Preliminary examination of mineral structure effect on relative permittivity

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The surface of the Moon is covered with regolith formed by the bombardment of meteorites and micro-meteorites. Although drill core samples collected during Apollo missions revealed that the subsurface (1-2 m) structure changes vertically over centimeter to meter scales at landing sites, deeper (> 10 m) structure and spatial continuity is still unknown. Ground Penetrating Radar (GPR) can detect potential variations in subsurface structure which result in permittivity contrasts, therefore, understanding of factors that affect the permittivity of the regolithis important.

Relative permittivity depends on multiple factors such as radar frequency, porosity, temperature, moisture content and chemical composition (e.g., Campbell and Ulrichs, 1969). Correlation between Ti and Fe concentration and the relative permittivity of Apollo samples was previously addressed by Shkuratov and Bondarenko(2001). On the other hand, Fa and Wieczorek (2012) reported that there was no correlation between chemical composition and relative permittivity althoughthe bulk density varied between samples in this study. Because previous workshave not focused specifically on the influence of mineral composition (while keeping bulk density and composition constant), we prepared samples to isolate the influence of mineral composition on relative permittivity.

Bulk density of regolith mostly depends on porosity and the constituent minerals among samples which have the same bulk chemical composition. Lunar regolith contains Fe- and/or Ti-bearing spinel minerals and other oxide minerals (e.g. ilmenite, magnetite, armarcolite), andthe abundance of those minerals depends on the sample. Differences in abundance of constituent minerals indicate different origins of precursor rocks. If we can detect the permittivity contrast resulting from those mineral differences, it could help further our understanding of the subsurface structure and evolution of surface of the Moon. Therefore, we examine whether crystal types of opaque minerals with the samechemicalcomposition affect the relative permittivity.

We prepare a mixture of rutile and iron oxide (II) to create same chemical composition as ilmenite. Porosities of samples are uniform (40%), therefore, densities of the mixture and ilmenite samples are 2.96 and 2.90, respectively. In order to avoid the effect of moisture content, samples are dried for a few days, and we then measure the relative permittivity using a coaxial probe in the range of 1 MHz to 6 GHz at room temperature.

There is a difference of relative permittivity of about 3.6-4.2 when comparing the mixture (10.6-10.7) with ilmenite (6.4-7.0). This result indicates that crystal structure can affect the relative permitivity.In this presentation, we will discuss the effect in more detail.

References:

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Keywords: relative permittivity, GPR, lunar regolith, ilmenite

