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Integrated Geophysical Examination of the CRREL Permafrost Tunnel's Fairbanks Silt Units, Fox, Alaska

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We report on a recent geophysical survey of the U.S. Army Corps of Engineers' Cold Region Research and Engineering Laboratory's Permafrost Tunnel in Fox, Alaska. The tunnel consists of an adit and winze excavated into late-Pleistocene loess (Fairbanks Silt), segregated lens ice, chaotic reticulated ice, foliated massive wedge ice, clear thermokarst cave ice, and gravel pseudomorphs. From within the tunnel and at land surface above the tunnel, we used ground-penetrating radar reflection and transillumination soundings, multielectrode and capacitively coupled resistivity profiling, and electrical resistivity tomography to identify geophysical signatures of permanently frozen loess and massive wedge ice. We exploited the increasing path length through the septum between the adit and winze in the direction away from their junction to observe how radar signals attenuate in these media. GPR transillumination soundings of this septum at 100, 200, 250, 500, and 1000 MHz clearly demarcated the difference between ray paths transiting relatively conductive permanently frozen loess versus those transiting relatively resistive massive wedge ice. Multielectrode resistivity tomography of the septum also clearly distinguished between massive wedge ice with estimated resistivities >100,000 ohm-m and permanently frozen loess with resistivities ranging from 4000 to 40,000 ohm-m. Capacitively coupled resistivity data gathered at land surface above the distal end of the adit show signatures consistent with its delaminating roof at this location. Analysis of dipole-dipole multielectrode resistivity data gathered at land surface with 48 electrodes and 2-m spacings produced adit-level resistivity estimates in the 10,000 to 26,000 ohm-m range. Both surface resistivity methods revealed the 0.75-1.0-m-thick seasonally frozen active layer above the tunnel to be relatively resistive (>1000 ohm-m) during midwinter. Core samples of foliated wedge ice, clear thermokarst cave ice with bubbles, segregated lens ice, microlenticular Fairbanks Silt, massive Fairbanks Silt, massive Fairbanks Silt with organics, and massive sandy Fairbanks Silt with organics were collected. Supporting laboratory measurements of a subset of these samples (Grimm et al., this meeting) indicate that the broadband electrical properties of permanently frozen loess can be described by the superposition of five relaxation mechanisms: defect rotation in ice, rotation of adsorbed water, transverse motion of charges in absorbed water, the Maxwell-Wagner effect due to salt hydrate conductivity, and an anomalous low frequency relaxation that is due to translation of charges in the absorbed water along silicate surfaces. This work was funded by NASA Mars Fundamental Research grant NNX08AN65G.

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