

DEPTH OF 3- μm LUNAR ABSORPTION BANDS: THE EFFECT OF SURFACE BRIGHTNESS

L. V. Starukhina, Astronomical Institute of Kharkov National University, Sumskaia 35, Kharkov, 61022, Ukraine, starukhina@astron.kharkov.ua

Introduction: IR spectroscopy near 3 μm is one of instruments for search of water on the lunar surface. However, 3 μm absorption can be due to OH-groups formed in chemical trapping of solar wind (SW) protons on dangling bonds of oxygen in the implanted zone damaged by ion bombardment. This hypothesis was supported by theoretical simulation [1-3] as well as by experiments [4-7] before the discovery of 3 μm absorption on the Moon [8-10]. Deeper band depths in polar regions were explained by stronger retention of the implanted SW protons with decreasing temperature [1-3]; local variations of the depth being due to variance of retention ability with surface material. Mapping of the absorption depth over the lunar surface [11] stimulate further analysis of the observed spatial variations.

Theoretical modeling of lunar 3 μm absorption: *Shape and position of 3 μm absorption.* The shape and depth of the SW-induced 3 μm feature for the Moon was simulated in [12] on the base of spectral model for regolith [13]. Calculations have shown that the deepest 3 μm feature observed in [9] can be obtained at reasonable values of surface concentration of OH $n_s = 2 \cdot 10^{17} \text{ cm}^{-2}$.

3 μm absorption is most probably due to OH, because H_2O molecules in silicates dissociate into OH and H ions [14], so the shift of the band minima from $\sim 2.8 \mu\text{m}$ to $\sim 2.9 \mu\text{m}$ observed for highland-type material [11] may be due to difference in surface mineralogy. The band shape and width were reproduced in [12] taking account of different vibration frequencies of OH (between 2.7 and 3.5 μm [5-7]) located near different cations in various positions in complex atomic structure disordered by ion bombardment. In present work, such calculations are carried out for varied reflectance of regolith and OH abundance.

Surface brightness effect on the depth of 3 μm band.

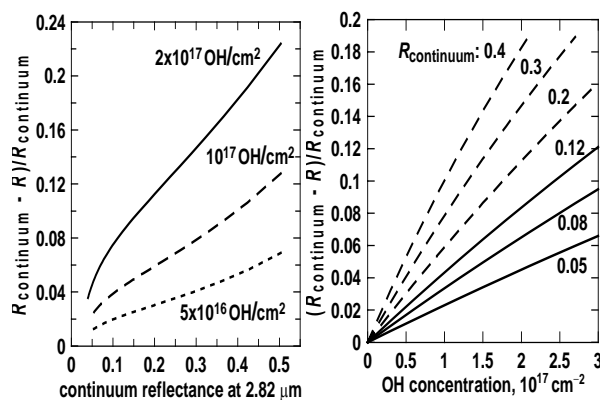


Fig. 1.

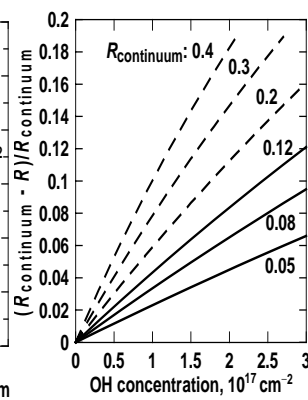


Fig. 2.

In Fig. 1, calculated 3 μm depths are shown vs. reflectance of regolith at different surface concentrations n_s of OH. The range of OH abundance is from $5 \cdot 10^{16} \text{ cm}^{-2}$, typical of trapped hydrogen in lunar regolith particles from low-latitude regions [15], to $2 \cdot 10^{17} \text{ cm}^{-2}$, which is lower than $5 \cdot 10^{17} \text{ cm}^{-2}$ obtained as saturation value for hydrogen implanted into olivine and enstatite in laboratory experiments [16]. In Fig. 2, OH abundance are varied and 3 μm band depths are shown for different values of continuum reflectance of a powdered surface. The upper (dashed) and the lower (solid) lines present highland-like and mare material, respectively.

The calculated 3 μm depth ranges are in consistence with M^3 observations [11]. The lower (dot) line in Fig. 1 covers 2.8 μm depth range 0.015-0.045 observed for equatorial regions in reflectance range 0.067-0.32 and $n_s = 5 \cdot 10^{16} \text{ cm}^{-2}$ typical for such regions. The deepest absorption (0.1-0.2) shifted to longer wavelengths is observed in polar regions. There highest OH abundance (due to lower temperatures) and bright highland material dominate (see the top right corner of Fig. 2).

Conclusions: The observed spatial variations of the OH absorption are due not only to dependence of outgassing rates on surface temperature and composition, but to variation of regolith brightness, brighter soils showing deeper bands than the darker ones at the same OH concentration on particle surfaces. Calculated variations of 3 μm absorption depth with surface brightness and OH abundance are consistent with those observed for lunar surface.

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