IDENTIFICATION OF MORPHOLOGICAL FEATURES OF LUNAR CRATERS IN A REGION OF LUNAR SOUTH POLE USING MINISAR DATA. Saumitra Mukherjee and Priyadarshini Singh, Remote Sensing and Geoinformatics Laboratory, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, 110067, India. (saumitramukherjee3@gmail.com)

Introduction: Identification of distinct morphological features in shadowed as well as illuminated regions of lunar surfaces can be easily done using miniSAR data [1]. Mini-SAR imaging radar onboard CHANDRAYAAN-1 mission was the first mono-static lunar orbiting synthetic aperture radar [2]. A number of surface morphological features have been identified in the lunar south polar region using mini-SAR data. Scattering contributions from single, double and multiple backscatter obtained from m-χ decomposition technique helps to view these morphological features in detail [1,2].

Rock avalanches: Rock avalanches on terrestrial regions are commonly seen in steeply sloping terrains where rocky debri breaks and flows down a slope with a very high velocity (~5 km/hr) riding down on an air cushion [3]. Similar mass wasting features can also be identified on the lunar surface primarily on sloping inner crater walls.

Hidden craters: Many smaller craters present on the permanently shadowed crater floors of lunar polar regions are not visible in optical images [2]. Identification of such craters can easily be done using miniSAR data [1]. Apart from identifying the presence of such craters, their ejecta blankets can also be conveniently viewed on circular polarization ratio maps where a value above 0.5 depicts surface roughness. It is usually seen that fresh craters have high CPR inside and outside their rims due rough blocky ejecta. Therefore fresh hidden craters can be identified on CPR and m-χ decomposition images derived from MiniSAR data [4].

Collapsed crater walls: Large lunar craters (>20km diameter) often have blocks of unconsolidated material slumping down from the inner crater walls [5]. This could possibly be triggered from a nearby impact or from a seismic event occurring in the region leading to formation of terraced-type inner crater walls [5]. It is difficult to view these features in optical images within permanently shadowed craters. Mini-SAR data hence reveals these features thereby helping to understand the crater morphology better as well as for crater classification [1,2].

Study Area and Methodology: The above mentioned features were identified in the lunar south polar region lying roughly between 80°S-90°S. Each pixel in the MiniSAR image strip consists of 16 bytes data in four channels of 4 bytes each as $|LH|^2$, $|LV|^2$, Real (LH ▪ LV*) and Imaginary (LH ▪ LV*) [1].

CPR maps and m-χ decomposition maps were generated using mathematically derived Stokes parameters (S_0, S_1, S_2 and S_3) and degree of polarization (*m*) using ENVI software after applying phase correction for band 3 and band 4 of the miniSAR data [1].

The following band math equations were used to generate the "child" stokes parameters, degree of polarization and m-χ scattering contributions for single, double and multiple scattering:

$$\begin{pmatrix} S_0 = \langle |LH|^2 + |LV|^2 \rangle \\ S_1 = \langle |LH|^2 - |LV|^2 \rangle \\ S_2 = 2\Re\langle LH \cdot LV^* \rangle \\ S_3 = -2\Im\langle LH \cdot LV^* \rangle \end{pmatrix}$$

* indicates conjugate of the complex number

[1]

$$m = (S_1^2 + S_2^2 + S_3^2)^{1/2} / S_0$$
$$CPR = (S_0 - S_3)/ (S_0 + S_3)$$

$$B = [m^*S_0(1 - \sin 2\chi)/2]^{1/2}$$
$$R = [m^*S_0(1 + \sin 2\chi)/2]^{1/2}$$
$$G = [S_0(1 - m)]^{1/2}$$
$$\sin 2\chi = -S_3 / (m^*S_0)$$

[4]

The m-χ decomposition image was made as a false color composite depicting blue for 'surface', red for 'double bounce' and green for 'diffuse/ volume' scattering.

Results and Discussion:

Rock avalanches: Possible presence of rock avalanches can be predicted using m-χ decomposition images derived from miniSAR data. One such location can be seen on the inner wall of Cabeus B crater lying roughy at 82°18'S and 47°18'W.

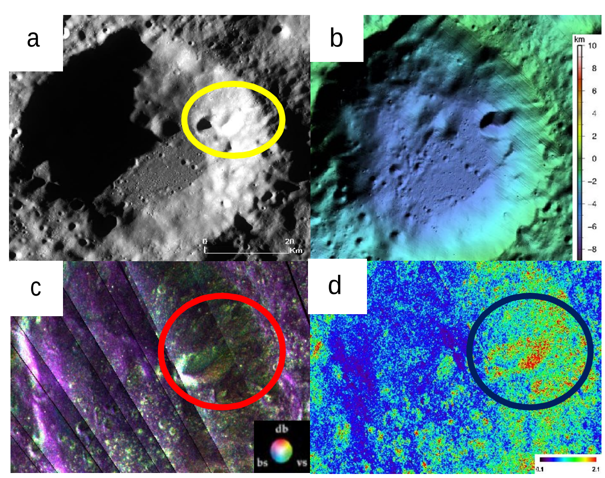

Fig 1: **a.** LROC Wide Angle Camera of Cabeus B crater. [Yellow circle marks the rock avalanche]. **b.** LOLA color-shaded DEM.of the region **c.** m-χ decomposition image of Cabeus B crater [red circle marks the region of the rock avalanche]. **d.** CPR map of Cabeus B crater. [dark blue circle marks the high CPR region due to rough surface possibly created from the avalanche.]

Hidden craters: Several hidden craters in the permanently shadowed regions can be viewed using mini-SAR data [1] . An example of such a crater can be seen on the floor of an unnamed crater directly south of Malapert C crater lying roughly at 82°S and 11°E. This unnamed crater contains a fresh crater in the shadowed region which is not visible on optical images.
CPR images of this region give high values (0.1-1.8) suggesting presence of highly rough surfaces probably from the rough proximal ejecta blanket of the fresh crater [6,7].

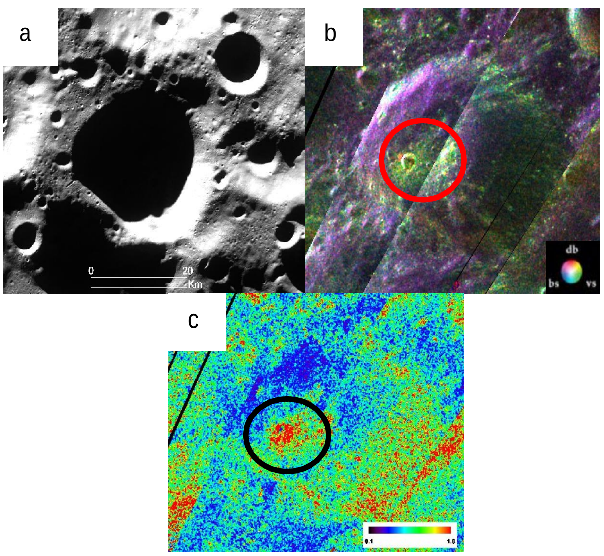

Fig. 2. **a.** WAC image of the unnamed crater with the hidden fresh crater. **b**. m-χ decomposition image of the region [red circle marks the hidden fresh crater]. **c.** CPR map of the region [the rough ejecta of the hidden fresh crater has high CP values]; the color ramp shows the range of CPR values only of the pixels covering the hidden fresh crater.

Collapsed crater walls: The terraced structure of the inner crater wall due to slumping can be observed within the Weichert J crater located roughly at 85°7'S and 179°25'E.
The unconsolidated material seems to have slid down the inner walls in single or multiple blocks. Such features are mostly seen in large lunar craters (>20km diameter) [5].

CPR images of the region show rough surfaces along the terraces formed with values ranging from 0.1 – ~1.5.

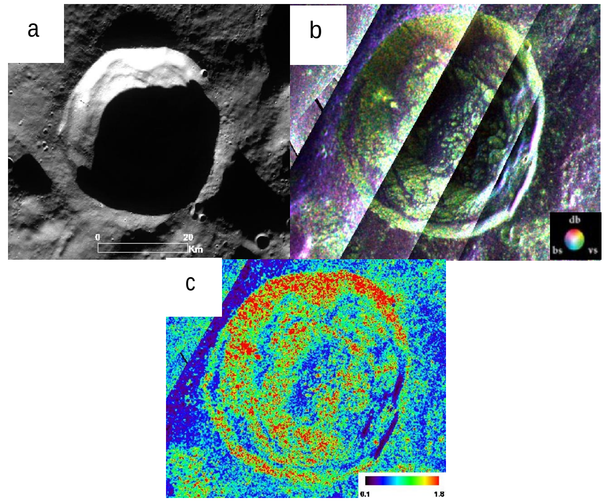

Fig 3: a. WAC image of Weichert J crater, **b**. m-χ decomposition image showing terraced walls, **c**. CPR image of the region.

Conclusion: Microwave sensors reveal a number of distict features on varying terrains. MiniSAR data makes it easy to view several of such unique features over the lunar surface both in the illuminated and the shadowed regions.

The identification of such features can help to further understand the geological activity taking place resulting in the formation of such features as well as explain the physics behind the process of impact cratering and the subsequent formation of other secondary structures. Further the results obtained can be correlated and compared with similar features seen on terrestrial surfaces.

References: [1] Mohan, S. et al. (2011) *Current Science,* 101(2), 159-164. [2] Spudis, P., et al. (2009) *Current Science*, 96 (4), 533-539. [3] Grotzinger, J. et al. (2007) Understanding Earth, 5th ed. 389-398. [4] Raney, R.K. (2007) IEEE Trans. Geosci. Remote Sensing, 45, 3397-3404. [5] Wilhems, D. et al. (1987) US geo. survey professional paper, 1348. [6] Wenzhe Fa and Yuzhen Cai (2013) *LPS XLIV*,Abstract # 1470. [7] Wenzhe Fa and Yuzhen Cai (2013) *JGR*, 118, 1582–1608.