

**CHARACTERIZATION OF THE COLLISION SITE OF THE ROCKET BOOSTER ON FAR SIDE OF THE MOON USING CHANDRAYAAN-2 DFSAR DATA.** Tathagata Chakraborty\*, Deepak Putrevu, Sriram S. Bhiravarasu, Anup Das, Dharmendra Kr. Pandey, V.M. Ramanujam, Raghav Mehra, and Gaurav Seth, Space Applications Centre, Indian Space Research Organization, Ahmedabad, India \*(tathagata@sac.isro.gov.in)

### Introduction:

A three-tonne piece of rocket debris from rocket booster crashed on the Moon surface on 04<sup>th</sup> March 2022 at around 07:25 am EST on the far side of the Moon near Hertzprung crater [1]. Using Lunar Reconnaissance Orbiter-Narrow Angle Camera (LRO-NAC) pre- and post-collision data, LROC team has identified the collision location [2-3]. It is interesting to note that the impact actually created two co-joined craters of roughly 28 m wide in the longest dimension. An eastern crater of 18 m diameter superimposed on a western crater of 16 m diameter. Actual impact co-ordinates are 5.226N, 234.486 E. In the present study, radar based characterization of the newly formed impact craters are carried out.

### Chandrayaan-2 DFSAR Observations:

Chandrayaan-2 DFSAR, was employed to acquire SAR images over the predicted collision sites by various space agencies and space enthusiasts. As the predicted impact crater dimension is extremely small, 75 MHz bandwidth high resolution (~4m ground resolution) images in L-band compact-pol (CP) mode were acquired before and after the collision of the rocket debris.

As discovered from LROC NAC images, the newly formed co-joined double impact crater is ~28 m wide in the longest dimension, which can occupy around 7-8 pixels in the ground range high resolution DFSAR data products. Among all the collected DFSAR datasets, we could able to screen one pre- (ch2\_sar\_ncx1\_20220221t091222922\_d\_cp\_d1 8) and post-collision (ch2\_sar\_ncx1\_20220307t002237387\_d\_cp\_d1 8) dataset (Fig. 1). The datasets are analysed for

radar based characterization of the collision site.

### Analysis results:

Fresh craters usually have high intensity in SAR images due to ejecta distribution, which appear prominently over the low intensity dark regolith background. However, due to extremely small dimension of the crater, the backscatter response is equivalent to the speckle noise of SAR image. Hence, detection of the newly formed crater using SAR intensity image is extremely difficult and erroneous. So, polarimetric analysis of the pre- and post-collision datasets are carried out. In particular, m- $\chi$  polarimetric decomposition [4] and Circular Polarization Ratio (CPR) [5] is determined using level-1 SLC data. Four Stokes parameters are calculated using level-1 SLC data [4], which are further georeferenced and orthorectified using LOLA DEM with 120m/pix spatial resolution, to obtain SAR derived polarimetric products of ~4m pixel spacing in both azimuth and range direction.

The decomposed images clearly reveal the location of the collision site as shown in Fig.1d-e, which is not visible in the pre-collision dataset (Fig. 1a-b). The collision site is majorly showing volume scattering (green in m- $\chi$  decomposed image in Fig. 1e). Even and odd components are not showing prominent difference between the pre- and post-collision SAR acquisitions. However, the collision site is decipherable in the volume scattering image (Fig. 3d). We also investigate the CPR value in the collision location. It is interesting to note that, the collision site is showing high CPR (~0.8) value compared to low CPR (0.2 - 0.3) neighbouring regolith (Fig. 1f). The results indicate that, the impactor excavated materials primarily composed of regolith and centimetre

to decimetre scale rock boulders which in turn leading to volume scattering and 2-3 times CPR enhancement. There are no prominent meter-scale rock boulders, as double bounce component is absent in the collision site. As the spread of the ejecta is restricted to an extremely small location, hence, the quantity of excavated rock materials is small. The excavation depth is limited upto subsurface ejecta layer, situated below few meters of regolith layer.

#### References:

- [1] <https://www.nationalgeographic.com/science/article/a-rogue-rocket-part-is-about-to-collide-with-the-moon>; [2] <https://www.lroc.asu.edu/posts/1261>; [3] <https://www.nasa.gov/feature/goddard/2022/nasas-lunar-reconnaissance-orbiter-spots-rocket-impact-site-on-moon>; [4] Raney et al., J. Geophys. Res., 117, E00H21, doi:10.1029/2011JE003986 (2012); [5] Spudis et al., J. Geophys. Res. Planets, 118, 2016–2029, doi:10.1002/jgre.20156 (2013).

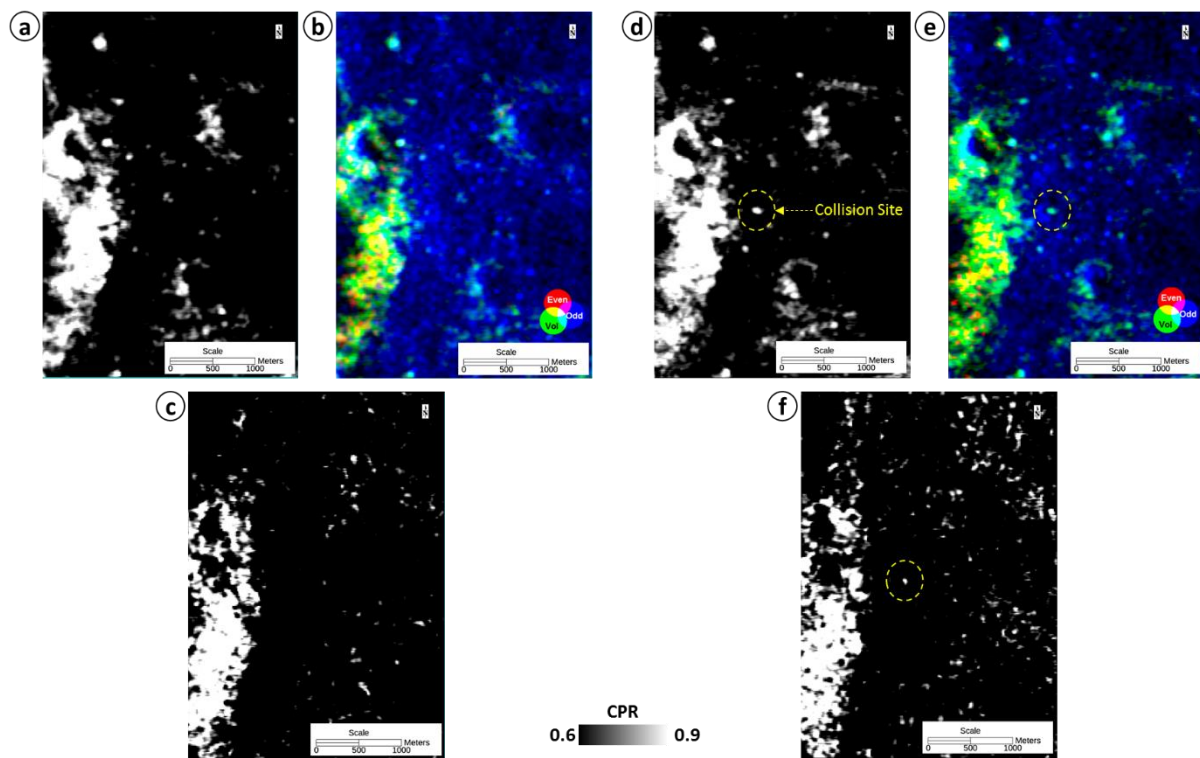


Fig. 1: Pre-collision SAR image showing (a) volume scattering component, (b)  $m\text{-}\chi$  decomposition image, (c) CPR image. Post-collision SAR image showing (d) volume scattering component, (e)  $m\text{-}\chi$  decomposition image, (f) CPR image.