Water Ice Detection: Methodology Implementation and its Results over the secondary Crater on Rozhdestvensky Floor

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Abstract
The paper presents the study of secondary Crater on Rozhdestvensky Floor for detection of water ice. This work describes results obtained from analysis of Mini-RF backscattered data over lunar surface. As the radar signatures helps in detecting icy volatiles in the permanently shadowed areas of lunar polar region, the PSR region has been examined for enhanced Circular Polarization Ratio (CPR). The detailed follow up investigation has been carried out with two methodologies considering the integration of different techniques, model and decomposition behavior using Mini-RF data to remove ambiguity between high CPR and roughness, detect the presence of water ice and confirm the same. From the analysis it can be concluded that the crater has been classified as an icy crater using Thompson model. Analysis confirms the presence of Water–ice in the crater and also estimates the total water-ice coverage area over the crater.

Keywords: PSR, Mini-RF, CPR, Same Sense, Water-Ice.

Introduction

Research done by historical and recent missions confirms the presence of water-ice in different forms at cold traps in Permanently Shadowed Region (PSR) at lunar poles[1]. These water ice regions will have a considerable enhancement in radar data which is characterized by a circular polarization ratio (CPR) values greater than unity. In this paper permanently shadowed region (PSR) of fresh crater on Rozhdestvensky floor in North Polar Region has been chosen for water ice detection as shown in figure 1(a). It is potentially ice rich crater located at 84° N, 172° W of about 13.3 Km diameter located near central peak of the Rozhdestvensky crater. S-band (2.38 GHz, 12.6 cm wavelength) datasets of Mini-RF onboard LRO [2] have been used for the analysis. These radar signatures help in detecting icy volatiles on lunar PSR region. The permanently shadowed region (PSR) of fresh crater on Rozhdestvensky floor has been shown in figure 1(b).

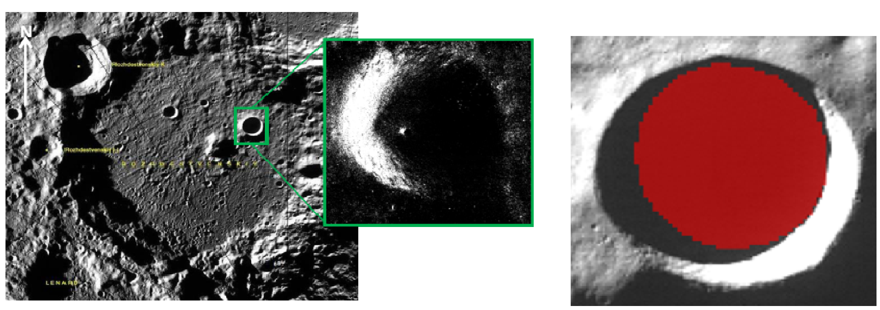

Figure 1(a): Shows the Wide angle camera (WAC) image of Rozhdestvensky crater in left. Study area marked with the green box. Zoomed image of study area i.e. secondary crater of Rozhdestvensky obtained from Mini-RF data has been shown in the right side box.(b) The PSR of fresh crater on Rozhdestvensky floor prepared by overlaying LOLA PSR data over WAC datasets.

Methodology

First model i.e. Weighted Geometric Mean Interpolation[3] method is concerned with scattering components from a lunar surface as the received echo is a combination of specular and diffuse scattering components. The specular component corresponds to the smooth surface and subsurface layers while diffuse component is associated with either rocks or ice. Therefore it is important to consider the effect of CPR, diffuse component. This interpolation technique used to classify the crater as the Icy, blocky or double bounce crater. It calculates approximately scattering differences associated with slopes, surface roughness, thin regolith over ice and patches of ice. These icy points further analyzed for different SC enhancement values using Specular-Diffuse Scattering Models [3] with i.e. weak, moderate and strong magnitudes. Using image processing software's ISIS and ENVI, various scattering parameters and CPR values have been calculated.

Results and Discussion

As this crater has been categorized under the PSR region due to reduced illumination conditions, it has been selected as study area for water ice detection. Variation in CPR values have been observed for both inside and outside region of the crater. From result it can be conclude that it is a fresh crater since the CPR values for both inside and outside region of the crater is almost all greater than 1. The high CPR regions are ambiguous as it may be either because of roughness or due to presence of water ice.

In order to resolve the high CPR ambiguity, Weighted Geometric Mean Interpolation method has been used. The behavior of same sense(SC), opposite sense (OC) and weighted sum (WS) components have been observed from received datasets of SAR. Crater has been classified in the category of the icy crater. It evidently separate out the water ice points from roughness thereby resolving the ambiguity of high CPR regions.These icy points can be seen on the rim of the crater in figure 3. The results have been further confirmed using Specular-Diffuse Scattering Models.Weak magnitudes of SC enhancement (i.e. for SC greater than 2 and less than 4) have been observed over the crater rim. The average SC observed for icy points over Weak SC Enhancement is 2.101. These weak SC points corresponds to the presence of water-ice in low concentraion i.e. less than 20% of surface layer compsition.

Backscattered signal over icy region get polarized (DoP) by average of 57.168 % exhibiting the surface and double bounce scattering. Thus water ice is present in the form of ice patches or mixed with fine regolith over surface. The analysis shows that the essential conditions is satisfied with regard to the presence of water ice at the location which is indicated by this method is shown in figure 4.

Conclusion

Detection of water- ice using Mini-RF data and analyzing the high CPR regions in PSR region of secondary crater on Rozhdestvensky floor confirms the presence of water-ice. Backscattered signal over icy region get polarized (DoP) by average of 57.168 % exhibiting the surface and double bounce scattering. From Interpolation method we classified the crater as icy region and also the Specular-diffuse scattering model for different SC enhancement values confirm the presence of water-ice in study area.

It can be concluded from the data analysis that the meet the requirement for the presence of water ice in the PSR at poles of lunar and the traces of water ice have been found near crater rim and few points on its central floor with the total coverage of 1149.96m^2 of area. Water ice is present in permanently shadowed region of secondary crater on Rozhdestvensky floor in the form of ice patches or mixed with fine regolith over surface in small amount.

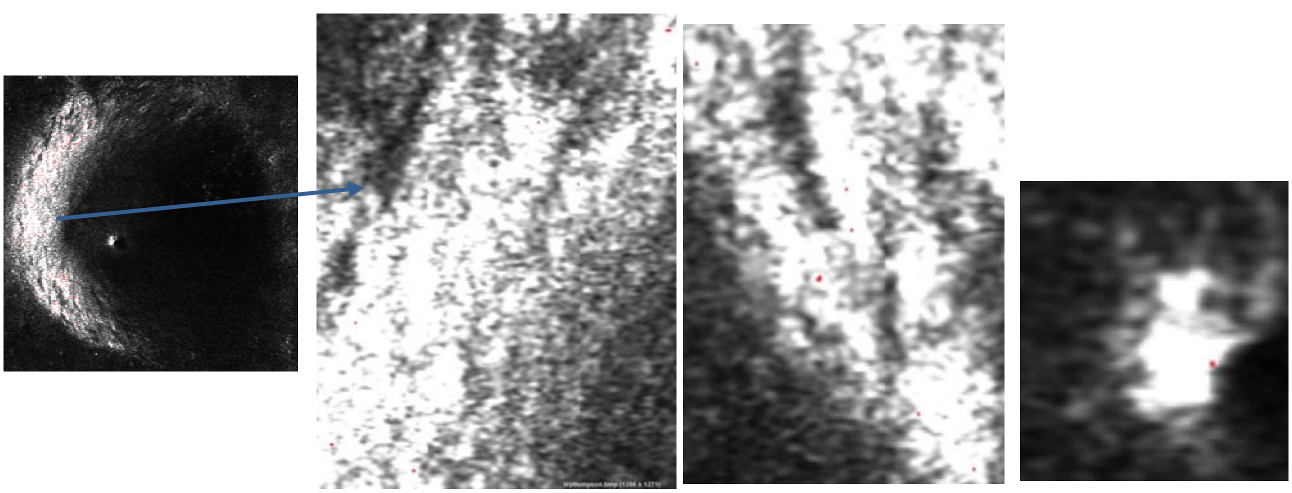

Figure 3: Illustrate the overlaying of Icy scattering points over Secondary crater of Rozhdestvensky crater.

Figure 4: Illustrate the zoomed images of icy points marked with red (SC Enhancement of 2-4) over the Secondary crater of Rozhdestvensky crater

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