THE EUROPEAN SPACE AGENCY EXPLORATION SAMPLE ANALOGUE COLLECTION (ESA³C) AND CURATION FACILITY – 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 an Exploration Sample Analogue Collection (ESA³C) and Sample Analogue Curation Facility (SACF) in support of the Human & Robotic Exploration mission preparation programme. The ESA³C and SACF will support the ongoing and future technology development activities that are required for human and robotic exploration of Mars, the Moon, Phobos, Deimos and C-Type Asteroids. The long-term goal of this work is to produce a useful and useable resource for scientists and engineers developing technologies for ESA missions and for appropriately qualified international users as well.

Sample Analogue 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 or remotely analyse 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. Samples selected include a variety of aggregates from the olivine-rich basalts from the Antrim Lava Group of Northern Ireland and clay samples from Cyprus, Spain and Senegal. Detailed characterisation of the analogue samples’ physical and chemical properties has been carried out [1,2,3]:

Chemical properties: Whole-rock chemistry – major, minor and trace element analyses. Mineralogy – analytical SEM, EPMA and XRD (whole-rock). Physical and mechanical properties: Particle Size Distribution (PSD) (aggregate and granular samples). Grain Size and Morphology – SEM, X-ray micro-CT and visual inspection. Density and porosity (all samples) – mass-volume measurement and helium pycnometry, X-ray micro-CT. Shear strength (aggregate, granular and powder samples) – shear box apparatus. Compressive and tensile strength (rock samples) – UCS testing and Brazilian indirect tensile method. As part of ongoing work, further samples have been acquired for the ESA³C – including anorthosite (Norway), basaltic sand and basaltic/hyaloclastite (Askja Region, Iceland), volcaniclastic/sedimentary/clay masonry unit (CMU) analogues that will be used for system level testing of the Exo-Mars crushing station, and other commercially available analogues such as the Zybek NU-LHT-2M, USGS NU-LHT-2M and EAC-1 lunar analogues, and carbonaceous chondrite simulants (CI, CM, and CR).

ESA Sample Analogue Curation Facility: This unique venture will build on ESA’s Human & Robotic Exploration mission preparation programme by establishing methodologies and protocols/procedures for curating the ESA³C, as well as defining and validating the distribution mechanisms and information exchange protocols for the analogue materials. The overarching role of the SACF is to: Curate ESA³C samples and associated data pertaining to those samples; make samples available for study and provide access to relevant data pertaining to those samples; carry out fundamental physical and chemical properties testing in the SACF (or testing via appropriately qualified external laboratories). All analogues in the ESA³C will undergo fundamental properties characterisation using procured (or outsourced) equipment in the SACF laboratory, which include the following: Mineralogical and Chemical Properties: X-ray diffraction (XRD) – bulk mineralogy; SEM – mineral chemistry by point analysis of dominant phases; X-ray fluorescence (XRF) – minor and trace element identification and quantification; fourier-transform infrared (FTIR) and raman – chemical/molecular bonding and fingerprinting. Physical and mechanical properties: soil PSD – sieving and laser particle analysis; soil grain size and morphology – SEM and visual inspection; soil bulk density and rock dry density – mass-volume measurements; rock and soil particle density (for porosity) – gas pycnometer; soil shear strength – direct shearbox; rock UCS – uniaxial/unconfined compression.

Future Opportunities: The facility formally opened on the Harwell campus (UK) in January 2019. Specimens from the ESA³C are being used by engineers and scientists in the United Kingdom, Hungary, Germany, Italy, Australia, and the US to support planetary research, related technology developments and testing activities for a variety of missions and mission architectures. The analogue materials in the ESA³C, which have been well characterised, i.e. have known fundamental physical/mechanical and chemical/mineralogical properties, provide a unique resource for scientists and engineers to carry out comparative and collaborative investigations into the vast sector of space exploration. The ESA Sample Analogue Curation Facility hopes to spearhead and centralise access to these resources for many years to come.