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Deliverable 2.6- Second annual report of TA1 access

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Responsible WP Leader: INTA, Felipe Gómez

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Dissemination level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (excluding the Commission Services)	

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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.

Three Planetary Field Analogues, PFA (Rio Tinto (Spain), Ibn Battuta (Morocco) and cold and hot environments in Iceland) (PFA) were selected to provide Transnational Access (TA) during the first two years 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 main goals of proposals presented during the first year of the project were related to the quantification of the complex (bio) geo-chemical feed-back processes that control planetary evolution so that researchers can develop quantified models to explain observations made of planets in our Solar System. Other proposals focussed on the study of processes that influence the survival of life under extreme conditions and the detection of records of past or present biological activity. In this context some of the characterized habitats are similar to where life is thought to have most likely evolved on Earth and consequently will be a valuable resource for Earth and life scientists] with important astrobiological implications. Finally, other proposals were focussed on testing instrumentation under development by industry for future planetary space missions, evaluating analytical-operational-management concepts in fully operational settings.

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 low number of applications overall Rio Tinto field site. Final selection by an external independent panel of experts approved the visits described in this report.

Description of the Trans-national Access activity in Rio Tinto

Project Title – Mars Analog Spectroscopic Technology for Exobiology Research

Team: Pablo Sobron

Institute: SETI

Scientific Report Summary.

The MASTER project focuses on Rio Tinto, a well-established Mars-analog site; the mineralogy and hydrochemistry make Rio Tinto a unique analogue for sulfate formation and habitability investigations in extreme conditions. The external team conducted field work in three sites near Peña de Hierro, the source of Rio Tinto. They used both VNIR and LRS instruments to investigate a total of 15 locations featuring a combination of sulfate-rich evaporation products and iron-rich precipitates from acidic stream waters (pH = 2.4). The results show that the combined use of VNIR and LRS is widely justified for achieving unique mineral identification of Fe-bearing oxides and sulfates on natural samples from acidic Mars analog sites, and likely on samples from Mars surface and surface. They concluded that the synergies between these two techniques should be explored in the context of the science objectives of future Mars missions, e.g., ESA's ExoMars and NASA's Mars 2020 through assessing their potential to characterize additional types of minerals relevant to Mars exploration.

Full Scientific Report on the outcome of the TNA visit to Río Tinto:

The MASTER project focuses on Rio Tinto, a well-established Mars-analog site; the mineralogy and hydrochemistry make Rio Tinto a unique analogue for sulfate formation and habitability investigations in extreme conditions.

The main goals of MASTER are to:

1) Foster a better understanding of how to seek, identify, and characterize habitats and biosignatures that may exist, or have existed, on Mars;

2) Field test two technology elements that will support science investigations on the upcoming ExoMars and Mars2020 missions: to NASA's Mars 2020 and ESA's ExoMars rover missions, visible-near infrared reflectance spectroscopy (VNIR) and laser Raman spectroscopy (LRS);

3) Develop system science & operations through an analogue mission to ensure that VNIR and LRS can address mission-level objectives and to enable the optimization of science return in the ExoMars and Mars2020 missions.

The external team conducted field work in three sites near Peña de Hierro, the source of Rio Tinto. We used both VNIR and LRS instruments to investigate a total of 15 locations featuring a combination of sulfate-rich evaporation products and iron-rich precipitates from acidic stream waters (pH = 2.4). They used the VNIR instrument to identify sulfates, hydrated iron minerals, and C-H & N-H bonds in organic species. The interpretation of the VNIR spectra relies on a search-match procedure performed against a database of reference materials. The spectra show relatively high SNR and distinct spectral features in the 1.14-4.76 μm spectral range that, in principle, can be associated with unique minerals or mineral mixtures. In practice, one of the difficulties associated with the interpretation of VNIR reflectance spectra of H_2O and OH-bearing minerals is that O-H bonds are very intense absorbers thus the strong band from fundamental vibration modes (2.5-3.3 μm) (deep and broad bands in the spectra) often mask the M-OH band near 2.4 μm (where M represents a metallic cation). For this reason, the identification of the reflectance VNIR spectral features associated to most of the minerals present in our field location is not definitive.

One of the advantages of LRS is that water is a relatively poor scatterer, and hence the hydroxyl stretching of the M-OH units can be better resolved. As a result, more accurate band assignments can be achieved. Specifically, the LRS instrument returned *in-situ* identification of sulfates, iron oxides/oxyhydroxides, and organic pigments such as β-carotene, and facilitated measurements of the hydration state in the mineral precipitates. Dedicated inspection of the Raman spectra allowed us to identify gypsum, melanterite, and mixtures of hydrated hydroxysulfates belonging to the copiapite group, namely ferricopiapite and copiapite. The Raman spectra of the samples were, however, difficult to interpret, showing overlapping bands and shoulders that may be due to the inclusion of unidentified sulfates, hydroxides, and other impurities in the main mineral matrix. Some of the LRS spectra showed variable intensities peaks associated to β-carotene, a measure of the relative abundance of this organic compound in the field samples.

The results show that the combined use of VNIR and LRS is widely justified for achieving unique mineral identification of Fe-bearing oxides and sulfates on natural samples from acidic Mars analog sites, and likely on samples from Mars surface and surface. Synergies between these two techniques should be explored in the context of the science objectives of future Mars missions, e.g., ESA’s ExoMars and NASA’s Mars 2020 through assessing their potential to characterize additional types of minerals relevant to Mars exploration.

Publications In preparation:

Sobron P., Sansano A. (2018) Synergistic reflectance and Raman spectroscopic investigation of terrestrial acidic environments – Implications for the Mars 2020 and ExoMars missions. *European Planetary Science Congress* (EPSC)

Description of the Trans-national Access activity in International Research School of Planetary Sciences (IRSPS)

Report of the IRSPS activities 2015 – Feb. 2017

The activity on the Ibn Battuta Centre field sites has been concentrated in three sub-activities: fieldwork of host scientists, fieldwork of IRSPS personnel for the identification and analysis of further sites, implementation of the field facility.

Hosting scientific teams

Currently we hosted 4 research teams for a total of 6 accesses:

1. **Meteorological Signatures of Vertical Convective Vortices.** Dr. Dennis Reiss from Institut für Planetologie**,,** Westfälische Wilhelms-Universität, Münster, Germany and Jan Raack, Department of Physical Sciences, The Open University, Milton Keynes, UK from 4th to 18th May 2016 for a total of 14 day (2 accesses)
2. **Mars analogue drills and laboratory analysis at dry, salty terrains to support ExoMars rover's activity, workflow optimization and later interpretation**. Dr. Akos Kereszturi and Dr. Gabor Ujvari from Research Centre for Astronomy and Earth Sciences (MTA CSFK), Csatkai, Hungary from 15th to 21st September 2016 for a total of 7 days (1 access)
3. **The Azrou Plateau (Middle Atlas, Morocco): a perfect terrestrial analogue for studying both karst and lava tube collapses with remote sensing techniques and field geology.** Prof. Jo De Waele from Italian Institute of Speleology, Universita' di Bologna, Italy and Dr. Maria Teresa Melis from Dipartimento di Sciense Chimiche e Geologiche, Universita' di Cagliari, Italy from 2nd to 9th October 2016 for a total of 8 days)1 access)
4. **Astrobiological potential of microbial biogeomorphology in arid, evaporite-dominated environments: an aid to the use of image spectrometers in future landed missions on Mars** Prof. Roberto Barbieri and Dr. Barbara Cavalazzi from Dipartimento Scienze Biologiche, Geologiche e Ambientali dell' Universita' di Bologna from 1st to 15th February 2017 for a total of 15 days (2 acceses).

The team from Munster/Open Universities spent two weeks in the area of Merzuga (Erfoud, Tafilalt) is to obtain a comprehensive quantitative dataset of convective vortices signatures which will help to interpret data obtained by past lander/rover mission, the upcoming ExoMars and InSight landing missions as well as future missions on Mars. They used an improved version of their array of meteorological sensors that they used for the identification and monitoring of dust devils: The data rate was improved from the proposed 4 Hz to 20 Hz which allows detecting smaller dust devils and is important for future missions such as InSight (data rate of comparable meteorological sensors of 10 Hz). Beside the proposed sensors (horizontal wind speed, vertical wind speed, wind direction, pressure, temperature, solar irradiation, magnetic field, and sound level) we added a sensor for measuring the atmospheric electric field. In addition, we sampled six active dust devils collecting vertical grain size distributions within dust devils up to a height of 5 m.

Observed dust devil frequencies near Merzouga during our stay were very high compared to other regions the proposers were conducting dust devil field work so far. We measured meteorological signatures of about 50 dust devils in the diameter range of 1 – 30 m, which passed directly over, between or close to one of the five logger stations.

During the 7-days field work organized by the Ibn Battuta Centre in Morocco, the Hungarian team examined 65 potentially interesting sites (most of them imaged only) along the route: Marrakesh-Ouarzazate-Erfoud-Zagora-Ouarzazate-Marrakesh. Altogether 572 images were taken, 2/3 of them for correlation analysis with GoogleMaps-based data aimed at improving site evaluation by comparing remote sensing and in-situ information. Samples were collected at 5 sites including sampling after drilling at 4 sites. At these sites borehole walls were imaged by a probe and nearby open air outcrops using a commercially available camera. The acquired samples are to be investigated using optical microscope, FTIR and Raman spectrometers at the Hungarian home institute. Establishing of such complex datasets are aimed at providing suggestions for targeting and interpreting ExoMars rovers' drilling and laboratory analysis activities, especially for identifying and discriminating fluvial and aeolian transport modes on Mars.

The Cagliari/Bologna universities team worked in several collapsed features in the basalt plateau in the Middle Atlas area near Azroou. These collapses are linked to a complex system of lava tubes that has been mapped using geo-referenced Google Earth images, while geological limits between the different formations (mainly the basalts and the underlying carbonates) have been traced using Landsat and especially Sentinel-2 imagery. These preliminary elaborations allowed us to draw a map of the sinkhole features (over 300 were identified) and to organise our fieldtrip to Morocco. During the field work almost 150 of these giant collapses have been visited. They measure maximum and minimum diameter with a Sokkisha (now Sokkia) optical range finder with 50 cm base, and depth with a Suunto clinometer. These data were then compared with the remote sensing data and enabled to redefine in a more detailed way the geological limits and the dimensions of the mapped sinkholes. Three main morphological types of caprock sinkholes have been identified: bowl-

shaped with a concave or a flat bottom, asymmetric sinkholes, and funnel-shaped sinkholes with vertical walls. From a genetic point of view both collapse and sagging sinkholes are present, the most spectacular of which are the collapse sinkholes, reaching diameters of more than 200 m and depths up to 67 metres.

The Bologna University project was centred on the investigation, in an astrobiological perspective, of the surface morphologies produced during on-going, mixed sulphate-carbonate mineral precipitations in the sabkha Oum Dba of the Western Sahara, approx. 45 km north of the city of Laayoune. Thanks to a relatively easy access, the field observation and samplings were optimally performed throughout the entire period. Following field observations, description of the environmental contexts, and physical measurements, samplings included both fresh (i.e. living) and fossil (carbonates and evaporite deposits) materials. Once in Marrakech, at the end of the field work, we had sufficient time to require, through the Ibn Battuta office at the Cadi Ayyad University, the necessary documents for a safe delivery of the materials collected during the field work.

Identification and analysis of further sites

It is of important to provide to the potential applicants new planetary analogue sites to increase the scientific possibility and improve the Ibn Battuta capability in representing scientific and technological analogues. In the area of Zagora several scientific targets have been identified for both astrobiological and geological purposes. In addition some site for simulations large-scale operations have been identified. The area north of Tata is reach of Precambrian conglomerates that may mimic catastrophic flooding similar to the cataclysmic flows that formed outflow channels on Mars. Other new sites are the lava tunes of the Azrou area and coastal deposits and paleovalleys along the coast of the Atlantic Ocean South of Sidi Ifni. The identification of new sites is continuing in order to provide new targets for the potential users.

Field facility

Some of the proposal involve some operational activities with a large impact in the logistic. In this case there is a need of a complex support. In order to cope with this need that would improve the Europlanet impact on the community a field facility has been prepared at no cost for the project. The use of this facility will be well within the celling cost of single access.

Therefor IRSPS this a parallel effort has built, along with the Hotel Kasbah Xaluca, a facility consisting of two large workshops, storage room, offices, recreational rooms and kitchen. A satellite connection provide internet through a WIFI system. An area of download and upload

of trucks is next to a large parking area and they are connected with a cement pathway to the workshop and helipad.

Fig. 1 – The Ibn Battuta Field Facility

The facility has been already used for large and complex operation for the simulation of the landing system for both 2016 and 2020 Exomars missions and other activity. The facility, created with an independent budget will be anyway available for Europlanet activities and will be particularly suitable for industrial applications.

Description of the Trans-national Access activity in Iceland

In the third call to access the TA1: Planetary Field Analogue Site "The glacial and volcanically active areas of Iceland, Iceland", seven applications were received of which five were successful (Table 1). Most of those applicants have already contacted the Icelandic host organisation Matís to arrange their visits and research.

Table 1: Successful applications in the third call to access the Icelandic TA-RI site.

Appl. No.	ESF Project No.	Title	Proposer	Planned visit
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	October 2017 (in combination with 16-EPN-064)
11228	17-EPN3-020	Microbial colonization and weathering of terrestrial basalts	Anu Hynninen, University of Helsinki, Finland	23. – 31.08.17
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

11294	17-EPN3-052	MILaCE : Mars Investigations and Landing Cameras Experiment	Giacomo Colombatti, CISAS G. Colombo - University of Padova, Italy	No date yet
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	No date yet

Visits to the Icelandic TA site since the last report:

ESF Project 15-EPN-006 (Complex eukaryote life in Mars analogue field sites on Iceland - environmental (meta)genomics approaches in astrobiology): The project aims to investigate eukaryote diversity in Mars-analogue field sites on Iceland through targeted isolation and cultivation of extremophile microbial eukaryotes for subsequent genome and transcriptome analyses. After a delay of the visit in 2016, the applicants Thorsten Stoeck and Sabine Filker visited Iceland between 04.07-13.07.17. They successfully sampled a variety of mars-analogue sites in close collaboration with scientists at the host organisation Matís. The proposed analyses are currently ongoing but preliminary results already suggest a diverse community of extremophile eukaryotic microorganisms.

ESF Project 15-EPN-028 (Microbes at mineral interfaces in sub-seafloor young volcanic rocks): The main objective of the project is to study microbe-rock interaction and colonization of volcanic rocks in seawater at the volcanic island Surtsey in the eastern Icelandic Rift. The proposed research had to be conducted in association with the SUSTAIN project of the International Continental Scientific Deep Drilling Program (ICDP) which was originally planned for 2016 but was delayed to 2017. SUSTAIN is now undertaken between 01. – 30.08.17 and the applicant Andreas Türke is in Iceland during this time to carry out his research in the frame of his EUROPLANET project.

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 is 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 applicant will try to identify which microbial metabolisms would be plausible in an early Martian environment and analyse which biosignatures are produced by these microbial communities. The applicant Arola Moreras Marti is conducting his planned fieldwork and sampling in Iceland at the end of July/beginning of August 2017.

2. Deviations from Annex 1 (if applicable)

An amendment of WP2 is currently under evaluation:

-Rio Tinto (INTA): units of access decreased from 32 to 6

-Ibn Battuta (IRSPS) units of access increased from 16 to 20

-Danakil (IRSPS and INTA): units of access increased from 8 to 13.

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 Rodriguez Manfredi Prof. Ricardo Amils Dr. Olga Prieto-Ballesteros Dr. Juan Angel Vaquerizo Nuria Rodríguez Fernando Camps	
9. IRSPS	Prof. Gian Gabriele Ori Professor Kamal Taj Eddine 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 TA1 report after second year of the project. Managed by INTA.*
- *Task 2.5. Danakil Depression (Ethiopia). Applicable as TA1 report after second year of the project. Managed by INTA.*