LATERAL DENSITY VARIATIONS ON THE SURFACE AND IN THE CRUST OF THE MOON. J. S. Du[1], C. Chen[1], Q. Liang[1] and C. Zhou[1], [1]Institute of Geophysics and Geomatics, China University of Geosciences, 388 Lumo Road, Wuhan 430074, China, E-mail: djsfly@sina.com, chenchao@cug.edu.cn, qingliang.cug@gmail.com, zhoucong323@126.com.

Introduction: The lately topography and gravity data of the Moon obtained from Kaguya, Chang'E and Lunar Reconnaissance Orbiter (LRO) give us some new insights of the lunar internal structures [1-5]. The anomalies of the external gravity field of the Moon would also be produced by the density variation in the crust not only by the variations of the crust-mantle interface. The previous studies have shown that the density of lunar crust present the lateral variation [6-8], which is an important information to understand the crust evolution of the Moon. Therefore, we attempt to reconstruct a global density distribution by introducing a sort of constraints. The following approaches are considered to reveal this nonhomogeneity of the lunar crust. Firstly, we statistically model the density distributions on the Moon from petrologic mapping and densities of the rock samples. Secondly, the average lateral density variations in the lunar crust is modeled based on the topograpgy and gravity field of the Moon.

Data and Methods: Based on the distributions metal elements Fe, Th and Mg on the lunar surface derived from the measurement of Lunar Prospector mission [9], the global petrologic distributions of plagioclase, Mg-rich rock, basalt and KREEP rock can be interpreted mineralogically and geochemically [10]. In this study, the rock density distribution on the lunar surface is calculated according to petrologic distributions and densities of the rock samples, meteorites and estimations from recent achievements as well [11]. Values of density in the near surface are adjusted with the relationship between the contents of Fe and rock-density [12].

The density model of lunar crust has been inverted using separated lunar Bouguer gravity anomaly data, which calculated from topography model CLTM-s01 [4] and gravity model SGM100h [13]. Here, the gravitational attraction of the undulated terrain is calculated utilizing equations 9 and 10 in [14], the average density value is 2920 kg/m^3 which is determined by area weighted average of the density distributions on the Moon. Moving average is commonly used to separate the gravity anomaly, which is adopted in this study by controlling the moving window size and by choosing the polar angle in spherical cap. Utilizing the residual Bouguer gravity anomaly and the methods in [11], the lateral variations of density within the depth of 40 km in crust is calculated.

Results: On the lunar surface, the statistical result (Fig. 1) shows that the density distributions in some flat and large Maria, e.g. Crisium, Serenitatis, Imbrium, Nectaris and Humorum are very high because of the basalts filling, but are widespreadly small in highlands due to the highly feldspathic compositions, i.e. ferroan anorthosite rocks which constituting over 60% of the Moon's surfce. The "high-Th Ovl Region" [15], located in the Oceanus Procellarum, shows a little high density value in Fig. 1. Based on this model, the average lunar crust density is 2920 kg/m^3 by area weighted average, that is coincide with the variation range from 2900 to 3000 kg/m^3 [16] and the previous results [17].

In the lunar crust, the lateral density variations can be retrived by analyzing the residual gravity anomalies. Through the moving average in the spherical cap, the spherical harmonic amplitude spectrum (Fig. 2) of lunar Bouguer gravity anomaly shows that the energy of regional anomaly dominates from the degree 0 to 4, and the local high energy is between degree of 4-15 due to the Mascons. In this study, the polar angle of 50° is chosen to separete the regional and residual anomalies. With our method [11] and the average thickness of lunar crust [18], the lateral variations of density are obtained (Fig. 3). The minimum and maximum density contrasts are approximately from -170 to 440 kg/m^3. This average model is very different from the surface density distribution.

Discussion and Conclusions: The difference between the density model on the surface and that in the crust tells more understanding of the crust formation. The former model delineates the material components variations on lunar surface, the latter one reflects material components variations and local changing of crust-mantle interface. If the thickness of surface layer is 500 m, its gravitational attraction at 10 km height is only 11 mGal in maximum so that it has little influence on the density model in crust.

Excluding the Mascon basins and the South Pole-Aitken basin (SPA is also the Mascon basin [19]), the density vary in the region of 2850~3050 kg/m^3, indicating that the upper part the lunar crust is dominated by light silicate rock with rich aluminium, calcium and magnesium elements. Ohtake also drew a similar conclusion that the upper crust consists of nearly 100 vol.% plagioclase [20]. Comparing with the surface density model, the crust averge density in the KREEP covered region do not present high density, which is probably explained that the primary lunar crust was composed globally of light and calcium magnesium silicate rocks. The KREEP rock, as a thin layer, covers the original lunar crust.

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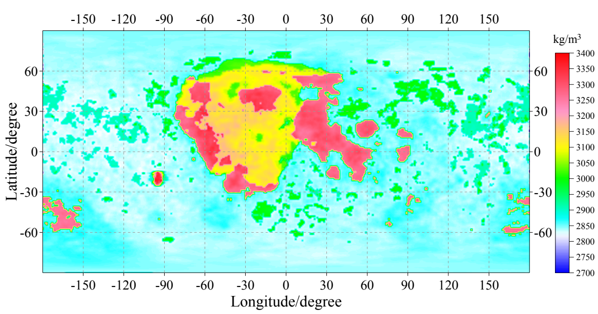

Figure 1. Density distribution on the lunar surface.

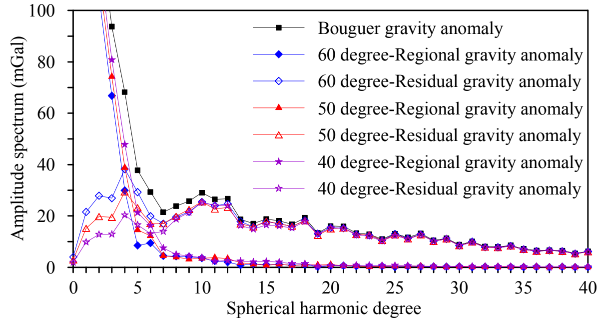

Figure 2. Spherical harmonic amplitude spectrum of lunar Bouguer gravity anomaly at height of 10 km.

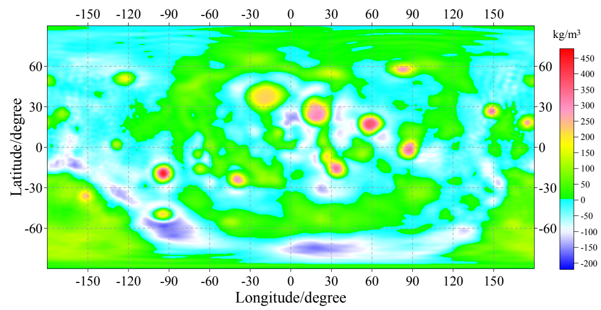

Figure 3. Lateral variations of residual density in the lunar crust (relative to the value of 2920 kg/m^3).