

The European Space Agency Exploration Sample Analogue Collection (ESA²C) and Curation Facility – progress update

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Introduction: Since 2014, the Natural History Museum (NHM) has been the prime contractor to the European Space Agency (ESA) for defining and initiating the development of a Sample Analogue Collection and Curation Facility in support of the Robotic Exploration mission preparation programme. The ESA Sample Analogue Collection (ESA²C) will support the ongoing or future technology development activities that are required for human and robotic exploration of Mars, Phobos, Deimos, C-Type Asteroids and the Moon. The long-term goal of this work is to produce a useful and useable resource for engineers and scientists developing technologies for ESA missions.

Analogue Sample Collection: The complex mission architectures and diverse target bodies of interest means that a variety of different analogue materials are required to test all systems that come into contact with the target body, whether these be part of the spacecraft system, such as landing and/or roving systems (e.g. wheels), sample collection systems (e.g. drills or scoops) or scientific payload. The analogue materials must replicate as far as possible the expected ‘geological’ environment of the target body in terms of both physical/mechanical properties and chemical/mineralogical properties. In addition to ensuring that the samples as accurately as possible represent the physical and chemical properties of the target bodies of interest, it is important to select materials that can be readily obtained both now and in the future, in enough volume that will ensure a sustainable collection. As is the case for the existing NASA lunar and martian analogues (JSC-1A and JSC-Mars-1A) [1] we have selected samples that are available from commercial suppliers to mitigate the risk of materials becoming unavailable and to ensure large quantities can be sourced if necessary. Additionally, as our chosen suppliers provide materials to a number of industries we are confident in the quality control procedures in operation during material production, which should allow for good reproducibility in sample properties over time.

Samples selected include a variety of aggregates from the olivine-rich basalts from the Upper Lava Formation of the Paleogene Antrim Lava Group of Northern Ireland and clay samples from Cyprus, Spain and Senegal. During 2016 and 2017 we carried out a detailed characterisation of the analogue samples’ physical and chemical properties [2,3]: *Chemical properties:* Whole-rock chemistry – major, minor and trace element analyses by ICP-AES and ICP-MS. Mineralogy – analytical SEM, EPMA and XRD (whole-rock). *Physical properties:* Grain size and shape – sieving and visual inspection, X-ray micro-CT. Bulk density and porosity – mass-volume measurement and helium pycnometry, X-ray micro-CT. Shear strength (aggregate and powder samples) – shear box apparatus. Compressive and tensile strength – UCS testing and Brazilian indirect tensile method.

Sample Analogue Curation Facility: This unique venture will build on the Robotic Exploration mission preparation programme by establishing methodologies and protocols/procedures for curating the ESA²C, as well as defining and validating the distribution mechanisms and information exchange protocols for the analogue materials. Underpinning the work will be the development of the ESA²C database that is currently being developed. Samples will be available to suitable qualified PIs and we welcome requests for information on the samples we have already acquired and characterized and dialogue with colleagues who are also working on analogue samples as part of mission development e.g. JAXA’s Martian Moons eXploration (MMX) mission [4].

As part of ongoing work, further samples have been acquired for the ESA²C - anorthosite blocks from a Norwegian quarry and basaltic sand/gravel and basaltic/hyaloclastite blocks were collected from the Askja Region in Iceland. Additionally, sample mixtures will be made up using the characterised clays and basalts for varying grain sizes and clay:basalt ratios to better replicate the Phobos/Deimos/C-Type Asteroids and Martian regoliths. We will continue to seek sources of new materials for potential acquisition and subsequent characterization to enhance the initial collection. A critical part of our work is to actively collaborate with our colleagues in the space mission engineering and planetary sciences communities to ensure that the ESA²C is a relevant and practical resource for technology development.

References: [1] NASA: <https://isru.msfc.nasa.gov/simulantdev.html>, 2016. [2] K. Manick et al. LPSC XLVIII, #1220 (2017). [3] K. Manick et al. LPSC XLVIII, #1222. [4] M. Fujimoto et al. European Planetary Science Congress, vol. 11, EPSC2017-136