China Probe CE-1 Unveils the World First Moon-globe Microwave Emission Map — The Microwave Moon

---Some Exploration Results of Chang'E-1 Microwave Sounder

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Introduction: Until China Probe Chang'E-1 Lunar Microwave Sounder (CELMS) onboard China's first lunar orbiter had flown in the lunar orbit more than one year and have got huge lunar microwave data, there were no microwave emission information of the moon globe. Before retrieval from microwave emission information by global coverage of CELMS, the microwave features of globe moon, such as moon surface microwave brightness distribution, global regolith layer thickness, helium-3 deposit information and other information concerning lunar history, were obtained mostly by analyzing the very sparsely local in-situ data of Apollo and Luna landing sites, which makes the results much uncertain. So the moon nature is far from its real truth, especially for the far side of the moon. The new results CELMS probe, can make the moon more close to its nature truth, so it is a new milestone in lunar exploration[1][2].

With the CELMS, we have got the moon globe microwave brightness temperature (TB_L), and established the world first "The Microwave Moon (MicM)" [3]. The microwave moon values importantly not only for lunar resources and applications, but also for lunar science and cosmic science.

Some New Scientific Results of CELMS: As a main result of CELMS, MicM is established world first and it provides several types of TB_L maps with different projects: TB_L maps for interested local areas, craters, Mares and land; TB_L features of Apollo landing sites; Lunar South and North Pole TB_L anomalies, etc.

1 Global Microwave Brightness Temperature of Moon Surface (5)(6)

1.1 MicM Equidistant Cylindrical Projection

Using CELMS data we have created global TB_L maps for 3GHz, 7.8 GHz, 19.35 GHz and 37 GHz in equidistant cylindrical projection and orthographic azimuthal projection, respectively..

From these maps we can see some special features as following: For all frequencies in day and night, equator TB_L is much higher than other latitudes, and the higher the latitude, the lower the temperature

For a same frequency, TB_L differs much in different areas and TB_L of Mare is higher than land, moreover, there are some correlation between TB_L and elevation.

For different frequencies, it appears remarkable TB_L difference for a same area, and appears different features for day and night.

For a same area, high frequency TB_L of day is much higher than TB_L of night.

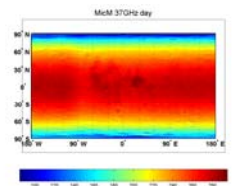

Fig. 1a. Eqdcyl in Maps for 3GHz Day

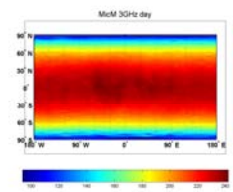

Fig. 1b. Eqdcylin Maps for 37GHz Day

For a same area, big day and night TB_L differences of 37 TB_L implies that the dielectric constant is high. For 3GHz, big differences of day and night TB_L means the regolith thickness is relatively thinner, which contains information of the internal structure and content of lunar regolith.

1.2 MicM in Orthographic Azimuthal Projection

We have created day and night MicM maps in Orthographic Azimuthal Projection for frequencie 3GHz and 37 GHz in night time for explanation. Fig 3 gives TB_L of near and far sides in 3GHz and 37 GHz in day.

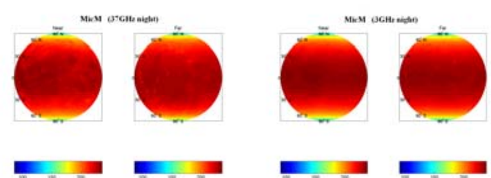

Fig. 2. Near and Far sides TBL in Ortho Project Map

From fig 2 we can see that the TB_L distribution for far- and near-sides follows global TB_L distribution law. But TB_L of far side is lower than near side in general, that may mean in the origin process of moon several billion years ago, temperature of far-side have been lower than the near-side. And during the long evolution history, regolith constitution, density, scatters and dielectric constant and internal structure and other properties of the far-side. have been formed differently from near side.

2 Lunar Regolith Layer Thickness Mapping and Estimation of Helium-3(Helium-3) Deposit in Moon Surface

Regolith Layer Thickness Calculation [4,5,6,11,12]: The layer thickness value estimated by different methods and different scientist differed significantly, since there were no global data references for such estimations.The regolith layer thickness value obtained by CELMS, based on global TB_L distribution and global dielectric constant, should be more accurate and more close to natural truth.

Estimation of Helium-3 Deposit in Lunar Surface(7,8,9) : To estimate Helium-3 deposits more accurately, it is very important to know more exactly about the global distribution of regolith layer thickness. Up to now, the estimation value, given based on Apollo site data, is around 1-5 million tons, although this estimation is much different from the results given by different scientists. CELMS estimation of Helium-3 was based on globally measured thickness data and dielectric constant data, therefore it should be a more accurate estimation. The CELMS result shows that the Helium-3 deposit should close to 1 million ton instead of 5 million tons[10].

This paper provides initiative results of the CELMS, from which we reached some new conclusions, differing from earlier results by other lunar scientists. The results are of great revolutionary value both for future lunar and cosmic science researches, which improves human knowledge to reach more closely to real nature of the moon.

Conclusions: 1. Using CELMS of China's Chang'E-1 lunar orbiter, China has been realized world first moon globe microwave observation and created moon globe microwave brightness temperature distribution map, with which the differences of far-side and near-side microwave features are analyzed as an emphasis. 2. MicM is established for the first time in the world by using moon globe TB_L data obtained by CELMS. The moon microwave brightness temperature reveals the effect of physical characteristics of lunar surface, lunar process, outer factors of the moon to moon evolutions, and an interactions between moon and the around environment. Through MicM research, we have got more knowledge about the change of moon internal consistence, the lunar surface and inner temperature distribution law, where the TB_L is the synthesized reflection of the regolith surface dielectric constant, surface layer temperature distribution in general. 3. Moon surface regolith layer thickness is estimateed more accurately using real measured moon globe TB_L, especially in calculation involved far-side microwave data obtained first time in the world and reached the average thickness up to 5-6 meters, which is thinner than earlier estimation of more than several tens even hundreds meters [16,17]. These results may concern moon evolution history[7]. 4. Moon globe Helium-3 deposit and a Helium-3 distribution map for global scale is created based on the retrieval from microwave TB_L distribution, with which Helium-3 deposit of lunar surface is estimated as closer to 1 million tons instead of 5 million tons [10]. 5. Up to now, many scientists make an assumption that the rock layer under the regolith will not affect to calculation of lunar surface brightness temperature and its effect can be ignored in modeling the moon surface structure for TB_L calculation [7,12]. CELMS results appear that these assumptions may not be correct. Actually the rock layer does affect to the surface brightness temperature and these effects must be considered in calculating the $TB_{L.}$ 6. In MicM investigation, we give more attention to the differences of the two half sides, the unique feature and anomalies of far-side microwave feature. As results, we have reached some innovative conclusions that is the TB_L for far-side is lower than near-side in general and the dielectric constant of area 40S-70S and 150W-150E is fairly low, which differs significantly from the Clementine results in which the dielectric constant of this area appears very high. 7. In research of MicM results, we give more attentions to the two polar regions, the main aim is to investigafe the possibility of water presence in permanent shadowed area, especially for the south pole. Our preliminary results show that until now we should not rule out a possibility of water presence in lunar polar regions.

References: [1] Jiang J S, Sun H X, Preliminary Analysis in Scientific Exploration of China First Lunar Probe; (In Chinese, English Abstract), Science and Technology at the Frontier in China, 11.2008, Higher Education Press ,2008,Vol.11:41-99; [2] Jiang J S. etc, Microwave Sounding the Lunar Soil from China Lunar Orbit Satellite Chang'E-1(CE-1)(C), Key Note Speech on 2008 International Conference on Microwave and Millimeter Wave Technology (JCMMT), April 21-24, 2008, Nanjing, China; [3] Jiang Jingshan, Wang Zhenzhan: The Microwave Moon---Microwave Sounding the Lunar Surface from China Lunar Orbiter CE-1 Satellite: 37th COSPAR meeting, Montreal, Canada, June 2008; [4] WANG Z Z, LI Y, JIANG J S, DONG X L, ZHANG X H, ZHANG D H, YIN X B, LIU J Y，2008b, A Microwave Radiative Transfer Model Applied to Lunar Soil Remote Sensing. ICEF2008, Chongqing, China; [5] Jiang J S, Wang Z Z, Li Y, Research on CE-1 Microwave Lunar Sounding Mechanism and Application [J], Engineering Science, 2008(10):16-21; [6] Wang Z Z, Li Y， Jiang J S, et.al., Methods of remote sensing Lunar surface by Microwave sounder on CE-1, 2008 International Conference on Microwave and Millimeter Wave Technology, Nanjing, China.2008,4: 21-24; [7] Shkuratov Y G，Bondarenko N V. Regolith Layer Thickness M aping of the Moon by Radar and Optical Data. Icarus, 2001,149 (2):32 9-338; [8] Li Dihui, Jiang Jingshan, Experimental Research and Statistical Analysis on the Dielectric Properties of Lunar Soil Simulators, Chinese Science Bulletin 2005, vol.50 no.10; [9] H SCHMITT, G L KULCINSKI: Helium-3: the Space Connection, WSCAR-TR-AR3-9304-2, April, 1993; [10] O. Y. Ziyuan, The Information on China Territory Resources. l. 2004; [11] Springer Netherlands: On the Depth of the Lunar Regolith, Earth Moon and Planets 0167-9295, Vol 1, Nov. 4, 1970; [12] Stuart Ross Taylor: Luanr Science, An Overview J. Earth System Science, 114 No.6, Dec. 2005, pp:587-591; [13] Bruce A. Campbell Comment on "Regolith Layer Thickness Mapping of the Monn by Radar and Optical Data" by Y,G.. Shuratov and N.V.Bondorenko. Icarus 158 560-561 doi;10.1006/icar2001.68073;