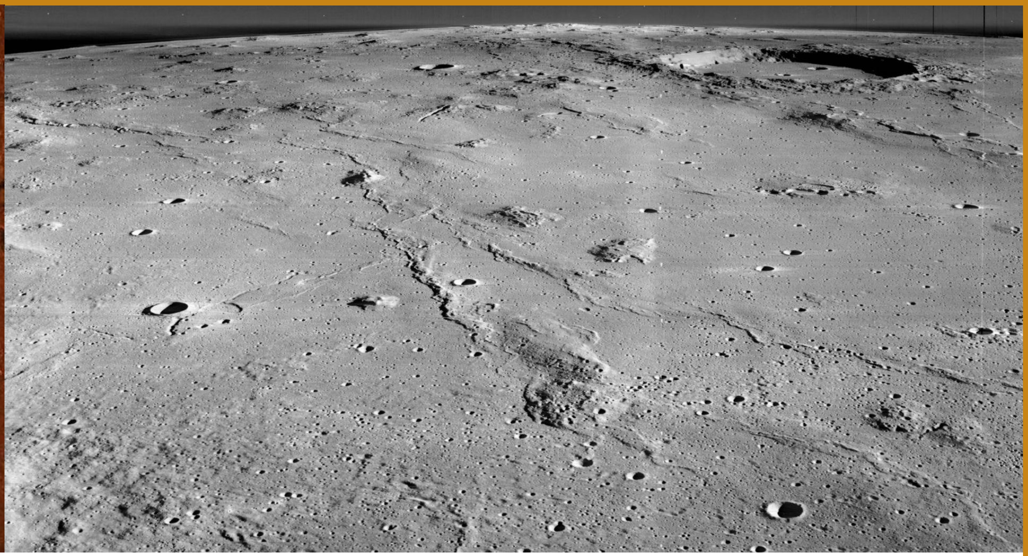

Mini Grant

ANTHELIA - ANalysis of illumination and THermal Environment of Lunar pIts and lavA tubes

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ANTHELIA - ANalysis of illumination and THermal Environment of Lunar pIts and lavA tubes

The human return to the Moon is a fundamental step to improve the knowledge about the evolution of our Solar System. One of the biggest challenges when it comes to creating settlements on other planets is building a safe space to live.

Different lunar surface features are evidences of the past volcanic activity, including lava tubes. Lava tube is a natural conduit formed by flowing lava from a volcanic vent that moves beneath the hardened surface of a lava flow. Once the lava diminished, the tube drains, and a hollow void is formed.

Lunar lava tubes are considered good candidates to provide astronaut shelter against possible impacts, radiations, and temperature variations.

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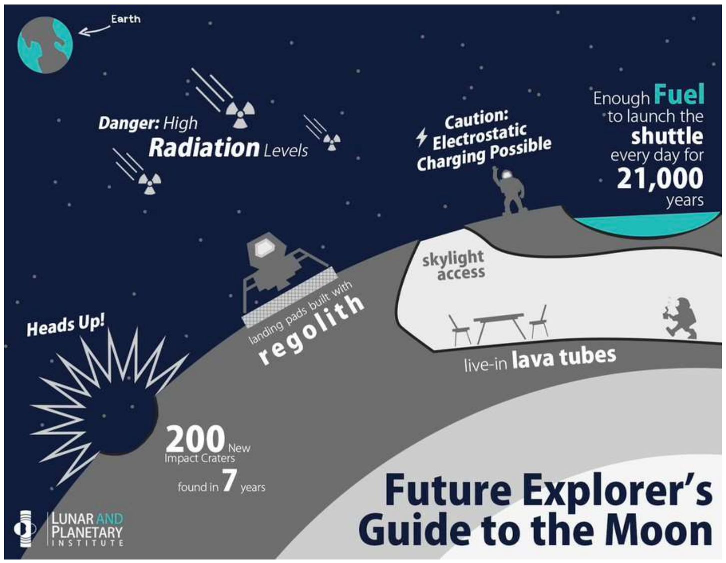

Credits: LPI

The solar radiation is the major source of energy that can significantly contribute to surface and subsurface degradation due to the repeated cooling and heating of the surface over daily cycles. This can result in the failure of the material to adapt to temperature changes through the combined action of differential dilation and thermal gradients. For these reasons, estimation of illumination conditions and surface radiative intensity on airless bodies becomes essential.

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The possibility to accommodate astronauts in subsurface lunar bases needs to be investigated in terms of temperature variations to verify which are the best conditions (e.g., size, latitude, and depth of the lava tube) that could offer a thermally stable lunar base, since constant temperatures offer favorable environmental conditions both for human and industrial operations.

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This research aims to characterize the thermophysical properties of such features by modelling near-surface temperature and thermal stress evolution within pits, considered as possible lava tubes skylight, and lava channels by applying a thermophysical model for airless bodies. This research will also investigate the stability of water ice since it represents an essential resource that enables the astronaut's stay.

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Objectives: this research aims to characterize the complex illumination and thermal conditions within lunar pits and lava tubes to

•support future lunar missions,
•improve our understanding of lunar cave thermal behavior,
•investigate the link between their size, morphology, and latitude with the thermal behavior,
•study the thermal stress they undergo as a result of temperature changes,
•investigate the extent of any temperature changes to identify what the depth of a tunnel might be to ensure a thermally stable environment,
•constrain theories about lunar vulcanism and lava-flow thermodynamics,
•study the possible presence of water ice by investigating how temperature, geometry, and latitude affect its stability.

Method: we will apply a ray-tracing illumination and thermal model we developed to study the self-heating effect on the surface of airless bodies.

Any thermophysical model which aims to consider realistic physical conditions such as topography, surface roughness, and thermophysical parameters needs to consider both the direct illumination (with the consequent formation of shadows and penumbra), the back-scattering, and the re-radiation cases.

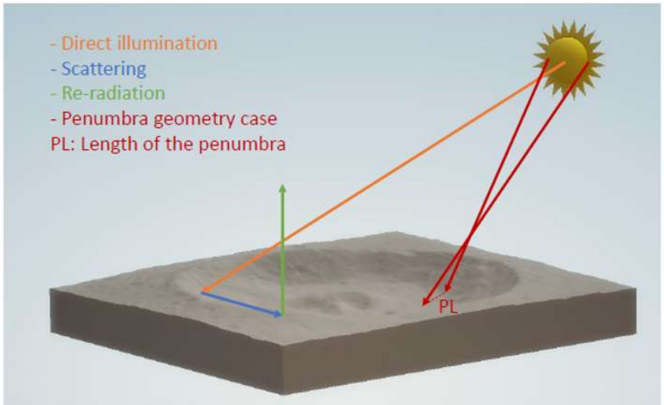

Fig.2: Direct (orange arrow), back scattering (blue arrow), and re-radiation (green arrow) cases. Red arrows refer to the penumbra geometry case and PL indicates the length of the penumbra

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