Accessing and Assessing Lunar Resources with PROSPECT

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“the surface of our satellite must now be at a low temperature—at least, near the poles. There is even cause to ask if it is not totally or partially covered with ice…”

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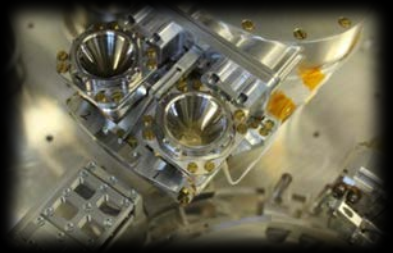
PLATFORM FOR RESOURCE OBSERVATION AND IN-SITU PROSPECTING IN SUPPORT OF EXPLORATION, COMMERCIAL EXPLOITATION & TRANSPORTATION

DRILL

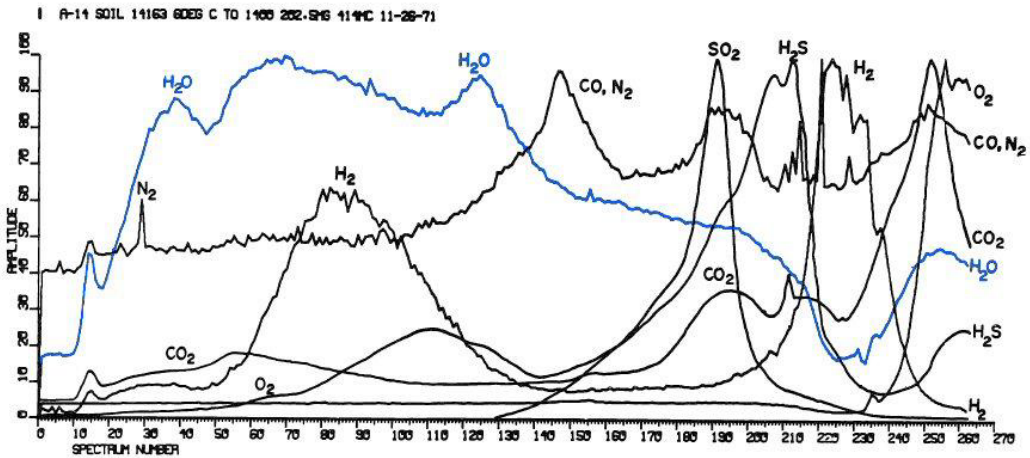
EXTRACT

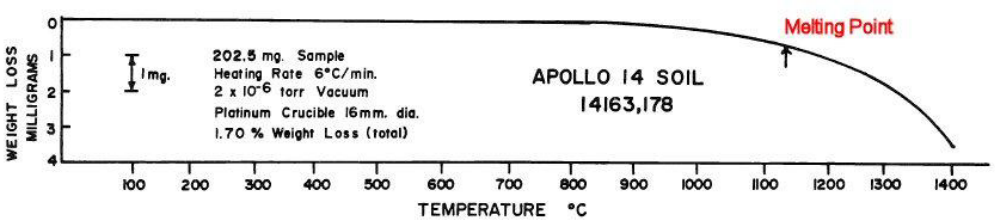


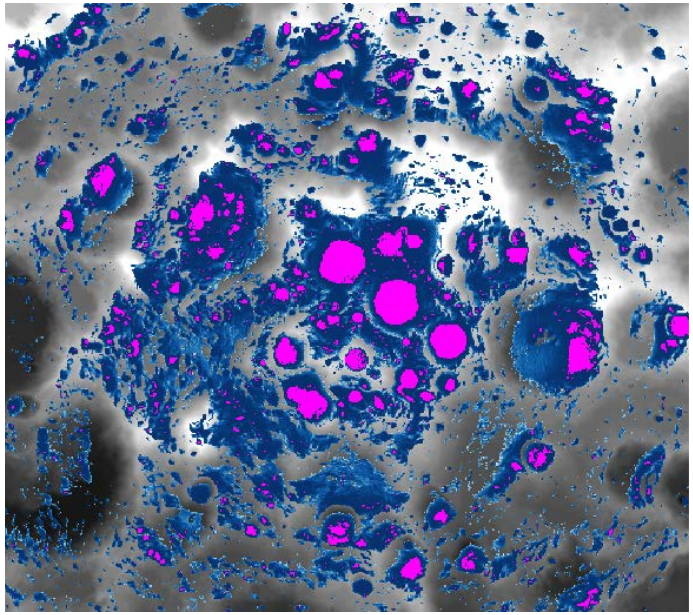
ANALYSE

PROSPECT GOALS: Understanding Resources

1. **Water ice**
    a. Abundance, distribution, form and extraction
2. **Grain surface bound volatiles**
    a. Composition, abundance, distribution, extraction
3. **Oxygen in regolith**
    a. Thermochemical extraction efficiency (reduction and oxidation reactions)





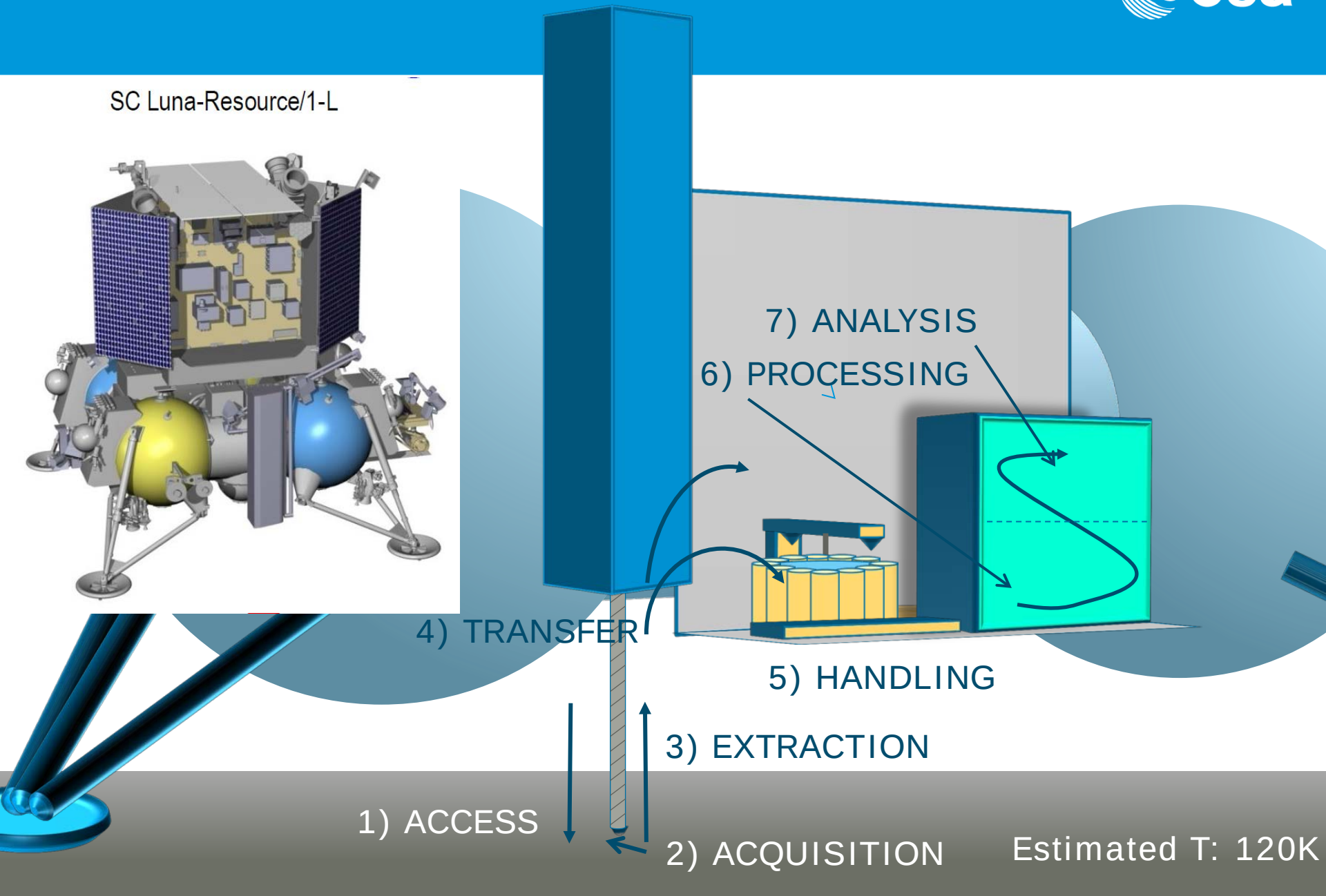


Paige et al. 2010

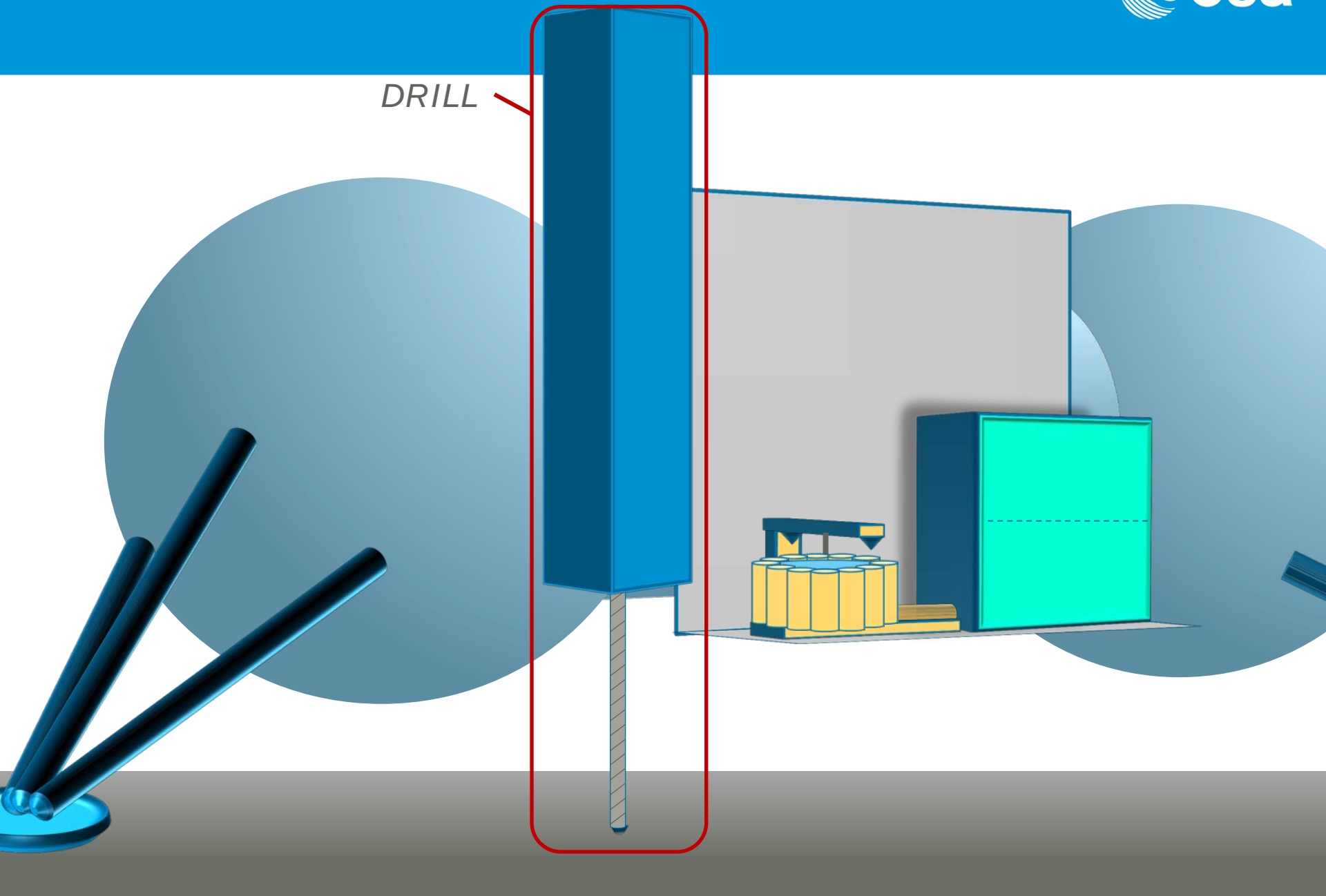
Objectives

1. **Drill** to access volatiles
2. **Remove samples** of volatile bearing material
3. **Extract** volatiles from samples thermochemically
4. **Identify** the volatiles released
5. **Quantify** the volatiles released
6. **Isotopic** characterisation:
    a. Measured precisely against agreed international standards
    b. % accuracy → sources of volatiles
    c. ‰ accuracy → sources, transport, processes, distribution, fate e.g. water cycle
7. Relate all of the above back to the **original nature** of the volatiles in the regolith

PROSPECT: System



PROSPECT: Drilling and Sampling



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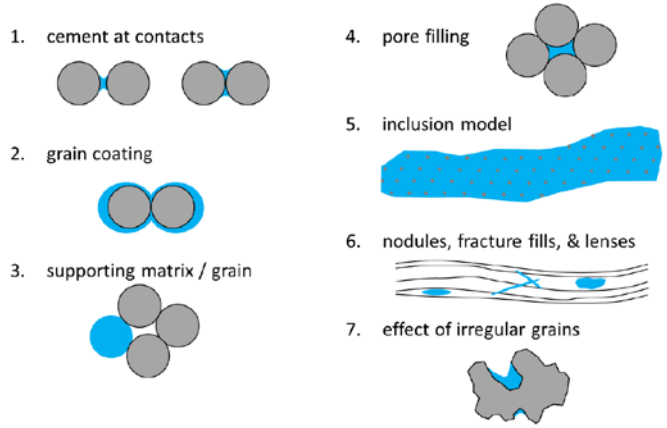
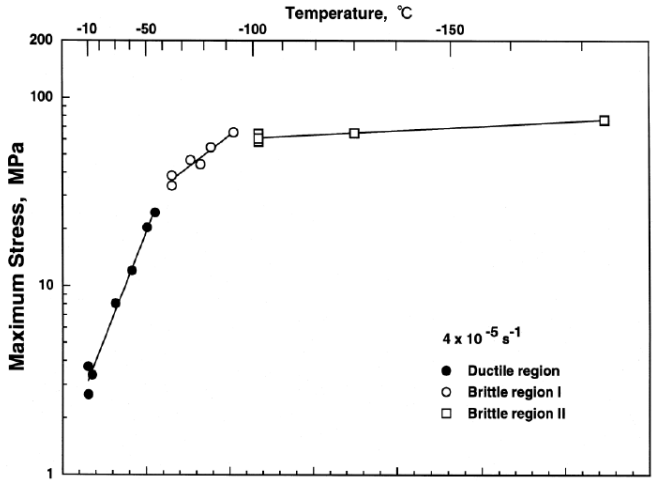
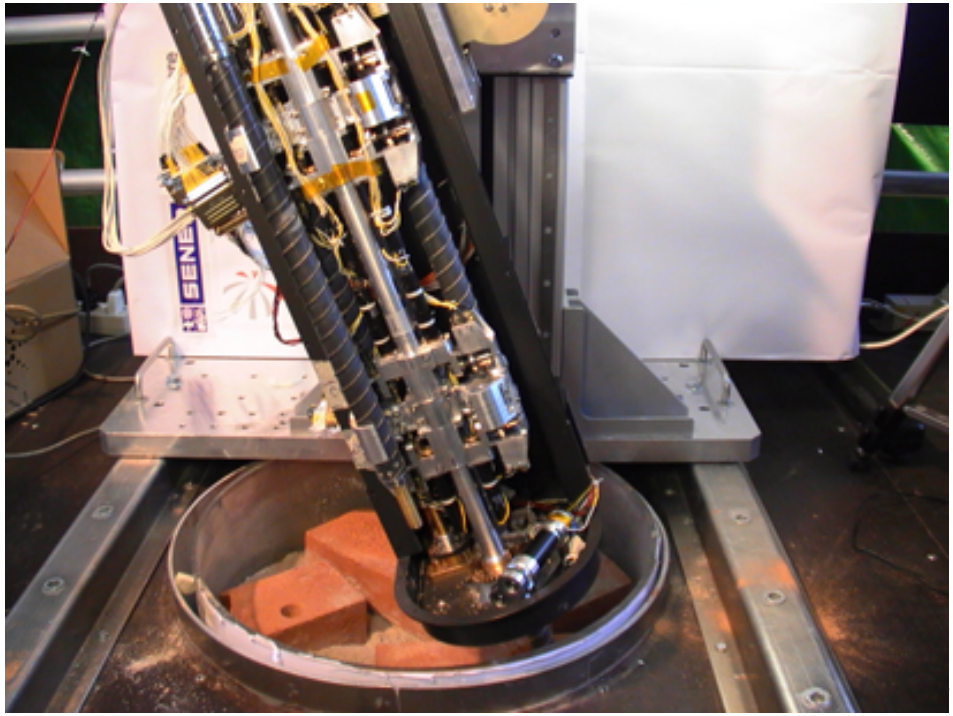


Potential forms of ice inclusion in lunar regolith (Gertsch, 2013)



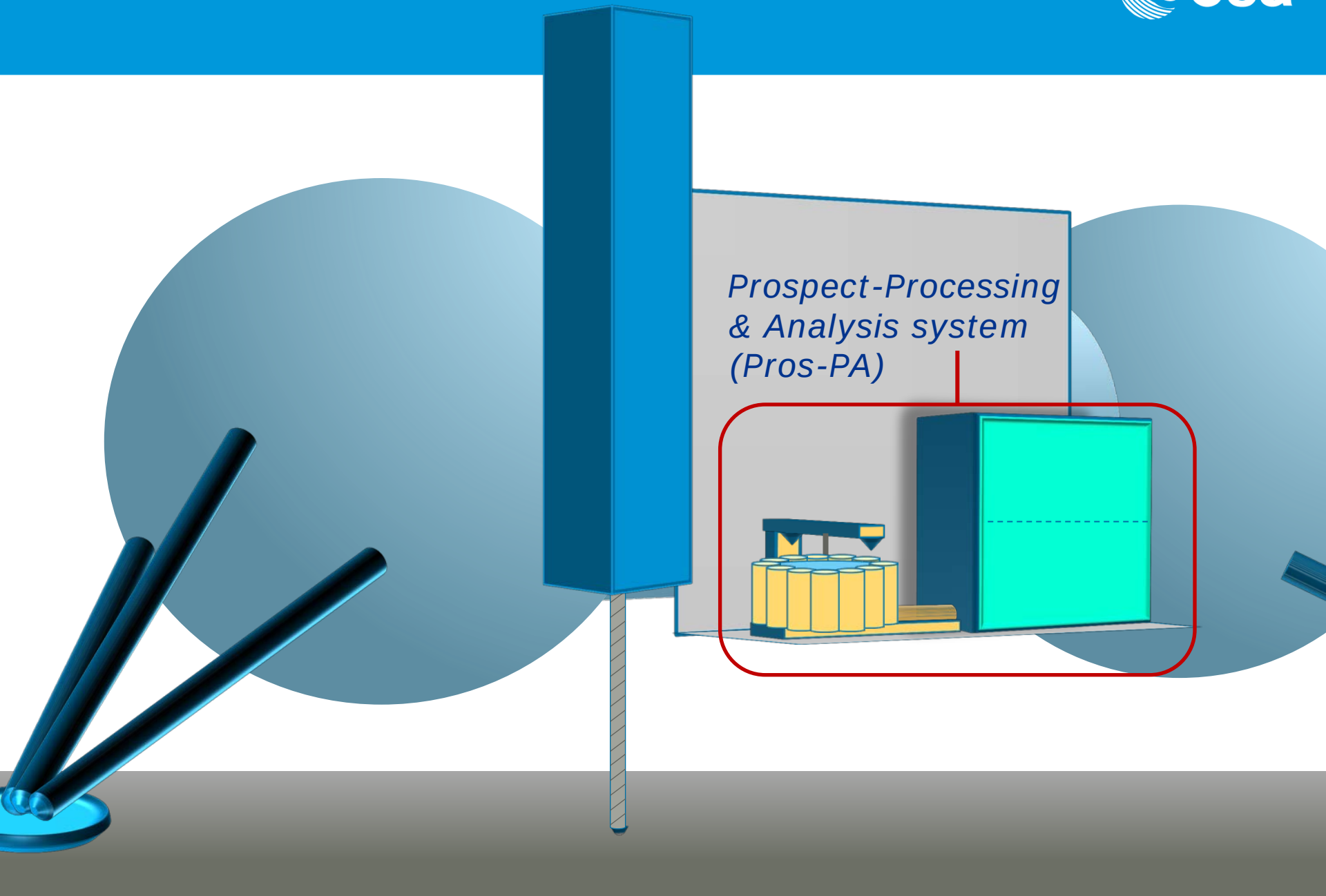
Strength of pure *polycrystalline* ice as a function of temperature (Arakawa and Maeno, 1997)

- Drill and sample from up to 2m
- Ice form and preservation
- Material Properties
- Sample size and handling requirements for different users



Exomars drill breadboard

PROSPECT: Sample Processing and Analysis



PROSPECT: Sample Processing and Analysis

Extract

Stepped heating to 1000°C

Introduction of reactant gasses

O_2, H_2, CH_4, F_2

Identify

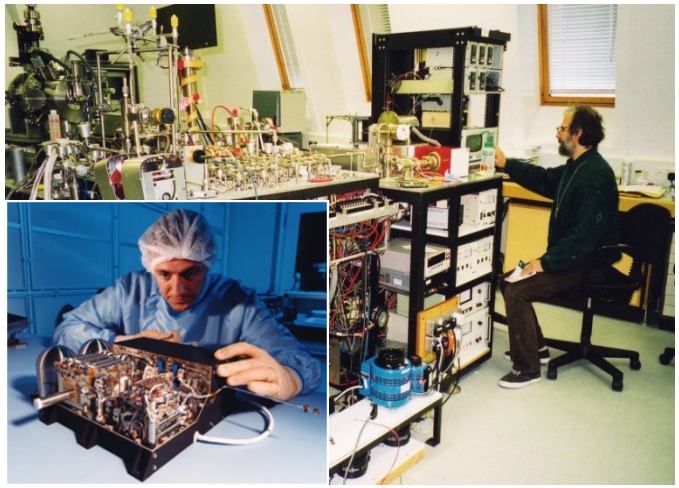
Ion trap mass spectrometer against standards

Quantify

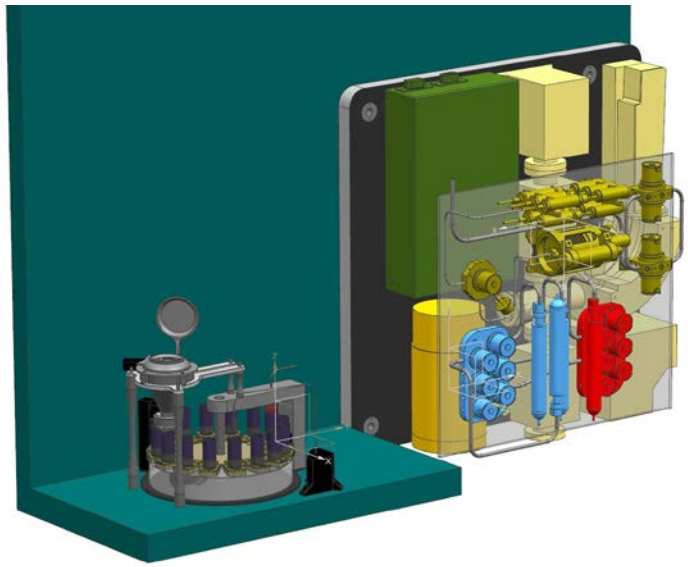
Determine total yield

Isotopes

Gas processing and magnetic sector mass spectroscopy against standards

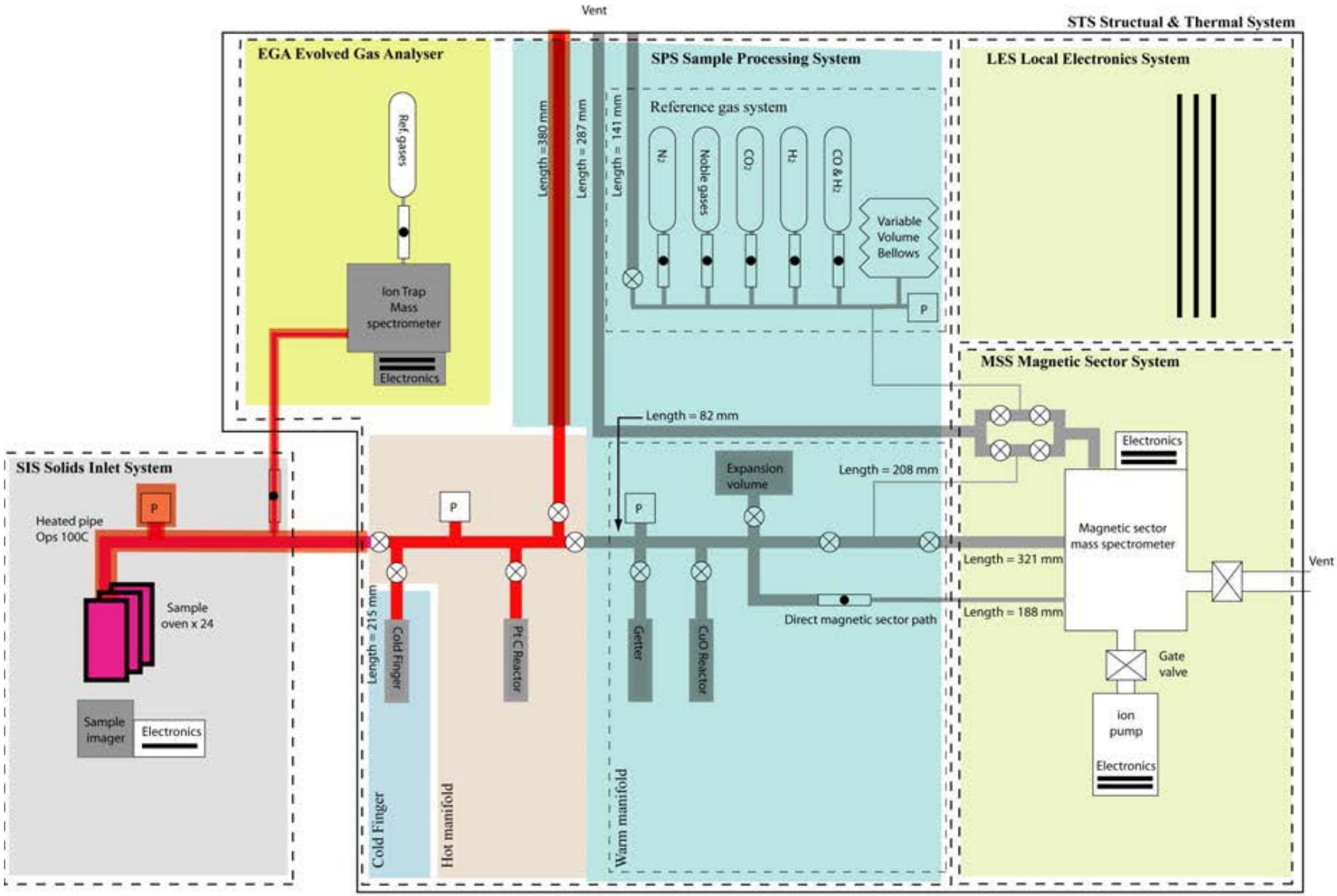


Ptolemy onboard Philae
Pros-PA for Luna-27



Isotopic ratio	Associated molecular species	Expected Precision
δD	H2, H_2O, -OH, hydrocarbons	10 ‰
$\delta^{13}C$	CO, CO_2, hydrocarbons	0.1-1 ‰
$\delta^{15}N$	N_2, NH_3, nitrogen oxides	0.1-1 ‰
$\delta^{18}O$	H_2O, CO and CO_2	0.1 ‰

Pros-PA Schematic



Some Important Areas Where Science Community Inputs are Needed

1. **Sample size**
    a. Size Vs extraction efficiency and handling
    b. Size Vs measurement requirements
2. **Alteration**
    a. What level of sample alteration is acceptable?
    b. What are the implications for the sample chain (e.g. temperature)?
3. **Contamination**
    a. What are the potential risks posed by contamination?
    b. How can these be characterised?
    c. How can they be understood and mitigated?
        - By design
        - By operation
4. **Analogues for verification**
    a. What analogues could be used to verify sub-system and system performance?

International Cooperation