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Basic study of dielectric dispersion of moist rocks at kHz to mHz range - dielectric dispersion observed in moist glass beads

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It has been commonly considered that moist rocks do not cause strong dielectric dispersion at frequency lower than kHz and thus they are considered almost pure conductor. However, some studies have presented the possibility that moist rocks show peculiar type of dielectric dispersion leading increase of dielectric permittivity in reciprocal proportion to frequency from kHz to mHz. Coplementary angle of loss angle, f, becomes frequency independent, and dielectric property is not dissipated even at mHz range. This phenomenon, may be termed 1/f type dielectric dispersion, is observed for brine-saturated sandstone and granite (Lockner & Byerlee, 1985, Lesmes & Morgan, 2001), and moist sands (Shahidi et al., 1975) and the angle f was of the order of 10ˆ-2 radian. However, few works has been done on this dispersion phenomenon and the mechanism of dielectric dispersion is not yet clarified.

This work is intended to establish the mechanism and property of 1/f type dielectric dispersion, employing the moist glass beads as an artificial imitation of moist rock. The change of complex dielectric permittivity by saturation and salinity of water is studied to inspect the the mechanism of conduction of electric charges and dielectric polarization.

Glass beads of 1mm in diameter was moistened by 10ˆ-2 to 10ˆ-4 mol/l NaCl water at different saturation from 0.01 to 0.5. The sample was put in the cylindrical cell and complex dielectric permittivity was measured by four electrode method at 0.1 Hz to 10 kHz. The samples showed 1/f type dielectric dispersion and the angle f was of the order of 10-2 radian. Change of complex dielectric permittivity showed that at saturation lower than 0.1, electric current is mainly conducted through electric double layer (EDL) developed at the water-glass interface, and the angle f increases as the electric conductivity increases. It suggests that migration of ions through EDL causes dielectric polarization. At saturation larger than 0.1, the angle f is decreased as electric conductivity increases, following the relation f = - 0.01 log s + b. The decrease of f is considered due to the increase of electric current conducted through bulk water which is regarded as pure conductor.

It was shown that moist glass beads 1/f type dielectric dispersion. The mechanism of dielectric polarization is not clear but is related to the conduction of ions through EDL developed at glass-water interface. The empirical relation between the angle f and electric conductivity s was obtained.

References

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