europlanet 2024 Research Infrastructure

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Deliverable D4.4

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Contributing beneficiaries:	VUA, AU, DLR, CNRS, ATOMKI, UNIKENT
Document status:	Final

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Project Duration:	48 months
Co-ordinator:	Prof. Nigel Mason

1. **Nature:** R = Report, P = Prototype, D = Demonstrator, O = Other
2. **Dissemination level:**

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

Executive Summary / Abstract:

The under-utilisation of TA facilities during the first years of the project due to COVID-19 allowed additional potential upgrades to the facilities to be recognised. Five of the initial planned JRA projects were therefore expanded with the aim to complete and implement upgrades by the end of 2022. This would allow applicants to apply to use the upgraded facilities in TA Call 3. All upgrades have been implemented and TA applications were made to use the facilities in Call 3. Four of the five facilities had applications approved in the peer review process.

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1. Explanation of JRA1 & Overview of Progress

a) Objectives

Objective 4: to provide ground-breaking capabilities to determine isotopic and elemental compositions of planetary samples, including analyses at high spatial resolution, high precision and high sensitivity.

The aim of TA JRA1 is to provide the international community with access to leading laboratory facilities, 24 in Europe and 13 in South Korea that either provide state-of-the-art analytical capabilities or are capable of simulating conditions at the surface or interior of planetary bodies such as Mercury, Venus, Mars, Jupiter, Titan, Europa, Uranus, Neptune, comets, asteroids and the Moon. Europlanet 2024 RI has expanded the facilities available for the TA program through a strategic international collaboration with Korea Basic Science Institute (KBSI).

b) Explanation of work carried out

Task 3.1 – Management (NHM, VUA, UNIKENT, DLR, AU)

Management of JRA1 is overseen by the Transnational Access Sub-Committee (TASC), which is responsible for coordinating the exchange of personnel and samples between institutions, ensuring optimal synergy between tasks and the timely achievement of deliverables. Communication within JRA1 during Year 3 has been achieved through bi-monthly telecons. Despite the continued impact of the COVID-19 pandemic which has increased delivery times of components, the new capabilities offered by the JRA are close to being on schedule and the new capabilities are available through the TA programme in the last 18 months of the Europlanet 2024 RI project. Regular progress reports have been submitted to the TASC from the JRA facilities which summarise the status of the design, commissioning and implementation of new capabilities at AU, DLR and Atomki and the development of new analytical techniques at NHM-CRPG-VUA. Management of TA2, along with TA1, is overseen by the Transnational Access Sub-committee (TASC) and supported by the TA office at the VUA. The TASC has provided input to the text of the four TA calls issued so far and has supported DPLF leads in interactions with potential applicants.

The TASC, in consultation with ESF, oversaw the TA calls. The TASC has provided input to the Europlanet 2024 RI Data Management Plan and in collaboration with members of VESPA is finalising a data storage protocol for data generated by TA visits. The TASC reviews post-visit evaluation forms in collaboration with the Evaluation Officer, and takes any action deemed necessary to improve the implementation of TA visits.

Task 4.2: Expansion of Facilities (NHM, DLR, CNRS-IPAG, AU, LTU1, Atomki, OU, UniKent, Bruker Nano GmbH, ThermoFisher, CNRS-CRPG)

Task 4.2.1: Cryogenic reflectance spectroscopy under vacuum conditions for outer planets exploration: DLR, CNRS-IPAG, AU, LTU

The JRA task has delivered increased analytical capability at DLR for spectral and gas analysis of icy samples under low-pressure atmospheres comparable to outer Solar System bodies. The expansions of capabilities to TA 2.5 are specifically:

- Improve the automation of the cooling system and mechanical parts under high vacuum.
- Addition of a gas analyser to monitor gases released by the sample during the whole process of icing and measurement.
- implement a sample lock mechanism inside the cold chamber.
- Addition of 2 diamond windows to the existing design to allow measurement of an increased range of wavelengths.

The facility is undergoing final validation before access is allowed to external users from March 2023.

Task 4.2.2: Upgrading an astronomical ice-spectroscopy UHV chamber with UV/Vis and mass spectroscopy extensions for improving its TA potential: Atomki- UNIKENT

The initial JRA task involved installation of an ultra-high vacuum (UHV) chamber at the beamline of the 2MV Tandetron accelerator in Atomki to determine the structural-chemical modifications induced by the ion-impact on ices. This task was completed early and has been used for several TA visits with more planned for 2023.

The JRA extension was the installation to the beamline of the electron cyclotron resonance (ECR) source at Atomki of an additional UHV chamber (named BIC) gifted from Queens University of Belfast. This would provide a significant expansion of capabilities to TA 2.12.

The new installation provides an analytical facility to enable vacuum ultra violet (VUV) irradiation as well as ion beam irradiation. Fourier-transform infrared spectroscopy (FTIR) measurements for spectroscopic investigations of ice samples may be conducted simultaneously with quadrupole mass spectrometry during irradiation. This is a powerful addition to the offered facilities. The UHV chamber BIC was installed, vacuum system, gas-inlet system, cooling system and the mass spectrometry unit (QMS) tested and used in preliminary measurements in June 2022. A new sample holder for the cold head was manufactured and a new Bruker VERTEX 70v FTIR spectrometer installed and tested. The entire BIC system was validated in September 2022 and subsequently used for measurements. Multiple applications were made to use the BIC system within TA Call 3. The facility proved so popular that it was not possible to accommodate all applications that passed the peer review threshold.

Task 4.2.3: New capabilities for icy jet simulation at Aarhus wind tunnel: AU-Luleå-OU

The task involved modifications to the Aarhus wind tunnel facility and will improve the vacuum capabilities and develop a dedicated system for cryogenic aerosol generation. As a response to user demand and as a result of experiments performed under the Eurplanet 2020 RI program it became clear that modifications to the Aarhus planetary environment facility would allow exploration of entirely new avenues of planetary simulation; specifically, the study of icy jets and cryo-volcanism observed on icy moons. An extension to this activity also included constructing a new (dedicated) section to the facility.

Part 1 of the JRA involved installing and testing a two-stage roots pump system. This will reduce the lowest achievable pressure by at least one order of magnitude giving improved simulation of airless bodies such as moons, comets and asteroids: completed in 2021.

Part 2 of the JRA involved developing a dedicated system for cryogenic aerosol generation and installing this system. The new aerosol generation system will be based upon a previous system design but will operate at higher overpressure (more than 1bar). This will allow controlled icy jets/plumes to be generated within the facility giving the capability for the detailed study of both water and CO2 snow under Martian conditions and at even lower atmospheric pressures completed in 2021.

Extension of the JRA involved constructing a new module which was specifically designed to cater for Europlanet 2024 RI TA users to the facility and allow them additional and enhanced capabilities compared to the existing test section, including;

- Specialized access port for icy samples
- Dedicated optical access for aerosol detection
- Various new cryogenic orientations (faster/efficient cooling/heating)
- Specific modifications for vacuum operation (without wind flow)

The current test section was specifically constructed for testing of ESA ExoMars rover parts; however, the modular design of the AU facility allows this new module to be used in various combinations with the existing construction and all of the current capabilities will be maintained.

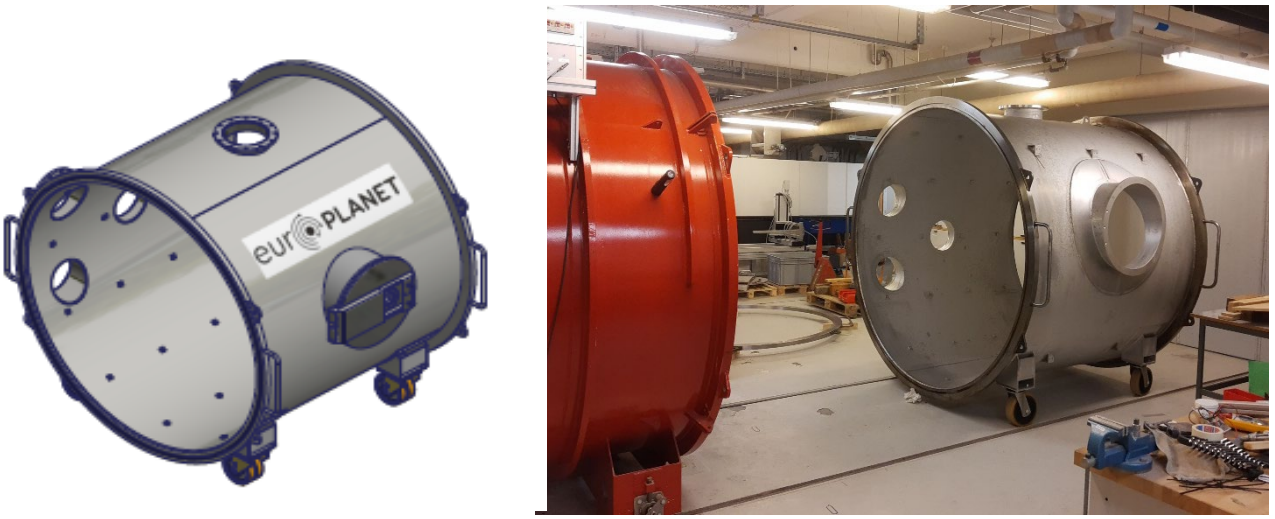


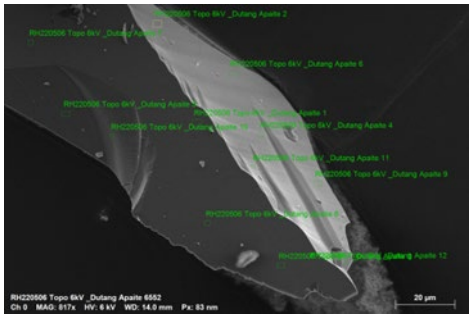
Figure: left schematic (CAD) of the new module and right a photograph of the final constructed module delivered to the facility, which is now available for use to the TA visitors to the PEF laboratory, as of January 2023.

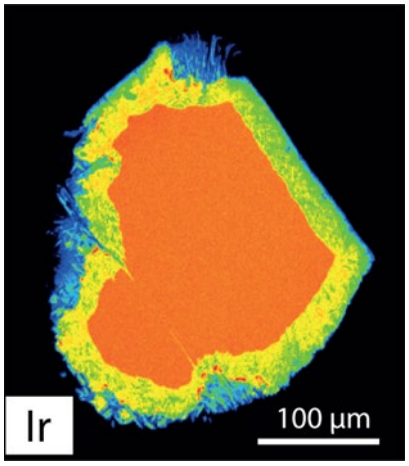
Task 4.2.4: Non-destructive characterisation of meteorites: NHM, UniKent, Bruker Nano GmbH (*plus new partner DLR*)

This JRA is designed to deliver non-destructive mineralogical characterisation at smaller scale using state of the art scanning electron microscopy (SEM) combined with energy-dispersive spectrometry (EDS). The work was undertaken on an annular Bruker FlatQUAD silicon drift detector (SDD) for expansion of capabilities to TA 2.3 at NHM and University of Kent in collaboration with Bruker Nano GmbH, Berlin. The initial work was successful; PGE nuggets from terrestrial geological settings were used to optimize quantification procedures under conditions that will be suitable for small (<1mm) extra-terrestrial grains. A publication that is close to submission: Heard et al. is in preparation.

The JRA extension was to develop an analytical protocol for SEM-EDS quantification of samples with a topography. This work is potentially of high importance for the analysis of planetary materials, enabling the characterisation of high value samples like sample return material without any destructive preparation. Surface roughness and topography leads to inconsistencies in the numbers of X-rays hitting the detector, making quantification challenging. Using a variety of mineral species relevant to extra-terrestrial samples (apatite, olivine, calcite, SiC, glass) we have investigated standard-less peak-to-background (P/B) quantification. A method has been developed that allows quantification, albeit with higher errors than is possible for polished samples.

The work on the JRA projects is complete and the techniques were offered in TA Call 3. The images below are; left, a lunar apatite grain used to test the quantification on topographic samples; right, an Ir map produced on a PGE nugget.





Task 4.2.5: Improvement of analytical methodologies for the use of 10^{13} Ohm resistors in state-of-the-art analytical instrumentation *(VUA; CNRS:CRPG; ThermoFisher)*

The initial task to develop new analytical methods to reduce sample size and open up new analytical possibilities was completed on time. The project has already yielded great success with ~10 times reduction of Os and Nd at CNRS and VUA respectively and has led to two publications (Reisberg et al. 2021; Weiss et al, 2022) with more expected in the near future.

The JRA extension was to further develop the Os method at CNRS and develop improved and cleaner sampling and chromatographic techniques to reduce sample blanks for Pb to allow in situ sampling of smaller samples with a portable laser ablation instrument. This latter work will allow sampling of unique material, for example in a museum setting under supervision of curators. All work was completed and initial validation of the Pb isotope work was conducted in collaboration with the Rijksmusem Amsterdam led to a major public outreach event related to the origin of gold in the state coach. The work was nationally number 1 on twitter on the day of the press release; https://www.dutchnews.nl/news/2022/09/gold-in-gouden-koets-came-from-suriname-experts-conclude/.

c. Impact to date

COVID-19 has caused significant delays to the expected impacts for the TAs and JRAs due to the reduced number of conferences and the lower number of TA visits than expected. However, TA Call 3 resulted in numerous requests to use the improved TA facilities. Peer reviewed publications have been/ are being produced based on the new TA capabilities and new collaborations are being forged both within the planetary science community and with cultural heritage.

2 Update of data management plan

Please see deliverable D1.3 for details.

3 Follow-up of recommendations & comments from previous review(s)

The main focus for the next 18 months is to ensure that the new capabilities of all the improved TA facilities are widely disseminated within the planetary science

community and beyond. This will be accomplished through additional peer reviewed publications and presentations at conferences.

c. Impact to date

COVID-19 has caused significant delays to the expected impacts for the JRAs in that it caused delays in the overall implementation. However, all phase one of the JRAs were completed in time to make them available for the Second and FAST track calls and multiple applications were made to use the updated facilities. The overall satisfaction of the TA visits to these new facilities was particularly high, partly because exciting new state of the art capabilities were offered. Phase two of the JRA were implemented by the end of 2022 such that the new capabilities were offered in Call 3. Multiple applications were received and approved to use the new facilities in Call 3.
Visitors who have conducted TA visits to the improved facilities have all committed to make presentations of their results at the Europlanet Science Congress (EPSC) and also have plans for journal articles as well as conference papers and wider outreach/dissemination based on their visits. Despite recent completion of the new capabilities, presentations were made at EPSC based on the use of the Atomki, Aarhus and Amsterdam and publications from the VUA-CNRS collaboration (Europlanet 2024 RI Publications – Europlanet Society (europlanet-society.org). More publications detailing the new methods and capabilities are expected in the next year.

d. Summary of plans for Year 3

The JRA activities are complete with only further routine validation work required. The first TA visits will be conducted at the facilities over the next 18 months.

2 Update of data management plan

The TASC has provided input to the Europlanet 2024 RI Data Management Plan and in collaboration with members of VESPA is finalising a data storage protocol for data generated by TA visits.

3 Access provisions to Research Infrastructures

Links to summaries of all the TA visits reported to date can be found on the project website
https://www.europlanet-society.org/europlanet-2024-ri-ta-visit-report-summaries/

We note that despite extensive action, that the number of URS applications remains relatively low (~20%) and that they have a lower success rate (<40%). In any future RI, we will continue to follow up on the successful workshop held in 2021, where advice was given on how to prepare and submit successful TA proposals. Such activities will be written into any future RI applications.