LUNAR REGOLITH DEPTH MEASUREMENT BY PASSIVE MICROWAVE RADIOMETER ONBOARD CHANG'E ORBITOR. S. B. Chen[1] and Z. G. Meng1. [1]College of Geoexploration Science and Technology, Jilin University, 6 Xi Minzhu Str., Changchun, China. chensb@jlu.edu.cn

Introduction: Lunar regolith covers virtually the entire lunar surface, which has been imaged, cored, walked on, modeled and studied (Wilcox et al.2005). The depth of the regolith have attempted to be determined by using small crater morphology, the blockiness of craters over a range of sizes, and number of craters per unit area (Quaide and Oberbeck 1968, Shoemaker and Morris 1969). Regolith depth has also been examined seismically. At the Apollo 12, 14, and sites, three-dimensional nature of the regolith was gleaned incidentally from passive seismic experiments. At the Apollo 14, 16, and 17 sites, active seismic experiments were designed to provide regolith depth. However, the depth in a small area or landing sites were just determined.

Chang'e orbitor was the first unmanned Chinese lunar orbiting spacecraft, which was launched on October 24, 2007. It carried 24 pieces of equipment, including a CCD stereo camera, microprobe instruments and a high-energy solar particle detector. Passive microwave radiometer is the first time to be sent to lunar orbit for detection of lunar regolith depth by the measured bright temperature at 4 channels (3.0GHz, 7.8GHz, 19.35GHz, 37GHz) (Jin 1998, 2007, Lan et al. 2004).

In this study, based on a multi-layer lunar surface model, the bright temperature at 4 frequecies are simulated by the microwave radiant theorem in a solid medium. A look-up table is generated by the simuluted results for the retrieval of regolith depth. And the lunar regolith depth are detected by the passive microwave radiometer data on Chang'e orbitor.

Theoretic Algorithm: The physical model of lunar regolith is constructed (Meng et al. 2008), which has thermal grads, changeable dielectric constants and rough upper surface (Figure 1).

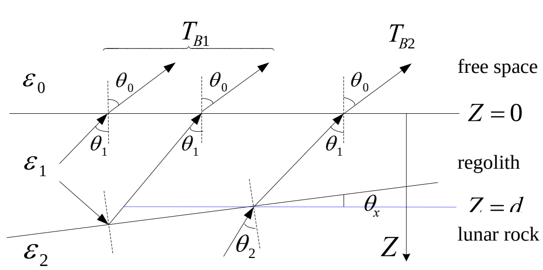

Figure 1. Microwave radiative transfer model in lunar regolith

Based on the passive microwave radiative transfer within the solid medium, the equation of passive microwave emission in lunar regolith follows as

$$T_B = T_{B1} + T_{B2} = T_{1up} + T_{1dn} + T_{2up} \quad (1)$$

where

$$dT_{1up} = \frac{1-r_{p1}}{1-L} k_{a1}(z) T(z) \sec\theta_1 e^{-\int_0^z k_{a1}(z')\sec\theta_1 dz'} dz \quad (2)$$

$$dT_{1dn} = \frac{(1-r_{p1}) r_{p2}}{1-L} k_{a1}(z) T(z) \sec\theta_1 \quad (3)$$
$$e^{-(\int_z^d k_{a1}(z')\sec(\theta_1+\theta_x)dz' + \int_0^d k_{a1}(z')\sec\theta_1 dz')} dz$$

$$dT_{2up} = \frac{(1-r_{p1})(1-r_{p2})}{1-L} k_{a2}(z) T(z) \sec\theta_2 \quad (4)$$
$$e^{-\int_d^z k_{a2}(z')\sec\theta_2 dz'} dz \cdot e^{-\int_0^d 2k_{a1}(z')\sec\theta_1 dz'}$$

Look-up Tables: By the theoretic algorithm, The look-up tables are generated by simulating the relationships between the measured bright temperature and lunar regolith depth.

Based on the above theoretic algorithm, the effect of thermal grads, dielectric constants, surface roughness, and obliquity of the under interface on lunar surface bright temperature is analyzed. Taking as an examples, the lunar regolith depth to bright temperatures are presented with exponential temperature grads, imaginary part of dielectric constants (ε_2 = 5.0 + i0.5), and no surface rounghness and obliquity (Figure 2).

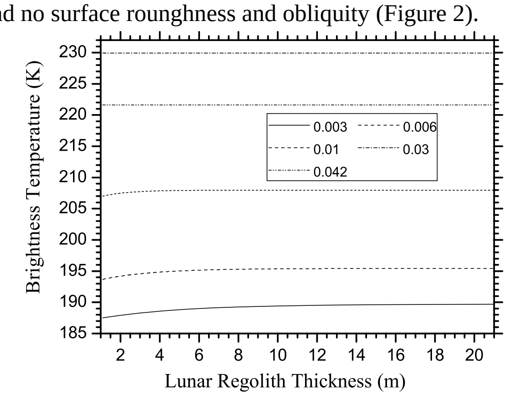

Figure 2. the relationship between BT and

regolith thickness under different imaginary

When the exponential temperature grads of lunar regolith are supposed, real parts of dielectric constants are taken to be 3.22, imaginary part of dielectric constants are thought to be within 0.003-0.04, the upper surface roughness is 0 or 0.1, the incident angle is 30 degree, the polarization is vertical, and the frequency is 3 GHz, thus a look-up table is generated for the retrieval of lunar regolith depth (Figure 3). Similarly, more look-up table can be generated for different lunar surface constant.

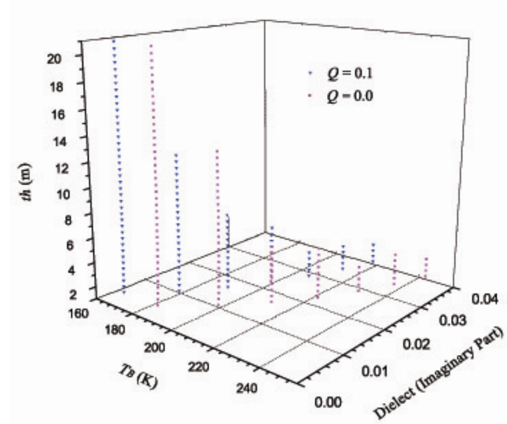

Figure 3. look-up table for retrieval of lunar regolith under some lunar surface constants

Retrieval Experiments: Based on different look-up tables and the measured bright temperature by passive microwave radiometer on Chang'e orbitor, the lunar regolith depth are determined. The retrieval depths of lunar regolith are presented in Figure 4.

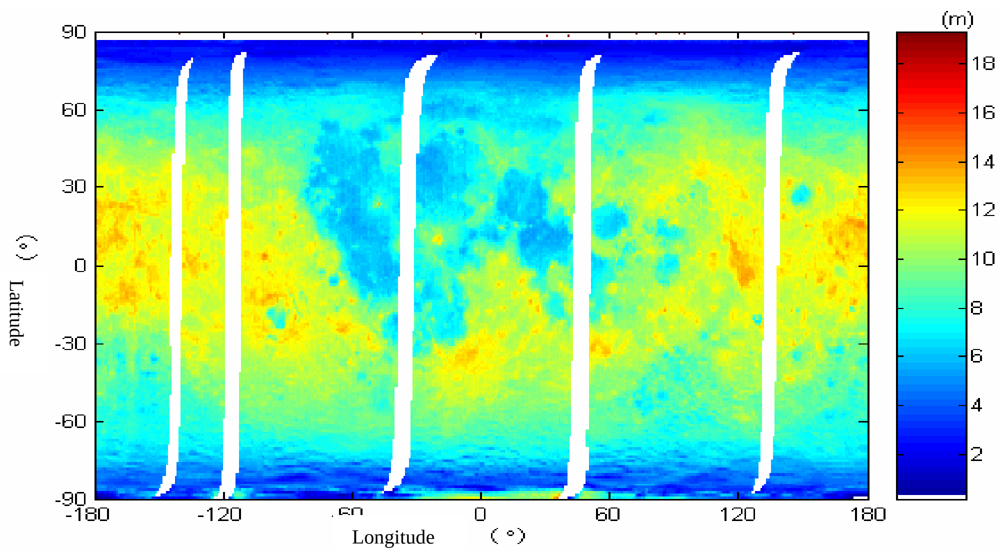

Figure 4. the retrieval depth of lunar regolith by look-up tables and the measured bright temperature by passive microwave radiometer on Chang'e orbitor

The retrieved regolith depths are validated by the depths at the landing sites of Apollo 11, 12, 14, 15, 16, and 17. The maximum difference is 3.3m at the landing sites of Apollo 16, and the minmum difference is 0.45m at the landing sites of Apollo 17. The average difference is 1.235m.

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