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Influence of brine filtration on thermal expansion of saline ice

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We develop a model of the thermo-mechanical behavior of saline ice, based on Darcy's law for liquid brine and an elastic model for the solid ice fraction. The coefficient of thermal expansion is calculated from the model equations and compared with experimental data. Experiments were performed with Fiber Bragg Grating strain and temperature sensors in the cold laboratories at UNIS and UCL in 2011-2013. In the experiments, the curve describing the dependence of the coefficient of thermal expansion on the temperature is always located in between the theoretical curves for saline and fresh ice. Such thermal behavior can be explained by the assumption that only some of the brine exists in enclosed pockets. The other brine exists in channels and can easily leak out of the ice. Brine in enclosed pockets controls the abnormal properties of thermal expansion. The remaining brine, in more permeable regions of the ice, has little effect on thermal expansion. Boundary conditions in our experiments may have a strong influence on the brine filtration. Several experiments performed with saline ice samples inside steel pipes gave a lower temperature for the point of zero thermal expansion than those with unconfined saline ice.