



EURO-CARES
A PLAN FOR EUROPEAN CURATION OF RETURNED
EXTRATERRESTRIAL MATERIALS



WORK PACKAGE 5

**LIST OF OBTAINABLE NATURAL AND ARTIFICIAL ANALOGUES NECESSARY FOR THE CURATORIAL
FACILITY (DELIVERABLE D5.2)**

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D 5. 2 Interim Report: List of obtainable natural and artificial analogues necessary for the curatorial facility

Motivation

The aim of the EURO-CARES project is to create a curation and analytical facility dedicated to extra-terrestrial samples brought to Earth from different bodies in the Solar System (Mars, planetary satellites, asteroids, the Moon), either by unmanned and/or by manned missions. These samples will require specific storage conditions and handling procedures. For practical reasons and sterility concerns it might be necessary for the curation and analytical facility to have its own collection of analogue samples.

Objectives

- to evaluate specific storage conditions and handling procedures during curation and analysis of extraterrestrial materials
- to identify analogue samples crucial for evaluating and defining the protocols necessary to accomplish safe and sustainable handling of extra-terrestrial materials.
- to create a list of different types of samples that would be required for a sample curation facility (analogues and standards)
- to create a preliminary list of analogue materials already available
- to complete these lists over the course of this project in response to the requirements established by the other work packages
- to include recommendations for the fabrication of new artificial analogues

WP5 Team Members:

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External Members: Katherine Joy, Martin Lee, Jesus Martinez Frias, Joe Michalski, Penny Wozniakiewicz

Scientific Activity

Our main activity during the first period of the project was a survey of the existing literature and the creation of a preliminary list based on input from the WP5 team members, of the kinds of samples necessary for a curation facility including geological samples (rocks and minerals), chemical sample (ices and organics), and technical samples as well as of the analogues characteristics necessary. This list was submitted as delivery D1.5. We presented results of our literature reviews and an updated list of "Analogues in a European Sample Curation Facility" at the EURO- CARES International

Conference and Invited Workshop in August 2015. In delivery D1.5 we had already covered aspects of the analogue characteristics necessary for the curatorial facility. For this reason as well as for logical reasons we moved delivery D5.1 to month 15 in order to incorporate results from the first workshop to be held in month 14 on the exact same topic. Deliverable 5.1 was thus an interim report on analogue characteristics necessary for the curatorial facility based on discussions from the workshop held in Orléans February 4-5, 2016.

Deliverable 5.2

On June 1-3rd we held an expert workshop at the Senckenberg Gesellschaft für Naturforschung in Frankfurt, Germany to discuss the nature of analogues necessary for a curation facility through discussion with external experts who have experience in this field and to reach collective definitions of the various kinds of analogue materials needed, as well as a list of what are considered to be the most essential materials. This deliverable is the result of the discussions held at the workshop.

The invited experts were:

- Dr. Hilde Schroeven-Decuininck, ESA, responsible for creating the ESA analogue curation facility
- Dr. Frederic Foucher, CNRS-CBM-Orléans, on analogue samples from the engineering point of view
- Dr. Nicolas Bost, CNRS-Orléans, creator of the International Space Analogue Rockstore (ISAR; www.isar.cnrs-orleans.fr)
- Dr. Mike Zolensky, NASA Johnson Space Center, cosmic dust curator
- Dr. Gerhard Kminek, ESA, responsible for planetary protection issues
- Dr. Michel Viso, CNES, responsible for planetary protection issues
- Dr. Hajime Yano, ISAS-JAXA, Hyabusa curator

Workshop programme

June 1st

Smith/Westall/Zipfel: Introduction to the EURO-CARES project, WP5 (analogue) activities and general logistical information

Presentations from the experts:

Hilde Schroeven-Decuininck on ESA activities regarding analogue samples
Frederic Foucher on analogue samples from the engineering point of view
Nicolas Bost on the International Space Analogue Rockstore (ISAR)
Mike Zolensky on curation of cosmic dust
Gerhard Kminek on planetary protection issues
Michel Viso on shared curation facilities

June 2nd

Report on WP 2 workshop by Luigi Folco
Hajime Yano on Hyabusa curation

Discussion:

Glossary and definitions
What analogues for what purpose?

Analogue samples storage considerations for WP3
Implementation of analogues in a facility database
Evaluation of minerals and rocks already chosen as analogues

June 3rd

Agree on terminology

Make recommendations for:

- function and material types
- level of detail

Results of the workshop and input for deliverable 5.2

1. Definitions:

- Sample receiving facility

In this report, we assume that there is a sample receiving (SR) facility and that it is being addressed by other WPs. Obviously flight spare hardware/engineering models will be needed for staff training (but these are not classed as analogues from our point of view)

- Curation facility has the following functions

- opening of the returned sample canisters
- handling and preparation of the returned samples
- basic analysis of the returned samples, *i.e.* initial sample characterisation
- long-term storage of the returned samples

Sample types:

- **Analogues** are materials (e.g. rocks, minerals, ices, gases) that have one or more physical or chemical properties similar to those expected in extraterrestrial samples returned with sample return missions.

- **Reference samples** are well-characterised materials with known physical/chemical properties used for testing the flow of the whole process or part of it. They may not necessarily be the same materials as the analogues defined above.

- **Standards** are internationally recognised, homogeneous materials with known physical/chemical properties that are used for calibration (e.g. silicon for Raman spectrometry). They can also be used as reference samples in certain circumstances. They may be made of natural materials (e.g. the *Belemnitella americana* from Pee Dee Formation in South Carolina, used for ¹³C isotope studies) but are often produced artificially (e.g. the calibration targets used on the instrument ChemCam in the MSL mission).

- A **voucher specimen** is a duplicate of materials used at any stage during sample acquisition, storage, transport, treatment etc, e.g. space craft materials (including solar panels), lubricants, glues, gloves, saws, drills, and other....., and stored for when needed. In addition, **Earth landing site samples (from the touch down site)** would be necessary in case of doubtful analysis even if normally this type of contamination is not expected (cf. Stardust).

- A **witness plate** is defined material left in an area where work is being done or assessed for e.g. biological, particulate, chemical, and/or organic contamination. It is a spatial and temporal document of what happens in the work area.

In order to illustrate the different types of samples listed above, Figure 1 shows the types of samples necessary for a camera.

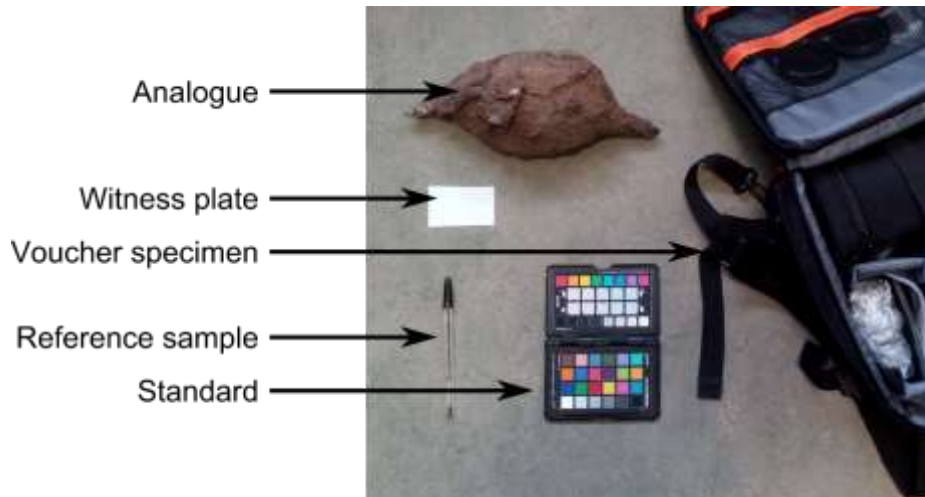


Figure 1. Illustration of the different types of samples considered by the WP5 of the EURO-CARES project. The example is given for a standard camera. The analogue here is a volcanic bomb representative of expected structures on Mars, the witness plate is a sheet of paper that will stay in the area where the observation are made, the voucher specimen is the camera bag that could potentially appear on an image, the reference sample is a pen for scale, and the standard is a ColorChecker target used to calibrate cameras.

2. The nature of analogue materials:

- **State of matter** – analogue materials may have different states e.g.:

- solids including ices
- liquids
- gases

- **Type** – analogues may be natural or manufactured

Natural analogues include:

- rocks (all size ranges, including dust)
- minerals
- regolith

N.B. These materials could contain biological (extant and/or extinct) and/or organic components.

Manufactured analogues include:

- mixtures of different components in predetermined ratios for specific purposes
- biological doped samples
- organically doped samples

N.B. Manufactures analogues need to be produced in sufficient amounts such as to ensure the uniformity of each batch. The source provider needs to maintain quality control between batches. Such samples will be produced on a case by case basis.

3. What analogues for what purpose?

- **Sample handling** requires samples with different physical or geotechnical properties, e.g. porosity, yield strength, compressive strength, density, temperature, cohesivity; as well as electrical and magnetic properties; different size distributions; and in different states of matter (solid/liquid/gas). For example, analogues for returned samples from:

e.g. Mars could be an homogenous basalt, a mudstone, coarser grained (sand to ?conglomerate?) sediment, soil, dust;

e.g. an asteroid could be meteoritic material, loose regolith-like material, and dust;

e.g. Moon could be lunar samples, regolith, icy samples.

N.B. It will be important to produce protocols for keeping the analogue samples temporally and/or spatially isolated from the returned extraterrestrial samples. This does not necessarily mean that they need not be in the same room.

- **Transport protocols** for movement of the returned samples within the facility and for shipment out of it. It will be necessary to practice with empty containers and appropriate analogue samples (cores, fragments, dust) (sample size and nature are important). In this case, analogue samples exhibiting different physico-chemical-technical etc. properties will be necessary.

- **Sample preparation protocols**, for example, sectioning, powdering, splitting, chemical/heat extraction, and imaging (optical-SEM EDS). All analogue types exhibiting appropriate physical/chemical properties will be appropriate.

- **Training of science and curation teams** and science lab quality assessment, *i.e.* making sure that the external laboratory facility can handle/analyse the returned samples. ISAS/JAXA made a blind test of laboratories interested in analysing the Hyabusa 1 samples (Kushiro et al., 2003). Such activities would use reference analogue materials.

- **Long-term storage** needs to be tested using witness plates, hardware samples, voucher specimen and reference materials (including frozen materials).

4. What mass of material is needed?

The mass necessary will depend on the objective and analogue types. Suggested masses will be driven by mission architecture and the target body of interest, as well as the defined science requirements, and availability.

We suggest the following:

~40 kg of terrestrial analogues (rocks)

~1 kg minerals

~1 kg meteorites

5. Storage considerations for WP3:

Analogue, reference, standard, and voucher samples all need to be isolated from each other and temporally and/or spatially isolated from extraterrestrial samples while, at the same time, being accessible.

N.B. In the case of restricted Earth-return samples (e.g. from Mars or Europa), the above listed materials should strictly NOT share space with the extraterrestrial samples either temporally and/or spatially.

With respect to witness plates, those in use actively need to be in close proximity to the returned extraterrestrial samples, while the past plates need to be stored elsewhere.

N.B. Since planetary protection aspects need to be addressed from the beginning of the curation activities, contamination assessment and control plans should be emplaced during mission planning and development.

6. Curation facility data base and analogues

There should be one database for the curatorial facility in which different database subsections, e.g. the analogue database, will be embedded.

7. Evaluation of analogue minerals and rocks necessary for the curation facility and potentially already available – or available when needed

N.B. Standards and reference materials will be chosen in accordance with WP2, 3, 4

Discussion among the workshop participants concluded with the following is a suggested list of analogue samples, the selection of which will be **mission-dependent**:

Natural analogues			
Rocks	Primitive basalt	Minerals	Olivine
	Anorthosite		Pyroxene
	Dolerite		Plagioclase
	Tuff		Metal (Fe-Ni alloys)
	Suevite,		Jarosite
	Mudstone		Magnetite
	Sandstone		Hematite
	Lunar regolith		Calcite
	Chondrite (CC,OC)		Dolomite
	HED meteorites		Gypsum
		Anhydrite	
		Perchlorates	
		Sulphides (troilite/pyrrhotite)	
		Mg smectites	
		Serpentine	
		Silica (amorphous/opal)	
		Ices	
Gas*	¹³ CO ₂		
	¹³ CH ₄		
Liquid*			

* Provided on demand

Manufactured analogues

- Regolith/soil
- Soil mixtures (e.g. with perchlorate, ice)
- Icy/dusty mixtures
- Doped samples (biological)
- Doped samples (organic)

8. Analogue sample spreadsheets

Each spreadsheet for the proposed analogue samples (Figure 2) contains information regarding its:

- nature and provenance
- EURO-CARES code number

- the target extraterrestrial body for which it is an analogue (specific mission, if relevant)
- the target body geological context
- the curation facility storage
- the analogue's state of matter
- a general geological description of the target including petrography, mineralogy, chemistry, etc.
- physical properties, including density, hardness/compressive strength, porosity, tenacity, cleavage, fracture, electrical properties, magnetic properties, thermal behaviour
- health risks
- location of the sample, if relevant
- other information
- associated data
- history of the sample

The spreadsheet data for each analogue will be an integral part of the database.

The spreadsheet template is organized as follows:

- Header Row:**
 - Name:** Includes a logo and a field for "Name from Country".
 - Reference:** Field for "Reference number. Nomenclature to be determined. Here I used 'EURO-CARES-' followed by the first letter of the name (e.g. B for basalt) and by a number."
- Target Section:**
 - Target Number:** Includes fields for "Name", "Mission", "Astroble", and "Other (1)".
 - Target Geological Context:** Includes a field for "Image from internet" with a note: "Include art if taken from the internet or reference etc. Make sure you cite the source of the image, even if it is one you have taken yourself!"
- Curation Facility Usage:**
 - Includes checkboxes for: "Analogue for testing/verifying curation equipment", "Analogue for testing/verifying protocols", "Analogue for testing/verifying processes", "Witness sample", "Standard for instrument(s)", "Weather sample", "Rock", "Mineral", "Gas", "Liquid", "Sediment", "Amorphous material".
 - Includes a note: "For the standards add the instruments."
- General Geological Description:**
 - Petrography:** Includes a note: "Petrography i.e. grain size, texture, porosity, grain shape etc also use terms such as fractured, brecciated".
 - Mineralogy (for rock sample):** Includes a note: "Mineralogy (for rock sample) - modal min i.e. 50% olivine, 40% pyroxene, 10% plagi".
 - Mineral type (for mineral sample):** Includes a note: "Mineral type (for mineral sample) e.g. sulphate, oxide, carbonate".
 - Chemistry:** Includes a note: "Chemistry - any bulk chemical analyses if available otherwise any information that is relevant e.g. Fe-rich or Ti-rich etc".
- Physical Properties:**
 - Includes fields for: "Density: 100", "Hardness/Compressive strength: 100", "Porosity measurement: 100", "Quantity: 100", "Health hazard: 100", "Any other relevant physical properties data: 10".
- Location and Contact:**
 - Source:** Field for "Location/Country/Locality (parent item)/Outcrop: 0%".
 - Collector:** Fields for "Name" and "Address".
- Additional Information:**
 - Links to other WPs:** Field for "E.g. useful reference(s), any information you consider important".
 - Further references, information:** Field for "Name of the document (here EuroCares reference number followed by the type of document such as ICP, ref.) followed by a short description".
 - Associated data:** Field for "History of the sample" with a note: "EURO-CARES-X2.xlsx".

Figure 2. Template of the analogue spreadsheet data.

9. WP 5 Recommendations:

- At definition of a sample return mission, the science team can make recommendations with respect to suitable standards to be used in the curation facility (cf. WP4)...
- Finally, Earth landing site samples (from the touch down site) would be necessary in case of doubtful analysis even if normally this type of contamination is not expected.
- A second set of analogue materials is necessary for training in non-sterile conditions (except for biohazard testing)

- **A third collection will be needed for training in sterile conditions**
- **Other analogue samples should be made available for public outreach associated with the curation facility, such as a small museum.**