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Joint Acoustic and Electrical Measurements for Unfrozen Water Saturation of Frozen Saline Soil

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Abstract. The climate change has aroused great concern on the stability and durability of the infrastructure installed on permafrost, especially for frozen saline clay with a large amount of unfrozen water content at subzero temperature. The joint electrical resistivity and acoustic velocity measurements are conducted for frozen saline sand and onsøy clay with 50% clay content and 20~40 g/L salinity in order to determine the unfrozen water content. A systematic program of tests involves the saline sand with different salinity, natural onsøy clay with the variable of temperature and freezing-thawing cycles and reconstituted onsøy clay with distinctive density and salinity. The data analysis of measurement results in combination with previous joint measurements for frozen soil resolves the effect of temperature, salinity, soil type and freezing-thawing cycles on the acoustic and electrical properties. An increase of temperature, fine content and salinity results in a decrease of both acoustic velocity and electrical resistivity. Electrical resistivity is sensitive to salinity, while acoustic velocity changes substantially near thawing temperature. We also find that both natural and reconstituted clay with similar water content and salinity show quite different acoustic velocity and electrical resistivity, which indicates that ice crystal structures are distinctive between natural and reconstituted samples. Besides, P-wave velocity is much more sensitive to the fabric change or induced cracks than electrical resistance during freezing-thawing cycles. In the end, acoustic models like the weighted equation (Lee et al., 1996), Zimmerman and King's model (King et al., 1988) and BGTL (Lee, 2002) are applied to the UWS estimates based on P-wave velocity and electrical models like Archine's law are adopted based on electrical resistance. Both estimated UWS from different methods is not always consistent. The difference can be up to 20%.

Keywords: Frozen Saline Clay, Acoustic Velocity, Electrical Resistance, Unfrozen Water Saturation

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