Foamed lunar regolith simulant slurries for the in-situ production of porous construction materials

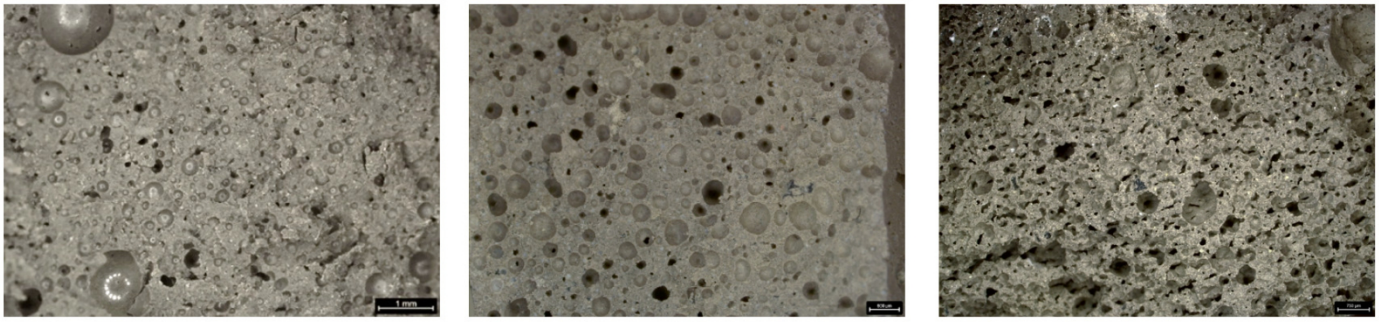
Michela Elena Pedretti [1,2], Libero Liggieri [1], Francesca Ravera [1], Alberto Lagazzo [2], Eva Santini [1]

[1] Institute of Condensed Matter Chemistry and Technologies for Energy, CNR, Genoa, Italy,
[2] Department of Civil, Chemical and Environmental Engineering, University of Genoa, Genoa, Italy

michelaelenapedretti@cnr.it

The development of advanced porous materials with tailored functional properties is becoming increasingly relevant in several applied fields, particularly in the context of human space exploration and long-duration space missions. The establishment of sustainable lunar outposts represents a crucial step toward future extra-terrestrial habitats, and it requires the use of local resources according to In Situ Resource Utilization (ISRU) principles in order to minimize the transport of materials from Earth [1].
In this framework, materials designed for lunar construction must be able to withstand extreme environmental conditions, including reduced gravity, severe temperature fluctuations, and continuous exposure to micrometeoroid impacts. This work focuses on the development and optimization of geopolymeric materials based on lunar regolith simulants with controlled porosity, aiming to achieve a balance between thermal insulation performance and mechanical strength [2].
Porosity within geopolymeric systems is introduced through different strategies, such as the use of surfactants and the addition of gas-releasing agents [3]. In particular, surfactant systems are employed to generate and stabilize foams within the slurry and define the final structure, while aluminum powder is used as a chemical foaming agent to produce hydrogen and induce controlled pore formation. The resulting materials can be further processed into structural components using advanced technologies, including additive manufacturing. The overall goal is to develop multifunctional, lightweight, and durable materials suitable for future lunar habitat construction. To this aim, the mechanical properties and morphology of the consolidated samples have been also investigated.

Keywords:
regolith foams, geopolimerization, porous materials



(a) (b) (c)

Foamed regolith geopolymer produced using: (a) TTAB foam; (b) aluminum powder; (c) aluminum powder and thickeners.

References:

[1] Zhang, P.; Dai, W.; Niu, R.; Zhang, G.; Liu, G.; Liu, X.; Bo, Z.; Wang, Z.; Zheng, H.; Liu, C.; et al. Overview of the Lunar In Situ Resource Utilization Techniques for Future Lunar Missions. *Space: Science & Technology* 2023, *3* , doi:10.34133/space.0037.
[2] Bai, C.; Colombo, P. Processing, Properties and Applications of Highly Porous Geopolymers: A Review. Ceram. Int. 2018, 44, 16103–16118, doi:10.1016/j.ceramint.2018.05.219.
[3] Radina, L.; Sprince, A.; Pakrastins, L.; Gailitis, R.; Sakale, G. Foamed Geopolymers: A Review of Recent Studies. *J. Phys. Conf. Ser.* 2023, *2423* , 012032, doi:10.1088/1742-6596/2423/1/012032.

Acknowledgements:
This research is funded by the Italian Space Agency (Agenzia Spaziale Italiana, ASI) in the framework of the Research Day “Giornate della Ricerca Spaziale” initiative through the contract no. ASI-2023-6-U.0

SPACE IT UP! – Spoke 8: “Robotic and Human Exploration of Extraterrestrial Habitats, Architectures and Infrastructures”, funded by the Italian Space Agency (ASI) and the Ministry of University and Research (MUR) - ASI N. 2024-5-E.0