MODELLING THE SOURCES OF LUNAR MARE BASALTS MAPPED BY CHANDRAYAAN-2. Harsh Thakur[1], Netra S Pillai[1,2], S. Narendranath[2], and R. Chakrabarti[1], [1]Centre for Earth Sciences, Indian Institute of Science, Bengaluru (harshthakur@iisc.ac.in), [2]Space Astronomy Group, U. R. Rao Satellite Centre, ISRO, Bengaluru

Introduction: One of the most significant early results from returned lunar samples is the concept of a lunar magma ocean (LMO) that resulted in the flotation of an anorthositic crust. Major episodic impact events that excavated the large nearside basins resulted in mare volcanism that could have lasted as recent as ~2 Ga. Most of our understanding of the origin and evolution of the mare basalts are from the returned samples from Apollo, Luna and Chang'e-5 missions. In this work, we use elemental abundances derived from the Chandaryaan-2 Large Area Soft X-ray Spectrometer (CLASS) [1] X-ray Fluorescence experiment to suggest possible sources for the parent magmas.

Methods: Concurrent fractional and equilibrium crystallisation modelling of the LMO was carried out using FXMOTR program (part of SPICEs suite) [2] with LPUM [3] as the initial composition starting from 40 kb (corresponds to 1000 km). The cumulate layers that were formed were mixed along with some degree of crustal assimilation to model the sources of the lunar mare basalts. Gradient descent optimisation algorithm was used to retrieve the contribution from each component. Results of the model are compared with elemental abundances from CLASS [4] over the mare.

Results: Cumulate layers formed at different P-T conditions contain minerals like olivine (Ol), orthopyroxene (Opx), plagioclase (Pl), augite (Aug), and ilmenite (Ilm).

Layer (PCS)	Mineral modes	Depth (km)
0 - 43	100% Ol	1000
44 - 77	10% Ol + 90% Opx	400
78 - 87	20% Ol + 30% Opx + 50% Pl	115
88 - 89	30% Ol + 20% Opx + 50% Pl	49
90 - 94	20% Ol + 40% Pl + 40% Aug	42
95 - 96	20% Pl + 80% Aug	19
97 - 99	10% Pl + 60% Aug + 30% Ilm	12

Table 1: Mineral mode and depth of the modelled cumulate layers.

Plagioclase floats upon crystallisation due to its lower density while the other phases settle. Oxide compositional data of the different layers of this model is consistent with the measurements from lunar anorthosite meteorites Dhofar 908 and Dhofar 081 (data from [5]). The high density ilmenite rich layer formed at 96 Percent solidification (PCS) causes instabilities which leads to a cumulate overturn event and mixing of late-stage and earlier formed cumulate layers. Components considered for theoretical mixing are deep mantle layer (400 km), shallow mantle layers (115, 42 and 12 km), crustal anorthosite and 0.5% KREEP (assumed lower limit). Layers formed at 49 and 19 km were not considered due to similar composition and depth with adjacent layers (42 and 12 km respectively). Cost function for gradient descent takes into account the deviation in MgO, FeO, Mg#, TiO_2, and Al_2O_3 with highest priority for TiO_2 since it is an important characteristic of mare basalts. Solutions for the sources of mare show that maximum contribution from deep layer is 55% while shallow layer contribution is highly variable (25-90%). Among the shallow layers, mixing trend was observed and majority of the pixels have maximum contribution from the 12 km layer.

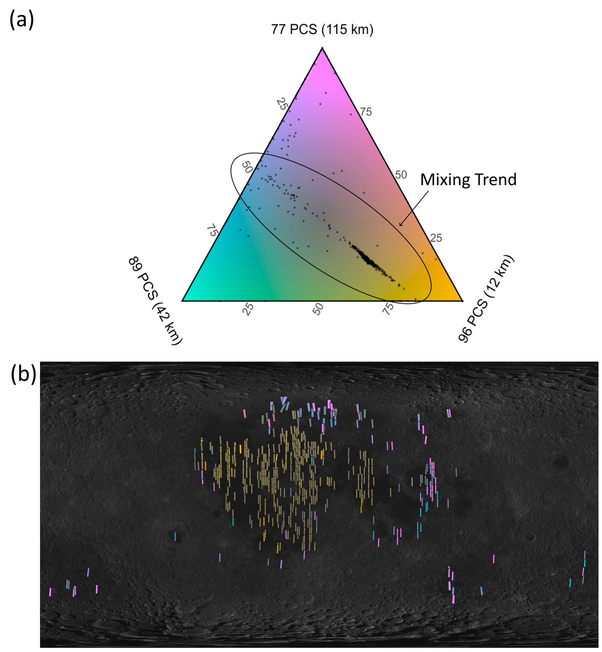

Figure 1: Ternary color map (a) of the shallow mantle layers and their locations (b) on Moon.

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