**NATURE AND DISTRIBUTION OF OLIVINE IN MOREUX CRATER IN NORTHERN MID-LATITUDE OF MARS.** Rishitosh. K. Sinha and S.V.S. Murty, PLANEX, Physical Research Laboratory, Ahmedabad 380009, India (rishitosh@prl.res.in).

**Introduction:** The geologic character of northern plains material is overprinted during the past by regional/local volcanic and sedimentary infillings to broad/episodic erosion and modification of volatile-rich material [1]. Their qualitative assessment based on identification of key mineral species using the entire VIS/NIR/TIR spectrometer data set has anticipated implications for surfaces having basaltic and either andesitic or partly altered basalt compositions [2]. The outcrops and deposits of the most important rock forming mineral olivine have been observed to occupy isolated massifs, crater rims, inter-crater dunes, floor sand and crater ejecta or extended deposits in the northern plains [3]. Global estimations of Mg/Fe content (Fo#) within solid-solution series of olivine have postulated their origin to exposure of intrusive or extrusive buried crustal materials and undifferentiated magma derived from deep-impact and widespread volcanism [4].

This work examines the nature, distribution and Mg/Fe content (Fo#) of olivine in Moreux crater (~138 km, 41.7˚ N, 44.5̊ E) inferred from MRO CRISM, HiRISE and CTX data. We support our results with THEMIS images, compare/contrast our results with USGS spectral library and make inferences about the origin and exposure of olivine-bearing materials.

**Data and Methods:** The half-resolution long MRO-CRISM NIR images (36 m/pixel, 6.55 nm/channel) used in this study for spectral analysis were processed, corrected for artifacts and converted into apparent reflectance using the methodologies described by CRISM instrument science teams [5-8]. The identification of specific spectral features in the region of interest was performed using spectral parameter summary maps [9]. In order to reduce the systematic instrument noise, pixel spectra from the region of interest were ratioed taking spectra of unremarkable region. The purest pixels were retrieved from the images using Minimum noise fraction transform (MNF) combined with the Pixel purity index (PPI) method [10, 11]. The results were then given as input for Spectral angle mapper (SAM) classifier for identification of similar pixels in the image. The combination of spectral features derived from our region of interest were compared with the laboratory spectra retrieved from USGS spectral library database.

The spectral variability within Mars Odyssey THEMIS image (100 m/pixel, 10 channels) was identified by examining decorrelation stretch (DCS) images of THEMIS band combinations 9, 7, 5 [12]. Surface texture and morphology were characterized using data from High Resolution Imaging Science Experiment (HiRISE) and Context Camera (CTX). The data sets described here were processed and analyzed using CRISM Analysis Tool 7.2 (CAT), ENVI 4.8 and ArcMap 10.0.

**Results:** Olivine has a broad and composite absorption centered near 1.0 µm resulting from crystal field transitions of $Fe^{+2}$ ions situated in two distinct distorted octahedral coordination sites (M1 and M2) within the olivine structure [13]. The width, shape and position vary with the grain size and Fo number. In comparison to the USGS spectral library samples (Ids: GDS70.a GSB and GDS71) (Fig. 1B) [14], the spectral shape and absorption characteristics of the ratioed spectra (5X5 pixels) (Fig. 1A) obtained from Moreux crater inter-crater dunes (Image Id: HRL0000BEC3) closely resemble combination of an olivine composition of $\sim Fo_{89}$ and $\sim Fo_{91}$. The extended absorption feature to ~1.55 µm for $\sim Fo_{89}$ and $\sim Fo_{91}$ was retrieved from both the USGS and CRISM spectra. We have not made any assumption for the grain size of olivine from our spectral comparison and therefore identify Moreux crater as a prime candidate for future experimental investigations. Characteristic absorption feature of olivine was also observed from the other CRISM images available for Moreux inter-crater dunes.

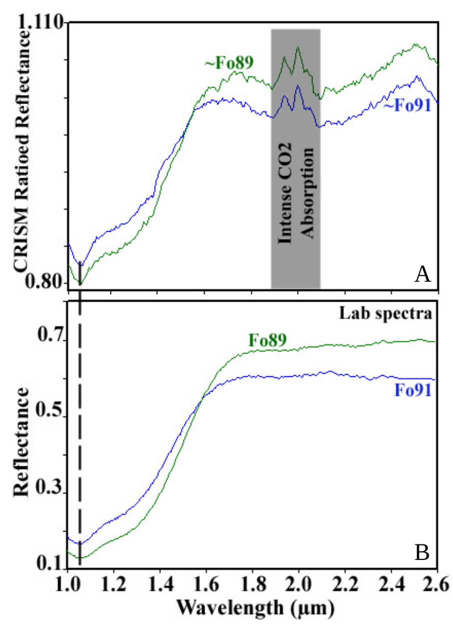


**Figure 1.** A) CRISM ratioed spectra and B) USGS library spectra for olivine-rich materials.

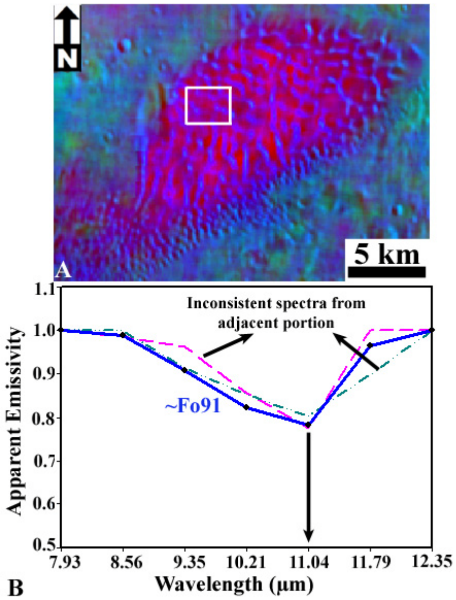


**Figure 2.** A) Region of high olivine abundance (42.17˚ N, 44.28˚ E) is displayed in magenta to purple-blue using DCS image of study region. B) Apparent emissivity spectra in bands 3-9 of olivine (~$Fo_{91}$) (blue). Box in A indicates location of data shown in B.

Exposure of olivine-rich materials in the inter-crater dunes was well observed from the DCS image of bands 9, 7, 5 (Fig. 2A). Our analysis of the apparent emissivity spectra produced using the seven THEMIS (Image Id: I35853003) wavelength bands 5-9 (9.35-12.57 µm) exhibited significant reduction in the emissivity (Fig. 2B). The comparison of THEMIS spectra to the spectra of Mg-rich olivine suggests that the composition is ~$Fo_{68-91}$ [12].

**Conclusions and Inferences:** Significant exposure of Mg-rich olivine in the inter-crater dunes of Moreux crater has been detetcted and confirmed from the analysis of CRISM spectral features. Our THEMIS based results are consistent with detection of olivine by [12] and collectively support the analytical results produced from CRISM hyperspectral images.

Based on our identification of Mg-rich olivine (~$Fo_{68-91}$) in the dunes of northern mid-latitude Moreux crater, we propose these four implications for its origin and exposure: (1) The presence of olivine bearing material at proximity of Moreux central peak suggest towards possible aeolian transport of eroded crustal materials excavated by impact (Fig. 3A); (2) Global dichotomy of Mars is believed to have resulted from one or more large impacts [15], which would have obviously deposited the buried olivine-rich materials onto its surrounding. The formation of ~138 km Moreux crater and overlay of its southern rim on the dichotomy boundary possibly penetrated the unaltered olivine-rich units, which have got exposed in the crater at a later stage; (3) The erosional degradation of olivine-rich bedrock has initially produced clusters of meter-sized olivine boulders. The mechanical weathering of these boulders at a later stage would have then produced the olivine-rich sands, identified as dark materials in Moreux crater (Fig. 3B). At CRISM/THEMIS spatial resolution (36/100 m), the spectral consistency from bedrock, boulders and dunes is difficult to be inferred. Alternatively, if olivine was present in exposed bedrock, it may have got heavily altered, resurfaced, or covered by dust; (4) The resurfacing from volcanic activity in northern plains would have possibly distributed the primitive magma from upper part of the mantle. The crystallization of these magmatic materials would have resulted in formation of Mg-rich olivine (e.g. ~$Fo_{91}$) at several locations. We believe that formation of Moreux crater has exposed these unaltered Mg-rich olivine materials, which has survived the dense hydrous and glacial activities during the past.

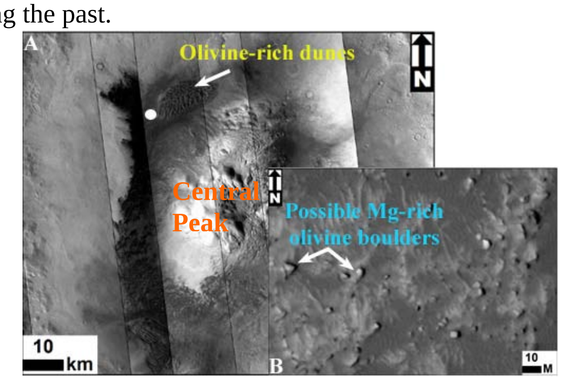


**Figure 3.** A) MRO CTX mosaic of inter-crater dunes at proximity of Moreux central peak. B) Example of a 200X150 sq.m. boulder cluster exposed in the dune field. Circle in A represents the location of figure B.

**References:** [1] Tanaka K. L. et al. (2003) *JGR, 108,* E4. [2] Wyatt M. B. et al. (2004) *Geology, 32,* 648-654. [3] Ody A. et al. (2012) *JGR, in press*. [4] Koeppen W. C. and Hamilton V. E. (2008) *JGR, 113,* E05001. [5] Murchie S. et al. (2007) *JGR, 112,* E05S03. [6] Murchie S. et al. (2009) *JGR, 114,* E00D07. [7] Mustard J. F. et al. (2008) *Nature, 454,* 305-309. [8] Parente M. (2008) *LPS XXXIX,* Abstract #2528. [9] Pelkey S. M. et al. (2007) *JGR, 112,* E08S14. [10] Green A. A. et al. (1988) *IEEE Trans. Geosci. Remote Sensing 26 (1),* 65–74. [11] Boardman J. W. et al. (1995) *Summ. Fifth JPL Airborne Earth Sci., 1,* 23-26. [12] Hamilton V. E. and Christensen P. R. (2005) *Geology, 33,* 433-436. [13] Sunshine J. M. and Pieters C. M. (1998) *JGR, 103,* 13,675-13,688. [14] King T. V. V. and Ridley W. I. (1987) *JGR, 92,* 11,457-11,469. [15] Wilhelms D. E. and Squyres S. W. (1984) *Nature, 309,* 138-140.