3D scanning and modelling of regolith simulant to characterise surface structures and micro-shadowing

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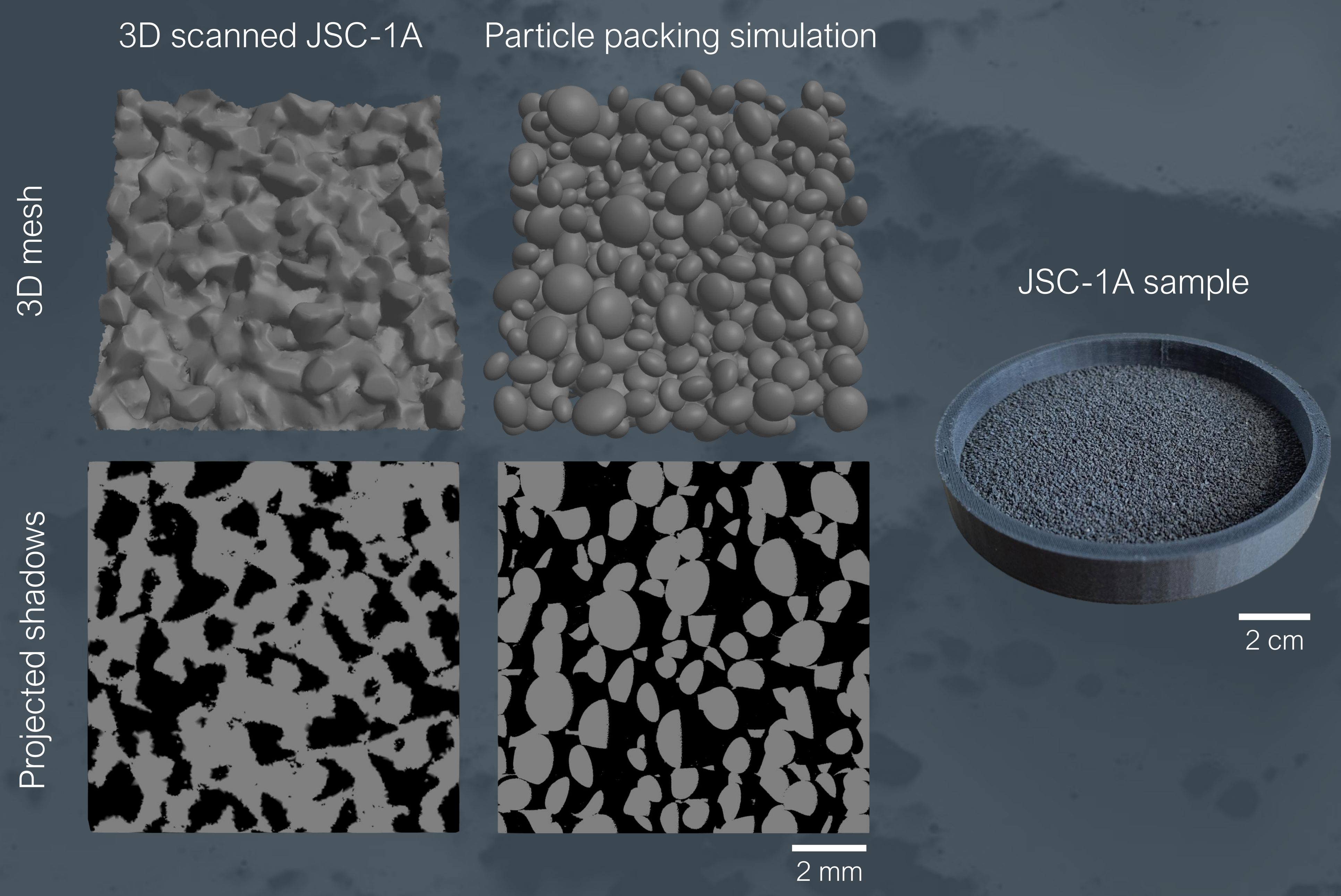
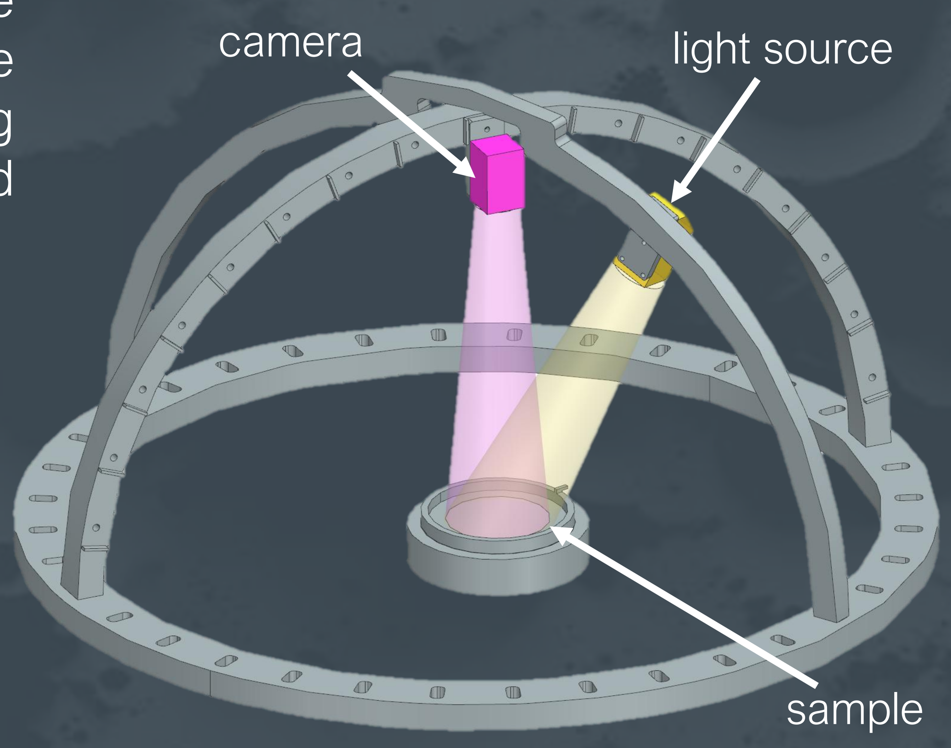
Image credit: LRO - LOLA (Smith et al, 2017)



- Regolith samples with particle size ranges (250-500) and (500-1000) µm were 3D scanned using a Keyence VL-700 optical 3D system.
- Particle packings were created using the Molecular Dynamics Software LAMMPS (Thompson et al. 2022), where the Johnson-Kendall-Roberts contact model was used with known regolith parameters.
- The shadows were calculated over the 3D meshes with a ray casting algorithm. Then, these shadows were projected onto the z-plane.

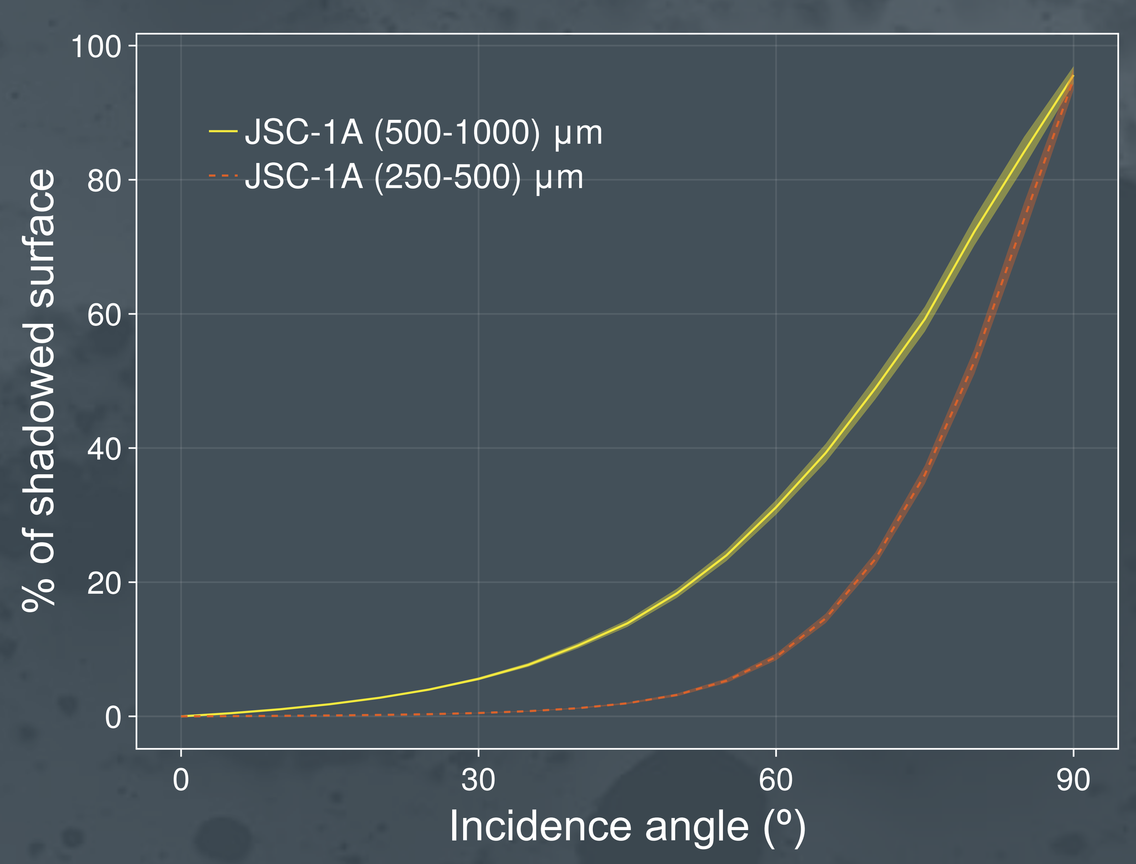
An experimental setup to characterise the influences of size range, size shape and surface topography on the shadow cast by capturing and analysing optical images of illuminated sample surfaces is being built:

- Illumination with different incidence angles between 0° and 90°.
- Optical images of the surface from different observing angles between 0° and 90°.
- Rotatable sample to observe irregularities of the samples and simulate different azimuth angles.

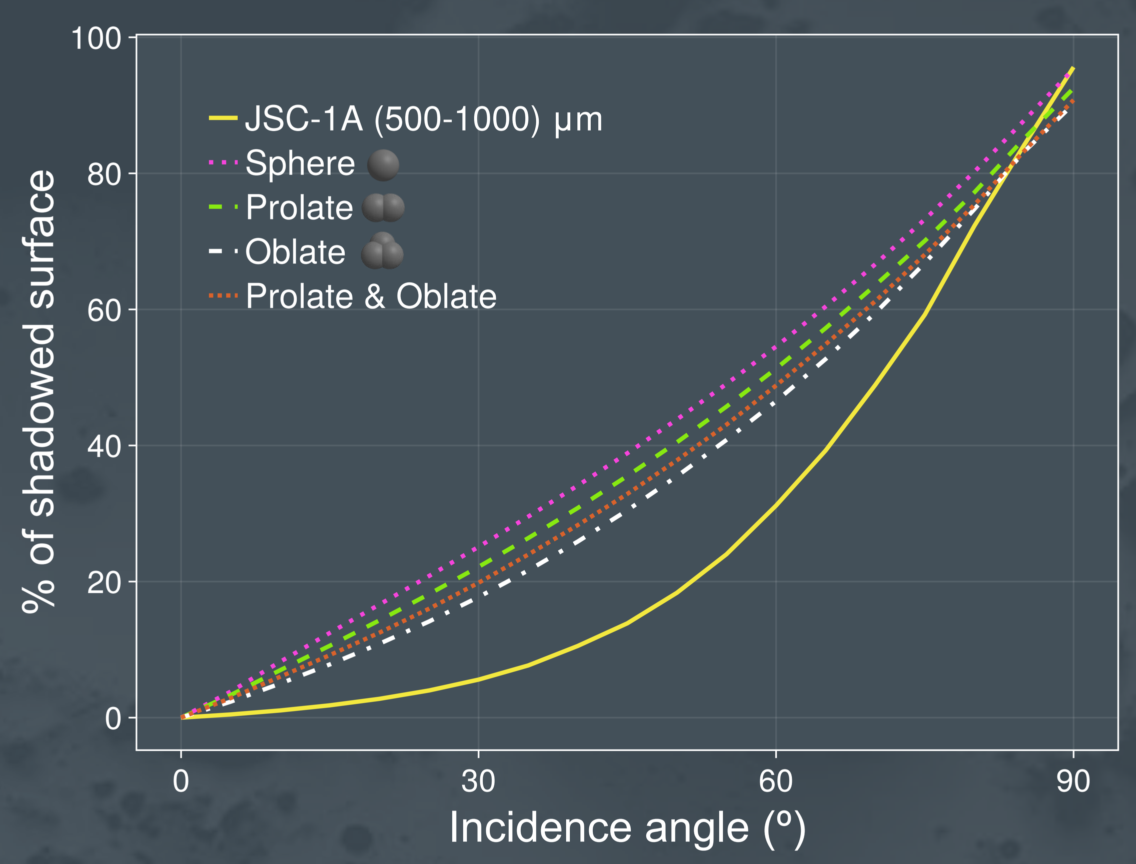


Credit: Y. Beldjilali, M. Einsel and S. Schwarzenberg

Shadowed surface of 3D scans



Comparison of shadowed surface between modelled particle shapes and 3D scans



Particle packings were created using spheres, oblate and prolate ellipsoids. With those, we showed how the shadow profile is strongly influenced by particle shape.

Nonetheless, simulations using ellipsoidal particles could not reproduce the observed behavior of the measured data.

Further simulations incorporating more complex particle geometries are needed. Additional measurement data is necessary, particularly for smaller particle sizes.

Particle shape notably influences the percentage of shadowed area on regolith surfaces

Previous research on volatile water on the Moon revealed that the local concentration strongly correlates with the surface temperature (Prem et al. 2018). The surface structure greatly influences the temperature distribution, both on scales of topography, as seen in the Diviner Lunar Radiometer Experiment (Williams et al. 2017), as well as on smaller roughness scales, where the complex geometry leads to an irregular surface illumination. This changes non-thermal effects like photon-stimulated desorption by introducing a sunward directionality (Sarantos and Tsavachidis 2023) and thermal effects like sorption kinetics by casting micro-shadows and creating additional colder surface areas (Prem et al. 2018). To improve the understanding of the lunar water cycle, we investigate the surface roughness of lunar regolith simulants on a thermally relevant spatial scale, using 3D surface scans together with the simulation of particle packings to obtain information on the distribution of micro-shadows.

Our next steps will focus on an experimental setup to measure micro-shadows created by surface roughness and topography to answer our main research question: How do roughness, topography and particle sizes influence micro-shadowing on regolith surfaces?

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