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PP	Restricted to other programme participants (including the Commission Service)	
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Abstract: The main goal of TA2 (Distributed Planetary Simulation Facility – DPSF) is to give European and international scientist access to seven world-leading laboratory facilities to study planetary analog materials. The urgent requirement for access to these facilities is that Europe is operating, preparing and planning a fleet of spacecraft to investigate the surface and atmospheric environments and compositions of Mercury, Venus, comets, Mars, Jupiter, Titan and Europa. These disparate bodies are made up of remarkably diverse environments, many totally incomparable to terrestrial conditions. The expanding planetary exploration programme is generating an increasing demand for simulation facilities from European scientific and industrial communities to aid with key mission goals; instrument design; validation of instrument performance; to obtain a better understanding of the physical-geological processes that formed specific planetary environments and the biogeochemical processes that control the likelihood that life could evolve or survive. To address this demand DPSF has retained the three laboratories most in demanded in Europlanet-RI, all of which have introduced new infrastructure and expanded their methodologies since 2008. Four new laboratories have been added extending the capabilities to include spectroscopy in low temperature environments, life detection techniques, high temperature and pressure petrology and petrology-geochemical characterisation techniques. The three laboratories that were part of the previous Europlanet-RI allow visitors to measure samples under analogue conditions of Mercury, Venus, Mars, the Moon and near-Earth asteroids. The new low temperature spectroscopy laboratory has extended capabilities to comets and the icy moons of the outer planets. The added life detection techniques are supporting the study of terrestrial extremophiles educating us about the range of potential habitable environments in the Solar System. The new high temperature and pressure petrology laboratory extended our studies from the planetary surface to the workings of planetary interiors and ultimately to the evolution of planets. Finally the computer tomography facility is providing high quality geochemical imaging data of samples returned from space and allows detailed comparisons with analogue studies. DPSF is continuously over the reporting periods providing major synergies between the laboratories, allowing the use of multi-disciplinary approaches and giving the European scientific community access to a wide range of world leading technologies and in many cases unique methodologies.

Document history				
Date	**Version**	**Editor**	**Change**	**Status**

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03/08/2018	1	J. Helbert	Deliverable to project office	Revised
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1. Explanation of the work carried out by the beneficiaries and Overview of the progress

The seven TA host institutions have all contributed to the publicity associated with the calls for access to TA facilities. This was achieved at international conferences and through dedicated planetary science and geochemical e-mail forums. Details of the application procedure for the TA facilities that allows rigorous appraisal of the scientific impact is detailed in previous sections.

Full details of the individual calls completed can be found at the Europlanet2020 RI website (http://www.europlanet-2020-ri.eu/research-infrastructure/public-deliverables) along with reports submitted and approved at the completion of the individual visit, which have been stored in a private part of the website. The amount of data and the wide range of research performed at the seven facilities cannot be fully displayed in this summary report. We can highlight here only some examples of research undertaken.

Task 3.1: Planetary Spectroscopy Laboratory, Institute for Planetary Research, DLR, Berlin, Germany

Proposal number	Access provider short name	Installation ID	Installation	Approved days	Actual days visited	Name of visitors	Project Title
17-EPN3-053	PEL	TA2-1	Planetary Emissivity Laboratory	5	5	Giulia Alemanno	Emissivity and reflectance measurements of particulate mixtures for the interpretation of planetary remote sensing data
17-EPN3-047	PEL	TA2-1	Planetary Emissivity Laboratory	10	10	Paola Comodi (Max Fastelli)	New insight on the surface on the icy planets
17-EPN3-082	PEL	TA2-1	Planetary Emissivity Laboratory	5	5	Fabrizio Dirri	Emissivity investigation of Ceres surface analogue materials and application to Thermal IR telescopic observations
17-EPN3-006	PEL	TA2-1	Planetary Emissivity Laboratory	5	2	Lisseth Gavilan	Infrared properties of Titan aerosols by using tholins powders and thin films produced in a plasma simulating Titan's atmosphere
17-EPN3-061	PEL	TA2-1	Planetary Emissivity Laboratory	5	5	Kerri Donaldson Hanna (Neil Bowles)	Spectral characterization of a suite of well-characterized bulk lunar soils from the ultraviolet to the far infrared
17-EPN3-023	PEL	TA2-1	Planetary Emissivity Laboratory	5	5	Jacopo Nava	Mineralogical composition of the asteroid Ceres derived from thecomparison between Antarctic-weathered and laboratory-weathered meteorites spectra, micrometeorites spectra and the NASA-Dawn space mission data
17-EPN3-050	PEL	TA2-1	Planetary Emissivity Laboratory	5	5	Giovanna Serventi (Cristian Carli)	Sample characterization under hermean conditions

Table 1 Visits to PEL facility at DLR during reporting period

17-EPN3-047: New insight on the surface on the icy planets (Paola Comodi)

Icy planets, in particular Jupiter's moon Europa, have attracted the scientific attention due to the likely presence of oceans under the crust which may potentially support life. NASA plans for new a mission to Europa boost our will increasing the knowledge of the surface composition trough the analysis of exiting spacecraft data and telescopic observation. The *nonice* Europa's materials represent a question up to know not completely solved notwithstanding its relevance in planetary science and astrobiology. Preliminary data indicate sulphate hydrates are especially important on hydrous worlds, and are expected to be important extra-terrestrial salts but a good database on the spectral features of some of them is lucking. The collection of a library of possible *nonice* spectra is fundamental to interpret the remote data.

During experiments at PSL, emissivity and reflectance spectra of an accurately selected group of minerals were collected at different temperature, to investigate the role of chemical substitutions (cations as well anions) and of the amount of water molecules on spectral features. In particular the samples investigated were subdivided in the following sub groups:

a) Alcaline-earth alkaline sulphates: Thenardite Na2SO4, Arcanite K2SO4, Barite BaSO4, Gypsum CaSO4 2H2O,

b) Magnesium sulphates with different water contents: Kieserite MgSO4 (H2O), Pentahydrite $MgSO_4 \cdot 5(H_2O)$,Epsomite $MgSO_4 \cdot 7(H_2O)$

c) Chlorides: Halite NaCl, Silvite KCl

d) Mixed (chloride and sulphates) 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 up to 130 °C

b) Emissivity under vacuum at temperature between 200 and 500 °C

c) Reflectance in a vacuum environment at room temperature

d) Reflectance in a vacuum environment with the samples frozen at -80 °C

Reflectance measurements were collected on the same set of samples, both on the fresh and recoiled after heating samples, for a total of about 30 samples.

Emissivity measurements were taken using two identical Bruker Vertex 80V FTIR spectrometers, with a nitrogen-cooled MCT detector and KBr beamsplitter, connected to an emissivity chamber: one for moderate temperature (from room temperature up to 130 °C under purging conditions) and one for high temperature measurement (from 180 °C to about 500° C in vacuum). Figure 1 shows the spectral measurements taken on the sample thenardite.

A freezer device operating at -80 °C was used to bring the samples at that temperature and a special apparatus (containing N2 liquid) was used to maintain the specimens at -80 °C during the spectral measurement. All samples were recovered after the heating and freezing cycle

measurements and will be characterized by a chemical and structural point of view by using electron microprobe and X-ray diffraction.

The final aim of the project will be 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 in a wide temperature range, from -80 °C to about 500°C allows us to know the temperature 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.

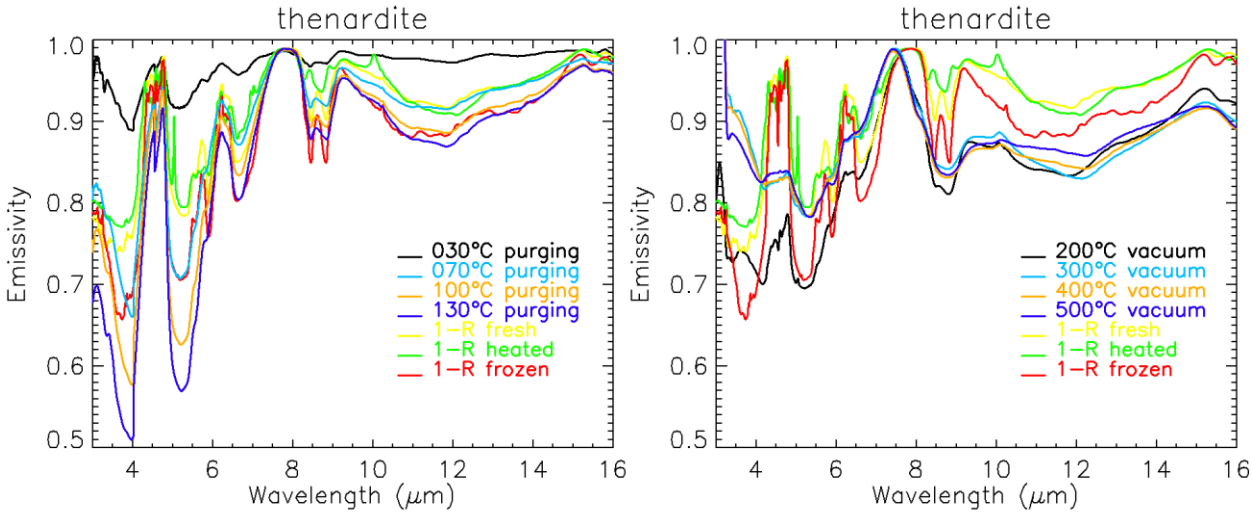


Figure 1. Spectral measurements on the thenardite sample

Task 3.2: Interactive Microbiome Research Facility (IMRF) Medical University Graz (MUG), Centre for Medical Research (ZMF), Graz, Austria.

Proposal number	Access provider short name	Installation ID	Installation	Approved days	Actual days visited	Name of visitors	Project Title
16-EPN2-021	MUG	TA2-2	IMRF	10	10	Nikea Ulrich (Ralf Möller)	Microbial diversity in the vicinity of the Concordia research station on the high Antarctic plateau: studying spatiotemporal dynamics of indigenous and human-associated microorganisms (Short title “IceBacs”)
17-EPN3-067	MUG	TA2-2	IMRF	5	5	Rahela Carpa	MICROBIOTA AND THEIR MICROENVIRONMENT IN MUD VOLCANOES FROM HASAG AND BOZ, ROMANIA
17-EPN3-026	MUG	TA2-2	IMRF	5	5	Martina Cappellett i/Daniele Ghezzi	In-depth microbial composition analysis of speleothems from the quartz-sandstone cave Imawarí Yeuta in Auyan Tepui (Venezuela)
17-EPN3-021	MUG	TA2-2	IMRF	5	5	Ilenia D'Angeli	Sulfur as a key for life? The microbial potential of sulphuric

						(Stefan Leuko)	caves in Italy and the implications for extant or extinct life on Mars
17-EPN3-018	MUG	TA2-2	IMRF	10	10	Cyprien Verseux	Microbiome evolution during the HI-SEAS IV mission and impact on human space travel
17-EPN3-031	MUG	TA2-2	IMRF	10	3 (remaining will follow in fall 2018)	Jenni Hultman/ Sirja	Microbial diversity and selection of key members for single cell sequencing from arctic soils

Table 2 Visits to PEL facility at DLR during reporting period

17-EPN3-018: Microbiome dynamics during the HI-SEAS IV mission and impact on human space travel (Dr. Cyprien Verseux.)

The main objective of the reported project was to advance our knowledge on the evolution of microbial communities associated with crewed missions in isolated and confined environments, notably long-term space missions. Indeed, pathogens (or opportunistic pathogens) and technophiles may pose a threat to space crews and mission objectives. In addition, dynamic changes of the microbiome must be considered when designing planetary protection strategies.

This project took advantage of the HI-SEAS IV mission, which took place in 2015-2016. HI-SEAS IV gathered for a year 6 people selected for their astronaut-like features, in an 11-meter-in-diameter dome located on the barren slopes of the Mauna-Loa volcano in Hawaii, USA, primarily for NASA BHP research. The crew was isolated and confined, and hygiene practices were restricted.

The Project Leader, who was one of the crewmembers, collected surface samples on ground and furniture surfaces, and on the crewmembers' front torso skin. Those samples were taken every other week from September 18th, 2015 to August 26th, 2016, and an extra series of skin wipe samples was taken one week after the mission. In brief, the habitat/furniture surface samples were taken with swabs at 4 different locations: i) external surface of the toilet bowl, ii) wooden table surface in an individual compartment, iii) plastic table surface in the common area, and iv) gap between two pieces of furniture in the kitchen, where dust tends to accumulate. The skin surface (front torso) samples were taken by each crewmember on themselves, following written instructions.

The samples were then analyzed at the Center for microbial life detection at MUG, Austria, using NGS-based amplicon sequencing.

Samples from the built environment were very similar to each other over the whole sampling period, while samples from the crew showed some events of very high dissimilarity, mostly due to an archaeal lineage. Indeed, surprising abundances (up to 80%) of the archaeon *Methanobrevibacter* were found in some wipe samples. Metadata predictions with Forest Classifiers worked very well for different sampling categories with an overall accuracy of 97%, while predictions of different time points were less accurate ($R=0.8$, $P=1.7*10^{-9}$).

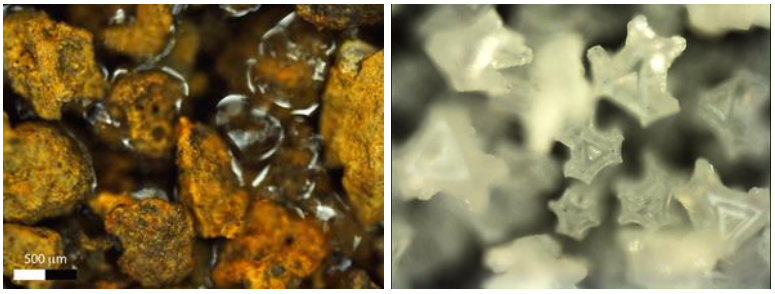
Further work is ongoing to obtain a deep understanding of the microbiome's nature and dynamics throughout the HI-SEAS IV mission.

Task 3.3: Planetary Environment Facilities at Aarhus University, Denmark

Proposal number	Access provider short name	Installation ID	Installation	Approved days	Actual days visited	Name of visitors	Project Title
17-EPN3-005	AU	PEF	AWTSII	5	5	John McClean, Robin Vinther Nielsen	Investigation into the long-term effects of dust loading on atmospheric in-situ resource utilisation on Mars
15-EPN-009	AU	PEF	AWTSII	5	3	Fernando del Campo Deustua, Bahillo Mugarza	EXOMARS ROVER SOLAR ARRAY MECHANISM DUST TEST
17-EPN3-072	AU	PEF	AWTSII	5	5	Anya Portyankina, Zurine Yoldi, Clemence Herny	Variety Of CO2 Ice Crystals And Their Creation And Metamorphism In The Martian Polar Regions
15-EPN-031	AU	PEF	AWTSII	5	5	Fabio Cozzolino, Cesare Molfese	Measurements and tests of a Martian Dust Analyser in Martian relevant environmental conditions

Highlight (17-EPN3-072): Variety Of CO2 Ice Crystals And Their Creation And Metamorphism In The Martian Polar Regions (Anya Portyankina, Zurine Yoldi, Clemence Herny)

Vast seasonal ice caps of CO_2 form every fall on the Martian poles and sublimes every spring. In order to understanding the physics of this process simulations at the Aarhus Planetary environment facility were carried out. Important new observations of the various phases and properties of CO_2 ice were made and how they evolve. This will help in analyzing remote-sensing data of CO_2-covered surfaces on Mars. The figures show microscope images; (left) CO_2 ice depositing as transparent slab ice and beginning to immerse sand under Martian conditions and (right) shows as yet un-researched crystal forms created at even lower temperatures and pressures. This work is presented at the EGU 2018 and EPSC 2018 conferences.



Task 3.4: Cold Surfaces spectroscopy, Institut de Planétologie et Astrophysique de Grenoble (IPAG) Grenoble France

Proposal number	Access provider short name	Installation ID	Installation	Approved days	Actual days visited	Name of visitors	Project Title
17-EPN3-042	IPAG	TA2-4	CSS	5	5	Assimo Maris, Camilla Calabrese	Spectroscopic Investigation Of Terrestrial Analogues Of Mars By Simulating Different Environmental C
17-EPN3-054	IPAG	TA2-4	CSS	5	5	Federico Tosi, Simone de Angelis, Cristian Carli	Characterization Of Na-Sulfates At Cold Planetary Conditions
17-EPN3-057	IPAG	TA2-4	CSS	10	8	Zuriñe Yoldi, Romain Cerubini,	Measurement Of The Infrared Reflectance Spectra Of Icy Solar System Analogue Material

						Antoine Pommerol	

17-EPN3-054: Characterization of Na-carbonates at Cold Planetary Conditions (Federico Tosi)

The proposal carried out a series of laboratory measurements of the VIS-NIR spectra of sodium carbonates with different levels of hydration (decahydrate / Natron, monohydrate / Thermonatrite and anhydrous / Natrite), in three different grain sizes and in a wide range of temperatures (93-279 K), representative of real planetary surfaces. These measurements are key to correctly interpret data acquired by spectrometers carried onboard ongoing and future interplanetary space missions at various planetary bodies, particularly Ceres (Dawn), Mars (ExoMars 2018, Mars 2020), and the Jovian icy satellites (JUICE, Europa Multiple-Flyby Mission).

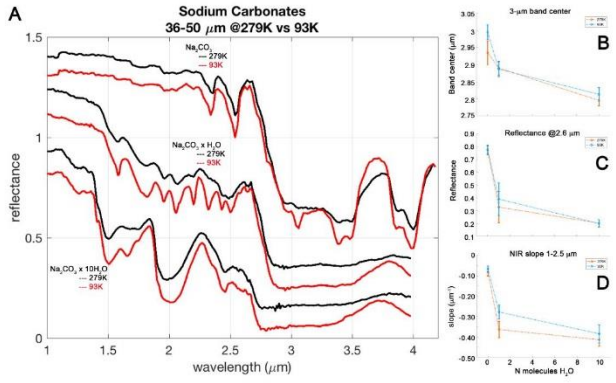


Figure 13. A. Spectra acquired for the three species for 36-50 μm grain size, at 279 K (black) and 93 K (red). Spectra of Na_2CO_3 and Na_2CO_3•H_2O are shifted in reflectance by 0.2 and 0.1 for clarity, respectively. B. Band minimum of the 3 μm band, as a function of number of water molecules. C. Reflectance @2.6 μm as a function of water molecules. D. NIR slope (1-2.5 μm) versus water molecules. For each specie, the spectral parameters have been averaged over the three grain sizes.

The SHINE spectro-gonio radiometer coupled to the CarboN-IR cryogenic cell was used to allow reflectance measurements at temperatures as low as 93 K on large samples of powdered Na-sulphates, sieved to 3 separate grain size ranges (36-50, 75-100 and 125-150 μm).

9 samples and 2 references were measured at 11 temperatures over the 93-279 K range. Each experiment took one full day (+ night). In total 110 spectra covering the 0.8-4.2 μm range were recorded. Six of them are plotted in the left figure.

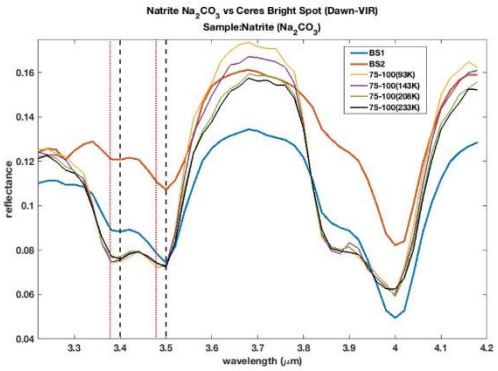


Figure 15. Spectra of Natrite sample with 75-100 mm grain size at 4 temperatures compared to two spectra of Ceres Bright Spot. VIR data have been resampled on the same set of wavelengths used in the lab (the average VIR spectral sampling is ~10 nm in the infrared range 1-5 μm, De Sanctis et al., 2011).

The temperature-dependent laboratory spectra recoded during this TA have been compared with Dawn-VIR spectra of 29 Ceres and with Galileo-NIMS spectra of Europa. In particular the data allowed to confirm the Natrite identification in Cerealia Facula, the brightest feature found in the crater Occator of Ceres (Figure), and to constrain the temperature of this anhydrous Sulphate.

This project leaded to the submission of a paper to Icarus (under review):

De Angelis, S., C. Carli, F. Tosi, P. Beck, O. Brissaud, B. Schmitt, S. Potin, M.C. De Sanctis, F. Capaccioni, and G. Piccioni 2018. NIR reflectance spectroscopy of hydrated and anhydrous sodium carbonates at different temperatures. Icarus, submitted (26/04/18).

Task 3.5: High-Pressure, High-Temperature Laboratory (HPHTL), Geology and Geochemistry, VU University Amsterdam.

The facility had no visitors in this reporting period.

Task 3.6: Large Mars Chamber Facility (LMCF), Open University, Milton Keynes, United Kingdom

Proposal number	Access provider short name	Installation ID	Installation	Approved days	Actual days visited	Name of visitors	Project Title
17-EPN3-069	OU	TA2-6	Large Mars Chamber	2	5	Lauren McKeown	An Investigation Of The Role Of CO2 Sublimation And Levitation As A Geomorphic Agent Under Martian Conditions
17-EPN3-078	OU	TA2-6	Large Mars Chamber	2	3	Sabrina Carpy, Marion Masse	Emergence Of Exotic Ripples Formed Under A Tenuous Atmosphere: Exploration Of Their Size And Dynamic behaviour

17-EPN3-069: An Investigation Of The Role Of CO2 Sublimation And Levitation As A Geomorphic Agent Under Martian Conditions (L. McKeown)

The Martian atmosphere is comprised predominantly of carbon dioxide which is deposited in the form of ice, frost and snow each winter. The spring sublimation of this seasonal ice deposit is now widely recognised as a cardinal agent of landscape modification in the present day. A variety of sublimation hypotheses have been offered for the formation of these features. Previous experiments indicated that pressurised sublimating carbon dioxide gas beneath a CO_2 ice overburden can form a variety of furrow networks and that a stationary sublimating CO_2 ice block can erode pits and surrounding levees on level beds of grain sizes ranging from 4-212 μm. However, the efficacy of these individual geomorphic mechanisms has never been investigated under Martian atmospheric pressure, which is three orders of magnitude lower than ambient Earth pressure and hence would significantly affect sublimation rate and sediment transport. Additionally, the patterns resulting from a central vent within the ice have never been investigated, which may produce radial and even dendritic radial morphologies similar in pattern to the araneiform terrain on Mars. This visit performed a suite of experiments at the Open University Mars Simulation Laboratory which were designed to investigate the efficacy of CO_2 block sublimation in the context of pit and furrow formation under Martian conditions. To investigate radial furrow formation, Guyson Honite glass spheres were poured into a 60 x 40 x 40 cm glass tank positioned in the Mars Chamber and were levelled and smoothed. A CO_2 block was drilled at its centre to create a hole using a drillbit measuring either 3 mm or 5 mm. The chamber was depressurised and when ambient pressure reached 6 mbar, the block was gently lowered onto the surface using a pulley. Initial data show excellent agreement with the numerical model of CO_2 block sublimation and levitation indicating CO_2 block sublimation and levitation may be responsible for linear gully pit formation on Mars. Additionally, for the first time, radial furrow formation analogous in morphology to the enigmatic araneiform terrain of the Martian south polar cryptic region were observed. These were formed by cryoventing in a similar manner to that suggested for the araneiform terrain and furrows on Martian dunes, where subsurface gas and material was transported above the ice in a plume. This is the first observation of its kind and we expect this particular result will be presented in a high impact journal. A summary of this work along with other merits was awarded the Planetary Science Institute's Pierazzo International Student Travel Award to present at the Lunar and Planetary Science Conference in Houston, TX. Two peer reviewed journal manuscripts are currently being prepared on the results from these experiments.

Task 3.7: Petrology-Mineralogy Characterisation Facility (PMCF), Mineral and Planetary Sciences Division, Natural History Museum, London, UK

Proposal number	Access provider short name	Installation ID	Installation	Approved days	Actual days visited	Name of visitors	Project Title
17-EPN3-033	NHM	TA2-7	PMCF	5	5	Keyron Hickman-Lewis	High-Resolution Correlative Microscopy Of Biogenic And Abiotic Carbonaceous Matter In Archaean Chert
17-EPN3-079	NHM	TA2-7	PMCF	10	10	Christopher Hamann	Element Fractionation During Vapour Condensation In Nature And Experiment: Implications For High-Tem

17-EPN3-033: High-Resolution Correlative Microscopy of Biogenic and Abiotic Carbonaceous Matter in Archaean Cherts (Keyron Hickman-Lewis)

Keyron Hickman-Lewis visited the X-Ray diffraction laboratory and CT laboratory at the Natural History Museum, London in December 2018. In collaboration with Dr Sara Russell at the NHM, this research visit sought to:

- Investigate morphology and context of the earliest traces of life on Earth from the early Archaean (>3 billion years ago) of South America and Western Australia.
- Analyse the mineralogical and elemental associations of surficial colonies commonly associated with biofilms in order to constrain substrate relations.
- Assess the potential of these biosignatures to be preserved and detected during the search for life on Mars, particularly emphasising the ExoMars2020 mission.

High resolution CT scans conducted on material from the Barberton greenstone belt of South Africa and the East Pilbara terrane of Western Australia permitted the assessment and refinement of 3-D biogenicity criteria for a range of biogenic and sedimentary samples. This research also supports the utility of CT scanning when applied to the Precambrian fossil record. Further detailed XRD measurements, specifically targeting clay mineralogy, enabled better understanding of how microbes are governed by their substrates, and the way in which morphologies and ecosystem diversity are controlled by geosphere bio-availability.
The research carried out during this highly successful visit greatly extends our understanding of ancient microbial biomes in the Archaean, and will contribute towards a number of publications.

2. Deviations from Annex 1 (if applicable)

2.1 Tasks (if applicable)

No deviations

2.2.1 Unforeseen subcontracting (if applicable)

Not applicable

2.2.2 Unforeseen use of in kind contribution from third party against payment or free of charges (if applicable)

Not applicable