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Surprisingly low resistivity values in an ice-cored moraine in continuous permafrost, Svalbard

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An ice-cored moraine, Crednermorenen, located in continuous permafrost in Svalbard, was studied to assess the ice content for better geomorphological interpretation of the modern and former landscape development. Methods used include borehole temperatures, geomorphological mapping and 2D DC resistivity measurements. Crednermorenen is a 3 km^2 ice-cored lateral moraine located at sea level in the inner parts of Van Mijenfjorden (77.5ºN), near the coalmine Sveagruva. It is part of a large moraine system deposited by a major surge by the tidewater glacier Paulabreen at the head of Van Mijenfjorden, and the moraine is located 16 km from the present ice front. The surge most likely took place around 650 yr BP. Mean annual air temperature at sea level at Sveagruva was -8˚C in 2002-2004. The western part of Crednermorenen has typical dead ice topography, with many steep hilltops up to 30 m a.s.l. and small lakes. In summer back-wasting exposes glacier ice in niches and slopes. The eastern part of the moraine is flat and the surface gravelly apart from a zone containing stratified marine clays with a high salt content. This part is interpreted as consisting of sea-bed sediments pushed up during the glacier surge. Patches of similar marine sediment are incorporated in the western part of the moraine.

Four 8 m boreholes were drilled in different parts of the Crednermorenen, the blowup material logged and thermistor-strings installed. In one borehole ice was present from 2.7 m to the bottom, whereas the others did not contain massive ice. Temperatures at the borehole bottoms are typically between -4.5 and -6˚C, with an annual amplitude of up to 1˚C. The active layer thicknesses are between 1 and 1.7 m. The borehole thermal conditions indicate continuous permafrost at sea level. Six resistivity profiles, 200 to 400 m long, were measured on the Crednermorenen. Electrode spacing was 5 m, and a Wenner array was used. Three profiles crossed one of the boreholes, and

another was located close to an active back-wasting niche. The resistivity profiles in the glacial debris showed a low resistivity 100 – 400 Ωm surface layer interpreted as representing the active layer. Where ice is present the resistivities rise sharply up to 20.000 Ωm. The profiles indicate that the high resistivity layer of glacier ice at places is more than 30 m thick. Most of the eastern part of the moraine with marine sediments has resistivity values below 30 Ωm and the active layer cannot be identified from the resistivity values.

In the marine clay the low resistivities can probably be explained by the presence of unfrozen water due to high salt content in the sediment. The low resistivities for the glacier ice are difficult to explain. During surging glaciers gets heavily crevassed, and salt water can enter these crevasses changing the chemical composition of the ice when refrozen. This could lead to an irregular pattern of resistivities, however, this we have not observed. We suggest measurements of the chemical composition of the glacier ice in the exposures and direct measurements of the resistivities could be useful. Laboratory tests on the influence of salt in permafrost sediments and in ice would also be useful for improved use of the resistivity data for geomorphological interpretation.