The Planetary Laboratories Department at DLR – one stop shop for planetary science analog data. J. Helbert, A. Maturilli, A. Lorek, G. Alemanno, I. Büttner, M. D'Amore, M. Baqué, S. Adeli and S. Garland, Planetary Laboratories Department, Institute for Planetary Research, DLR, 12489 Berlin, Germany, joern.helbert@gmail.com.

Introduction: The newly formed Department for Planetary Laboratories bundles spectroscopy, and the astrobiological and analytical laboratory activities of the Institute for Planetary Research. Within this department we offer a wide range of laboratory techniques as well as environmental chambers that cover almost all bodies in the solar system and beyond. This includes the Planetary Spectroscopy Laboratory (PSL), the Planetary Analog Simulation LABoratory (PASLAB), the Raman-Mineral-Biology-Detection lab (RMBD), the Mars Simulation Facility (MSF) and the new Sample Analysis Laboratory (SAL).

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 like Raman spectroscopy and ultimately sample return can significantly enhance the scientific return of the global remote sensing data.

The overarching question driving the future activities of PLL are the formation and evolution of planetary surfaces and the potential for current or past habitability. Remote sensing spectral data for Mars, the Moon, Mercury and even Venus has provided us with insights into the evolution processes of terrestrial planets, but also raised a number of open questions. PLL is ideally situated to help address these questions by performing laboratory work under relevant conditions, studying extra-terrestrial material, analyzing mission data and developing new generations of instruments for planetary missions.

PASLAB and MSF: The Planetary Analog Simulation LABoratory (PASLAB) and the Mars Simulation Facility (MSF) are investigating the habitability of Mars, the detection of life in Mars-like and (soon) icy Moon-like environments, using planetary simulation experiments in the field, in the laboratories, and in space (Low Earth Orbit). While the Mars (MSF) simulation facility mimics the present Martian conditions the new Planetary Analog Simulation laboratory (PASLAB) is able to simulate the environmental conditions of early Earth, early Mars, and exoplanets with an extension to icy moon conditions planned. Due to the flexible nature of the setup, we can perform experiments for biological, physical and geo-chemical research. This allows to combine empirical results of investigated organisms in different planetary environments with results obtained by modelling.

PSL: The Planetary Spectroscopy Laboratories (PSL) [1] are building on the long-standing heritage in infrared remote sensing and infrared laboratory spectroscopy for planetary surfaces at DLR. Hyperspectral remote sensing instrument are integral part of almost every planetary mission. In combination with appropriate analysis techniques and supporting laboratory measurements they provide key information on surface composition and mineralogy. The institute has consolidated all UV, visible and infrared spectroscopy in the PSL. PSL is the only spectroscopic infrastructure in the world that offers the capability to measure emissivity of powder materials, in air or in vacuum, from low to very high temperatures (300-900K), over an extended spectral range (0.7-200 μm) in a range of planetary simulation chambers [2]. Emissivity measurements are complimented by bi-directional and hemispherical reflectance and transmittance measurements produced simultaneously with the same setup, covering the wide 0.2 to 200 μm spectral range.

RMBD: The Raman-Mineral- Biology Detection Lab (RMBD) is able to detect minerals, salts, biomolecules and organisms under ambient and icy planetary environmental conditions. The Raman micro-spectrometer can perform measurements 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).

SAL: Building on the available infrastructure and the long heritage in spectral studies of planetary (analogue) materials DLR has allocated dedicated funding for the setup of a Sample Analysis Laboratory (SAL). SAL will focus on the geochemical and mineralogical analysis of returned samples from unrestricted targets like e.g. asteroids, the Moon, comets and the Martian moons. Housed in a clean room SAL operates as core instruments an Electron Microprobe, a Scanning Election Microscope, as well as a X-ray diffraction (XRD) system including μ-XRD capabilities. SAL is currently the only facility in Europe directly dedicated to the analysis of extra-terrestrial samples. So far, the lack of such a facility was putting Europe at disadvantage in terms of getting access to samples from sample return missions. SAL has here the

potential to become a central coordination point within Europe for such activities.

Sample Preparation: The laboratories are supported by a sample preparation laboratory including a newly installed rock cutting room – allowing to prepare samples in various grain size fractions as well as slab geometries.

Access via Europlanet RI: PSL and PASLAB are part of the Horizon 2020 Europlanet Research Infrastructure. Europlanet 2024 RI's Transnational Access (TA) programme supports all travel and local accommodation costs for European and international researchers to visit these facilities. For details on the application process and eligibility see https://www.europlanet-society.org/europlanet-2024-ri/transnational-access-ta/.

PLL and Planetary Missions: The department is providing laboratory measurements and data analysis as support to a wide range of planetary missions. Based on the expertise in the department PLL has leading roles in several instruments and missions. PLL is host to the Co-PI of the Mercury Radiometer and Thermal Infrared Imaging Spectrometer (MERTIS) on the ESA-JAXA BepiColombo mission, as well as to the PI of the Venus Emissivity Mapper (VEM) instrument on the NASA VERITAS mission and of the VenSpec-M (VEM) instrument (and the VenSpec consortium) on the ESA Envision mission. For all three instruments and the operation and data processing is performed at PLL and the instruments are validated at PSL. PLL is host to the Co-PI of the BioSigN exposure experiment on the ISS, a successor of the successful BIOMEX exposure experiment[3].

Members of the department are co-investigators on numerous missions led by ESA, JAXA and NASA. For the JAXA Hayabusa 2 and MMX PLL has a member in the respective sample analysis working groups.

PLL and Industry: The work on measuring and generating accurate humidity levels for Mars research in MSF has also industry application, generating patents and an industry spin-off. In addition, PSL is providing service measurements for a range of industrial applications especially in the rapid prototyping community.

What will PLL do in 2022: 2022 will be a busy year for the department – so we just picked a few highlights on planned and ongoing scientific activities.

New spectral orbital data acquired by the ExoMars 2016 Thermal Infrared (TIRVIM) spectrometer contain valuable information about the surface and atmospheric composition. Laboratory experiments on Martian analogues at PSL including clays, silicates, carbonates, oxides and sulphates in emissivity under "Mars-like conditions'' as well as in bidirectional and hemispherical reflectance have provided new insights into the detectability of carbonates on Mars [4]. The improved spectral library will be used for the interpretation of orbital data incl. ExoMars 2016 TIRVIM and in preparation for the up-coming in-situ measurements of the NASA Mars 2020 rover and the ESA ExoMars 2022 rover.

Due to the strong link between water abundance and habitability the question of how much water was present during the formation of terrestrial planets is key to understand when habitable conditions existed. This has been long discussed for Mars, but is still little addressed for Venus. While we are searching for habitable planets around other stars, we do not yet understand why Venus is currently not a habitable planet. PSL already has world-wide unique capabilities to study Venus' spectroscopy that will help address the key questions on what caused Venus to follow a divergent path to its present hostile environment, devoid of oceans, magnetic field, and plate tectonics that may enable Earth's long-term habitability [2]. Putting this in a bigger context the question is really how do we know if an exoplanet is an Earth 2.0 or rather a Venus 2.0? And where does Mars fit in this range? PASLAB will setup environmental simulations for terrestrial planets around M-class stars to study atmospheric biosignatures as well as potential of habitability on such bodies.

Asteroids (and comets) as remnants of the accretion process provide sample material that reveals insights in the early stages of the planetary evolution that are extensively studied within the "small body" topic in the institute. PLL is already part of the JAXA Hayabusa 2 mission with co-investigator the MASCOT lander as well as the TIR imager on the orbiter and importantly a membership in the initial sample analysis team [5]. The orbital data revealed the presence of hydrated minerals on the surfaces of Ryugu, through the identification of the 3-µm spectral absorption band indicative of the presence of (OH)-bearing minerals. The thermal infrared data showed a highly porous surface structure. Analog measurements are currently underway at PSL and all this prepares for the first samples expected at SAL by the end of 2022.

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Additional Information: For more information check the details on the instrumentations in the various laboratories on our website at: https://www.dlr.de/pf/desktopdefault.aspx/tabid-17241/