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Magnetic resonance imaging of freezing and melting of water in fully saturated porous media

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The freezing of water porous media is a complex process dependent, among other effects, on pore size distribution and shape of particles. Magnetic resonance imaging (MRI) of freezing and thawing process was performed on two samples of different porous materials, each one in two replicates. The soil freeze sample assembly consisted of two Plexiglas cylinders, the outer dimensions of the set-up was 6 cm in diameter and 12.5 cm high. The inner cylindrical container (3 cm in diameter, 6 cm high) was filled with the sample material. The inner cylinder was insulated by vacuum. On the top of the porous media, a glass disk (2.8 cm in diameter, 1 cm thickness) was placed to define the upper boundary of a material during freezing and thawing. One inflow tube and two outflow tubes at the top of the inner cylinder were used for circulation of cold nitrogen gas as a freezing medium to the top of the sample. The temperatures of the freezing medium were continuously recorded by the temperature sensors located outside of the MR coil. The first sample packing consisted of 72 glass beads, 0.8 cm in diameter immersed in the 1 mM/L GdDTPa2-•2Na+. In the second sample, the coarse sand was packed in 0.5 cm thick layers in the same sample solute. Total eight freezing-thawing cycles were performed and recorded on the samples. As a result, time-lapse series of 3D MR images were obtained. The geometric distortion of these 4D MR images due to magnetic field inhomogeneity had to be elaborated prior to the process analysis. The analyses of the freezing-thawing process on glass beads revealed interesting effects while thawing, where the thin layers on the glass beads surface exhibited faster melting in otherwise homogeneous ice. The impact of MRI heat transfers has to be evaluated. The freezing-thawing fronts recorded of sand samples were relatively uniform. Small changes in sand structure as a consequence of volumetric ice-water changes are studied. The spatiotemporal analysis of the frozen water volume is done. The data are available for a two-phase ice-water simulation models evaluation.