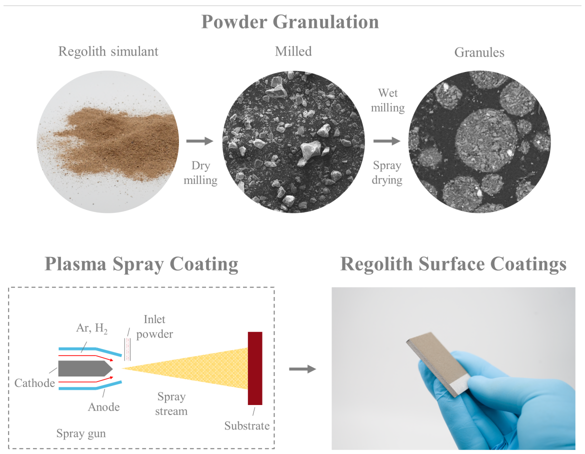
A novel approach to increase flowability of planetary regolith: Agglomeration of regolith simulants for powder-based SRU coatings on metallic surfaces via thermal spraying. D. Karl[1,3], C. He[1], P. Junge[2], R. Kleba-Ehrhardt[1] and C. Rupprecht[2] and A. Gurlo[1], [1] Chair of Advanced Ceramic Materials; [2]Chair for Coating Technology both at Technische Universitaet Berlin, Sekr. BA3, Hardenbergstr. 40, 10623 Berlin, Germany and [3]Center for Space Resources, Colorado School of Mines, Golden, Colorado, USA. Correspondence: karl@tu-berlin.de.

Graphical abstract:



Introduction: The world economy is on the verge of a second space age, with a huge increase in investment and attention to activities in space, often from the private sector. Many forward-looking proposals envision using fine regolith particles with low flowability that cover planetary bodies' surfaces as base materials for a future in-space economy.

Flowability of planetary regolith: The flowability and packing density are essential properties of ceramic powder feedstock for powder-based manufacturing technologies. Poor flowability can result in uneven powder deposition and bad surface quality of the powder bed, which negatively affects the properties of the parts by forming a defective structure and loss of shaping accuracy. The packing density of the powder bed mainly decides the density of the green body for powder-based additive manufacturing (AM), thus intensively affecting the sinterability of the printed parts. The planetary regolith materials usually have an irregular shape and wide particle size distribution (PSD), which would cause poor flowability and bulk density. Thus, it is unsuitable for them as a direct feedstock direct. Spray drying is one of the most convenient methods that can efficiently produce good flowability powder with controllable morphology and PSD. *H*ere, we report on the first proof of concept for a novel flowability-enhanced powder feedstock from regolith and its use for thermal spray coatings on metallic surfaces. Our concept includes using the agglomeration of fine planetary regolith particles via spray-drying to increase their flowability and their sinter performance. For this, we employ low amounts of phyllosilicates (clay minerals) as binders in a spray-drying process—materials that could be available from (i) asteroids in the cis-lunar economic sphere, (ii) directly on the surface of Mars, (iii) from the PSRs on the lunar south pole [1,2] or (iv) from SRU clay production of lunar regolith [3].

Agglomeration of regolith simulants: For our agglomeration process, we will report on various spray drying parameters such as rheology and particle size distribution of feedstocks and granules. The optimized powder product showed excellent flowability confirmed via angle of repose, bulk density, tapped density, Hausner's ratio and powder rheometer characterization.

Coatings via thermal spraying: For the thermal spray coating processes, we will discuss the delivery characteristics of such powders in a continuous gas stream through a hose and evaluate the produced coatings on metal substrates in regard to their microstructure, density and thickness.

Application potential of thermal coatings: Ceramic coatings on metallic parts that could be used for (i) thermal barrier protection, (ii) oxidation and corrosion resistance, (iii) abrasion and wear resistance, (iv) chemical stability, and (v) electrical insulation; in applications for dust mitigation, thermal insulation, radiation shielding, as coatings for functional electrical parts or possibly as structural reinforcement.

Application potential of granulation approach: Finally, we will evaluate the potential of our novel regolith powder product for powder-bed AM applications (BJ and PBF) and powder spraying (DED). Further work will explore various AM methods to fuse spray-dried granules, especially focusing on prospective space resource utilization (SRU) applications.

References:

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[2] Vilas et al. Earth, planets and space, 2008, 60, 67–74. https://doi.org/10.1186/BF03352763
[3] Karl et al. Earth and Space 2022, 291 – 297. https://doi.org/10.1061/9780784484470.027