi-directional and hemispherical reflection, transmission and emission spectroscopy are the techniques we use to acquire spectral data of target materials. This paper describes all of the measurements that can be done at the PSL.

1. Introduction

Two identical FTIR instruments (Bruker VERTEX 80v spectrometer) are operating in an air-conditioned room at PSL. The spectrometers can be evacuated to ~.1 mbar or work under purging with dry air or nitrogen. One spectrometer is equipped with aluminum mirrors optimized for the UV, visible and near-IR, the second features gold-coated mirrors for the near to far IR spectral range. The identical spectrometers share a collection of optical units (fully automated) in our equipment to efficiently cover a very wide spectral range. Table 1 list the spectral coverage of detectors we have available at PSL, Table 2 describes the beamsplitters that we can select to and associate with the desired detector to cover the spectral region of interest. Two detectors can be mounted simultaneously to improve the measured spectral range saving measurement and waiting time. Remotely controlled automatic exchange of up to four different types of beamsplitters under vacuum conditions would become possible. To allow high precision transmission and reflectance measurements, three external sources feature the PSL set-up. A deuterium lamp covers the UV (0.2 to 0.5 µm) spectral range. A 24V, water cooled, Tungsten lamp allows covering the VIS (0.4 to 1.1 µm) spectral range. Another high power Globar lamp (24 V, water cooled) is used in the VNIR+TIR (1 to 16 µm). For emissivity measurements, the source used is the sample itself heated from below and around.

Detector	Spectral Range (µm)	Operating T
GaP Diode	0.2 – 0.55	Room T
Silicon Diode	0.4 – 1.1	Room T
InGaAs Diode	0.7 – 2.5	Room T
InSb	0.78 – 5.4	Liquid N_2
2x MCT	0.8 – 16	Liquid N_2
MCT/InSb SW	1 – 16	Liquid N_2
2x DTGS/KBr	0.8 – 40	Room T
DTGS/CsI	0.8 – 55	Room T
DTGS/PE	14 – 1000	Room T

Table 1. Detectors equipment at the PSL.

Beamsplitter	Spectral Range (µm)
2x UV/VIS/NIR CaF_2	0.18 – 2.5
2x Si on CaF_2	0.66 – 8.3
2x Ge on KBr (Wide)	1 – 25
Ge on KBr substrate	1.2 – 25
Multilayer	14.7 – 333
50 µm Mylar	181 – 666

Table 2. Beamsplitters in use at the PSL.

2. Facility Support Equipment

In addition to sample collection including a collection of hundreds of rocks and minerals, synthetic minerals, an Apollo 16 lunar sample, several meteorites, a full set of sample preparation and analysis tools and experiment sub-systems are available to the facility operated by a dedicated lab technician:, set of sample holders for reflectance (plastic, aluminum or stainless steel), various sets of sieves, grinders, mortars, saw, balances, microscope, an oven (20° to 300°C), ultra-pure water, wet chemistry materials, a second ovens (30° to 3000°C) for sample treatments, a press to produce pellets (10mm or 20mm diameter), a large dry cabinet (moisture < 1%) for sample storage, 3 small exsiccators (moisture < 20%) for sample storage, a rotating device for producing intimate mixtures, purge gas generator for water and CO_2 free air, liquid-nitrogen tank, an ultrasonic cleaning unit, 2 microscopes, air compressor pistol for cleaning. Typical grain size separates produced for spectral measurements are <25 µm, 25-63 µm, 63-125 µm, 125-250 µm. Larger separates as well as slabs are often measured too.

3. Emissivity Measurements

An external chamber is attached to each one of the FTIR spectrometers to measure the emissivity of solid samples. One chamber (cooled to <4° C) allows measuring the samples under purging conditions for temperature from 290 to 420K. A second chamber (working under vacuum) features high efficiency induction system heating the samples to temperatures from 320K up to 900K. A sample carousel driven by a stepper motor allows measuring several consecutive samples without breaking the vacuum. Large number of temperature sensors serves monitoring sample, equipment, and chamber temperature. A webcam in the emissivity chamber monitor the heated sample and its vicinity.

4. Reflectance Measurements

With the Bruker A513 accessory on Vertex 80V, we obtain bi-directional reflectance of samples, with variable incidence and emission angles between 13° and 85°. We measure from 170K (extension to 70K is under planning) to room temperature, under purge or vacuum conditions, covering the 0.2 to above 200 µm spectral range. Two integrating spheres allow measuring hemispherical reflectance of samples under purging in the entire PSL spectral range.

5. Transmittance Measurements

The Bruker A480 parallel beam accessory mounted on the Vertex 80V allows us to measure transmission of thin slabs, optical filters, optical windows, slabs, etc, in the complete spectral range from UV to FIR avoiding refraction, typical in this kind of measurements.

6. Facility Access

PSL is a Trans-national access (TA) facility supported by the European Union within the EuroPlanet Research Infrastructure framework over a four year period. In this period once per year a call for proposals is issued for investigations using PSL. So far PSL has granted closed to 100 days of access. Details can be found at:

http://www.europlanet-2020-ri.eu/.

7. Conclusion

The PSL provides the planetary community with reflectance, transmission and emissivity measurements highly complementary to existing spectral databases, covering the very large spectral range from UV (0.2 µm) to the FIR (≥ 200 µm).

In addition the high temperature spectroscopy capabilities of PSL are currently extended to start at 700nm instead of 1000nm.

A compact low-temperature reflectance chamber for FT-spectroscopy at the PSL is under development. The expected cryogenic temperature to reach is approximately within the range of 70K – 100K.

8. Acknowledgments:

Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

References

[1] Maturilli, A. and Helbert, J.: Emissivity measurements of analogue materials for the interpretation of data from PFS on Mars Express and MERTIS on Bepi-Colombo, PSS, Vol. 54, pp. 1057-1064, 2006.

[2] Maturilli, A., Helbert, J., and Moroz L.: The Berlin Emissivity Database (BED), PSS, Vol. 56, pp. 420-425, 2008, spectral library now available at http://figshare.com/articles/BED_Emissivity_Spectral_Library/1536469.

[3] Helbert, J. and Maturilli, A.: The emissivity of a fine-grained labradorite sample at typical Mercury dayside temperatures, EPSL, Vol. 285, pp. 347-354, 2009.

[4] Maturilli A, Helbert J: Characterization, testing, calibration, and validation of the Berlin emissivity database. Journal of Applied Remote Sensing, 2014.

[5] Maturilli A, Helbert J, St. John JM, Head III JW, Vaughan WM, D'Amore M, Gottschalk M, Ferrari S: Komatiites as Mercury surface analogues: Spectral measurements at PEL. EPSL, Vol. 398, pp. 58-65, 2014.

EPSC Abstracts
Vol. 12, EPSC2018-765, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Evolution of the thermal properties of ocean aqueous solutions from Archean chemical compositions to modern seawaters

Victoria Muñoz-Iglesias and Olga Prieto-Ballesteros
Centro de Astrobiología (INTA-CSIC). Ctra. Ajalvir km. 4, 28850 Madrid, Spain (vmunoz@cab.inta-csic.es, prietobo@cab.inta-csic.es)

Introduction

Chemical composition of Earth seawater has changed with time. Despite the uncertainties, there is an agreement that the first seawaters formed on Earth were in balance with a primitive atmosphere rich in carbon dioxide (CO_2). They were anoxic, poor in sulfate, and with a concentration in bicarbonate (HCO_3^-) higher than calcium (Ca^{2+}), resulting in an alkaline brine where the precipitation of carbonate minerals such as nahcolite and trona was propitious. Later, the decrease in temperature favored the continental crust formation and the weathering of the CO_2, probably causing the acidification of the ocean to a neutral state. The following "Great Oxidation Event" introduced the oxygen (O_2) to the environment and subsequently sulfate (SO_4^{2-}) concentration started to increase from around 10 m in the Silurian to 29 m nowadays. The ratio HCO_3-/Ca^{2+} inverted, promoting the precipitation of gypsum instead of carbonates. Attending to the Mg/Ca ratio from the Phanerozoic, it has occurred a periodically exchange between brines rich in Ca and brines rich in Mg, for instance, this ratio was around 1.5 at Silurian times while currently it has a mean value of 5.2 [1,2 and references therein].

With these premises, the goal of this study is to determine the effect on the thermal properties of the solutions of: A) The balance between CO_2 and CO_3^{2-} dissolved according to the temperature and pressure, B) The addition of SO_4^{2-} ion, and the increase in its concentration, C) The change in the Mg/Ca ratio.

Changes in the thermal properties of the seawater affect the interaction among the atmosphere-crust-ocean and, consequently, the cycles of energy and some elements and the habitability conditions during the planet's history. In some cases, data can be applied to other planetary oceans.

Experimental Procedure

Starting from an aqueous solution simulant of modern seawater chemical composition, we prepare series of solutions with decreasing $MgSO_4$ concentration while keeping the other salt concentration constant (KCl, NaCl, $CaCl_2$). In these series we study the influence of points B and C at 1 bar. For point A, we change $MgSO_4$ by $MgCO_3$, and perform a second series of runs with the alkaline solution mineral concentrations constant but adding CO_2(g) at pressures up to 1000 bar.

The high pressure μDSC7 evo calorimeter (SETARAM Instrumentation, France) allows the direct determination of the specific heat (Cp) in a temperature range from 228 to 293 K.

Objective A is complemented with Raman spectroscopy under high pressure. The setup composed by the iHR550 Raman spectrometer (Horiba JobinYvon, France) coupled to a homemade high-pressure cell that has been already shown and validated for the kind of study proposed in previous works [3-5].

Results

Specific heat and thermal conductivity data of present composition seawater at different salinities, and under wide range of temperature and pressure is available in the literature for comparison [6, 7 and references therein].

As an example, we show in Figure 1 three tests performed for the calculation of Cp in pure H_2O, NaCl eutectic composition aqueous solution (23.3 wt% NaCl, melting point 252 K) and $MgSO_4$ eutectic composition aqueous solution (17.0 wt% $MgSO_4$, melting point 269 K), before and after melting. Cp varies with temperature and suffers dramatic shifts when there is a physical change of the sample. The data obtained in previous works [8] for NaCl solution at 24 wt% is added to the plot to demonstrate the validation of the calorimeter.

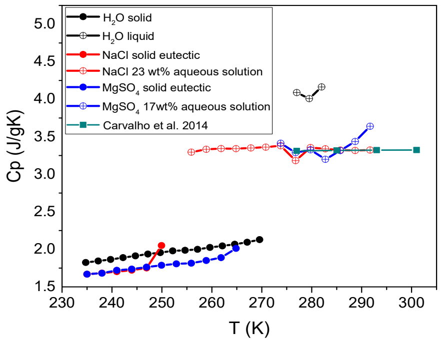

Figure 1. Cp vs. T for H_2O, NaCl and $MgSO_4$ solutions.

Acknowledgements

This work is funded by the project ESP2014-55811-C2-1-P.

References

[1] www.saltworkconsultant.com

[2] Warren, J. K.: Evaporites: A Geological Compendium, 2nd edition, Springer, 2016.

[3] Bonales, L. J. et al.: Raman monitoring of carbonate dissolution/precipitation in a CO2 atmosphere at high pressure. Planetological applications. Abstract 435. EPSC, 23-28 September, Madrid, Spain, 2012.

[4] Bonales, L. J. et al.: Raman spectroscopy as a tool to study the solubility of CO2 in magnesium sulphate brines: application to the fluids of Europa's cryomagmatic reservoirs, European Journal of Mineralogy, 25, 735-743, 2013.

[5] Méndez, A. S. J. et al.: Salting-out phenomenon induced by the clathrate hydrates formation at high-pressure, Journal of Physics: Conference Series, 950, 042042, 2017.

[6] Nayar, K. G. et al.: Thermophysical properties of seawater: A review and new correlations that include pressure dependence, Desalinization, 390, 1-24, 2016

[7] Safarov, J. et al.: (p,ρ,T) properties of seawater: Extensions to high salinities, Deep-Sea Research, I 65, 146-156, 2012.

[8] Carvalho G. R. et al.: Physicothermal Properties of Aqueous Sodium Chloride Solutions, Journal of Food Process Engineering, 38, 234-242, 2015.

EPSC Abstracts
Vol. 12, EPSC2018-901, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Spectroscopy on silicate glasses from two magmatic series: implications for planetary studies.

Alessandro Pisello (1,2), Maria Cristina De Sanctis (2), Alessandro Maturilli (3), Simone De Angelis (2), Marco Ferrari (2), Francesco Vetere (1), Cristina Pauselli (1) and Diego Perugini (1).
(1) Department of Physics and Geology, University of Perugia, Piazza dell'Università, 06123Perugia, Italy (2) Istituto di Astrofisica e Planetologia Spaziali, Istituto Nazionale di Astrofisica, Rome, Italy. (3) Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin-Adlershof, Germany.

Abstract

Silicates are the main constituent of terrains on terrestrial planets in the solar system [1, 2]. Silicate glasses represent the amorphous phase of silicate crystals. Typically, volcanic rocks are afanitic or porphyric rather than holocrystalline: the fraction of amorphous material is therefore more relevant than the fraction of crystalline material. Thus it is of paramount importance to study silicate melts and glass properties to better interpret available and future remotely sensed spectra from past and future missions [3]. Other works focused on the spectral investigation of natural samples along the Total-Alkali-Silica diagram [4,5]. Here we report on our study concerning synthetic glasses: two series of silicate glasses were synthesized starting from natural samples in order to be spectroscopically characterized in the near- and mid-IR.

Samples preparation

Samples were produced by melting and mixing two couple of natural endmembers, related to volcanism generated in two different geodynamic settings: a subduction zone volcanism (Vulcano, Aeolian islands, Italy; 5 samples) and an intraplate-derived volcanism (Snake River Plain, hereon SRP Yellowstone, USA; 6 samples). Chemical compositions are respectively ranging between shoshonitic and rhyolitic, and basaltic and rhyolitic, The main difference is lying in the alkali content, wich is constant in Vulcano series and varying in SRP series. We know that alkali play important structural roles in glasses and may influence their physical properties [6] and spectral response [7].

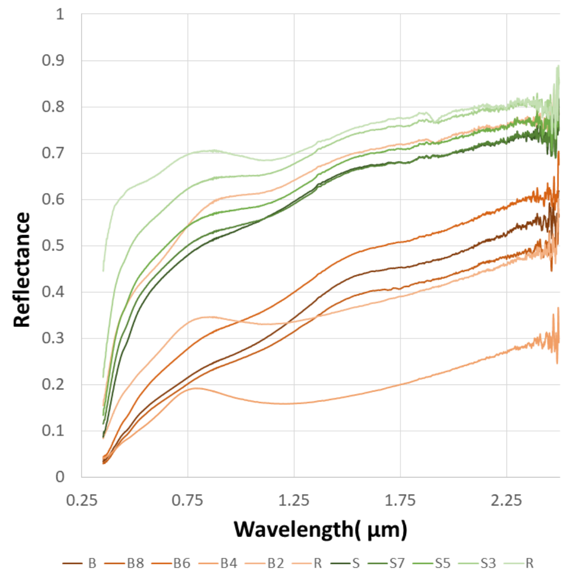

Figure 1: Set of spectra obtained in the near-IR range. Vulcano alkaline samples are green-shaded, SRP samples al orange-shaded. The darkest the colour, the more mafic the composition, the higher the iron content.

Samples analysis

Samples were analysed using electron probe microanalyses, and spectroscopically characterized in different laboratories and under different conditions.

Planetary Emissivity Laboratory: mid-IR data at different temperatures, at the Planetary Emissivity Laboratory of the German Aerospace Center in Berlin (DLR), have been acquired. Reflectance (fresh and after heating at 700°C, spectral range 1-18 µm) and emissivity (150°C, 300°C, 450°C, 700°C; spectral range 5-16 µm) spectra were collected [8].

Institute for Space Astrophysics and Planetology: near-IR spectra (fresh sample, spectral range 0.35-2.5

μm) at the *Institute for Space Astrophysics and Planetology* (IAPS-INAF) in Rome, has been acquired in reflectance (Figure 1).

For what concerns mid-IR, characteristic Christiansen Feature (CF) was observed for all samples ranging between 7.3μm and 8μm. Reststrahlen bands were observed to dominantly characterize the spectra between CF and ca. 13 μm. Transparency feature typical of fine material was observed at 11.7 μm, especially for reflectance measurements.
For reflectance measurements the shift of CF is observed to be in linear correlation with SiO_2 content, and in particular with depolymerisation degree NBO/T (Figure 2), whereas for emissivity measurements the same dependency was observed with a little but important dependence on temperature. Variations in alkaline content seems to strongly influence the shape of RB, and secondarily the temperature dependence of CF shift.

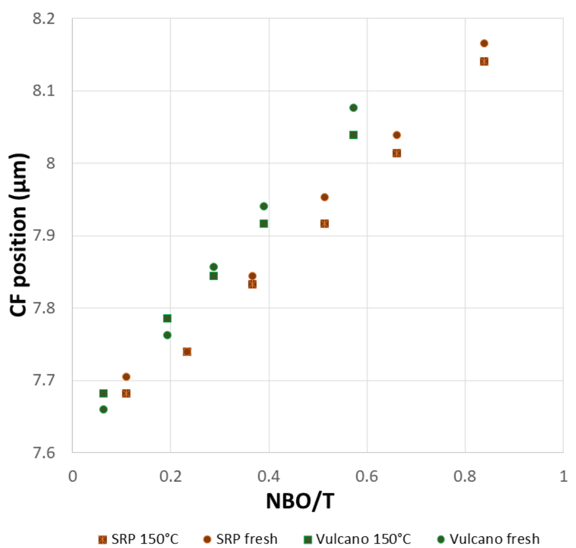

Figure 2: Example of the shift observed for CF in relationship with polymerization degree NBO/T, regarding the reflectance spectra obtained in the mid-IR range for two different temperatures.

For what concerns near-IR reflectance (Figure 1), for the shoshonite-rhyolite series an expected inverse relationship was observed between the albedo of spectra and the iron content. For SRP series, where alkali content is varying sensibly, the same relationship is not observable. These observations may help the interpretation of remotely sensed spectra, characterizing not only chemical composition but also a possible geodynamic setting of planetary volcanic products.

References

[1] Namur, O. and Charlier, B. (2017). Silicate mineralogy at the surface of mercury.Nature Geoscience, 10(1):9.

[2] Rossi, S., Morgavi, D., Namur, O., Vetere, F., Perugini, D., Mancinelli, P., and Pauselli, C. (2016). Nvpmelt/magma viscosity: insight on mercury lava flows. InEGU General Assembly Conference Abstracts,volume 18, page 12127

[3] Di Genova, D., Hess, K.-U., Chevrel, M. O., and Dingwell, D. B. (2016). Models for the estimation of fe3+/fetotratio in terrestrial and extraterrestrial alkali-and iron-rich silicate glasses using raman spectroscopy.

[4] De Angelis S., Carli C., Manzari P., De Sanctis M.C., Capaccioni F.: Spectral characterization of volcanic rocks in the VIS-NIR for martian exploration, DPS-EPSC abstract, 2016

[5] Carli C., Serventi G., Sgavetti M., De Angelis S., Capaccioni F.: VNIR Reflectance Spectra Of Volcanic Rocks: Mineralogical Composition And the Influence Of Texture As seen from Terrestrial Samples, 48th ESLAB abstract, 2014

[6] Vetere, F., Holtz, F., Behrens, H., Botcharnikov, R. E., & Fanara, S. (2014). The effect of alkalis and polymerization on the solubility of H_2O and CO_2 in alkali-rich silicate melts. Contributions to Mineralogy and Petrology, 167(5), 1014.

[7] King, P., McMillan, P., Moore, G., Ramsey, M., and Swayze, G. (2004). Infrared spectroscopy of silicate glasseswith application to natural systems.Infrared Spectroscopy in Geochemistry, Exploration Geochemistry andRemote Sensing, 33:93–133..

[8] Maturilli, A., Helbert, J., Ferrari, S., Davidsson, B., and D'Amore, M. (2016). Characterization of asteroidanalogues by means of emission and reflectance spectroscopy in the 1-to 100-μm spectral range.Earth,Planets and Space, 68(1):113.

EPSC Abstracts
Vol. 12, EPSC2018-906, 2018
European Planetary Science Congress 2018
© Author(s) 2018

CRPG facilities available through Europlanet 2020 RI

C. Cloquet, A. Galy
CRPG-CNRS, Univ. Lorraine, UMR 7358, Vandoeuvre les Nancy, France, agaly@crpg.cnrs-nancy.fr / Fax: +33 383511798

Abstract

Europlanet H2020 program include Transnational Access (TA) supporting travel and local accommodation costs of European researchers to conduct their own research. At CRPG, TA3-Distributed Sample Analysis Facility is available, giving access to the state of the art of 4 analytical facilities.

1. EuroPlanet

Europlanet 2020 RI is a Research Infrastructure that is addressing key scientific and technological challenges facing modern planetary science by providing open access to state-of-the-art research data, models and facilities across the European Research Area. It is a 9.95 million euros project to integrate and support planetary science activities across Europe. The project is funded under the European Commission's Horizon 2020 programme; it was launched on 1st September 2015 and will run until 31 August 2019.

A series of networking and outreach initiatives will be complimented by joint research activities and the formation of three Trans National Access distributed service laboratories (TA's) to provide a unique and comprehensive set of analogue field sites, laboratory simulation facilities, and extraterrestrial sample analysis tools.

A central part of the Europlanet 2020 RI programme is to allow any European researcher interested in pursuing planetary science research access to a comprehensive set of laboratory facilities and field sites tailored to the needs of planetary research.
Access is provided by a **Transnational Access (TA)** programme that supports travel and local accommodation costs of European researchers (and of researchers from Third Countries under certain conditions) at the facility for an approved period of time to conduct their own research programme. Applications are made in response to annual calls and are subject to peer review. It should be noted that applicants must apply to use facilities outside the country in which they are employed (i.e. it is a transnational access). **Applications can be made for analytical time or access to planetary analogue sites ranging from single days up to several weeks and up to two researchers can be fully financed in each research visit**

Europlanet 2020 RI is designed to support planetary science but applications in other research disciplines are also considered based on innovation and potential scientific and technological impact to the planetary sciences field.

Here we report on the infrastructure that comprises the facilities offered at CRPG under TA3: Distributed Sample Analysis Facility (DSAF). The modular infrastructure represents a major commitment of analytical instrumentation and forms a state-of-the-art analytical facility. The centre perform research in the fields of geochemistry and cosmochemistry, studying fluids and rocks in order to better understand the keys of the universe..

2. Ion Probe facilities

This facility comprises a CAMECA IMS 1280 HR2 and a CAMECA IMS 1270 Ion microprobe, upgraded in 2014 to match the capabilities of the recently installed IMS 1280. Ion microprobe is a CNRS-INSU national facility. About a third of the useful analytical time of the ion probe (about 3 months each year) is allocated to the national community. French scientists have to submit their projects to a national committee for selection. The selected projects are allocated time in the following 6 months twice a year. About 15 to 20 projects are run each year. There are only few such instruments in Europe, with cosmochemistry only performed at CRPG. Different analyses can be performed on a routine basis; which include U-Pb dating on zircon, monazite or pitchblende, C, O, Si isotope ratios and light and trace elements contents of different matrixes. A notable speciality is the measurement, at high precision, of the isotopic ratios of light elements (H, Li, N, Mg, S) including mass independent fractionation of sulfur isotopes.

3. Helium and Nitrogen Facility

Helium isotope measurements can be performed to determine the origin of gases and to date surface exposure with cosmogenic 3He using the latest He isotope mass spectrometer, the GV Helix SFT, the first instrument of its kind installed in Europe. Analysis of nitrogen at the nanomole level in rocks can also be done on static gas-source mass-spectometer VG5400.

4. Stable Isotope Facility

ThermoFinnigan Neptune Plus MC-ICPMS, MAT253, Picarro L2140i and GV Isoprime provide the capability for C, O, S, H isotope analyses of rocks, minerals, organic matter and fluids (water, natural gases) by continuous flow mass spectrometry coupled with elemental analyser or off line extraction and "novel" stable isotopes (e.g. Mg, Fe, Zn, Ge,) by sector field ICP-MS (Neptune+). This includes O isotopes on silicates by fluorination and H, C & O on fluids from single inclusions. The determination of high precision Mg, Ca, Fe and Ge isotopes is offered.

5. Radiogenic Isotope Facility

Analysis by TIMS (Finnigan Mat 262 and Thermo Finnigan Triton). This includes the Re-Os isotopic system and the extinct system 146Sm-142Nd as well as the Sr Nd and Pb isotopic systems that are the “traditional” isotopic systems in meteorite, lunar and terrestrial rock studies.

6. Example of Application

A recent study on the habitability of desertic areas, such as the hyperarid Atacama desert used the Stable isotope facility to demonstrate that the δD values for the waters in the hydrous sulfate minerals suggest that small amounts of water accessible to microorganisms might be available even in these hyperarid soils e.g., in the form of thin H_2O films at mineral surfaces or as a product of mineral–water exchange reactions. These results have implications for the prospect of life on other planets such as Mars, which has transitioned from an earlier wetter environment to today’s extreme hyperaridity (Schulze-Makuch et al. 2018; www.pnas.org/cgi/doi/10.1073/pnas.1714341115).

7. Summary and Conclusions

Currently planetary research is limited to meteorites and lunar samples but future return missions will provide enough material from comets and asteroids. A major focus of research in the next 5-10 years will be comparative planetology to understand the types of geochemical processes that can be expected on the (former) water rich regions of Mars to be sure that the detection of past life is unambiguous. The aim of this infrastructure is to provide a structured access to state of the art analytical facilities for European users.

http://www.europlanet-2020-ri.eu/research-infrastructure/field-lab-visits

europlanet

EPSC Abstracts
Vol. 12, EPSC2018-909, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Emissivity and reflectance measurement at low and high T of different hydrous salts: a tool to study the surface of the icy planets

Paola Comodi (1), Maximiliano Fastelli(1), Azzurra Zucchini(1), Alessandro Maturilli(2)

1) Dipartimento di di Fisica e Geologia, University of Perugia, Italy
2) Planetary Emissivity Laboratory, DLR German Aerospace Center, Berlin Germany

Icy planets, in particular Jupiter's moons, have attracted the scientific investigation due to the likely presence of oceans under crust which may potentially support life. Recent decision of NASA to go forward with plans for new mission to Europa provides strong incentives to deep the knowledge of the surface composition trough the analysis of exiting spacecraft data and telescopic observation. Really for the present-day researchers consider the beneath the icy surface of Europa is the most promising place to look environments suitable for life

The *non-ice* Europa's materials represent a question up to know not completely solved notwithstanding its relevance in planetary science and astrobiology. Preliminary data indicate that chloride and sulphate hydrates are important as extraterrestrial salts but a good database on the spectral features of some of them is lucking. The data known usually are restricted in a small frequency range and the collection of data is a function of temperature, atmosphere composition and are well grain distribution is very lacking.

The collection of a library of possible *non-ice* spectra should be fundamental for a correct and exhaustive interpretation of the remote data.

Recently Hanley et al (2016) [1] published reflectance spectra of hydrated chlorite salts, at room and low temperature to observe the effects of temperature on diagnostic spectral features.

They showed that at low temperature increase the resolution of the spectra since the bands become narrower with sharper and better defined minima and showed distint spectra features which should be interesting to interpretate remote sensing data.

About sulphate minerals there are a more extensive library, but a systematic study of the evolution of the spectra with chemistry, temperature and atmosphere composition is lacking. Moreover the published data refer to a limited spectra range, usually under 2.5 micron, where the sulphate signature is very poor (Dalton III B., 2003) [2]

In this study the emissivity and reflectance spectra of an accurately selected group of minerals were collected at low and high temperature to investigate the role of both the chemical substitutions (cations as well anions) and the amount of water molecules on spectral features. The samples investigated were: alcaline-earth alkaline sulphate [thenardite Na_2SO_4, arcanite K_2SO_4, barite $BaSO_4$, gypsum $CaSO_4$ 2H2O], magnesium sulphates with different water contents [kieserite $MgSO_4$ (H_2O), pentahydrite $MgSO_4 \cdot 5(H_2O)$,epsomite $MgSO_4 \cdot 7(H_2O)$], chloride [halite NaCl, silvite KCl]and

mixed salts [bloedite $Na_2Mg(SO_4)_2 \cdot 4(H_2O)$,loweite $Na_{12}Mg_7(SO_4)_{13} \cdot 15(H_2O)$, kainite $MgSO_4 \cdot KCl \cdot 3(H_2O)$, carnallite $KMgCl_3 \cdot 6(H_2O)$, polyalite $K_2Ca_2Mg(SO_4)_4 \cdot 2(H_2O)$]

Four sets of measurements were collected:

a) Emissivity in a purging environment at different Temperature (T) up to 130 °C
b) Emissivity under vacuum at T between 200 and 500 °C
c) Reflectance in a vacuum environment at room T
d) Reflectance in a vacuum environment with the samples freezed at -80 °C

Refectance measurements were collected on the same set of samples, both on the fresh ones and recoiled after heating.

Emissivity measurements, in the 1-16 micron spectral range, were collected with two Bruker Vertex 80V FTIR spectrometers, a nitrogen-cooled MCT detector and a KBr beamsplitter. One spectrometer was connected to a purged emissivity chamber for T_{sample} less than 130 °C, the second was working in vacuum for T_{sample} between 180 and 500 °C.

Reflectance measurement at 20° and -80 °C (by using a sample cooling device) were collected with a Bruker Vertex 80V FTIR spectrometers. All samples were recovered after the heating and freezing cycle measurements and were characterized by a chemical

and structural point of view by using electron microprobe and X-ray diffraction.
The final aim of the project is to improve the spectral library of possible *non-ice* materials and to associate the structural and chemical changes to selected bands in the emissivity and reflectance spectra. Moreover the spectral evolution studied over a wide T range, from -80 °C to around 500°C allows us understanding the T dependence gradient for different spectral bands.
These data will help to extract more detailed information from the remote data, moreover suggestions on which area and which data should have higher priority for remote investigations in the future space missions, could be derived.

Acknowledgements

Europlanet TA program (project number 17-EPN3-047 Europlanet 2020 RI TA to Paola Comodi) we used to visit the Planetary Emissivity Laboratory at DLR in Berlin where we collected the measurement is

acknowledged. Thanks to Manuela Rossi (Naples University, Italy) and Tonci Balic Zunic (Copenaghen University, Denmark) who give us some samples we used for the experiments.

References

[1] Hanley J., Dalton III B., Chevrier, Barrows R.S. (2016) Reflectance spectra of hydrated chlorine salts: The effect of temperature with implications for Europa. JGR Planet http://dx.doi.org/10.1002/2013JE004565ts

[2] Dalton III B., 2003 Europa. Spectral Behavior of Hydrated Sulfate Salts: Implications for Europa Mission Spectrometer Design. ASTROBIOLOGY Volume 3, Number 4, 2003

EPSC Abstracts
Vol. 12, EPSC2018-1221, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Development of the Experimental Set-up for Lunar Dust Particles Investigation and Instruments calibrations

A.N. Lyash, I.A. Kuznetsov, A.V. Zakharov, G.G. Dolnikov, I.A. Shashkova
Space Research Institute of the RAS, Moscow, Russia, email: kia@iki.rssi.ru

Abstract

Introduction:

The complex of scientific instruments of the Lander "Luna-Glob" included device PML. This instrument is designed to study the dust component, its dynamics in the near-surface exosphere of the moon, the registration of micro-meteorites and secondary particles of the lunar regolith, impact by micrometeorites and the measurement of their physical characteristics. The device directly measured momentum, velocity, mass and charge of the particles.
For the purpose of conducting physical experiments on modeling of the dusty environment conditions in the surface layer was created an experimental setup. This unit is designed for carrying out functional tests, adjustments and calibrations of the instrument. The installation is carried out testing of the methodology of space experiment. It is planned to hold correction of the coefficients of relative sensitivity and verification of the scientific data obtained during the mission.

Experimental set-up:

The experimental set-up is realized on the base of the vacuum chamber and includes a system of supply and control of vacuum, the injector (generator) of charged particles. The setup includes the control system for measuring the speed of the charge of particles and the system to measuring and control electrical signals and instrument parameters. Vacuum system provides vacuum with a residual pressure sufficient to operate the injector of the dust particles and simulate the conditions of the dust of the atmosphere. Injector (generator) of dust, charged particles produces a stream of metallic, charged particles with dimensions from units to hundreds of microns with flow rates from units to tens of meters per second with a charge of not less than 1000 electrons per the particle. The measuring system for the control of the speed and charge of particles consists of the induction sensor and charge sensitive amplifiers that allow to display and measure the signal. Method of measuring charge is based on the measurement of the induced mirror charge from the moving particles in the metallic electrode of the induction sensor. The geometry data of the placement of the induction sensors is used to measure the speed of particles by time delays of signals.

The voltage applied to the injector governs the speed and charge of the injected particles. In the experiments are used different in size and mass of particles loaded into the injector.
Since the process of injection and the detection of particles are random, the statistical methods to handle the large volume of accumulated data are used.

Results:

The set-up made it possible to realize the streams of charged particles with velocities in the range of 2 to 60 m/sec for the metalized particles with sizes from 10 μm to 200 μm.
On the installation was carried out calibration of the engineering sample PML device, had allowed to determine the sensitivity of the sensors of the device. Threshold sensitivity for the charge is amounted to 2 000 the charge of the electron. The threshold sensitivity of the momentum is amounted to the value of $3*10^{-12}$ Newton*sec.

Acknowledgements

This work was supported by the Russian Scientific Foundation (the grant № 17-12-01458).