PROBLEMS IN INTERPRETING ELECTRICAL MEASUREMENTS FOR PLANETARY EM SOUNDING


Since the success of the Apollo missions to the Moon, interest towards future flights to Mars and other planets is increasing. Therefore study on effects of mineral content, texture, content of moisture or other liquids and of temperature on the electrical and EM propagation characteristics of rocks is becoming important.

All electrical measurements on lunar and terrestrial crystalline rocks indicate similar trends for most types. The variation of the dielectric constant or real relative permittivity ($K'$) with frequency is generally very small, the dissipation factor (D) or loss tangent generally decreases with frequency though some rock types show a slight increase around $10^4$ to $10^6$ Hz with a maximum around $10^5$ - $10^7$ Hz, and the real conductivity generally increasing with frequency. The electrical properties of mineral grains and grain boundaries are thought to be the main factors that determine the electrical characteristics of the rock. So far no clear evidence of the Debye Relaxation effect has appeared. Dispersed grains of conductive minerals such as ilmenite and iron, or voids also affect the electrical properties of the rock, but they are considered to be minor.

When liquid enters the grain boundaries of the rocks, its effect is very large at frequencies below the critical frequency (frequency at which the dielectric properties become important) if the liquid has a high conductivity. If its conductivity is low, it may be difficult to see any effect until the porosity of the rock becomes large. The effect of a large permittivity of the liquid, such as would be the case for water, would have a minor effect. However, if the measurement accuracy of EM sounding increases considerably in the future, there are a number of minor effects that can become important for exploration.

From high temperature measurements on rocks of the past, it seems possible to predict the existence of a critical frequency and a conductivity increase with temperature particularly below the critical frequency. This would mean an increase in attenuation of EM waves in high temperature rocks. "Increase of $K'$ with temperature" is the conventional concept. However, problems of micro-airgaps effects at the electrodes are suspected to exist in the measuring techniques that produce such results. It is suggested that the possibility of the existence of the micro-airgaps effect and methods to eliminate it should be considered.

Assuming that EM probing systems would be equipped with multi-frequency devices for frequencies from $10^2$ to $10^{10}$ Hz, detection of conductive liquid in the rock pores or high temperature regions in the subsurface, perhaps, has the highest possibility of success. If the measurement accuracy of the EM
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Probing systems is increased significantly, differentiation can be made between regions containing conductive liquids and high temperature. Also it should be possible to detect regions of low conductive liquids and type of rock texture. Under certain conditions detection of metallic minerals may also be possible.