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Surprisingly thick active layer of permafrost in the mountain slope in the SW Svalbard

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Two high arctic expeditions have been organized to use seismic methods to recognize the shape of the permafrost along inclined profile between the coast and the mountain slope in two seasons: with the unfrozen ground (October 2017) and frozen ground (April 2018). For measurements, a stand-alone seismic stations has been used with accelerated weight drop with in-house modifications and timing system. Seismic profiles were acquired in a time-lapse manner and were supported with continuous temperature monitoring in shallow boreholes.

Joint interpretation of seismic data using Multichannel analysis of surface waves, First arrival travel-time tomography and Reflection imaging show clear seasonal changes affecting the permafrost where apparent P-wave velocities are changing from 3500 to 5200 m/s. This confirms the laboratory measurements showing doubling the seismic velocity of water-filled high-porosity rocks when frozen. Independent refraction seismic analysis in two seasons shows in average 10 m thick sedimentary layer on top of compacted bedrock. In sediments P wave velocity is changing from 1500 m/s to 4000 m/s between seasons. Velocities in the bedrock are also changing from 4000 m/s to 5500 m/s. Moreover, tomographic interpretation shows that significant change in P wave velocities is observed down to 30 meters.

Such unusual active layer behavior is confirmed in in-situ thermal observations with above 0C temperatures at the depth of 19m. Those observations can be explained with strong underground flow during the frozen period confirmed with borehole.

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