LUNAR GLOBAL CRUSTAL THICKNESS ESTIMATION USING COMPENSATED TERRAIN GRAVITY EFFECT (CTGE) DATA. Li Fei[1], WangWenrui[1], ChenWu[2], HowWeifeng[1], [1]Wuhan University, 129 Luoyu Road, Wuhan (fli@whu.edu.cn) [2]Hong Kong Polytechnic University (lswuchen@inet.polyu.edu.hk)

Introduction: The crustal thickness of a planetary body can be used to constrain (among other things) the magmatic processes responsible for its formation, and the bulk composition and origin of the planet. Since Apollo missions, the estimation of the lunar global crustal thickness has been one of the important areas in lunar research [1,2,3], with various data and methods from seismic inversion to global topography and gravity data inversion. Compared with other inversion methods, using topography and gravity data has the advantage of being able to estimate crustal thickness globally. In general, there are three main algorithms for the inversion of the lunar crustal thickness based on gravity and topography data. The first approach is based on the inversion of Bouguer anomalies. However, as the downward continuation of Bouguer anomalies was not stable and the noises will be amplified during this process, the calculation error could be very large at the Moho interface. In 1997, Wieczorek and Phillips studied the highland compensation as well as the lunar crustal thickness with GTR, which can be treated as another method for crust inversion[4]. The third approach for subsurface studies of the Moon is the use of correlation filtering [5,6] which divides the free air gravity anomalies (FAGA) into two parts, based on their correlations with the terrain gravity effects (TGE). Potts [7] applied this method to construct the lunar interior structure models, including the crust, mantle and core. Compared with the other two methods, the spectral correlation analysis method has certain advantages. Firstly, it completely avoided downward continuation noises. Secondly, this approach separated other deep sources (i.e. possible mass variations of the lunar core and mantle) in free air gravity anomalies and therefore these sources will not affect the crutsal thickness inversion.

Spectral correlation analysis of lunar free-air and terrain gravity data: The terrain gravity effect (TGE) can be estimated according to the model proposed by Wieczorek and Phillips [8], with the 180 degree and order topography model LALT_STM359_grid-02_180. The result is shown in Fig 1. In Fig 1, the terrain gravity effect map is referenced to 1738.0 km sphere, with the maximum value of 1259mgal, the minimum value of -794mgal, and the mean value of 13.7mgal.

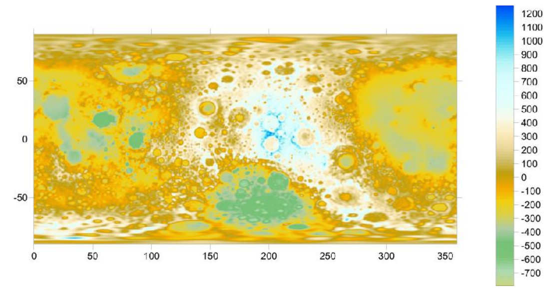

Fig 1. Terrain gravity effect from LALT_STM359_grid-02_180 (mgal)

The spectral correlation analysis method [5,6] tries to separate FAGA into Terrain Corrected FAGA (TCFAGA) and Terrain Decorrelated FAGA(TDFAGA). TCFAGA and TDFAGA can be separated using a correlation filter, using the correlation of FAGA and TGE [7]. The compensated terrain gravity effect (CTGE) can be obtained by the same method.

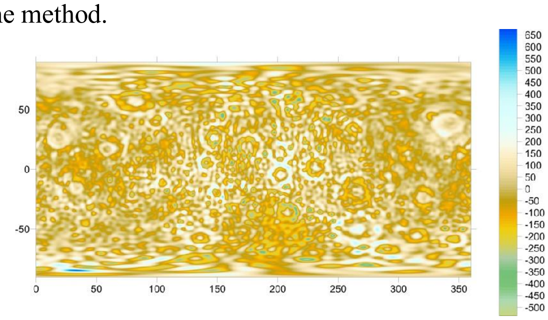

Fig 2. Terrain correlated FAGA (TCFAGA) (mgal)

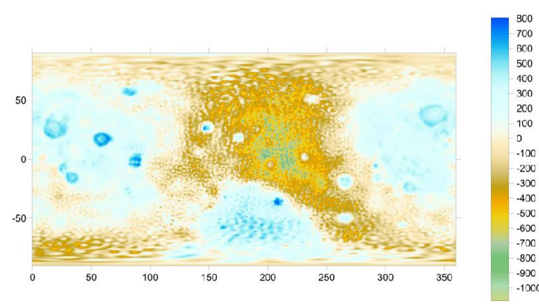

Fig 3. Compensated TGE (CTGE) (mgal)

Results and Discussions: Considering that the compensation of TGE (CTGE) occurs at crustal-mantle interface, the thickness of the lunar crust can be constructed by the inversion of CTGE using the GLQ method [9]:

$$\Delta g=\int_{\lambda a'}^{\lambda b'}\int_{\varphi a'}^{\varphi b'}\int_{ra'}^{rb'}\left(q\left(r,\varphi,\lambda;r',\varphi',\lambda'\right)\Delta\sigma\right)dr\,d\varphi'\,d\lambda'$$
$$\approx \Delta\varphi_k{}'\left\{\Delta\lambda_j{}'\left[\sum_j \Delta r_i{}'\sum_i\left(q\left(r_i{}',\Delta\lambda_j{}',\Delta\varphi_k{}'\right)\Delta\sigma\right)A_i\right]A_j\right\}A_k$$

where the source point coordinates are primed and the observation point coordinates are unprimed, Δg is the gravity anomaly, (φ,λ ,r) are the spherical coordinates of the point, $\Delta\sigma$ is the uniform density contrast, and A_i , A_j , and A_k are the Gaussian-Legendre Quadrature weights.

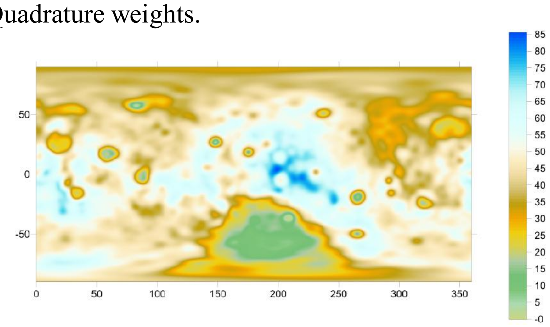

Fig 4. Lunar global crustal thickness model (km)

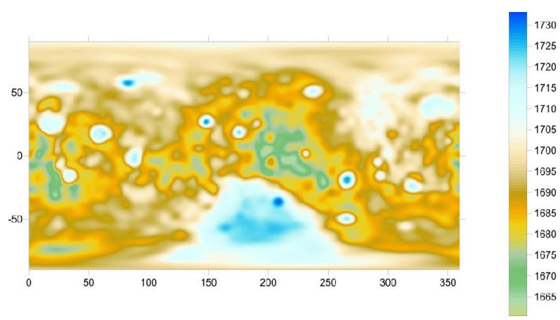

Fig 5. Moho terrain (km)

The maximum crustal thickness is 85.6km, located on (199°E, 4°N), and the minimum thickness is -0.6km, located on (151°W， 36°S), near the edge of SPA. The negative values mainly appears in (150°W-151°W, 35°S-36°S), which is the scope of Apollo crater. The global mean thickness is about 42.2km.

For the inversion of crustal thickness, seismic data are considered to be most accurate and reliable. Table 1 compares our results with those derived from seismic data.

Table 1. Comparison of our model with seismic results

	Apollo 12 (km)	Apollo 14 (km)	Apollo 15 (km)	Apollo 16 (km)
Khan et al (2000)	45			
Lognonne´ et al. (2003)	30			
Chenet et al. (2006)	33.4	31.1	35.1	38.0
Our Model	48.2	48.2	48.4	65.6

Compared with limited seismic results, the crustal thicknesses obtained from the gravity and topography data are overestimated. However, the mean thickness of our model is significantly smaller than all other results from gravity and topography data, so the results are considered to be closest to the “true values”.

References: [1] Toksöz, M. N.,et al. (1974), *Rev. Geophys., 12(4)*, 539–567. [2] Nakamura, Y., G. Latham, D. Lammlein, M. Ewing, F. Duennebier, and J. Dorman (1974), *Geophys. Res. Lett., 1*, 137-140 [3] Nakamura, Y., F., et al.(1976), *J. of Geophys. Res., 81*, 4818-4824. [4] Wieczorek, M. A., and R. J. Phillips (1997), *J. Geophys. Res., 102*: 10933–10943.[5] von Frese, R. R. B.,et al. (1997a), Geophysics, 62, 1, 342-351.[6]von Frese, R. R. B., L. et al. (1997b), J. Geophys. Res., 102: 25657– 25676.[7] Potts, L. V. (2000), Ph. D. thesis. Ohio State Univ., Ohio, USA.[8] Wieczorek, M. A., and R. J. Phillips (1998), *J. Geophys. Res., 103(E1)*: 1715-1724.[9] von Frese, R. R. B., et al.(1981), *J. Geophys., 49*: 234–242