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ИКИ ИНСТИТУТ КОСМИЧЕСКИХ ИССЛЕДОВАНИЙ РАН

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• The ESA PROSPECT Payload for Luna 27: Development Status

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• Data derived from King, O., Warren, T. et al. (2020), PSS

PROSPECT Overview

- **P**ackage for **R**esource **O**bservation and in-**S**itu **P**rospecting for **E**xploration, **C**ommercial exploitation and **T**ransportation (PROSPECT)
  - Payload developed by ESA for application at the lunar surface as part of international lunar exploration missions
  - Designed to perform an assessment of the volatile inventory in near surface regolith

- Planned for flight on Russia's Luna27 mission (est. launch 2025)
- Currently also discussing with NASA about an exciting possibility to fly PROSPECT on a future joint NASA/ESA polar delivery

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Industrial Lead LEONARDO AIRBORNE & SPACE SYSTEMS DIVISION

The Open University

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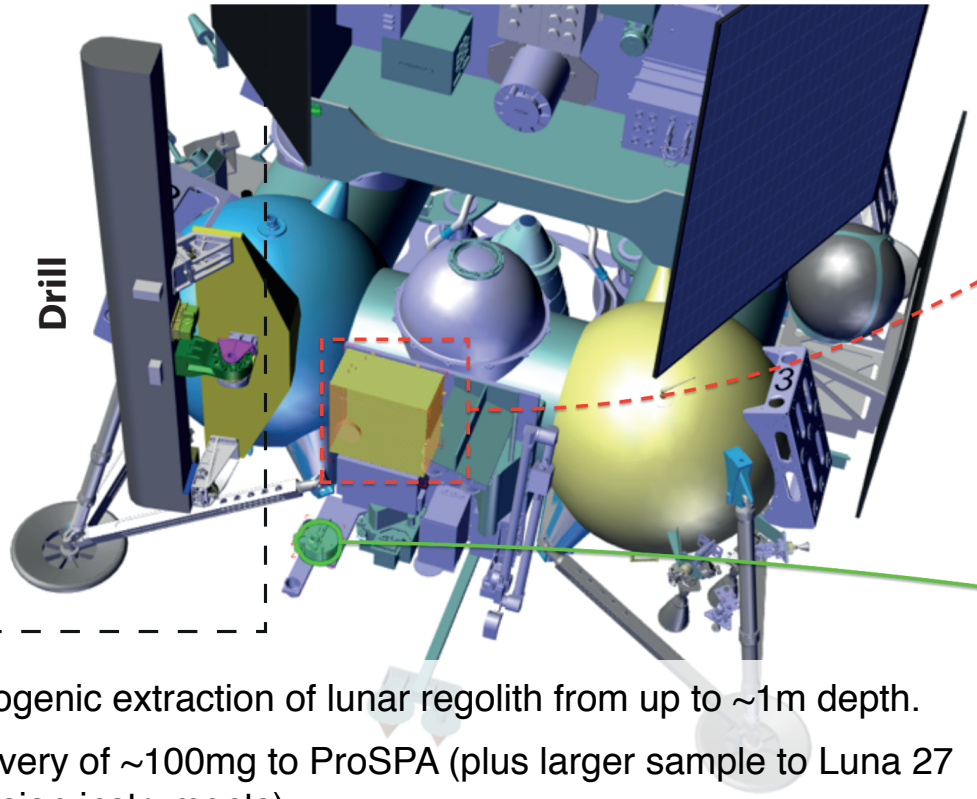
ProSEED



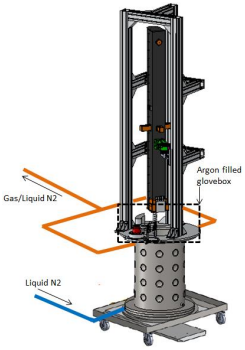
- Cryogenic extraction of lunar regolith from up to ~1m depth.
- Delivery of ~100mg to ProSPA (plus larger sample to Luna 27 Russian instruments)
- Drill sensors: Torque, temp., permittivity.
- Multi-spectral imager (DrillCam): 6 LED groups ~450-960 nm.

ProSPA

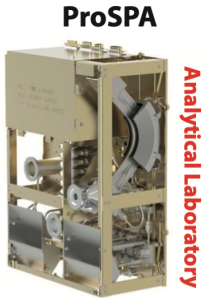
- Ion-trap MS
- Mag. sector MS (abundance + isotopes: H,C,N,O, Noble gases).
- Gas processing system (cold fingers, getters, gas supply sub-system, reactors, 120°C manifold).
- Carousel of ovens for evolving volatiles from regolith.
- Ramped and stepped heating for evolved gas analysis, up to ~1000°C (ISRU).
- Multi-spectral 3D imager (SamCam) to determine sample volume.

PROSPECT Investigations

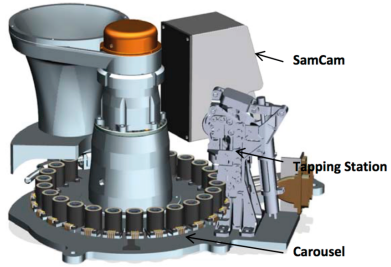
- 1. Drilling, Geotechnics, and Sample Handling
- 2. Imaging, Surface Modelling and Spectral Analysis



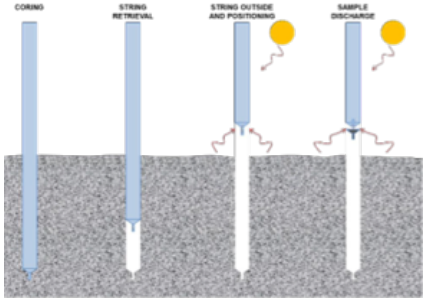
- **ProSPA Sample Analysis:**
- 3. Noble gases, and
- 4. Light elements+isotopes



- 5. Thermal Environment and Volatile Preservation



- **In-Situ Resource Utilisation:**
- 6. Precursor Experiments, and
- 7. Prospecting



- 8. Permittivity Sensor

Objectives (socially distanced…)

Determine the abs. abundance of volatiles, as a funct. of depth, at a location where enhancement, compared with average lunar values, is expected

Determine to what extent hydrogen and water in the lunar polar regions is found in ices or is chemically bound to regolith grains

Determine the volatile inventory at a location where their enhancement is expected

Identify the sources and emplacement processes of cold trapped volatiles at a location where their presence is confirmed

Determine the cold trapped volatile inventory at a location where their presence is expected

Determine the absolute abundance of cold trapped volatiles, as a function of depth, at a location where their presence is expected

Determine the composition of chemisorbed and solar wind implanted volatiles at new and distinct locations

Determine the abundance of chemisorbed and solar wind implanted volatiles at new and distinct locations

Determine the variation in concentration of chemisorbed H2O/OH with depth below the surface.

Determine the isotopic composition of the elemental components of chemisorbed H2O/OH found below the surface.

Demonstrate in-situ extraction of oxygen from minerals in lunar regolith.

Record key metrics to allow the determination of the feasibility of candidate oxygen extraction processes

Determine the composition of regolith at a new and unexplored location

Determine physical properties of lunar regolith at a new location

Volatiles

Constrain values for the fraction of volatiles which have been delivered to the Earth-Moon system by asteroids, comets and solar wind.

Assess the time averaged volatile inventory to the Earth-Moon system.

Infer any relationship between molecules associated with the building blocks of life and those occurring in lunar ices and their sources.

Establish whether the products of organic synthesis reactions occur in lunar ices

Establish the composition, chemistry and isotopic nature of any detected prebiotic organic molecules & compare with terrestrial ones

Determine the in-situ mechanical properties of the lunar regolith being sampled.

Understand the in-situ operational behaviour and performance of the PROSPECT package.

Make static imagery of all key PROSPECT operations available on ground to support operations and for post-operations analysis.

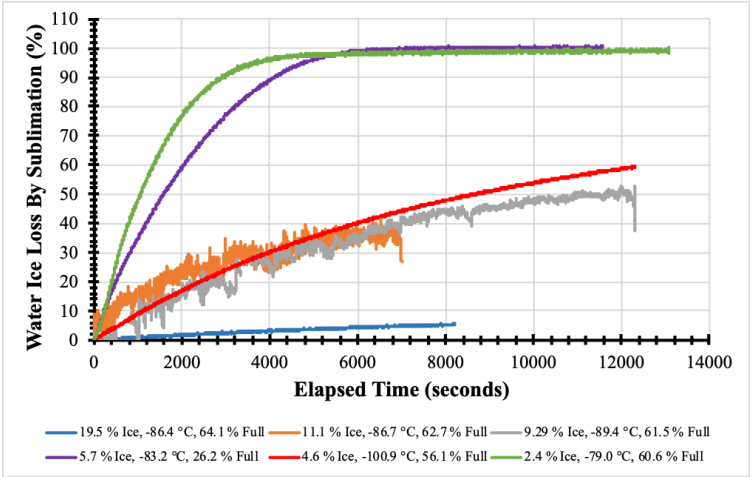
Ensure that a broad section of the general public are aware of PROSPECT and its objectives and are engaged prior to, during and post flight.

Top level:

- ✓ Perform cryogenic extraction of regolith samples from down to 1m depth.
- ✓ Characterise the lunar polar surface and sub-surface environment.
- ✓ Determine the **abundance**, **composition** (including isotopic) and **origin** of physisorbed (cold-trapped) and chemisorbed volatiles in lunar regolith.
- ✓ Demonstrate in-situ extraction of oxygen from minerals in lunar regolith.

Priority Science Activities in Phase C & D

- Volatile preservation studies to enable meeting science requirements (modelling, plus laboratory sample and simulant analyses).
- Camera characterisation activities (Analysis of EM data, calibration target definition, measurement analogues).



- Mortimer et al. (PROSPECT Science Team Meeting Nov. 2019

Perform investigations into ice sublimation processes in lunar regolith and a multi-analysis chemical study.

← Apollo sample analyses

This work will be used to validate high-priority mission requirements for PROSPECT, to verify the performance of the instrument concept and to support the preparation of analogue materials.

Data obtained on the ice sublimation process will be of fundamental importance for the understanding of volatile physical and chemical processes in the lunar polar regions and the interpretation of mission data.

- Assessing the magnitude and impact of all vectors of potential contamination relevant to elemental and isotopic measurements.
- Science prioritisation for PROSPECT operations: maximizing completion of science objectives while minimising resources (time, power, data).
- And several other key areas..