IMPLANTED HELIUM-3 ABUNDANCE DISTRIBUTION ON THE MOON. Yongchun Zheng[1], Ziyuan Ouyang[1], D. T. Blewett[2], [1]National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China (e-mail address for first author, zyc@bao.ac.cn), [2]Hawai'i Institute of Geophysics and Planetology, University of Hawaii, 2525 Correa Road, Honolulu, Hawaii 96822, USA.

Introduction: Helium-3 (^3He) is expected to be the cleanest fuel of choice for potential 21st century fusion reactors, because its reaction is efficient and produces low residual radioactivity. ^3He is very rare on the Earth and much concentrated in the lunar regolith. It is possibly the most valuable resource on the Moon.

As we had known, the mineral ilmenite [$FeTiO_3$] retains helium much better than other major lunar materials. The more mature soils should contain high concentration of ^3He, because they have been exposed to the solar wind longer and contain greater amounts of fine-grained aggregates that absorb ^3He. A map of implanted ^3He abundance distribution on the Moon is constructed in this paper. The map is calibrated using a correlation between the ^3He concentration and the TiO_2 concentration and maturity index Is/FeO of lunar regolith.

The distributions of the TiO_2 concentration and the regolith maturity Is/FeO are derived from the multi-spectral lunar digital image model (DIM) of the Moon in five spectral ranges (415, 750, 900, 950, 1000 nm wavelengths), which was obtained.

Data Source: This multi-spectral lunar digital image model (DIM) of the Moon is a radiometrically and geometrically controlled, photometrically modeled global image mosaic compiled using more than 400,000 images from multiple filter observations of the UltraViolet-Visible (UVVIS) camera onboard the Clementine Spacecraft.

The DIM mosaic is mapped in the simple_cylindrical projection at a spatial resolution of 100 meters per pixel. Final PDS (Planetary Data System) data set archive volumes CL_4001 through CL_4078 were produced in July, 1999 by a group led by the U.S. Geological Survey (USGS) branch of astrogeology at flagstaff, Arizona

(http://pdsmaps.wr.usgs.gov/maps.html)

Algorithm: Taylor (1994) found that the abundance of ^3He in the lunar regolith at a given location depends on surface maturity, and titanium content, because ilmenite *($FeTiO_3$)* retains helium much better than other major lunar minerals. He proposed a correlation between the abundance of ^3He and TiO_2 content and maturity index *Is/FeO* of lunar soil from the statistical analysis of the measurement of Apollo lunar soil sample [1]. The abundance of ^3He in the lunar regolith is determined by:

$$^3\text{He (ppb)}=0.2043\,[(\text{Is/FeO})\times \text{TiO}_2]^{0.645}$$

The abundance of TiO_2 in the lunar regolith is determined by [2]:

$$\text{TiO}_2\,\text{wt\%}=3.708\times[\theta_{\text{Ti}}]^{5.979},$$

$$\theta_{\text{Ti}}=-\arctan\left\{\left[(\text{R}_{415}/\text{R}_{750})-y_{0\text{Ti}}\right]/\left[\text{R}_{750}-x_{0\text{Ti}}\right]\right\}$$

Where, $x_{0\text{Ti}}$ =0.0, $y_{0\text{Ti}}$ =0.42 and coefficient of determination r^2=0.911.

R_{750} and R_{950} are the Clementine multispectral optical reflectance values of a remotely observed location at the wavelength of 750 nm and 950 nm. The algorithm was developed by Lucey et al. [2].

The ferromagnetic resonance (FMR) surface exposure (maturity) index I_s/FeO (the ratio of the value of the intensity in arbitrary units of the FMR resonance at g equal to about 2.1 to the FeO concentration) is recognized as the best maturity index for lunar regolith. Based on the statistical analysis of values of I_s/FeO for 164 Apollo surface and trench soils and six Luna 24 core soils obtained by Lunar Soil Characterization Consortium, I_s/FeO can be determined by [3]:

$$\log I_s/\text{FeO} = -0.200\text{R}_{750} + 0.161\text{R}_{950} + 0.018\text{R}_{1000} + 1.960$$

Where coefficient of determination r^2=0.92.

Discussion: We have developed a map of helium-3 abundance of the Moon (Figure 1) based on a combination of the titanium content (Figure 2) and maturity index (Figure 3) of the lunar soil. The highest ^3He abundances occur in the farside maria (due to greater solar wind fluence received) and in higher TiO_2 nearside mare regions. The highest concentration of ^3He is observed in the western regions of Mare Tranquillitatis.

For the Earth should shields the Moon's near side from the solar wind for a portion of each solar orbit, solar wind-implanted particles are more abundant on the far side. However, the algorithm of ^3He abundance in the lunar regolith was based on the measurement of Apollo lunar soil sample. All of the samples were obtained in the near side. Thus the algorithm might be not consistent for the far side. ^3He abundance map of the Moon should be refined in the next work.

Considering the limitation of aerospace technology in the first thirty years of the 21st century, only the resource of the near side might be utilized in the future. The map of ^3He abundance in the lunar regolith is valuable for our selection of lunar landing site and lunar base. In addition to that, where is higher ^3He

abundance, suggest that where is higher ilmenite content and more mature soil. ^{3}He abundance is an important reference for site selection of lunar base.

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References: [1] Taylor L.A., (1993) *Proc. 2nd Wisconsin Symp. Helium-3 and Fusion Power*. 49-56. [2] Lucey P.G. et al. (2000) J GR-Planets, 2000. 105(E8): 0297-20305. [3] Pieters C. et al. (2006) Icarus, 184: 83-101.

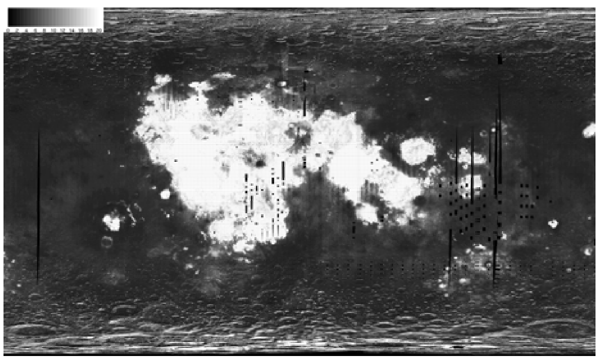

Figure 1. The TiO_2 content (wt.%) distribution of lunar surface, which is calculated from lunar optical reflectance.

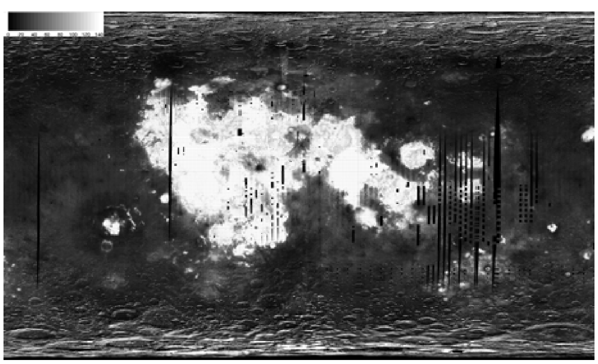

Figure 2. Surface exposure (maturity) index I_s/FeO of the lunar regolith on the Moon

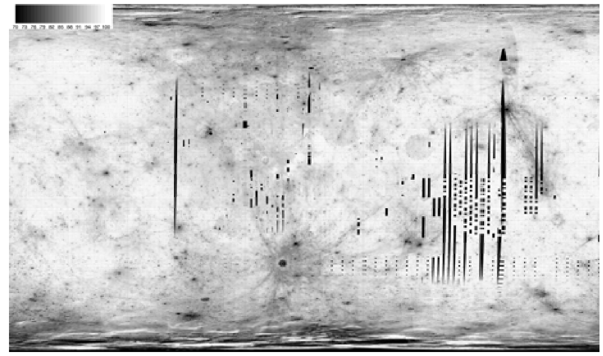

Figure 3. A map of implanted helium-3 abundance distribution on the Moon