MODELING AND SIMULATION OF THE CHANDRAYAAN-I HYSI DATA FOR MINERAL MIXING ANALYSIS. S.B. Sayyad and Mohammed Zeeshan R, (Department of Physics, Milliya College Arts Science and Management Science College Beed Maharashtra India. syedsb@rediffmail.com, zeeeshan.shaikh@gmail.com)

Introduction: The space weathering is the primary process involved on the lunar surface which has the strong influence on the reflectance properties because of the accumulation of small submicroscopic iron [1-2]. Long time exposure to the environment complicates the understanding of the surface composition [3-6] Theoretical model can be employed to understand the effect of space weathering and to study the composition of the lunar regolith. From the studies done on the lunar samples from the Apollo mission it was clear that there are the significant differences between the optical properties of spectra pulverized in the laboratory and spectra obtained from the lunar soil [7-9]. The lunar soil spectra shows systematic influence of space weathering which is reduction in overall reflectance reddened -slope continuum and attenuated absorption bands. To model the measured reflectance spectra of Chandrayaan-1 hyperspectral Imager (HySI) we have obtained an artificial reflectance spectrum using Bidirectional reflectance function (BRDF) based on the equation of radiative transfer proposed by Bruce Hapke and published in the series of papers [10-14]. The effect of space weathering, particle size, single particle phase function, porosity can be easily accommodated and it is considered to be most efficient for modeling asteroids and planetary surfaces

Modeling the Chandrayaan-1 HySI dataset:
The Band to band registered level-4 HySI image was downloaded from ISRO-issdc.gov.in website. The image subset covering the southern part of the mare Crisium having orbit number 684 with product Id HYS_NREF_20090104T161501992. The mare Crisium is located at the near side of the moon and centered at 17° N and 60° E. The Main ring diameter is 740 km and the basin depth is 4.57 km the Mare Crisium is a multi-ring basin has 555 km in diameter.The figure (1) shows the subset of the data set and the sampling location from where the spectral signatures were derived. The The figure (2) shows the scaled reflectance at 748.3 nm. All data processing was done in ENVI 5.3 and the procedures for model were written in IDL 8.5 platform. The active spectra were derived from the young relatively fresh craters which are appearing as bright areas from the mare area. These active spectra can also be selected from the steep slopes of the crater where because of the gravity the upper most material slumps down and hence it exposes the material beneath it which is fresh material. We have chosen such small fresh craters and their slopes for selecting the active spectra for investigating the mineralogy.
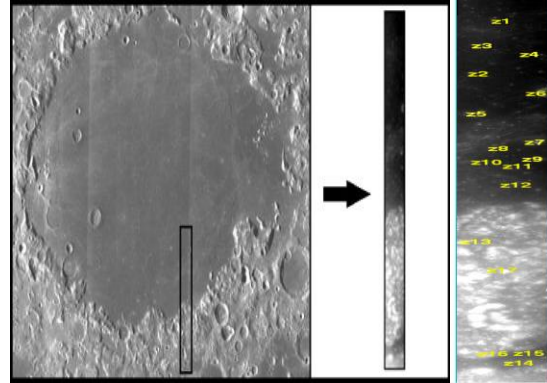

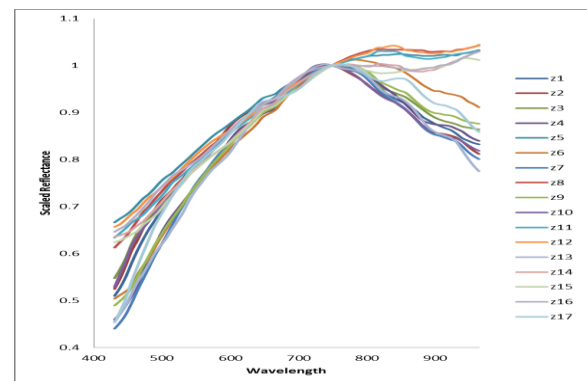**Fig. 1.** Site Location of Mare Crisium and data subset of Mare Crisium.

Fig.2. Scaled reflectance spectra at 748.3 nm of Mare Crisium.

Results and Discussions:
The mare crisium was sampled by LUNA 24 mission and the studies of the return sample reveals the abundance of different common major lunar mineral from the mare basalt as 34% to 39% plagioclase 4% to 10% olivine and 48 to 60% pyroxenes given by [15] parameters like porosity set to 60% typical for lunar surface and average phase function average grain size as specified in the lab details and iron fraction is initially set to zero. now to increase the overall contrast of the spectra we can decrease the grain size ,increase the phase function ,decrease the porosity. and increase the high albedo mineral like plagioclase and similarly to decrease the spectral contrast increase the low albedo mineral like agglutinates or increase the grain size ,increase porosity and adding more iron fraction thease all will results into decreased spectral contrast. the spectra z1 to z10 except z5 and z8 shows the absorption going towards the longer wavelength with around 30 % of reflectance exhibit 30 % to 40 % of clinopyroxene with 15 % of orthopyroxene with 5-

10 % of olivine. these spectras are relatively fresh with small iron volume fraction. around 10% of olivine was given by [15] from the return sample from the basalt of mare cresium.so spectra derived from fresh small craters is also showing the specified value of olivine.the spectra z6 derived from the farenhiet crater shows the active spectra from the crater slope may be because of the gravitational slumping which exposes the fresh soil and as we move from the fresh soil to mature soil the spectra gets redder with attenuated absorption and with reduced reflectance such spectral difference can be seen in figure (3). again the z6 spectra showing around 14 % of olivine which is relatively high from the remaing mare spectra may be the impact penetrated through the high olivine area that is exposed. The spectra having absorption going towards longer wavelength has more or less same minerological trends with slight differences. The spectra z13 and z17 from the highland region. having maximum reflectance with 32 to 39 % of clinopyroxene and around 50 % of plagioclase showing relatively fresh areas with 50 to 55 % of reflectance. The spectra z5,z8,z11,z12 and spectra z14 to z16 contains 31 to 36 % of orthopyroxene from the less bright matured surface may be the surface is having more iron so even after the long exposure the absorption are still prominent..the representative measured and modeled sample spectra shown in figure (4).
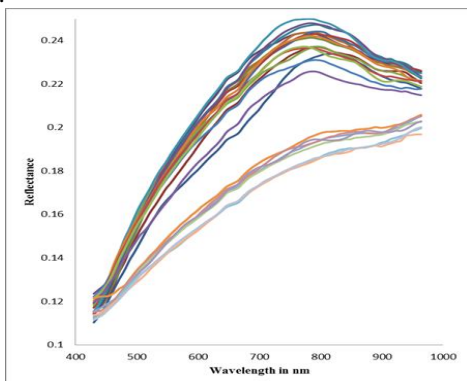

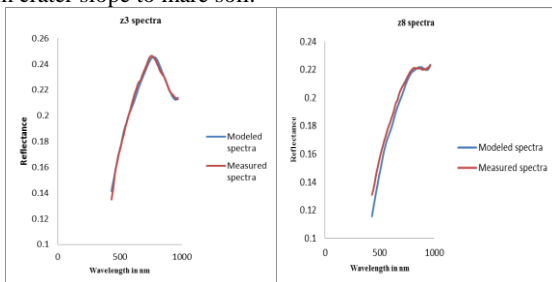**Fig. 3.** spectra from Fahrenheit crater (Z6 sample area) taken from crater slope to mare soil.

Fig. 4. Sample Measured and Modeled Spectra from Mare Crisium.

Conclusion

The results show the high mass fraction of clinopyroxne and low agglutinates for small fresh craters spread across the Mare areas for both datasets. The model shows 10% olivine from mare crisium and average 2% olivine from mare vaporum. The highland spectra shows high mass fraction values for plagioclase and agglutinates as they are relatively matured as compared to mare areas. It is also observed that the limited spectral coverage of Chandrayaan-1 HySI is a constraint to model the four pyroxene variations (augite, pigeonite, clinopyroxene and orthopyroxene) so the results can be improved significantly with more end members to model the data at longer wavelengths. The data from moon mineralogy mapper or the data from proposed Chandrayaan-2 IIRS(imaging infrared spectrometer) with ~80 meter spatial resolution will map the lunar surface in 0.8-5 μm spectral range in 256 contiguous spectral bands can be used for more accurate and better prediction of the surface mineralogy.

References:
[1]Pieters, C. M., E. M. Fischer, O. Rode, and A. Basu (1993), Optical effects of space weathering - the role of the finest fraction, J. Geophys. Res. – Planets 98, 20817-20824.[2]Chapman, C. R. (2004), Space weathering of asteroid surfaces, Annu. Res. Earth Planet. Sci. 32, 539-67.
[3]Keller, L. P., and D. S. Mckay (1993), Discovery of vapor deposits in the lunar regolith, Science 261, 1305-1307
[4]Keller, L. P., and D. S. McKay (1997), the nature and origin of rims on lunar soil grains, Geochim. Cosmochim. Ac. 61, 2331-2341.[5]Taylor, L. A., C. M. Pieters, L. P. Keller, R. V. Morris, and D. S. McKay (2001), Lunar Mare Soils: Space weathering and the major effects of surface-correlated nanophase Fe, J. Geophys. Res. - Planets 106, 27985-27999.[6]Taylor, L. A., C. M. Pieters, A. Patchen, D. S. Taylor, R. V. Morris, L. P. Keller, and D. S. Mckay (2010), Mineralogical and chemical characterization of lunar highland soils: Insights into the space weathering of soils on airless bodies, J. Geophys. Res. – Planets 115, E02002.
[7]McCord, T. B., and T. V. Johnson (1970), Lunar spectral reflectivity (0.30 to 2.50 microns) and implications for remote mineralogical analysis, Science 169, 855-858.[8] McCord, T. B., and J. B. Adam (1973), Progress in remote optical analysis of lunar surface composition, Moon 7, 453-474.[9] Pieters, C. M., L. A. Taylor, S. K. Noble, L. P. Keller, B. Hapke, R. V. Morris, C. C. Allen, D. S. McKay, and S. Wentworth (2000), Space weathering on airless bodies: resolving a mystery with lunar samples, Meteorit. Planet. Sci. 35, 1101-1107.[10] Hapke, B., 1981, Bidirectional reflectance spectroscopy. I - Theory, J. Geophys. Res., 86,3039–3054 [11] Hapke, B., Wells, E., 1981, Bidirectional reflectance spectroscopy. II Experiments and observations, J. Geophys. Res., 86, 3055–3060 [12] Hapke, B., 1984, Bidirectional reflectance spectroscopy. III - Correction for macroscopicroughness, Icarus, 59, 41–59 [13] Hapke, B., 1986, Bidirectional reflectance spectroscopy. IV - The extinction coe_cientand the opposition e_ect, Icarus, 67, 264–280.[14] Hapke, B., 1993, Theory of reflectance and emittance spectroscopy, Topics in Remote Sensing, Cambridge, UK: Cambridge University Press, c1993[15] Papike, J. J., Vaniman, D. T., 1978, Luna 24 ferrobasalts and the mare basalt suite - Comparative chemistry, mineralogy, and petrology, in Mare Crisium: The view from Luna 24, (Eds.) R. B. Merrill, J. J. Papike, pp. 371–401