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Seismic monitoring of thawing tundra

Presented by: Prof. Tor Arne Johansen – University of Bergen

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Virtual classroom: Join Zoom Meeting

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Abstract:

Temperatures in the terrestrial Arctic are today increasing at the highest rate on Earth, and heat flux into the cold sediments may result in extensive thawing. Thawing of frozen sediments reduces their mechanical strength and warming therefore has huge geomorphic consequences. We have combined heat flux, rock physics, and seismic modeling to estimate the change in elastic properties related to various published future climate scenarios in the Arctic, and thus investigate the feasibility of exposing thawing rates from seismic data. The heat flux model was validated using temperature data continuously recorded at the surface and within a well in Adventdalen, Svalbard, in the Norwegian Arctic. We estimated the evolving temperatures in an upper vertical section of the well using the heat flux model and compared with actual measured well temperatures. The modeled and measured data were consistent although our simplified model ignores heat transport due to fluid flow and the complicating effects of clay. Heat flux in sandy sediments depends on heat capacity, thermal conductivity, and volume fraction of the various constituents of the medium. Salinity and saturation of the pore fluid are particularly influential, which means that the origin of the sediments affects the heat flux extensively. Heat flux modeling resulted in subsurface isotherms that were input to rock physics modeling based on two-end member mixing of fully frozen and unfrozen elastic properties to delineate possible climate effects on the seismic properties of the sediments. The results show that elastic and seismic properties of (partly) frozen unconsolidated near-surface saline sediments are strongly dependent on heat flux into the subsurface and vary both seasonally and between different climate scenarios. Seismic data obtained by full waveform modeling and real experiments in Adventdalen show that time-lapse analysis of surfaces waves, as for instance Rayleigh waves, may be an efficient tool for monitoring heat flux into the terrestrial Arctic.

Biography:

Tor Arne Johansen received a PhD in geophysics in 1990 from the University of Bergen, Norway. He is currently a professor at Department of Earth Science at the University of Bergen and holds an adjunct professorship at The University Courses in Svalbard in the Norwegian Arctic. He has for decades been involved in research, supervision and teaching related to seismic reservoir characterization and seismic surveying in the Arctic. He has for the last 15 years regularly given courses on behalf of EAGE, SEG, CSEG and ASEG.