FIRST GLOBAL LUNAR MAGNESIUM AND ALUMINUM ABUNDANCE MAPS DERIVED USING CHANDRAYAAN-1 AND CHANDRAYAAN-2 DATA. M. Bhatt[1], S. Narendranath[2], C. Wöhler[3], N. S. Pillai[2], N. Srivastava[1], and A. Bhardwaj[1]. [1]Physical Research Laboratory, Ahmedabad, 380009, India. [2]U R Rao Satellite Centre, ISRO, Bengaluru, India. [3]Image Analysis Group, TU Dortmund University, Otto-Hahn-Str. 4, 44227 Dortmund, Germany (megha@prl.res.in).

Introduction: Global maps of Mg and Al along with the elements Fe, Ti, and Ca are important compositional indicators of different highland and mare rocks. The global mapping of major lunar refractory elements provides information about the petrological characteristics of the Moon [1, 2]. Reflectance spectroscopy in the UV-VIS-NIR wavelength range allows for the determination of the abundances of a variety of minerals and volatile species present on the uppermost layer of the regolith. For a comparable penetration depth as NIR, X-ray fluorescence (XRF) measurements allow for obtaining elemental concentrations at tens of km of spatial resolution. Since XRF and UV-VIS-NIR provide information from the uppermost layer of the regolith, merging them is favorable for determining major refractory elements at meter scale spatial resolution.

The Chandryaan-2 Large Area Soft X-ray Spectrometer (CLASS) [3] onboard Chandrayaan-2 [4] is capable of providing global maps of O, Mg, Al, and Si at a resolution of 12.5 km/pix based on lunar X-ray fluorescence measurements in the 0.5 to 10 keV range [3]. These measurements are considered as a direct approach of elemental abundance mapping which primarily relies on enhanced solar activity. In contrast, the indirect approaches of elemental abundance mapping uses reflectance measurements in the UV-VIS-NIR wavelength range but are mainly based on empirical relations between the spectral band parameters and the composition of returned samples [e.g., 5, 6] or gamma-ray spectrometer (GRS) derived global chemical composition data [e.g., 7, 8].

The objective of this work is to use CLASS-derived abundances of Mg and Al as a ground truth and develop an empirical multivariate linear regression (MLR) model by optimizing the selection of spectral parameters from the VIS-NIR wavelength range. We use a calibrated reflectance global mosaic derived from the Moon Mineralogy Mapper (M^3) [9] on Chandrayaan-1 [10]. This is our first attempt of deriving 20 pixels/deg global maps of Mg and Al by integrating the CLASS and M^3 datasets.

Data and Methods: The CLASS spectra have been modeled using an XRF model [11] after background subtraction. We used the background measured on the night side of the orbit closest to the XRF spectral measurements. The solar spectrum essential for deriving the elemental abundances in weight percent (wt.%) is measured with the solar X-ray monitor (XSM) onboard Chandrayaan-2 [12]. For this study, XRF spectra measured for solar flares of class C (GOES class) were used to ensure good signal levels. A forward modeling approach is used. The best-fit parameters are derived using the chi-square minimization algorithm in XSPEC. We used elemental wt.% measurements for which the spectral fits have reduced chi-square values between 0.9 and 2 and the 1 sigma error bars are less than 20% of the value. The available CLASS footprints for which Mg and Al abundances were derived are shown in Fig. 1.

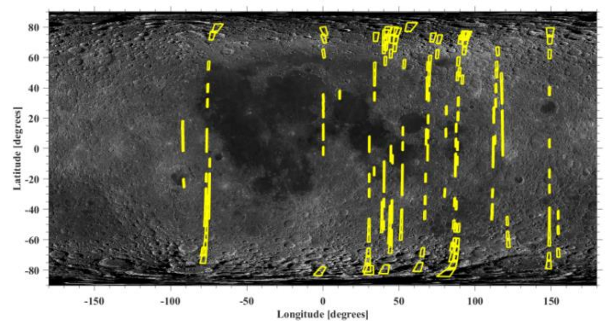

Fig. 1: Spatial distribution of Class footprints used as a ground truth for developing MLR model. Base map: LROC WAC mosaic [16].

The M^3 radiance data (level 1B) were processed using the framework of [13]. M^3 operated in the wavelength range of 0.4 to 3 μm at a spatial resolution of 140 m/pix from 100 km spacecraft altitude [9]. The M^3 radiance data were resampled to a global mosaic of 20 pixels per degree resolution. The nearly global coverage of M3 has been used efficiently for estimating abundances of the refractory elements Fe, Ti, Ca and Mg using GRS global coverage as ground truth [8, 14].

We used the same set of M^3 spectral parameters as proposed in [8] that is robust with respect to the effects of soil maturity. The spectral parameters have been derived as averages over the CLASS footprints for training a MLR model. The coefficient matrix obtained from MLR is applied to the 20 pixels per degree M^3 spectral parameter maps for deriving maps of the elemental abundances.

Results and Discussion: Fig. 2 shows the global Mg and Al maps constructed by using CLASS data as

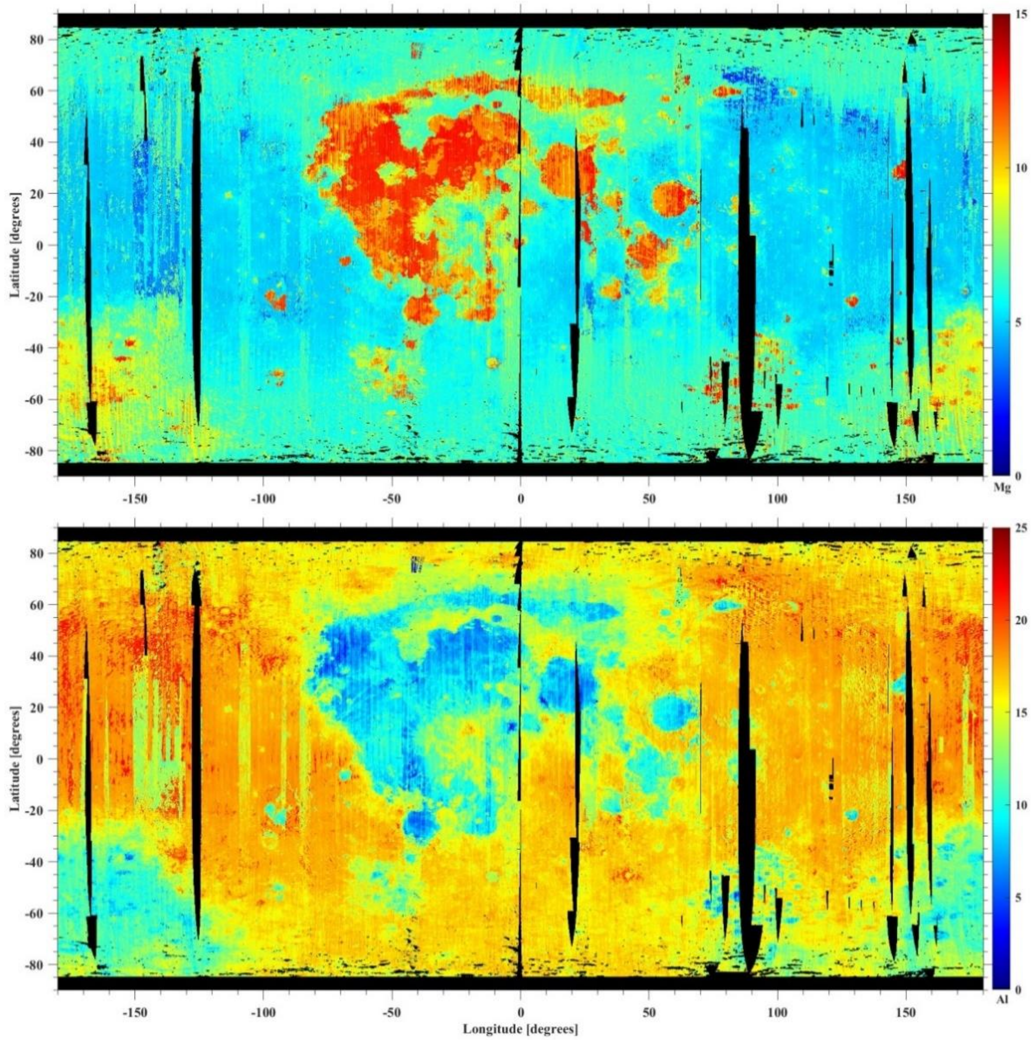

Fig. 2: M^3-derived global Mg (top) and Al (bottom) maps using CLASS data (Fig. 1) as reference. These maps were constructed using the MLR model.

a reference and applying the MLR model to the global M^3 mosaic. The main focus here is to establish a framework that can be applied to global and equidistant CLASS data once available. Our results demonstrate the usefulness of MLR that successfully expands sparse, independently measured elemental abundances from CLASS to a global coverage of M^3. The global maps in Fig. 2 clearly reflect the compositional differences between highlands and maria. The absolute values may get refined once spatially distributed CLASS footprints are available. The cross-correlation between the reference CLASS footprints and the estimated abundances is ~0.6 for both Mg and Al. We compared our Mg map to the Mg map estimated by using LPSGRS as a reference [8] and found a root mean square deviation of 1.2 wt.%, where the absolute values estimated using CLASS as a reference are systematically higher. We will conduct a systematic comparison between CLASS-derived and LPGRS-derived global elemental abundance maps once global and consistent CLASS data are available.

Summary and future work: This work demonstrate the first attempt of deriving elemental abundances on global scales by integrating XRF and VIS-NIR data sets acquired during different lunar missions. The derived abundances of Mg, Al and Si obtained by GRS are of limited reliability due to the poor spectral resolution and background in the detectors [15]. Therefore, we aim at deriving the abundances of these elements by calibrating M^3 spectral parameters to the CLASS-derived abundances of Mg, Al and Si. A systematic comparative analyses and site-specific studies are in progress and aim at improving our understanding of the underlying relationships between XRF and VIS-NIR datasets.

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