Interpretation template for the integrated geophysical investigation

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Theoretical background or physical based models for an interpretation of geophysical survey results is necessary for converting velocity and resistivity to other geotechnical properties or soil type classification. If the physical theory was completely developed to simulate geophysical properties from others, any required parameters could be obtained by solving an inverse problem. However, subsurface is heterogeneous and too complicated to formulate perfectly, and the geophysical property is affected many factors; therefore, it is not easy to solve the inverse problem. In contrast, preparing an interpretation template by a forward modeling based on simple physics based models and obtaining the parameters by comparing the interpretation template and observation seems to be practical solution. This approach is called rock physics template analysis in the reservoir characterization, and it has been used for facies and fluid discrimination (Avseth et al., 2005). In this method, only few specific properties are target parameters and others are regarded as constant values. Nonetheless, it will be a useful and practical solution by selecting dataset before applying it. Especially, this method will be valuable when the data set has limited numbers of observations because inversion and statistical approach is more beneficial for a dataset that consist of many kinds of properties.

A cross-plot analysis is a basic tool for the integrated geophysical survey. Particularly, S-wave velocity and resistivity cross-plot is accepted for a river levee survey. Thus, we created the interpretation template for the cross-plot of S-wave velocity and resistivity to estimate clay content and porosity. The clay content ranging from 0 to 1 represents volume fraction of clay in a sand and clay mixture. It can be regarded as a soil type. Porosity is a fundamental property of soil to indicate volume fraction of each phase (solid, water, and air). Additionally, the porosity can be regarded as an index of looseness for the same soil type.

We adopt unconsolidated sand model (Avseth et al., 2005) for velocity model. The model is based on Hashin-Shtrikman lower bound that calculates the effective elastic property of a mixture of two phases: one is solid and the other is an aggregate of grains. The elastic property of the grain aggregate is calculated by Hertz-Mindlin theory, but it sometimes overestimate for a sediment of shallow subsurface. Thus, Walton model is also available for it. The clay content is a parameter of the solid phase; therefore, S-wave velocity is associated with clay content.

In general, parallel circuit model is accepted to represent resistivity. Resistivity is not affected by soil type below water table, while soil type can be a dominant factor for unsaturated shallow subsurface soils. In the resistivity model, clay content and porosity are included in the conductivity of excess conductivity; therefore both parameters relate to the resistivity.

By calculating S-wave velocity and resistivity for any combinations of the clay content and porosity, we can create the interpretation templates for estimating clay content and porosity. Using the interpretation templates, we obtain soil type classification map and porosity distribution along a river levee.

S-wave velocity and resistivity are presently computed by considering only soil type and volume fraction of each phase. But, it is possible to calculate new template to estimate saturation by treating soil type is constant. In addition, using a range of uncertain input parameter, probabilistic interpretation template is also possible to be computed. Although it is difficult to implement whole theory in the model; instead, making interpretation templates from a simplified model will be effective for the interpretation of geophysical surveys.

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