The Microwave Anomalies of the Lunar Far-side and South Pole---the Chang'E-1 Microwave Sounder (CELMS) Results

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Introduction: Chang'E-1 Microwave Sounder (CELMS) is a main payload of Chang'E-1 Moon Orbiting Satellite. CELMS is a four-frequency microwave radiometer in 3GHz, 7.8GHz, 19.35GHz and 37GHz. During the one year and four months' working period, it has got huge scientific data covering full moon surface and obtained the moon globe microwave emission feature, moreover, we achieved the world first microwave brightness temperature map in global scale and established the Microwave Moon (MicM) [1,2]. In our research we give more attention to the far-side of the moon and the two lunar poles, especially lunar south pole, some initiative results has been achieved which may be of revolutionary value for lunar science and cosmic science.

Some Discussions on Lunar Far-side: Since earth based radar can not observe lunar far-side, not until CELMS flew around lunar orbit, there was no knowledge on the lunar far- side microwave feature. CELMS has explored lunar far-side world firstly and through analyzing CELMS data we can see that the Microwave Brightness Temperature(TB_L) of far- side is lower than near side in general, which may mean in the origin process of moon several billion years ago, temperature of far side have been lower than the near-side. During the long evolution history, regolith constitution, density, scatters and dielectric constant and internal structure, etc. have been formed differently from near side The regolith layer thickness of far-side is thicker than near side [3]. The dielectric constant of area 40S-70S and 150W-150E is fairly low, which differs significantly from the Clementine results of which the dielectric constant of this area appears very high [3].

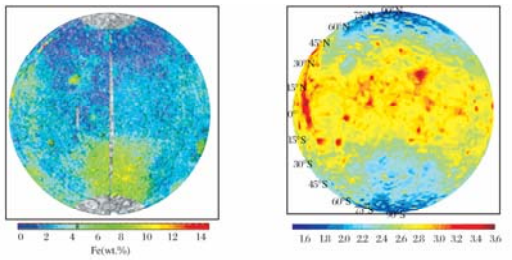
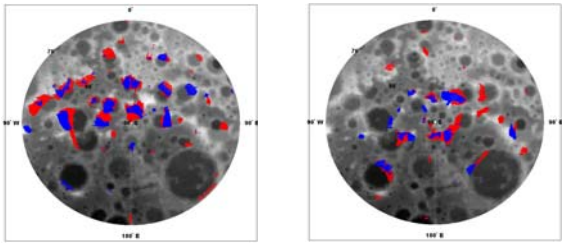


Fig. 1. Lunar far-side dielectric constant distribution

Lunar South Pole [4]: In "Back to the Moon" activities, many countries paid great attention to the two poles exploration to select appropriate landing sites and to establish the lunar base or "Human Country". For this purpose, "water" is a key condition for base site. According to results from Clementine and LCROSS experiment etc, U.S. scientists asserted that water DOES EXIST in permanent shadow area of South Pole. In our research, we give more attention to the two poles, the main aim is to investigate the possibility of water presence in permanent shadowed area. In this paper, we only focus on the South Pole and intend to identify the potential area where it locates plenty of thermal resources or has the possibility of ice deposits. So we assume that regolith thickness at LSP is relatively uniform or has only ignorable influence on microwave emission characteristics if it is not absolutely uniform. Using CELMS data, we just give the TB_L of the two poles and several areas of TB_L anomalies which may be helpful for seeking ice water in poles, and also analyze the microwave features of LCROSS impact area—CABEUS.



Places where the brightness temperatures deviate from the latitude-averaged brightness temperatures less than -10K. (Red color represents data in day time; blue color represents data in night time) .

Places where the brightness temperatures deviate from the latitude-averaged brightness temperatures bigger than 10K. (Red color represents data in day time; blue color represents data in night time)

Places where the brightness temperatures deviate from the latitude-averaged brightness temperatures less than -10K are mostly located in the centers of craters or shadows of crater rims, which may be related to ever-dark area. Places where the brightness temperatures deviate from the latitude averaged brightness temperatures bigger than 10K are mostly located the higher altitudes, which may be related to ever-illuminated area.

Fig. 2. Anomaly of Microwave Temperature at Lunar South Pole (left fig-2a, right fig-2b)

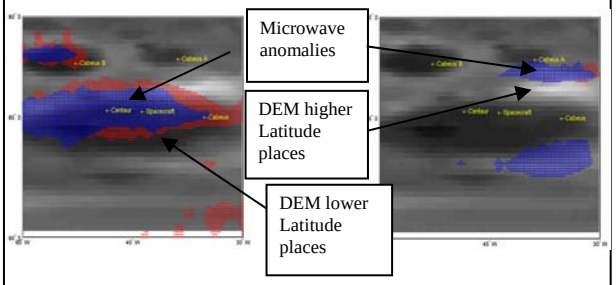
Bussey et al.[5] had studied on illumination resource at LSP. They calculated percentage of illumination within -88 degree at LSP and thought their works can be improved but need other kinds of data source.

Based on former analysis, we calculated distribution of deviation from brightness temperature to latitude averaged brightness temperature, which is shown in figure 2. All data including acquired in day and night time are illustrated. This map represents distribution of microwave brightness temperature hot points and cold points at LSP. By using all in-situ temperature profile measurements (Apollo and Luna mission) in multiple layer microwave radiative transfer model, variation of simulated brightness temperature is less than 10K when regolith thickness changes from 1meter to 10 meters. So we filtered out places or points where its brightness temperature variation is within 10K. and shown places where brightness temperatures deviate from latitude averaged brightness temperature biger than 10K.(fig.2-b) that places may be related to ever illuminated area. and places where brightness temperature deviates from latitude averaged brightness temperature less than -10K(fig.2-a). that places may be related to ever shadowed area. Ice deposit may exist in these areas.

Many techniques had been adopted to investigate ice deposit issue at LSP, such as Clementine bistatic radar, Lunar Prospect, SMART-1, Selene, and ground based long wavelength radar. But all have the common problem that the data can be interpreted in diversity directions. Based on analyzing characteristics of microwave radiometry at LSP, we draw out places where ever shadowed area may exist and various kind of ice may deposit. Using CELMS results, we analysed microwave features of LROSS impact area CABEUS and the CELMS analysis shows that the impact area IS THE permanent shadowed area and WATER may exist in this area (fig.3).

According to CELMS data analysis, we have reached a conclusion that it can not rule out a possibility of water existing in lunar pole.

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 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; [3]. Wang Z Z, Li Y, Jiang J S, Lunar surface dielectric constant, regolith thickness and helium-3 abundance distributions retrieved from microwave brightness temperatures of CE-1 Lunar Microwave Sounder[J], CHINA Science D, 2009(8); [4]. Zhang W G, Jiang J S, Analysis for the microwave emission distribution and traits in the south pole of the moon, CHINA Science D, 2009(8):1059-1068; [5]. Bussey B., Spudis P., Small spacecraft exploration of the Moon. Acta Astronautica 2007, 55, 637-64.



Places where the brightness temperatures deviate from the latitude-averaged brightness temperatures less than -10K in the impact areas. (Red color represents data in day time; blue color represents data in night time.)

Places where the brightness temperatures deviate from the latitude-averaged brightness temperature bigger than 10K in the impact areas. (Red color represents data in day time; blue color represents data in night time)

Base map uses CE-1 Laser Altimeter DEM data, which may have orbit determination deviations with CELMS data: lower brightness temperature anomaly areas are not entirely coincide with the DEM data at lower latitude areas, so as the higher areas. The deviation of latitude is about 1º.

Fig. 3. Microwave features of CABEUS