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Planetary Sample Analysis Laboratory at DLR

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Abstract

Building on the available infrastructure and the long heritage DLR is planning to create a Planetary Sample Analysis laboratory (PSA), which can be later extended to a full Sample Curation facility. The step-wise extension follows the successful development approach used for the Planetary Spectroscopy Laboratory (PSL) and Astrobiology Laboratories. The goal is to test and validate each extension step before planning the follow-up step. The goal of the first step is the preparation to receive samples from the Hayabusa 2 mission.

1. Introduction

Global reconnaissance of planetary surface can only be obtained by remote sensing methods. Optical spectroscopy from UV to far-infrared is playing a key role to determine surface mineralogy, texture, weathering processes, volatile abundances etc. It is a very versatile technique, which will continue to be of importance for many years to come. Providing ground truth by in-situ measurements and ultimately sample return can significantly enhanced the scientific return of the global remote sensing data. This motivates the planned extension of PSL with a PSA laboratory by support of the Astrobiology Laboratories.

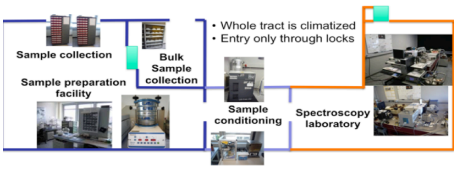
PSA will focus on spectroscopy on the microscopic scale and geochemical and geo-microbiological analysis methods to study elemental composition and isotopic ratios in addition to mineralogy to derive information on the formation and evolution of planetary surfaces, search for traces of organic materials or even traces of extinct or extant life and inclusions of water.

The DLR PSA will be operated as a community facility (much like PSL), supporting the larger German and European sample analysis community

2. Current facilities

The Planetary Spectroscopy Laboratory (PSL) at DLR (http://s.dlr.de/2siu) is the only spectroscopic infrastructure in the world with the capability to measure emissivity of powder materials, in air or in vacuum, from low to very high temperatures [1-3], over an extended spectral range. Emissivity measurements are complimented by reflectance and transmittance measurements produced simultaneously with the same setup. It is the ground reference laboratory for the MERTIS thermal infrared spectral imager on the ESA BepiColombo mission [4, 5]. Members of the PSL group are team members of the MarsExpress, VenusExpress, MESSENGER and JAXA Hayabusa 2 missions [6]. For the latter mission PSL has performed ground calibration measurements. In addition PSL has been used extensively in support of the ESA Rosetta mission. The samples analyzed at PSL ranged from rocks, minerals, to meteorites and Apollo lunar soil samples.

Figure 1: Current configuration of Planetary Spectroscopy Laboratory



In a climate-controlled environment PSL (Figure 1) operates currently three Fourier Transform Infrared Spectrometer (FTIR) vacuum spectrometers, equipped with internal and external chambers, to measure emittance, transmittance and reflectance of powdered or solid samples in the wavelength range from 0.3 to beyond 100 micron.
In addition the institute is operating a Raman micro-spectrometer lab (http://s.dlr.de/e49q) as part of the Astrobiology Laboratories with a spot size on the sample in focus of <1.5 µm. The spectrometer is equipped with a cryostat serving as a planetary simulation chamber which permits simulation of environmental conditions on icy moons and planetary surfaces, namely pressure (10-6 hPa – 1000 hPa), atmospheric constituents, and temperature (4K – 500K). The samples, which are analyzed in the laboratory range from minerals, Martian analog materials, meteorites, biological samples (e.g. pigments, cell wall molecules, lichens, bacteria,

archaea and other) to samples returned from the ISS (BIOMEX) [7, 8, 9] and the asteroid Itokawa (Hayabusa sample).

A sample preparation facility with a highly experienced lab technician and an extensive collection of analog materials and a large spectral database complement the equipment. Sensitive samples are stored in humidity-controlled environments with the option of nitrogen purging. Samples can be prepared in many ways, to match the wide range of techniques offered at PSL and the Astrobiological Labs. This includes producing grain size fractions as well as pressed pellets. Stereo microscopy as well as XRD (X-ray diffraction) analysis is used to characterize the samples before and after preparation as well as after measurements under different temperature conditions. Raman spectroscopic measurements can be performed before, during and after experimental planetary simulation.

All laboratory facilities undergo regular evaluations as part of the DLR quality management process. The evaluations address laboratory protocols, documentation, safety, data archival and staff training.

PSL is a community facility as part of the "Distribute Planetary Simulation Facility" in European Union funded EuroPlanet Research Infrastructure (http://www.europlanet-2020-ri.eu/). Through this program (and its predecessor) over the last 6 years more than 40 external scientists have obtained time to use the PSL facilities. PSL has setup all necessary protocols to support visiting scientist, help with sample preparation, and archive the obtained data.

3. Planned extension

4. The goal of the first step is the preparation to receive samples from the Hayabusa 2 mission. The current facilities are operating in climate-controlled rooms and follow well-established cleanliness standards. The PSA will be housed in an ISO 5 clean room, with one or two supporting clean rooms for sample handling, preparation and storage. The cleanrooms are equipped with glove boxes to handle and prepare samples. All samples will be stored under dry nitrogen. DLR in Berlin is already operating similar several clean rooms for (optical) instrument development.

To characterize and analysis the returned samples the existing analytical capabilities will be extended and complemented by the following capabilities:

1. Electron Microprobe Analyse (EMPA) for elemental analysis
2. Laser ablated inductive coupled Plasma Mass Spectrometer for elemental and isotope analysis
3. Dual Source TXRF & Grazing Incidence ED-XRF for mineralogical and structural analysis
4. Upgrade of the Fourier-Transform-Spectrometers with an IR-microscope to extend spectral analysis to the sub-micron scale
5. Supporting equipment incl. microtome to prepare thin sections, optical polarization microscope, etc.

Based on current planning the sample analysis laboratory is operational and ready for certification by mid of 2021. Analysis of first Hayabusa 2 samples will start by beginning to mid of 2022.

5. Outlook

Currently DLR is planning a Planetary Sample Analysis Laboratory. Following the approach of a distributed European sample analysis and curation facility as discussed in the preliminary recommendations of EuroCares (http://www.euro-cares.eu/) the facility at DLR could be expanded to a curation facility. The timeline for this extension will be based on the planning of sample return missions. The details will depend on the nature of the returned samples. Through the BIOMEX project a collaboration has been established with the Robert-Koch Institute (RKI) (http://www.rki.de) for question of samples that might pose a bio-hazard. RKI is operating BSL 4 facilities, which might be used as part of the DLR curation facilities.

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