PhD project in ASTROPHYSICS

Title of the project: Investigation of subsurface ice layers in the lunar polar regions through 3D subsurface imaging using lunar radar data.
Supervisor: Roberto Orosei

Scientific Case:
The Moon currently has a very thin atmosphere, but a temporarily thicker atmosphere may have formed. This transient atmosphere is hypothesized to have formed by volcanic activity during the early stages of lunar evolution, being closely linked to the amount of magma volatiles and the magnitude of volcanic activity. Therefore, determining whether this transient atmosphere existed is crucial for understanding the early evolutionary history of the Moon. Assuming a short-lived and large-scale volcanic eruption (flood basalt type) as previously considered, it has been suggested that the transient atmosphere could have persisted for approximately 70 million years [1]. In contrast, recent models proposing prolonged volcanic activity with relatively small-scale lava eruptions suggest that the transient atmosphere would not have formed [2]. These studies rely on theoretical models of lunar eruption styles, and currently, no observational evidence constrains the existence of the transient lunar atmosphere.

Outline of the Project:
Water ice deposits that are hundreds of meters thick would be expected in the lunar polar regions, if the transient atmosphere existed [3]. We investigate the existence of subsurface ice deposits in the lunar polar regions using the Lunar Radar Sounder (LRS) onboard SELENE. In the lunar polar regions, strong surface scattering caused from numerous impact craters makes it challenging to identify subsurface echoes. In this study, we integrate multiple LRS datasets in both polar regions to generate 3D radar volumes and apply 3D migration processing. This method theoretically enables the identification of subsurface echoes from surface scattered echoes originating from topographic features present in a direction perpendicular to the satellite movement direction, which conventional 2D migration cannot fully eliminate. Finally, we analyze the 3D-migrated radar data to assess the presence of subsurface ice deposits. If subsurface ice layers are detected, it would suggest the past existence of the transient atmosphere. If no such deposits are identified, it is likely that prolonged volcanic activity with low eruption rates occurred, preventing the formation of the transient atmosphere.

Reference:

[1] Needham, D. H., & Kring, D. A. (2017). Lunar volcanism produced a transient atmosphere around the ancient Moon. Earth and Planetary Science Letters, 478, 175-178.

[2] Head, J. W., Wilson, L., Deutsch, A. N., Rutherford, M. J., & Saal, A. E. (2020). Volcanically induced transient atmospheres on the Moon: Assessment of duration, significance, and contributions to polar volatile traps. Geophysical Research Letters, 47(18), e2020GL089509..

[3] Wilcoski, A. X., Hayne, P. O., & Landis, M. E. (2022). Polar ice accumulation from volcanically induced transient atmospheres on the Moon. The Planetary Science Journal, 3(5), 99.