



## **EPN2020-RI**

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**Abstract:** Under Horizon 2020, the Europlanet 2020 Research Infrastructure (EPN2020-RI) is promoting access visits to external users to already validated Earth Analogues to external users through the Trans National Activity 1 (TA1). The selected sites provide the most realistic terrestrial analogues of the surface and near surface geological-geomorphological environments of Mars, Europa and Titan.

Four Planetary Field Analogues, PFA Rio Tinto (Spain), Ibn Battuta (Morocco), Danakil depression (Ethiopia) and cold and hot environments in Iceland (PFA) Lake Tirez (Spain) were selected to provide Transnational Access (TA) during this reporting period of the project to a set of well-characterized planetary analogue field sites. These PFAs from part of EPN2020-RI's strategy to provide researchers from a board spectrum of disciplines with the capability to undertake comprehensive multi-disciplinary research strategies needed to support planetary missions..

*The focus areas of the projects that were carried out during this reporting period can be broadly grouped into three categories: 8 projects focussed on the analysis of geological structures and processes, 7 projects looked at biological processes to answer questions of planetary habitability and the remaining projects focussed on the development and testing of mission instruments.*

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## 1. Explanation of the work carried out by the beneficiaries and Overview of the progress

All the extreme sites offered to external users on TAs activities had applications..

Eighteen scientific teams were granted access to the Europlanet installations during this reporting period. Lake Tirez in Spain, managed by INTA, hosted two scientific teams, Ibn Battuta in Morocco, managed by IRSPS hosted four teams and another two will complete their visits within this reporting period, Danakil Depression in Ethiopia, also managed by IRSPS, hosted five teams and the Iceland installation, managed by Matis OHF (PFA) hosted three teams and one other team will complete its visit within this reporting period. A team selected in the previous Call also visited Iceland within this period. Very few proposals were received for access to Rio Tinto field site and finally no proposals were funded for this period.

Details of the scientific teams, the topics covered and publications resulting from these visits are listed below.

### Description of the Trans-national Access activity in Tirez Lake during the second reporting period

The two visits to this site were:

<b>ESF Project No.</b>	<b>Title</b>	<b>Proposer</b>	<b>Visit</b>
17-EPN3-040	A microbiological investigation examining Europa's potential as a habitable environment	Nisha K Ramkisson The Open University, Walton Hall, Milton Keynes	Oct 2017
17-EPN3-030	Extremophiles from Tirez and Peña Hueca: Implications for exploring habitability of Mars and Europa	Rebecca Thombre. Modern College of Arts, Science and Commerce, Shivajinagar, Dept. of Biotechnology, S.P.Pune University, Pune,India.	09. – 13.04.18

**17-EPN3-040: A microbiological investigation examining Europa's potential as a habitable environment:**

The objective of this project was to study the hypersaline lake, Tírez, which is rich in magnesium sulfates, because analysis of frozen brines from this site showed a spectral resemblance to the NIMS data obtained from Galileo, and these brines have high concentrations of Na, Mg, Cl and SO<sub>4</sub>. Additional lakes in the region were also sampled. This included Laguna del Taray, Laguna del Altillo Grande, Laguna del Altillo Chica, Laguna del Longar, Laguna de Peñahueca and Laguna Larga, which are also hypersaline lakes found in Villacañas region. SEM-EDX analysis of precipitates from water collected at Laguna de Peñahueca were rich in Mg, Na, and Cl, with some S also detected, which is similar that found at Tírez. The lakes visited all had a salt crust, presumably NaCl, over sediment on the lake bed, however, at lake Tírez large crystals of gypsum were also found. Damp sediments that appeared to have sulfur reducing bacteria was also identified at Tírez in a manmade pool (that had since dried up). Salt crusts, sediment and brine (where collection was possible) and microbial enrichments were prepared by the external team. These samples have been sub-cultured in the reception laboratory and the external team is using the serial dilution approach to isolate microorganisms from these samples. Once microorganisms have been isolated and characterised the external team will grow the microorganisms in a Europa brine simulant and will investigate whether the Europa sub-surface oceans are habitable. In addition, the external experts are in the process of developing a DNA extraction protocol for extracting DNA from these highly saline environments.

Publications:

Roth, L., Saur, J., Retherford, K. D., Strobel, D. F., Feldman, P. D., McGarth, M. A., Nimmo, F. (2014) Transient water vapour at Europa's south pole, *Science*, 343, 171-174.

Sparks, W. B., Hamd, K. P., McGarth, M. A., Bergeron, E., Cracraft, M., Deustua, S. E. (2016) Probing for evidence of plumes on Europa with HST/STIS, *The Astronomical Journal*, 829:121.

### **17-EPN3-030: Extremophiles from Tirez and Peña Hueca: Implications for exploring habitability of Mars and Europa:**

The main objective of this Project was to study Tirez lagoon system and the isolation of extremophiles that were able to survive in the conditions of the Jupiter's Europa Moon. Peña Hueca was a unique pink colored lagoon located at 653 m altitude, 39° 30' 56" N 3° 20' 21" W (UTM WGS84) with maximum depth of 40 cm. It was characterized by its bright pink colored water that had a thick layer of pink colored salt crust. Underlying the crust, a typical green mat was observed below which a black anoxic layer was observed. Samples and rocks were collected from the lagoon and analyzed for physicochemical parameters like sodium, potassium, chloride, magnesium content. Laguna de Peña Hueca had a salinity of 12.5 % with a sulphate content of 18.75g/L, magnesium content of 9.04 g/L and a pH range of 7.5-7.9. Extremely halophilic organisms were isolated from rocks collected from Peña Hueca using Sehgal and Gibbons médium containing 1.5 M NaCl and 0.5 M MgSO<sub>4</sub>. The organism was identified using biochemicals and 16 S rRNA gene sequencing. The organism was exposed to high concentration of salinity, epsomite, sodium sulphate and perchlorate as described earlier to explore its potential survival in Martian conditions.

Publications:

Extremophiles from Tirez and Peña Hueca: Implications for exploring habitability of Mars and Europa. Rebecca Thombre, Priyanka Kulkarni, Felipe Gomez, Bhalamurugan Sivaraman EPSC2018. Berlin, Germany.

### Description of the Trans-national Access activity in Iceland

During the third call, five applications were successful (Table 1), of which two took place during summer/autumn 2017 and one in spring 2018. The remaining two projects will be conducted during the summer 2018. In addition, one delayed project took place in 2017 that was approved in the second call.

Successful applications in the third call to access the Icelandic TA-RI site and occurring visits during the reporting period:

<b>Delete this column Appl. No.</b>	<b>ESF Project No.</b>	<b>Title</b>	<b>Proposer</b>	<b>Visit</b>
11132	16-EPN2-064	Analog studies on salt minerals assemblages for support of the MEDA instrument of the future Mars 2020 NASA mission	Olga Prieto-Ballesteros, Centro de Astrobiología, Spain	23. - 31.10.17
11193	17-EPN3-004	Searching for molecular evidences of life in extreme environments by exploiting molecular (geolipids) and isotopic forensic tools.	Daniel Carrizo, Centro de Astrobiología, Spain	17. – 24.04.18
11200	17-EPN3-009	Lithotrophic microbial communities and biosignatures in geothermal environments at Kverkfjöll: an analogue for Mars life	Arola Moreras Marti, St. Andrews University, U.K.	30.07. - 09.08.17
11228	17-EPN3-020	Microbial colonization and weathering of terrestrial basalts	Anu Hynninen, University of Helsinki, Finland	23. – 31.08.17
11294	17-EPN3-052	MILaCE : Mars Investigations and Landing Cameras Experiment	Giacomo Colombatti, CISAS G. Colombo - University of Padova, Italy	Summer 2018
11339	17-EPN3-076	Resolving chemical complexity of hot springs dissolved organic matter (DOM) from different geothermal areas in Iceland	Mourad Harir, Helmholtz-Zentrum München, Germany	July 2018

Visits to the Icelandic TA site since the last report:

**ESF Project 16-EPN2-064 (Analog studies on salt minerals assemblages for support of the MEDA instrument of the future Mars 2020 NASA mission):**

The Mars Environmental Dynamics Analyzer (MEDA) instrument is the MET sensors package of the NASA Mars 2020 mission. MEDA will characterize the weather and dust environment of Mars and will help to infer Martian potential habitability by studying the interaction between atmosphere and substrate. The Iceland analogue site was used in this project to produce unique and valuable data for the European science and technology teams of MEDA, by characterizing the mineral changes due to substrate-atmosphere interaction and thermal properties of hydrothermal mineral assemblages. Two main geothermal areas and some small geothermal patches were chosen for sampling because of the presence of high-Fe basalts and extensive sulphate and phyllosilicates-rich deposits from basalt weathering, but also according to the acid-sulphate alteration and oxidation conditions of the hydrothermal fluids, and 31 samples were taken. In addition, in-situ measurements were done using – among other instruments - a portable RAMAN spectrometer with similar characteristics to Mars 2020's SuperCam.

**ESF Project 17-EPN3-004 (Searching for molecular evidences of life in extreme environments by exploiting molecular (geolipids) and isotopic forensic tools):**

The aim of the project was to geochemically characterize Icelandic geothermal sites in order to investigate the habitability of these extreme environments with analogies on Mars, based on a new molecular marker approach (i.e. geolipidic markers, stable isotopes) and spectroscopic data (Raman). The characterization was done from diverse perspectives (physico-chemical, molecular, isotopic and mineralogy) to identify geolipidic biomarkers and mineral facies that are unambiguous indicators of life or water activity. The results from this project will be a valuable data set for calibrating a Raman Instrument (RLS) as part of the Rover vehicle in the ExoMars Mission 2020 for ESA. The principle investigator of the project had already visited Iceland during the thematically closely related EUROPLANET project 16-EPN2-064 in autumn 2017 and it was therefore possible to identify sampling sites and take samples and measurements that complemented the research done during 16-EPN2-064, adding value and benefit to both projects. Twenty samples were taken at four active and extinct geothermal sites displaying different colours, textures, and temperature/humidity gradients and representing hydrothermal minerals, mud pots sediments, and small microbial mat samples.

**ESF Project 17-EPN3-009 (Lithotrophic microbial communities and biosignatures in geothermal environments at Kverkfjöll: an analogue for Mars life):**

The main objective of the project was to understand the requirements for detecting extinct microbial life on Mars by studying subaerial hydrothermal systems on the Vatnajökull glacier in Iceland as an analogue for ancient hydrothermal systems on Mars. The project aimed to identify which microbial metabolisms would be plausible in an early Martian environment and to analyse which biosignatures are produced by these microbial communities. The fieldwork conducted in this project contained the collection of water and sediment samples from different geothermal pools in the Hveratagl geothermal area situated on the northern margin of the Vatnajökull glacier for microbiological and geochemical analyses, as well as accompanying in situ measurements of pH, temperature, DO, etc. The laboratory analyses of the samples are currently ongoing and include microbial enrichment cultures, phylogenetic and metagenomic analyses of microbial communities and stable isotope analysis.

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**ESF Project 17-EPN3-020 (Microbial colonization and weathering of terrestrial basalts):**

The goal of the project was to study primary microbial succession on lava fields in Iceland to reveal the pioneering microorganisms that colonize the bare rock and to show what metabolic properties give them the ability to survive in such a harsh environment. In addition, the project aimed to reveal the role microorganisms play in basalt weathering by comparing the chemical weathering profiles of shallow drill core sections of well-defined age lava flows with microbial activity in the same core sections. During the TNA visit to Iceland, samples were collected from 29 sites within five different volcanic systems of well-defined age. At least four samples (short drill cores, pebbles and surface rocks) were taken from each sampling site to reduce the influence of sample heterogeneity in the results. While the analysis of the samples is still ongoing, the results should characterise weathering profiles of recent Icelandic basalts and hyaloclastites, describing the microbial communities on and in these formations and by correlating microbial and geochemical data revealing microbial role in basalt weathering. The data can also be used to interpret the microbially induced weathering textures from the past and to evaluate their biotic origin. Furthermore, the study will explore the limits of life by revealing the metabolic properties required for inhabiting the seemingly lifeless interior of the rock devoid of freely available nutrients.

**Description of the Trans-national Access activity in Danakil depression (Ethiopia):**

During the second reporting period five teams participated in the Danakil Field Campaign, as shown in the table below:

<b>ESF Project No.</b>	<b>Title</b>	<b>Proposer</b>	<b>Visit</b>
17-EPN3-046	Ground-Truth for Remote Sensing of vast Dallol salt flats as Planetary Analogues	Ralph Lorenz	20-27 Jan 2018
17-EPN3-034	Geomorphologic assemblages and shallow plumbing system of the Dallol hydrothermal site: Implications for interpretation of the upcoming Mars exploration mission data	Daniel Mège	20-27 Jan 2018
17-EPN3-039	Dallol, in the Danakil depression: a model region to study if life can be present in one of the most extreme places on Earth.	Hugo Moors	20-27 Jan 2018
17-EPN3-073	The limits of life: Characterisation of the active microbial community within the saline, acidic, hot springs of the Dallol volcano, Danakil Depression, Ethiopia	Karen Olsson-Francis	20-27 Jan 2018
17-EPN3-037	The geometry and morphometry of normal fault scarps on the Afar Depression: constrains on the paleoclimatic evolution of Mars	David Alegre Vaz	20-27 Jan 2018

**17-EPN3-046 Ground-Truth for Remote Sensing of vast Dallol salt flats as Planetary Analogues:**

The roughness of a variety of playa and fan surfaces in the Danakil rift valley of NE Ethiopia was studied to compare with similar surfaces on Mars and Saturn's moon Titan. A comparison was made between the Synthetic Aperture RADAR (SAR) observations on Earth in the X-band (3 cm), which is similar to the wavelength of the Cassini SAR, 2.17 cm for Titan, and the ground surface. Rougher materials appear brighter in SAR images from greater signal returns, while smooth surfaces reflect the SAR signal away from the instrument and appear SAR dark. 16 field sites were studied by placing a scale on the ground and then obtaining dozens of images from a compact digital camera at shoulder height in a circular path around the scale. These revealed the correlation between SAR-bright and rough or variable surfaces and SAR-dark and smooth or sandy. The images will be placed into the Agisoft program to obtain 3D Digital Terrain Models of each field site for detailed analysis. Preliminary results indicate that characteristic SAR brightnesses can be correlated with surface roughnesses, which has important implications for planetary observations.

**Publications:**

J. Radebaugh, R. Lorenz, R. Dame, S. Hudson, L. Kerber, D. Vaz and L. Bandeira. Danakil Depression Flats as Analogues for RADAR-Smooth Surfaces of Titan, Mars and Venus. European Planetary Science Congress, Berlin, 2018.

R. Dame, J. Radebaugh, R. Lorenz and S. Hudson. Roughness of Surfaces in the Ethiopian Danakil from Remote Handheld Image Surveys. European Planetary Science Congress, Berlin, 2018.

**17-EPN3-034: Geomorphologic assemblages and shallow plumbing system of the Dallol hydrothermal site: Implications for interpretation of the upcoming Mars exploration mission data:**

Several hydrothermal sites in the Danakil depression were visited, some of them undocumented before along the western border of the Afar rift and south of the Dallol dome. The association between the magmatic systems and evaporites, and the likelihood that microorganisms live in this type of extreme environment, make this area a unique site for studying potential analogues of Martian rift zones. Detailed geomorphological observations could be done, documenting the diverse impact of hydrothermal fluid upflows on micro-scale geomorphology of the depression. Soil, salt and water samples were also collected for analysis of bacterial life below the surface and their associated liquid environment. Connections were established with microbiologists also participating to the campaign and sampling hydrothermal fluids of various compositions, temperature and pH, making it possible to think of an integrated biological-geological understanding of this very special planetary environment. Enough data were collected to be prepared for the next step of the project, a magnetic prospecting survey aiming at locating magmatic intrusions in the  $\geq 1$  km of evaporitic sediments of the Danakil rift.

**Publications:**

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Daniel Mège, Ernst Hauber, Mieke De Craen, Hugo Moors and Christian Minet. Discovery of a hydrothermal fissure in the Danakil depression. European Planetary Science Congress, 2018.

**17-EPN3-039: Project Title: Dallol, in the Danakil depression: a model region to study if life can be present in one of the most extreme places on Earth:**

The SCK•CEN microbiology unit studies the behaviour of microorganisms in ‘extreme’ environments, in order to understand how microorganisms might survive on e.g. nuclear waste sites or on surfaces of spaceships or planets. The Danakil depression (Ethiopia) is one of the most extreme environments on planet Earth, and therefore an ideal place to study whether microorganisms can survive there. During the Danakil 2018 expedition, the multidisciplinary SCK•CEN field team demonstrated that the newly proposed “closed-vial-field-sampling-technique” functioned. This was a major step to be able to guarantee solution sample integrity during the entire period of on site *in situ* sample handling and transportation towards the analytical laboratory. Representative water samples were also taken by submerging pre-sterilised septum bottles deep into the extreme solutions of in total 7 different Danakil lakes. Besides solution sampling, the SCK•CEN field team also sampled solids, rocks, sediments and filtered samples (= retentate on filter paper) that were well aseptically preserved in sealed Aluminium/Polyethylene bags that were made vacuum. In total, 25 liquid, 17 solid and 5 retentate samples were taken and transported to the analytical laboratories of the SCK•CEN. Together with the performed *in situ* hydro-chemical field measurements, the results of the analyses of these liquid, solid and retentate samples are expected to deliver consistent results that will hopefully provide a profound insights on whether and how microbes can survive extreme environments on Earth and in outer space.

Publications:

Hugo Moors and Mieke De Craen. A physico-chemical and geo-microbiological study of ten different lakes located in the Danakil depression. European Planetary Science Congress, 2018.

**17-EPN3-073: The limits of life: Characterisation of the active microbial community within the saline, acidic, hot springs of the Dallol volcano, Danakil Depression, Ethiopia:**

The limits of life within terrestrial environments underpins our understanding of potential habitable environments elsewhere in our Solar System. The acidic, sulphate rich hot springs, in the Dallol hydrothermal field ensures that the region is one of the most inhospitable places on Earth and is an ideal location to study the limits of life. The aim of this project was to identify and isolate potentially novel microorganisms that are actively growing within the main out-crop and Lake Karim.

The specific aims of the project were as followed:

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1) **Collect environmental samples from varying geochemically defined environments.** The selection of sample sites will be based on previous geochemical

analyses carried out by our collaborators Cavalazzi (University of Bologna, Italy) and Hagos (Mekelle University, Ethiopia).

- 2) **Characterise the active microbial community using high through-put sequencing.** Based on the DNA method that we have successful used to extract DNA we have developed a RNA extraction method (in collaboration with Moissl-Eichinger (Medical University of Gratz), which will be used to characterise the active community within these sites.
- 3) **Isolate novel halophilic acido-thermophiles.** Both aerobic and anaerobic microorganisms will be isolated from the sample sites using traditional culturing methods.

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To our knowledge this was the first microbial study of the active community within a hot, salty-acidic environment. The findings from this study will contribute to our understanding of the boundaries of habitability on Earth and on other planets.

**17-EPN3-037: Project Title: The geometry and morphometry of normal fault scarps on the Afar Depression: constrains on the paleoclimatic evolution of Mars:**

A field campaign in the Danakil depression was performed and a total of 426 points with an accuracy of ~5 cm were collected using a differential GPS. These points form eight topographic profiles that transect several fault scarps in two areas: 1) a NE-SW rift located SE of the Afdera volcano; 2) grabens located 40km south of Mat Ala volcano. This data provides an accurate representation of the scarps' morphologies and will be used to evaluate degradation models on Mars.

Two basalt samples were collected in order to date the faulted units. The radiometric dating of these samples will provide a lower bounding age of fault formation.

The initial objective was to sample different sets of scarps with different heights, slopes and ages. This was not possible to achieve since all faults in the surveyed area, present pristine morphologies with a nearly vertical scarps and reduced talus deposits. This attest the very young age of the deformation, and will difficult the comparison with the heavily degraded Martian scarps.

Even so, this data should be enough to assess the accuracy of the morphometric measurements made using remote sensing data.

For unknown reasons the electromagnetic sounding equipment did not work. Therefore, it will not be possible to analyse the subsurface geometry of the normal faults.

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**Description of the Trans-national Access activity in the Ibn Battuta Center (Morocco):**

During the second reporting period four teams carried out research work in Ibn Battuta. An additional two teams are due to visit this installation in July and August respectively.

Summaries of the research reports produced are shown below.

15-EPN-024	Dust Devil survey in the Moroccan desert as	Gabriele	13-27 Jul
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	analogue of Martian observations	Franzese	2017
15-EPN-032	Aeolian bedform dynamics on Earth and Mars. A terrestrial analogue approach	Simone Silvestro	13-27 Jul 2017
17-EPN3-043	Relationships Between Pressure Drop Magnitudes And Vertical Speeds In Dust Devils: Towards A Better Quantification Of Dust Fluxes On Mars And Earth	Dennis Reiss	13-23 June 2018
17-EPN3-044	In Situ Sampling And Diurnal Monitoring Of Active Dust Devils	Jan Raack	13-23 June 2018
17-EPN3-038	Moroccan Early Animal Record From Precambrian - Cambrian Transient Environments And Its Relevance For Life Detection On Mars	Micaela Glamoclija	July 2018
17-EPN3-045	Vision Based Navigation And Hazard Detection & Avoidance Realistic Test Campaign In A Mars Analogue Natural Terrain	Francisco Camara	August 2018

**15-EPN-024: Dust Devil survey in the Moroccan desert as analogue of Martian observations:**

Dust devil activity in the Tafilalt region of the Sahara Desert in Morocco was monitored by deploying a fully equipped meteorological station in combination with a camera system. The main purpose of the campaign was to produce a complete characterization of the recorded vortices, i.e. the evaluation of meteorological (translational speed, rotational speed, pressure drop and electrostatic signature), morphological (diameter and height), and impact parameters (minimum distance of the vortex from the station). We acquired continuous day and night time meteorological measurements for 7 days at a sample rate of 0.5 Hz, collecting camera images simultaneously.

The acquired data set is unique, as it allows the study of the interconnection between the different vortex parameters and hence a better comprehension of the physics and dynamics of the phenomena. For each dust devil, pressure, wind speed, wind direction, and electric field have different trends and dependence on the distance. The knowledge of the distance between the events and the station is therefore a key point to analyse the relations between the various vortex parameters. In most cases, the dust devils are studied using a fixed meteorological station without the possibility to unambiguously evaluate the impact parameter. For this reason, we also tested a new method to estimate this distance, using the recorded wind speed and direction time series and comparing the results with the ones obtained by the camera images.

**15-EPN-032: Aeolian bedform dynamics on Earth and Mars. A terrestrial analogue approach:**

Two different dune settings were surveyed by using time-lapse cameras and sonic anemometers to measure dune/ripple migrations and wind speed/direction. Sand fluxes were also measured and several sediment samples were collected. Strong winds and considerable aeolian activity were common during all the days spent in the field, which allowed monitoring and documenting a large variety of ripple dynamic behaviours resulting from changing wind regimes. This was one of the key objectives of the proposal. The analysis of more than 50Gb of data collected during the field campaign will lead to a better understanding of the Martian bedform dynamics and of the wind regimes necessary to shape dune and ripples on Mars.

**17-EPN3-043: Relationships Between Pressure Drop Magnitudes And Vertical Speeds In Dust Devils: Towards A Better Quantification Of Dust Fluxes On Mars And Earth:**

Dust devils are common on Earth and Mars. On Mars they significantly contribute to dust entrainment in the atmosphere, replenishing the background atmospheric dust haze. Meteorological signatures of vertical convective vortices (dust devils and dustless vortices) on the Martian surface were detected with meteorological instruments on landers and rovers. The most prominent temporal signature of passing convective vortices is the reduced atmospheric surface pressure within the vortex. Such pressure drops were measured and analysed at the Viking 2, Pathfinder, Phoenix, and MSL landing sites. Recently also large datasets were obtained on Earth as analogues for Mars. Pressure drop magnitudes are direct indicators of the intensity of dust devils and are, to a first approximation, directly related to the dust devil tangential speeds. Another important parameter is the vertical speed within dust devils, which is needed to calculate dust devil sediment fluxes on Earth and Mars. Vertical speeds within dust devils on Earth have been measured to be in the range of 0.1 – 10 ms<sup>-1</sup>. On Mars, vertical speeds were so far only estimated at the MER-A (Spirit) landing site tracking dust clouds within individual dust devils from time-lapse imagery. The estimated median vertical speeds are 1 ms<sup>-1</sup> (season 2 and 3) and 1.6 ms<sup>-1</sup> (season 1). However, no direct measurements of vertical speeds within dust devils on Mars are available to date. Terrestrial measurements of vertical and tangential speeds in dust devils suggest that the vertical speed is about a quarter of the value of the maximum tangential speed.

The main goal of our proposed fieldwork was to establish correlations between pressure drop magnitudes and vertical speeds in dust devils. Such relationships would enable the use of numerous pressure drop magnitude measurements for the calculation of dust devil sediment flux estimates at several landing sites on Mars. In 2016, we performed in situ dust devil studies near Merzouga (Morocco). Amongst other measurements, we measured pressure drop magnitudes and vertical speeds in dust devils at heights of 0.15 m above the surface at a sampling rate of 20Hz using 5 fixed meteorological stations. This study indicates that the vertical speed is about  $0.06 \times \Delta P$ . For comparison with other studies we calculated the tangential speeds from the pressure drop magnitudes. Our study indicates that the vertical speed is about half the tangential speed and in good agreement with previous studies. The reason for the discrepancy of our study with earlier studies that indicate that the vertical speed is about one fifth of the tangential speed is unclear but might be, for example, due to differences in instruments or sampling rate. However, this discrepancy supports the need for further studies.

**17-EPN3-044: In Situ Sampling And Diurnal Monitoring Of Active Dust Devils:**

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Dust devils are vertical convective vortices which occur on Earth and Mars. Although they have been observed on both planetary bodies for several decades, in situ sampling of dust devils is rare: very few publications deal with in situ grain size samples of dust devils and the grain size distribution data are limited to heights of up to 4 m. Such studies are significant for understanding the climatic and environmental impact of dust devils on Earth and for extrapolating to Mars. On Earth, particles smaller than  $\sim 25 \mu\text{m}$  in diameter can stay in suspension in the atmosphere, which makes up between  $\sim 60$  and  $75\%$  of the number of lifted particles. This quantity of lifted aerosols has an influence on the terrestrial climate and is an important consideration for human health, weather, and biogeochemistry. On Mars, particles smaller than  $\sim 20 \mu\text{m}$  can go into suspension, but due to the high Martian surface dust cover the amount of lifted particles will be generally higher, potentially exerting a large influence on the Martian climate. It is estimated that large dust devils may contribute  $>50\%$  to the total dust entrained in the Martian atmosphere.

During a field campaign in 2016 in the same region, dust devil sampling methods were tested and six dust devils were sampled at heights up to 5 m. This shows the feasibility of such in situ sampling, which is vital for understanding the internal structure (vertical grain size distribution), the relative particle loads of dust devils, and the erosional capacity of the sand skirt in the first couple of cm of the dust devil.

The analysis of the diurnal occurrence of dust devils in the study region is also part of this project. Current theories of the diurnal patterns of dust devil formation are based upon observations that dust devils are most active in the early afternoon, with activity levels driven by heating from insolation. However, a recent study of the diurnal behaviour of modelled Martian dust devils identified regions in which dust devil activity is higher during morning hours than would have been expected, based upon current terrestrial theories, and proposed that local winds may have more influence upon the timing of dust devil formation than previously considered. Full day surveys of dust devil activity within the designated study area are also part of this project. Of particular interest is the level of dust devil activity through early to mid-morning hours, which may have previously been excluded from some dust devil surveys due to expectations that activity during this period would be low.

To give a detailed and complete picture of dust devils and their influence on the climate, a connection with a second proposal regarding concurrent dust devil investigations in the Moroccan desert in the same study region will be made. In the other proposal intensive meteorological data will be collected and  $\text{PM}_{2.5}$  (amount of particles  $\sim 2.5 \mu\text{m}$  which will stay in suspension) at a height of 2 m will be measured. These datasets in combination with our datasets will give (a) calculations of the dust flux of dust devils, (b) estimations of daily dust lifting in the study region and beyond (dust flux measurements in combination with diurnal survey), and (c) a wider meteorological context for the observed levels of dust devil activity.

#### Publications:

J. Raack, D. Reiss, M.R. Balme, K. Taj-Eddine and G.G. Ori. In situ sampling of terrestrial dust devils and implications for Mars. Fifth International Planetary Dunes Workshop.

J. Raack, D. Reiss, M.R. Balme, K. Taj-Eddine and G.G. Ori. In situ sampling of terrestrial dust devils and implications for Mars. European Planetary Science Congress 2017

D. Reiss and J. Raack. In situ measurements of dust devil pressure drop magnitudes and vertical wind speeds. European Planetary Science Congress 2017.

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H. Kahanpää, M.T. Lemmon, D. Reiss, J. Raack, E. Mason and M. Battalio. Martian dust devils observed simultaneously by imaging and by meteorological measurements. 49th Lunar and Planetary Science Conference, 2018.

D. Reiss and J. Raack. Relationship between pressure drop magnitudes and vertical wind speeds in dust devils. 49th Lunar and Planetary Science Conference, 2018.

J. Raack. Chasing the devil - what do dust devils on Earth tell us about Mars? Europlanet webinar.

### **17-EPN3-038: Moroccan Early Animal Record From Precambrian - Cambrian Transient Environments And Its Relevance For Life Detection On Mars:**

The occurrence of the animals on our planet is one of few major evolutionary steps in life emergence and diversification that clearly characterized our planet as habitable. A few competitive hypotheses are set up as possible solutions and still we do not know the exact process(es) that set the stage up for this kind of evolutionary change. We are proposing to conduct a two weeks long field campaign that would allow us to collect the best set of samples from this transient period; and later permit meaningful integration of geochemical, mineralogical and paleobiological data. We will build on previous knowledge and expand by illuminating the specific connections between the evolution of the environments and the organisms, which were missing so far. The integration of the diverse data sets and the attempt to understand them as a unique ecosystem is still missing and we will aim to address this issue. The Anti-Atlas in Morocco is one of the best-studied locations on the Earth with lithological strata with high-resolution isotope record (measured at about every meter) clearly exhibiting the isotope shift in values between Ediacaran and Cambrian periods. The shift in isotope values indicates the change in C cycling due to transition in biological ecology. We will be looking to link the isotope and mineral records with studies of preserved organisms to learn more about this ancient environment. Further, we are planning to investigate preserved stromatolites from this stratigraphic border and to gather data about environmental changes from the microbial perspective close to rise of the Cambrian. Learning how the Earth has developed as a habitable planet is fundamentally important to our understanding of the data from other planets, in particular exploration of the habitability of extinct Martian environments, which have been target of multiple space missions. Our proposed research is directly relevant to the AstRoMap Roadmap Topic 4. Life and Habitability, and Topic 5. Biosignatures as Facilitating Life Detection; as we are going to investigate what made our planet habitable for multicellular organisms (animals) and the data collected will be a collage of geochemical, mineral and morphological biosignatures that can directly be used to understand what may constitute a biosignature on the other planet (e.g. Mars). We are also directly addressing the NASA Astrobiology Strategy 2015 Topics “Early life and Increasing complexity”, “Co-Evolution of Life and the Physical Environment”, and “Identifying, Exploring and Characterizing Environments for Habitability and Biosignatures”. Further, future missions to Mars, ExoMars and Mars2020, are set to look for life signatures, and our proposed activities will produce relevant data, and will generate a well-characterized set of samples that will be useful to the instruments’ development teams for testing the mission readiness of the flight instruments. Raman (SHERLOC) and XRF mapping (PIXL) will be used on Mars 2020 to select the best samples to be returned to Earth and we will perform preliminary analyses and mapping on our laboratory instruments and to select samples that would be the best to use as natural analogs for in-laboratory testing of the techniques and instruments to be used on Mars2020. ExoMars’ Raman and MOMA instruments will be looking for biosignatures on Mars, and be utilized as life detection techniques. Hence,

multiple terrestrial samples and paleoenvironments have to be analyzed to learn about an array of data that can reveal the presence of habitable environments and life signatures in the terrestrial context, and help us understand Martian strata that were deposited within the similar environments.

**17-EPN3-045: Vision Based Navigation And Hazard Detection & Avoidance Realistic Test Campaign In A Mars Analogue Natural Terrain:**

Visual Based Navigation and Hazard Detection and Avoidance (VN&HDA) systems will enable precision and safe planetary landing missions. We have been developing such systems for the past 10 years, which have been extensively tested in simulation environments. Current status of the technology is as follows: VN&HDA software has been implemented in a space flight representative real-time processor and tested with Processor-in-the-loop simulations. Synthetic terrains have been used for simulation purposes. Achieved performances are very promising (probabilities of hazard miss-detection <1%). Next step, for further validation and increasing the technology readiness level of VN&HDA, is to flight-test the real-time software, with real sensors and avionics test bench (not simulated), in a Mars analogue, natural terrain. All components needed for this work have already been developed and tested individually. Flight Test platform (Maximum Take-Off Weight < 25kg) is currently being integrated with the avionics test bench (carrying all the required sensors, flight computers, etc.) and testing of the complete integrated system will initiate soon. The work proposed consists of the execution of a flight test campaign to assess the performance of the VN&HDA system in a realistic/ natural landscape (Mars analogue terrain). Terrain shall have about 100m x 100m, few slopes (up to 15 deg), and high rock coverage (~1% of rocks with height above ground >30 cm, for a total rock coverage of 6.9%). Two types of tests are planned to assess distinct performances: Safe Landing Tests (to assess probability of safe landing, i.e., of selecting a safe landing site and actually reaching this safe site) and Safe Site Selection Tests (to assess the probability of safe site selection by the HDA system). In each test, a flight test platform will fly up to 120m above ground (always line-of-sight) and perform a descent autonomously.

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**Results of the fourth Call for proposals for visits to analogue sites**

The fourth Call for proposals closed in March 2018. Twenty six applications were received and 16 of these were supported. The breakdown is shown in the following table.

<u>Installation ID</u>	<u>Installation</u>	<u>Access provider short name</u>	<u>Applications received</u>	<u>Applications supported</u>
TA1-1	Rio Tinto Field Site	<u>INTA</u>	<u>2</u>	<u>2</u>
TA1-4	Lake Tirez	<u>INTA</u>	<u>2</u>	<u>1</u>
TA1-3	<u>Iceland</u>	<u>Matis</u>	<u>4</u>	<u>4</u>
<u>TA1-2</u>	<u>Ibn Battuta</u>	<u>IRSPS</u>	<u>12</u>	<u>5</u>
<u>TA1-5</u>	<u>Danakil</u>	<u>IRSPS</u>	<u>6</u>	<u>4</u>
		<b><u>TOTAL</u></b>	<b><u>26</u></b>	<b><u>16</u></b>

The Rio Tinto and Lake Tirez selected proposals are:

original number	Proposal number	Access provider short name	Installation ID	Installation	Approved weeks	ProjectTitle
11445	18-EPN4-048	INTA	TA1-1	Rio Tinto Field Site	1	Developing Phosphate O-Isotopes As A Tracer For Life In Acidic Environments
11484	18-EPN4-074	INTA	TA1-4	Tírez Lake	1	Assessing The Life Detection Potential On Europa Through Gc-Fid/gcms Analyses Of Lake Tírez Brines
11452	18-EPN4-053	INTA	TA1-1	Rio Tinto Field Site	1	Rio Tinto As A Natural Laboratory To Understand Formation Of Acidic Salts And Preservation Of Biosignatures Under Aggressive Low-Ph Conditions Of Early Mars

Four applications were granted Planetary Field Analogue Site “The glacial and volcanically active areas of Iceland, Iceland”, two with a duration of 2 weeks and the remaining two with a one week duration.

original number	Proposal number	Access provider short name	Installation ID	Installation	Approved weeks	ProjectTitre

11430	18-EPN4-036	Matis	TA1-3	Iceland	2	Icestar – Iceland Sample Tracing And Return
11419	18-EPN4-028	Matis	TA1-3	Iceland	1	Effect Of The Temperature Of Amorphous Silica Deposition On Its Spectroscopic Signature
11362	18-EPN4-002	Iceland	TA1-3	Iceland	2	Extremophile Microbial Eukaryotes In Mars-Analogue Field Sites
11463	18-EPN4-059	Matis	TA1-3	Iceland	1	Microbial Colonization Of Analogue Terrestrial Surfaces By Depositing Airborne Microorganisms

Five teams were selected in Call 4 to visit Ibn Battuta (Morocco), four of them with durations of one week and one of them with a duration of three weeks.

original number	Proposal number	Access provider short name	Installation ID	Installation	Approved weeks	Project Title
11509	18-EPN4-090	IRSPS	TA1-2	Ibn Battuta	3	Understanding The Nature Of The Martian Large Ripples Through The Study Of Potential Analogues In Morocco
11414	18-EPN4-023	IRSPS	TA1-2	Ibn Battuta	1	Moroccan Desert Electromagnetic Characterization Using Gpr And In Situ Dielectric Probes, As A Test For Martian

						Subsurface Investigations.
11432	18-EPN4-037	IRSPS	TA1-2	Ibn Battuta	1	Trace Gas Signatures From A Mars Analogue Site: Implications For Nomad
11446	18-EPN4-049	IRSPS	TA1-2	Ibn Battuta	1	Manganese Supergene Enrichment In Tafilalt Merdani Formation Morocco As Terrestrial Analogue For The Gale Crater Deposits
11511	18-EPN4-092	IRSPS	TA1-2	Ibn Battuta	1	Saharan Dust Devils: Study Of The Meteorological And Electric Signatures And Comparison With The Martian Data

Four teams were selected in Call 4 to visit the Danakil Depression (Ethiopia), two of them with durations of two weeks and the other two with durations of two weeks.

<b>original number</b>	<b>Proposal number</b>	<b>Access provider short name</b>	<b>Installation ID</b>	<b>Installation</b>	<b>Approved weeks</b>	<b>Project Title</b>
11424	18-EPN4-032	IRSPS	TA1-5	Danakil	2	Magnetic Characterisation Of The Danakil Magmatic Plumbing System North Of Erta 'ale: A Useful Contribution To Interpret Potential Trace Gas Sources

						That Will Be Detected In Volcanic Regions Of Mars By Exomars Tgo
11493	18-EPN4-079	IRSPS	TA1-5	Danakil	1	Mars Mastcam Field Analogue Work At Danakil Depression
11377	18-EPN4-008	IRSPS	TA1-5	Danakil	1	Life At The Limits: An Organic Molecular And Isotopic 'fingerprint' Of Microbial Metabolism In The Dallol Geothermal Sites, Danakil Depression
11413	18-EPN4-022	IRSPS	TA1-5	Danakil	2	Solhsalts – Solar Or Hydrothermal Salts? The Example Of Dallol Site.

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**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

## Annex. PFA participants

PFA participants are listed below.

Participant	Permanent personnel	Personnel hired by the project
5. INTA	Dr. Felipe Gómez Gómez Dr. José Antonio Rodríguez Manfredi Prof. Ricardo Amils Dr. Olga Prieto-Ballesteros Dr. Juan Ángel Vaquerizo  Nuria Rodríguez  Fernando Camps	
9. IRSPS	Prof. Gian Gabriele Ori Professor Kamal Taj Eddine Dr. Monica Bufill Daniela D'Alleva Dr Goro Komatsu Dr Monica Pondrelli Barbara Cavalazzi	
20. MATIS OHF	Dr. Viggo Thór Marteinsson René Groben	

### **PFA Structure – wp2 – TA 1: Planetary Field Analogues Coord.: INTA with partners INTA, IRSPS and MATIS OHF**

PFA activities consist of one work package with three different sites managed by three partners. These activities consist of the following tasks:

- *Task 2.1. Rio Tinto field site: Managed by INTA*
- *Task 2.2. The Ibn Battuta Field Centre. Managed by IRSPS*
- *Task 2.3. Iceland Field Sites. Managed by MATIS OHF*
- *Task 2.4. Tirez Lake. Applicable as TAI report after second year of the project. Managed by INTA.*
- *Task 2.5. Danakil Depression (Ethiopia). Applicable as TAI report after second year of the project. Managed by IRSPS.*