Lunar Magnetic Field Anomaly - Global Distribution and Possible Origin. Jayanta Ghosh (jayanta@prl.res.in), Garima Arora (garima @prl.res.in), and Amit Basu Sarbadhikari (amitbs@prl.res.in), Physical Research Laboratory, Ahmedabad 380009, India.

Introduction: The Earth's moon is believed to have no global magnetic field at the present day. However, Lunar Prospector [1] and Kaguya missions provided strong global lunar magnetic field anomalies at different regions of the lunar crust such as the Reiner Gamma, South Pole Aitken Basin, Airy etc. Origin of these anomalies is still not clearly understood but certain possibilities have been formulated and examined. Several models exist, e.g. lunar core dynamo [2], impact origin [3], amplified fields due to impact generated plasmas [4], and impact driven dynamo [5].

We have tried to map the global magnetic anomalous regions using the data available from the SELENE-KAGUYA mission. Magnetic field contours of various selected regions show a particular pattern of total magnetic field and its horizontal component for all these regions, which suggest the possibility of a paleopole. We have also estimated FeO and TiO_2 abundances in the magnetic anomalous regions to examine the relation between the compositional variability and the high magnetic field intensities. Through our observations, we predict an internal origin of the lunar surface magnetic field.

Methodology: In this study we used the data provided by Lunar Magnetometer (LMAG) that was board on KAGUYA-SELENE mission by JAXA [6]. The KAGUYA spacecraft was placed in a polar orbit at altitudes between 9-80 km to observe the magnetic field of lunar crust. The surface magnetic field values were then calculated using the Surface Vector Map (SVM) model [7]. We used these surface magnetic field values to study the higher magnetic anomaly regions and interpret the reason behind them.

Based on Clementine UVVIS [8] and Lunar Reconnaissance Orbiter Wide Angle Camera [9] images, chemical compositions (FeO and TiO_2 wt%) of the magnetically anomalous and surrounding regions were also estimated.

Results: Eight regions have been demarcated with higher crustal total magnetic field than the background values (Fig. 1). We plotted contours of total magnetic field and horizontal component of the magnetic field at those regions. Due to very low magnetic field strength (3-28 nT) we have excluded the Mare Basalt Region at the north-eastern most part of the global map.

The highly magnetic anomalous regions are: northern rim of South Pole Aitken Basin (SPAB), Eastern extended arm of SPAB, Reiner-Gamma, Airy, and three other selected regions (Fig. 1). Significant variations of the total and horizontal magnetic fields were observed. The Northern rim of SPAB shows a total magnetic field intensity in the range 50-300 nT and the Eastern extended arm of SPAB shows a variation of 50-600 nT. The Reiner-Gamma region shows a higher total magnetic field intensity between 100-500 nT, while the Airy region shows less magnetic field value between 10-70 nT. The Region-1 shows a variation between 100-600 nT, Region-2 shows lesser total magnetic field value between 50-200 nT and Region-3 shows a variation between 50-200 nT.

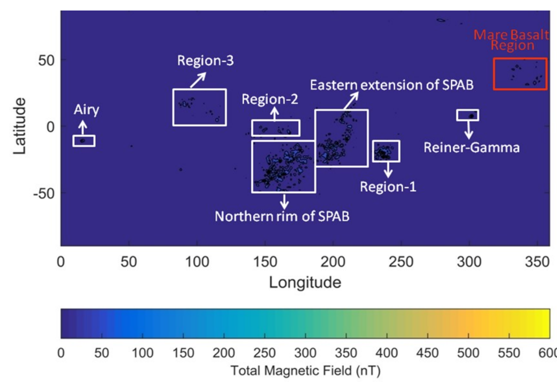

Fig. 1. Global distribution of crustal magnetic anomalies using KAGUYA LMAG data

Further, we have made an attempt to find the relative variation in FeO and TiO_2 abundance (wt%) in the high magnetic field regions w.r.t the surroundings. The TiO_2 abundances are approximately < 2 wt% in all the magnetically anomalous regions. However, TiO_2 value is as high as 7-8 wt% in the surroundings of Reiner Gamma and 6-7 wt% in the surroundings of highland regions. Also, the FeO abundance is found to be approximately between 16-18 wt% for the highest magnetic intensity portions of Reiner Gamma. In all the other regions, the map resolution is not sufficient enough to estimate the variation in the FeO abundance. However, the variation in the FeO abundance for these regions matches with that of the Reiner Gamma based on the Clementine FeO map.

Discussion: Large surface crustal magnetic field anomalies are found on the northern rim of the SPAB [4]. It was estimated that these magnetic anomalies were due to a significant quantity of deposited magnetized projectile materials [4], or due to magnetization of the source body in lunar dynamo field [10]. On contrary, the anomalies found at the Reiner–Gamma and Airy regions with swirl albedo feature have no known origin [11].

We suggest that the different range of anomalous magnetic values are because of the magnetic bodies, plausibly emplaced at different depths, which has resulted in variable attenuation of the magnetic field at the surface. The horizontal component of the magnetic field intensity have some global pattern or orientation for almost all the magnetic anomalous regions. This alignment of horizontal component gives an idea about the geometry of the source magnetized body. In case of Airy the source body is mainly vertical and is pointing downward at the centre, and for Reiner Gamma the source magnetization is mainly horizontal [11]. These regions might have been strongly magnetised by a source that acquired its long lasting magnetic field under the influence of the lunar dynamo.

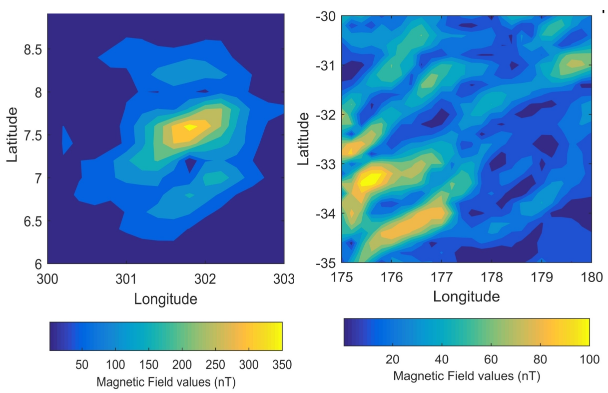

Fig. 2. Horizontal component of the magnetic field at Reiner Gamma (left) and at a selected area of SPAB (right)

The paleomagnetic studies of Apollo samples suggested that the lunar dipolar magnetic field can be best explained by a magnetic paleopole. We have also observed that the horizontal component of the magnetic field is oriented most plausibly following a NE-SW paleopole direction, which may suggest the internal origin of the magnetic anomalies.

The difference in FeO and TiO_2 between the magnetic anomalous and the surrounding regions are difficult to ascertain from this study. However, globally similar pattern is observed in the magnetic anomalous regions comprising lower FeO and TiO_2 than the surroundings. An earlier study [12] has mentioned two possibilities, either magnetic shielding causing anomalous space weathering effect on spectral image or plagioclase-rich dust layering, to explain the lower FeO concentration in the anomalous regions than its surroundings. It seems significant that the distribution of a non-magnetic element Ti in the anomalous and surrounding regions is correlating with that of Fe. Although difficult to explain but the global pattern of the horizontal field of the magnetized body and non-magnetic TiO_2 distribution has significance to the source magnetized bodies with a lunar magnetic paleopole.

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