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Permanently installed 2D electrical resistivity array for monitoring permafrost beneath pavement, Dawson City, Yukon, Canada.

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Dawson City, Yukon, Canada is situated in an area of discontinuous permafrost at approximately 64N latitude. The community has a mean annual temperature of -5.3C and is situated on an alluvial floodplain consisting of fine-grained silt. Roughly half of the town is underlain by warm permafrost with temperatures of -1.0C to -0.1C. Soils consist of 2.0 to 10.0 m of frozen, fine-grained silts and sands overlying fluvial gravels. This permafrost is ice-rich, with soil gravimetric water contents of up to 200% and frequent occurrences of massive ice and ice-wedges. Many of the buildings in Dawson were built during the Klondike Gold Rush of 1898. Ground instability due to thawing permafrost is damaging these historic structures as well as more modern infrastructure designed for permafrost locations. This region of the Yukon Territory is projected to be subject to climatic warming of 3.0C to 4.0C over the next 30 to 70 years. Such warming would lead to serious degradation of the permafrost, placing much infrastructure at risk.

The main street of the town (Front Street) was paved in 2009 using local white quartz aggregate and a clear binder, which results in a light-colored pavement with high albedo. This lowers the amount of solar energy absorbed by the pavement, resulting in reduced heat transfer to the underlying permafrost. This is the most northerly application of this pavement technology. The effectiveness of the paving technique is being assessed using both borehole thermistors and three permanently installed two-dimensional direct current electric resistivity arrays. The arrays each consist of 28 electrodes at intervals of 1.0 to 6.0 m connected by armored multi-core cables which were buried beneath the roadbed prior to pavement placement. Resistivity soundings were taken monthly from each array using a 200 W automated switching resistivity system and produced depths of investigation from 5.0 to 30.0 m.

Resistivity contrasts between the unfrozen active layer (1 to 400 Ωm) and permafrost (500 to 100,000 Ωm) provided an indication of varying active layer depths across and along the center of the roadbed. These were correlated with borehole thermistor results. Rapid refreezing of the active layer in October of 2010 is indicated by a sudden increase in active layer resistivity. Resistivity differences delineate the boundary between gravel/ fill roadbed and ice-rich silt. The influence of the adjacent Yukon River talik is indicated by decreased resistivities of thawed ground at depth. Resistivity imaging using permanently installed arrays beneath infrastructure such as roadbeds, railways and buildings may be valuable in monitoring permafrost degradation due to climatic warming or surface disturbance. In these areas permafrost conditions can fluctuate rapidly over small distances and timescales and cause considerable infrastructure damage.