General Assembly Meeting of the European Astrobiology Institute

18 June 2020

Resolution 4

The General Assembly approved the creation of the Project Team “Mars Sample Return” The plans for the project team are outlined on the subsequent pages.

Project Team proposal for the European Astrobiology Institute

Title:

Mars Sample Return Project Team (MSR-PT)

General goals:

The MSR-PT aims to support the preparation and realization of the Mars Sample Return (MSR) initiative, focusing on the European contribution for astrobiology aspects, and also working concurrently with related international efforts, mainly the activities of ESA and NASA. This project team will support the scientific agenda of MSR by direct research activities (providing expertise in astrobiological disciplines indispensable for MSR, such as microbiology, paleobiology, mineralogy, geology, geochemistry, planetology, chemistry, planetary protection, philosophy etc.). The project team will initiate collaborations, which will widen participation using the interdisciplinary links provided the EAI between their members. However, this project does not intend to orient or influence already existing groups and their activities, but to support collaborative interdisciplinary research that will lead to results in cross-domain disciplines. It will also provide opportunities for researchers at institutions that are not yet involved in the international research to become active in MSR research.

Specific goals of the MSR project team:

1. Research activities
    a. Identify specific scientific aims, including preparation activities for MSR in interdisciplinary topics (among those already emerged):
        i. improving sampling strategies and creating interdisciplinary sampling protocols using the analogue sites of the EAI as test-benches available to EAI (analogue samples should also be used for testing methods and help for choosing the right samples to be returned, with specific focus on the Mars 2020 landing site, Jezero Crater, and methodologies present aboard the *Perseverence* rover),
        ii. improve instrument usage strategies and instrument output formats, as well as the integration and interlinking of output data of different instruments with a focus on their holistic interpretation,
        iii. list instruments and processing capabilities expected from multiple different EAI laboratory facilities,
        iv. contribute to the organisation of the reception, quarantine and curation procedures; contribute to the design of related facilities for returned samples and the curation of analogue samples, including the permanent control of well-characterised reference samples to establish possible contamination monitoring and processes in time.
2. Collaborative activities
    a. Sustain the links between already existing teams that focus on related interdisciplinary and trans-domain aspects. This activity may cover funding from collaborative bids.
    b. Involve EAI member institutes and individuals that still have not been involved in the MSR but would be interested to do so.
    c. Work on the involvement of communities (like biology, chemistry, instrumentation, robotics and analytic capabilities from medicine related groups).
    d. Offer training to the next generation of Mars researchers and at the same time create a community of young Mars astrobiology researchers.
3. Outreach activities
    a. Offer teaching (including online) material to schools and other educational institutions, including establishing and maintaining a Mars analogue sample collection for European schools. Link and good connection / collaboration should be developed with already existing such collections, e.g. the International Space Analogue Rockstore (www.isar.cnrs-orleans.fr) and the ESA2C Collection (https://sacf.esa.int/sacf-home/esa2c-collection).

b. Inform the general public about benefits and risks associated with the MSR mission.

Interested members, organizations and their proposed contribution
(possible further members are listed below the table)

Name	**Organization, country**	**Proposed contribution**
Kereszturi, A.	Research Centre for Astronomy and Earth Sciences, Hungary	• coordination of project team activities • field sites related aspects of MSR • target selection in the view of the geological history of Mars and mineral paragenesis • role of liquid water, deliquescence and hygroscopic salts • strategy of join usage of different laboratory instruments
de Vera, J.P.	German Aerospace Center (DLR), Germany	• instrument and sample selection • analysis strategy for life detection in Mars-like environments • organization and experimental analysis in EAI available laboratory facilities
Rettberg, P.	DLR, Institute of Aerospace Medicine, Radiation Biology Department, Köln, Germany	• microbiology in extreme environments • habitability • planetary protection • international PP policy • experiences from iMOST, EURO-CARES, ESA PP projects
Javaux E.	University of Liege, Belgium	• criteria for biogenicity (which set of analyses, morphological and chemical signatures will be needed to convince us of Martian fossil life traces) • selection of samples based on landing site characteristics and chance of preservation of biosignatures: clay-rich shale or siltstone deposited in water bodies • studies early Earth clay-rich aquatic deposits • pseudosignatures by abiotic processes in Martian conditions (false positives) • instruments and, sensitivity • morphological, ultrastructural and chemical multiscale analyzes of early traces of life (microfossils, microbial mats
Martínez-Frías, J.	Spanish Planetology and Astrobiology Network (REDESPA); IGEO, CSIC-Universidad Complutense, Madrid, Spain	• mineralogical and paragenetic study of the samples • specific textural study and interpretation of the mineral phases and their genetic sequence • petrologic and geochemical make-up and Raman and mineral chemistry analysis
Debaille, V.	Université Libre de Bruxelles, Belgium	• radiochronologic dating of igneous samples (martian meteorites and returned samples) • trace elements measurements for biosignatures by rover at the surface of Mars • isotope biosignatures (Cu, Zn) for tracing paleo-redox conditions and possible biological activity • curation of returned samples • experiences from IMost and Euro-Cares projects • Mars 2020 participating scientist
Westall, F.	CNRS Orleans, France	• fossil identification • early Earth materials and conditions • analogue rocks (IRS collection)
Viso, M.	Centre National d'Etudes Spatiales, Paris (CNES), France	• Space science and Space policy • Planetary protection
Chatzitheodoridis, E.	National Technical University of Athens, Greece	• instrumental aspects, laboratory analysis and automation • mineralogy, petrology • Martian meteorites
Brucato, J.R.	INAF, Italy	• European curation and receiving facilities

		• sample analysis • experiences from NASA-ESA iMARS and iMOST projects
Olsson-Francis, K.	The Open University, UK	• bio-signature detection • planetary protection
Mason, N.	Kent University, UK	• Europlanet contact, coordination of activities between EAI and Europlanet
Novakova, J.	Charles University, Prague, Czech Republic	• MSR outreach activities (analogue samples, sample retrieval games, popular science activities etc.)
Hickman-Lewis, K.	CNRS, France	• High-resolution morphological, geochemical and mineralogical study of ancient traces of life • Palaeoenvironmental reconstruction using sedimentology and elemental geochemistry • Biogenicity studies (geobiology, palaeobiology • Mars 2020 participating scientist

Further EAI members interested in the activity of the MSR-PT: Arnould J., Breuer D., Briones C., Caterina B., Detsis E., Dunér D., Gargaud M., Henning T., Kanuchova Z., Kirsimäe K., L'Haridon J., Mas Hesse M., Messina P., Motlep R:, Povenzale A., Spohn T., Szuszkiewicz E., Taubner R.S., Vandermersch M., Walter N., Wolf D.G.

Short-term action items (2020 Q2-Q4):

- select and identify specific plans for 2020-2021 (see the list at the end of this document),
- focus activities on the specificities of the Mars 2020 landing site and the Mars 2020 instruments which will give us context information for the samples and their subsequent analysis on Earth,
- identify and outline the ways in which we can collaborate with ESA,
- identify how ESA, NASA, International Mars Sample Return Science Planning Group, MEPAG and other interested groups should be contacted by EAI, map the "landscape" of MSR activities in Europe,
- develop a framework for wider participation, which will involve for more European partners using the interdisciplinary links provided by the EAI amongst its members,
- acting as a voice of the European astrobiology community in MSR preparation,
- meeting in Höör November (24 - 26) 2020.

Connection with other EAI working groups:

- Lab Facilities,
- Field Work and Field Site Management,
- Planetary Environments and Habitability,
- Biosignatures and the Detection of Life beyond Earth,
- Evolution and Traces of Early Life and Life under Extreme Conditions.
- Outreach

Already emerged **specific proposed project ideas** (some should be selected and modified/improved among them during 2020 Q3-Q4)

- Sampling and field site related topics:
    - Map and characterise sampling areas representative for the Mars 2020 landing site, perform representative sampling, acquire a large number of images and produce **virtual documentations** with all information to study prior to visiting the area. (This initiative might be linked to remote access development of EAI field sites.)
    - Improve and optimize **sampling strategy** for different site and target types (specific location types might be identified at craters, hydrothermal sites, caves etc.), involving virtual presence to train new scientists or astronauts and improve methods. **Combine geographical-topographical data with all analytical data** and sampling positions. The results should be digitised, easily accessed and further processed to improve methodology.
    - Search for both past habitable environments and possible present habitable environments in the view of accessibility for sampling.
    - Palaeoenvironmental reconstruction and the exploration of potential resources/nutrients on Mars for life and their relevance for sample return.
    - Data collection and data archiving methods (open access databases), development or adoption of data tools for handling data, maps, media.

- Life detection topics:
    - Contributing to the development of **life detection and biohazard testing protocols**, enlarging the scientific communities to be involved in this endeavour including but not limited to: microbiology, bacterial metabolism, emerging diseases, ecology**.**
    - We should consider different types of **preservational matrices**. The ExoMars 2022 and Mars 2020 missions will be landing in areas supposedly rich in clay minerals, chosen because of the ability of clay minerals to trap organics (note, any organics, not just those of biogenic origin, and organics without fossils might be not convincing enough). Clays can trap organics including cells and microbial mat fragments, while coarser siliciclastics such as siltstones and sandstones can preserve microbial mats in situ, especially, but not only, if they are silicified. Both missions will be also aiming to study hydrothermal silica deposits, if present, because of the beneficial influence of such environments on biomass development. The Mars 2020 landing site, Jezero Crater, includes sequences of carbonates and local bodies of hydrated silica, both of which preserve a wide diversity on biosignatures in terrestrial rocks. Both missions will also be searching for potential biosignatures in various types of salt deposits. Thus, we will investigate preservation modes in clay-rich sediments, cherts and salts.
    - Sample selection and **characterization of sedimentary rocks** (Noachian aquatic environments: geological context, analytical instruments, samples protected from Mars radiation conditions to enhance the probability of preserving abiotic and/or biological organic material for billions of years), **preservation and detection of life traces** (morphological-cells, microbial mats-, stromatolites, chemical-isotopic, molecular, elements-, structural-MISS) i**n siliciclastic sediments** of early Earth and modern aquatic environments.
    - Identify what would be a **set of convincing features allowing the interpretation of biosignatures** (we need **reference data to differentiate abiotic organics** from meteorites, basalt alteration, minerals mimicking life morphologies, and contamination by rovers).
    - **Abiotic processes mimicking** life in sediments from early Earth and modern aquatic environments (perhaps focussing on anoxic-dysoxic environments) and on Mars (we need reference data to differentiate abiotic organics coming from meteorites, from alteration of basaltic rocks, minerals mimicking life morphologies, and contamination by rovers).
- Planetary protection (of Mars, of Earth), contamination:
    - **Reception of samples, quarantine and search for extant or dormant life. This not so easy while molecular tools based on terrestrial genes are probably not applicable and that** chemical biosignatures are often traces.
    - **Curation** of samples, analogue or actual Martian samples. Distribution and logistics of samples between labs (an international repository for samples).
- Instrumental and laboratory topics:
    - Devising analytical protocols concerning which instruments, non-destructive/destructive analyses to use and in which **order**, to characterize the returned samples to avoid loss of data and contamination, either during quarantine or to analyse samples in institutional laboratories. Apply a range of micro-instruments (XRF, XRD, FTIR/IR, Raman, microscopy tools, imaging systems, ICP-MS, μCT, synchrotron techniques, sampling tools, etc.) and test them on analogue materials. Organise relational databases and cloud systems to store this information. Combine the results with results from lab instruments, after reference samples have been distributed to the different labs.
    - Improving the understanding of how sterilization (notably by high energy rays and elevated temperature) could influence the isotope signature and biomarkers of samples.
- Scientific, **societal and philosophical impacts** of discovering or not discovering early life on Mars:
    - Preparation to improve general understanding what Martian samples could provide for science in general, prepare with answers and arguments against fake news and pseudo-science related to materials from Mars.
    - Preparing the science communities and the general public to understand the significance of finding (or not finding) a potential Martian life form or or biosignature in Martian samples
    - Improve the way to bring in more experienced people involved in Mars missions, instrument development.
    - the European MSR community is presently too small, we should work toward enlarge it

- Outreach and education topics:
    - Preparation of a set of Mars analogue samples, teaching materials and worksheets for schools (ranging across multiple levels).
    - A game to introduce the MSR mission, its importance, and related topics (such as planetary protection) to younger children.
    - A series of online talks, each focused on a specific issue of MSR (basically the topics outlined above).
    - Online teaching materials (ideally including translations into various member institute languages, especially for younger grades).
    - General public outreach through comics or a collection of short science fiction stories incorporating topics about the geological and climate past of Mars, possible past and current habitats, planetary protection, biosignature studied, and more.
- Further topics to discuss:
    - present PP proposals are, in my view inefficient and risky to say the least.
    - Developing suggestions of which sample types **could be analysed without strict planetary protection and isolation protocols** but provide useful results (this will enlarge the expected community and laboratory facilities for MSR by an order of magnitude without taking away the work from the sophisticated labs able to high protocols). ESA is not committed or even interested in the ground segment of the mission. EAI has to think and interact widely with a lot of European (EU) bodies.
    - wide range of topics related to biomarkers are there to clarify: Minerals can auto-assemble to form filaments, clusters of spheres, of course depending on context, however they role an separation from biogenic ones should be discussed and current state of art clarified. In all matrices, some biosignatures can be unambiguous and others not. For silicified biosignatures, it is easier to justify the presence of palaeobiology if there are silicified laminated sediments then massive chert precipitated from hydrothermal fluids in veins, or vents-these are much more challenging, as shown in the literature – but it does not mean we should not look in those.