EXPOSURES OF Mg-SPINEL ON AN EVOLVED SILICIC LITHOLOGY HANSTEEN ALPHA ON THE MOON. P. Kaur, P. Chauhan and Ajai, Space Applications Centre, (ISRO), Ahmedabad-380015, India. (prakash@sac.isro.gov.in).

Introduction: Hansteen Alpha region comes in the category of Lunar Red Spots, a class of spectral anomalies on the lunar surface. These red spots are known to have relatively high albedo and a strong absorption in the ultraviolet region [1, 2].

Detailed previous studies on red spots determined that these spectral anomalies exhibit distinct morphologies. Hansteen Alpha is an arrow shaped dome protruding through the Oceanus Procellarum basalts and located in the southern portion of the PKT terrain of the Oceanus Procellarum which is characterized by elevated Th abundances [1, 2]. The horizontal extent of the dome is about ~25 km and is rising ~700 km above the surrounding mare surface [3]. The Hansteen Alpha dome encompasses distinctive appearance in its surface texture, color and albedo from the nearby highland terrain [3]. The morphology of the Hansteen Alpha dome accords its derivation from a viscous highly silicic lava rich in Th, Silica and relatively low Mg as established from previous research using data from Clementine, Lunar Prospector (LP) and Lunar Reconnaissance Orbiter (LRO) data [4,5,6,7,8]. This study provides new results on composition of Hansteen Alpha dome using Moon Mineralogical Mapper (M^3) sensor onboard Chandrayaan-1, the first Indian mission to Moon.

New Compositional results using M^3: M^3 is an imaging spectrometer onboard Chandrayaan-1 covering the spectral range from 0.45-3.00 µm with 85 spectral bands and ~140 m per pixel (in Global mode) spatial resolution [9, 10]. M^3 reflectance data (level-2), corrected for thermal and photometric effects have been used for the present study [11].

The study reports detection of Mg-Spinel from the Hansteen Alpha dome with no detectible mafic mineralogy associated with the spinel exposures. The present finding is important since the Mg-spinel exposures from this type of evolved silicic lithology has not been reported earlier. The presence of Mg-spinel on the Hansteen α does not fit into the existing models explaining the origin of red spots. Mg-Spinel has also been reported from several other locations on the lunar surface which include central peak craters Theophillus and Tycho, Mare Moscoviense and crater Endymion [12, 13, 14, 15]. The occurrence of Mg-Spinel in silicic lithology however, opens a new window to understand the origin and evolution of these lithologies from a new perspective.

M^3 images were used to investigate the composition of the dome Hansteen α. The Mg-Spinel exposures are mostly concentrated on the central and western parts of the dome and appearing in yellow color in a RGB combination image and occur as small discrete patches of several hundred meters (500m - 1.5km) (Fig. 1). The integrated band depth images at 1000 nm and 2000 nm combined with 1508 nm albedo image display dome as blue color (no mafic absorption) with the surrounding basalt in yellow to green tone. However, some pixels in the central part of the dome display green color due to strong 2000 nm absorption (Fig. 2a & 2b). Reflectance spectra extracted from the green pixel exhibit characteristic Mg-Spinel absorption at 2000 nm and are lack of 1000 nm absorption feature (Fig. 2c). The strongest absorption at 2000 nm comes from the central portion of the dome (Spectra 1, fig. 2c), whereas the rest of the areas in blue color doesn't show any characteristic absorption related to Mg-Spinel or other mafic mineralogy (Spectra 7, fig. 2c). However, the basalts surrounding the dome are dominated by high-Ca pyroxenes.

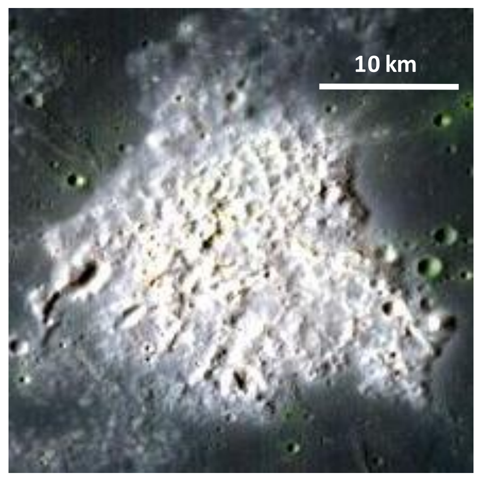
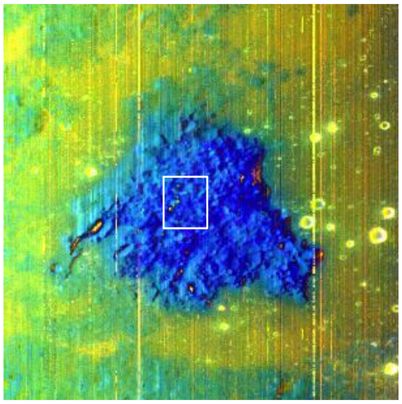
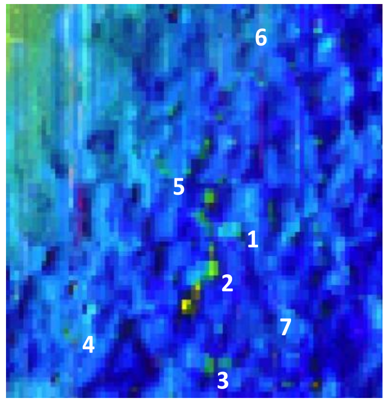


Figure 1. M^3 image showing Hansteen α dome in RGB combination (R = 1009 nm, B = 1309 nm and G = 2018 nm). The Mg-Spinel exposures are concentrated on the central portion of the dome.

DEM extracted using LROC WAC GLD 100 suggest that the central portion of the dome exhibits highest elevation values (-1057 to -948 mts.) [3]. Hansteen α is a steep sided dome that possesses hackly surface and the surface of the dome is marked by several small, linear, smooth-walled depressions which were interpreted as volcanic vents [16]. The Mg-Spinel exposures are widely distributed as small pockets all over the dome. Three dimensional view of the dome generated using M^3 radius file suggests that the Mg-Spinel rich areas are exposed on the slopes and near the depressions.

2a 

2b 

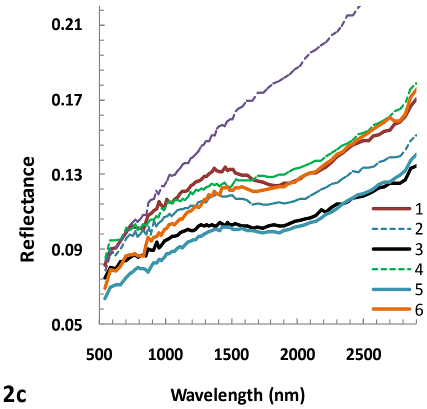
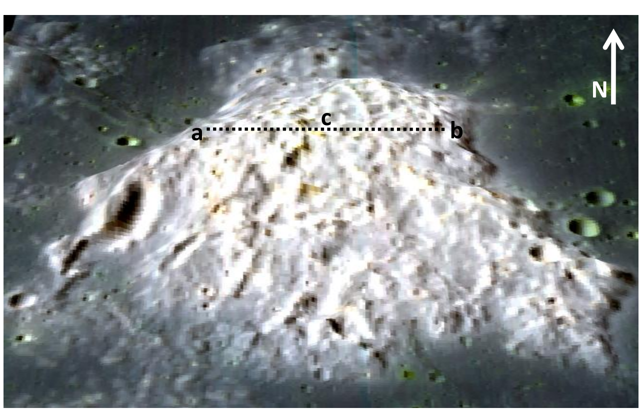
2c 

Figure 2a. IBD image (R = IBD at 1000 nm, G = IBD at 2000 nm and B =1508 nm) displaying Hansteen α dome in blue which represents mafic free lithology. (b). Showing the central portion of the dome encompass areas (pixels in green color) having strong absorption at 2000 nm. (c) Reflectance spectra showing 2000 nm absorption characteristic of Mg-Spinel extracted from the areas displaying green color in IBD image.

Discussion: Mg-Spinel exposures on the lunar surface in now known from several locations. But the exposures of spinel from the silicic lithology have been detected for the first time. The occurrence of spinel-bearing lithology on a highly evolved silicic lithology without any association with mafic counterparts merits for more understanding of the evolution of these silicic constructs. The reflectance spectra clearly show that the surfaces exposed represents a rock type that is dominated by Mg-spinel with no detectible mafic minerals. This new compositional information provides new insights and constrains into the formation of the Hansteen α dome. These lithologies have been suggested to form from the KREEP basalt, quartz monzodiorite and granitic lithologies and are analogous to terrestrial ryholite dome [6, 17]. The Mg-Spinel exposures spanning large area, for which fractional crystallization is one plausible process to concentrate such minerals during slow cooling of the magma. More complicated processes are involved that account for the formation and exposure of this rock type in a silicic volcanic construct.

3a 

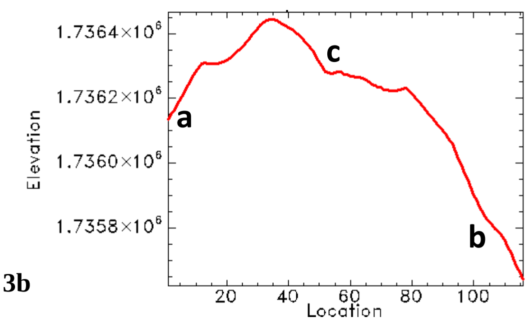
3b 

Figure 3a. Three dimensional view of the dome constructed by draping the M^3 RGB image over the M^3 radius file. The spinel exposures are in yellow color and concentrated mostly on the slope regions. 3b shows the spatial profile extracted along one of the Mg-Spinel rich zone exposed on the slope area, the location of which is marked as 'c' on the profile.

References: [1] Wood, C. and Head, J.W. (1975) *Conf. On Origins of Mare Basalts*, 189. [2] Head, J. and McCord, T. (1978) *Science, 199*, 1433. [3] Jolliff, B.L. (2012) *Second Conf. on the Lunar Highlands Crust*, 9037. [4] Hawke, B. et al. (2003) *JGR*, *108(E7)*, 5069. [5] Lawrence, D. et al. (2005) *GRL*, *32*, L0721. [6] Hagerty, J. et al. (2006) *JGR*, *111*, E06002. [7] Glotch, T. et al. (2010) *Science, 329*, 1510. [8] Greenhagen, B. et al. (2010) *Science*, *329*, 1507. [9] Goswami J. N. and Annadurai M. (2009) *Curr. Sci., 96, 4,* 486-491. [10] Pieters C.M. et al. (2009) *Curr. Sci., 96, 4,* 500-505. [11] Green, R.O., et al., (2011) *JGR*, *116*, E00G19. [12]. Lal, D .et al., (2012) *J. Earth System Sci.*, *121*, 3, 847-853. [13]. Hangar, D. et al. (2011), *Geophysics. Res. Let.*, *38*, L11201. [14]. Kaur P. et al. (2012) *LPSC XXXXIII*, Abstract #1434. [15]. Bhattacharya, S. et al., (2012) *Curr. Sci.*, 102, 12. [16] McCauley, J. (1973) *U.S.G.S. Map I-740*. [17] Head J. & McCord T. (1978) *Science 199*, 1433.