Earth and Planetary Science Letters 295 (2010) 287–291

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

journal homepage: www.elsevier.com/locate/epsl

Lunar regolith thermal behavior revealed by Chang'E-1 microwave brightness temperature data

Kwing L. Chan [a], Kang T. Tsang [a,*], Bruce Kong [a], Yong-Chun Zheng [b]

[a] Center for Space Science Research, Hong Kong University of Science and Technology, Hong Kong, China
[b] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China

ARTICLE INFO

Article history:
Received 7 September 2009
Received in revised form 2 April 2010
Accepted 8 April 2010
Available online 10 May 2010

Editor: T. Spohn

Keywords:
Moon
microwave
brightness temperature
Chang'E-1
data
map

ABSTRACT

Microwave brightness temperature data obtained by the Chinese Chang'E-1 lunar orbiter are analyzed with the lunar diurnal variations filtered. Resulting maps from the high frequency microwave channel show lunar topographic signatures with close similarity to those seen in Clementine's lunar topography maps, while the low frequency channels reveal intriguing lunar surface properties not previously observed. Here we focus on two characteristics displayed by the filtered brightness temperature maps: in the high frequency maps the existence of an anti-correlation between daytime and nighttime brightness temperature deviations in certain regions (especially in the lunar maria), and in the low frequency maps the appearance of cold spots which correspond with the hot spots observed in the infrared during lunar eclipses.

1. Introduction

Chang'E-1 (CE-1), the first Chinese lunar orbiter, was launched on October 24, 2007 and operated until March 1, 2009 when it crashed onto the surface of the Moon in a controlled impact. During CE-1's life time of more than a year, it covered the entire surface of the Moon many times in a precessing polar orbit 200 km above the lunar surface, transmitting 1.38 terabytes of data to Earth. In this letter, we describe the initial results from our analysis of the data obtained by CE-1's Lunar Microwave Radiometer (MRM).

Ground-based microwave brightness distribution maps of the nearside of the Moon had been obtained since the pre-Apollo era (e.g. Coates, 1961; Gary, 1967; Moffat, 1972; Schloerb et al., 1976). Compared to infrared radiation, microwaves originate from deeper layers and contain information about the physical properties of the regolith below the surface. Radar studies can probe deep and produce high-resolution maps (e.g. Zisk et al., 1974; Margot et al., 2000; Campbell et al., 2007), but do not provide information about the thermal behavior of the regolith. From space, lunar brightness temperature data were derived (Lawson et al., 2000) from images acquired by the Clementine's Long Wavelength Infrared camera (Nozette et al., 1994). Recent lunar orbiters, KAGUYA (Ono et al., 2009) and Chandrayaan-1 (Goswami and Annadurai, 2008), have obtained active radar images of the Moon. CE-1's microwave radiometry dataset is the first obtained from a passive sensor in lunar orbit, and covers the entire Moon in unprecedented spatial resolution and temporal span. Here, we show that when the diurnal variations of the brightness temperatures (TB) are filtered from the data, the resultant maps demonstrate detailed correspondence with lunar geographic features.

The DIVINER experiment on board Lunar Reconnaissance Orbiter is making high-resolution and global observation of the Moon in the spectral range 0.3–200 μm. Its year-long mission will provide important data about the surface temperature distribution and variation over most of the lunar diurnal cycle. The information can provide surface boundary conditions for further interpretation of CE-1's microwave data set.

The microwave thermal emission from the lunar surface layer is affected by a number of physical parameters including the dielectric constant, loss tangent, thermal conductivity, density, heat flow, and heat capacity (Krotikov and Troitsky, 1964; Keihm and Langseth, 1975a; Schloerb, et al., 1976; Naugol'naya and Soboleva, 2001). These physical parameters are in turn related to constituents of the regolith including metal abundances (especially that of titanium) and rocks of different sizes (Fisher and Staelin, 1977; Mendell and Wieczorek, 1993). CE-1's microwave data will be important for constraining the ranges of the physical parameters and for studying the physical/chemical environment of the lunar surface layer. This represents a large number of applications. The aim of the present letter is only to

* Corresponding author. United International College, Zhuhai, China.
E-mail addresses: maklchan@ust.hk (K.L. Chan), k2tsang@gmail.com (K.T. Tsang).

0012-821X/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.epsl.2010.04.015