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Frost heave in compressible soils

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Recent frost heave experiments on compressible soils find no pore ice in the soil near the ice lenses (no frozen fringe). These results confirm early observations of Beskow that in clays the soil between ice lenses is “soft and unfrozen” but have yet to be explained theoretically. Recently it has been suggested that periodic ice lens formation in the absence of a frozen fringe may be due to a morphological instability of the ice–soil interface. Here we use this concept to develop a mathematical model of frost heave in compressible soils. The theory accounts for heave, overburden effects and soil consolidation. In the limit of a rigid porous medium a relation is obtained between the critical morphological number and the empirical segregation potential. Analytical and numerical solutions are found, and compared with the results of unidirectional solidification experiments.