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Improvement of prospecting accuracy of subsurface structure by GPR using polarization and transmitted waves

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Visualization techniques of the subsurface structure using the electromagnetic waves have been used widely in many fields such as detecting underground pipe, existences of underground cave and fractures that can cause subsidence, excavation of archeological site, estimating geological structure, and natural resource exploration. Estimating subsurface physical properties such as dielectricity, electric conductivity, and magnetic permeability is indispensable to improve the prospecting accuracy, which can contribute to identify the subsurface materials in addition to geometrical properties of material boundaries. However, it is difficult to estimate such subsurface properties at the present because of strong heterogeneity concerning physical properties distribution and shape of stratum boundary.

For this problem, we developed a prototype system of Ground Penetrating Radar (GPR), termed POGRA (POlarimetry Ground penetration RAdar system) which separates transmission and receiving antennas. The merit of POGRA is that it can measure two types of microwaves: transmitted waves and two or more polarization waves by the arrangement of antennas. Transmission-type GPR (T-GPR) can receive the input signals more strongly than the traditional reflection-type GPR by reducing the travel distance of microwaves by half. Capability of the T-GPR was tested for a structure with caves under the water table: the T-GPR could detect the caves correctly. For a horizontal layer structure, geological box model was produced using many small boxes filled with sands whose dielectricity values were set as large, middle, and small by changing the water content. Polarization-type GPR (P-GPR) was applied to three layers structure, and dielectricity values of each layer were calculated. It was clarified that the dielectricity values could be obtained correctly for the structure in which the dielectricity increased with the depth.

Keywords: Dielectricity, Fresnel equations, Reflection coefficient, Transmittance, Geological model