

# Fostering future missions and curation: fine-particle simulant characterization for a lunar highland testbed (ESA, European Astronaut Centre - EAC)

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In the framework of the European Centre for Space Applications and Telecommunications (ECSAT), the UK site of the European Space Agency (ESA), the Vulcan Analogue Sample Facility is actively engaged in the establishment of a robust European network devoted to the acquisition, production, and management of extraterrestrial analogue samples (or simulants), both existing and prospective. The Vulcan Facility is primarily oriented towards advancing scientific inquiries into planetary analogues, encompassing celestial bodies such as the Moon and Mars. This pursuit is facilitated through the deployment of benchtop instrumentation for fundamental property analyses, and support for the curation of extraterrestrial materials and the development of associated technologies. European simulant priorities were determined following a user survey and simulant supplier workshop in 2022 (**Table 1**).

As part of supporting the European simulants network, Vulcan's role encompasses choosing the optimal fine-particle highland feedstock option for the ‘Dust Chamber’ [1] of the Luna Analogue Sample Facility in Cologne, Germany (EAC, ESA). The selection process entails a comprehensive exploration of the European network of simulant providers and both commercial and academic laboratories, entailing an exhaustive evaluation of the availability and logistical aspects of materials accessible in the market. This consideration encompasses critical factors such as loading times and associated costs. Furthermore, a rigorous assessment of simulant properties is conducted, including but not limited to particle size distribution, shape, and abrasivity. These parameters hold significant importance in the context of primary geotechnical and geomechanical objectives within the ‘Dust Chamber’.

Nonetheless, these deliberations serve to refine the pool of potential highland simulants obtainable in Europe. Ultimately, the most suitable simulant candidate will be meticulously chosen to facilitate comprehensive testing of geotechnical and engineering-related activities within the Dust Chamber. It comprises due diligence of the full simulant supply chain (including assessment of the source site, excavation and processing methods, and quality control). Consequently, discerning selection process aims to contribute substantively to the accumulation of essential knowledge, thus enhancing our readiness for the upcoming sample return and human lunar surface missions in this decade.

**Table 1.** Priority activities, among 36 simulant users surveyed in 2022 (35 European-based, 1 Japan-based), centring around exploration hardware and resource extraction studies. Red: 25-28%; Yellow: 11-16%; Green: 3-8%; Grey: No data.

	Lunar	Martian	Asteroids / Meteorites	Other
Spacecraft, instruments and/or software	Red	Yellow	Green	Yellow
ISRU (Resource extraction)	Red	Green	Grey	Green
ISRU (Additive manufacturing)	Yellow	Green	Grey	Green
ISRU (Unspecified)	Green	Green	Grey	Green
Planetary Science Research	Green	Yellow	Green	Green

## References

[1] A. Zemeny and K. Manick (2023) Lunar highland simulant selection of the Luna Analogue Facility Dust Chamber for future missions – Space Resources Week, Luxembourg