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Steady-state mushy layers: Experiments and theory S. PEPPIN, P. AUSSILLOUS, HERBERT E. HUPPERT, M. GRAE WORSTER, Institute of Theoretical Geophysics, University of Cambridge — A new facility has been developed to investigate mushy layers formed during the steady directional solidification of transparent aqueous solutions in a quasi-two-dimensional system. Experiments have been conducted on NaCl–H20 solutions by translating a Hele-Shaw cell at prescribed rates between fixed heat exchangers providing a temperature gradient of approximately $1\,^0$C/mm. Ice formed the primary solid phase and the dense residual fluid ponded within the mushy layer at the base of the system. Mathematical predictions of the steady-state temperature profile and mushy layer thickness as functions of freezing rate are in excellent agreement with experimental results. Experiments have also been performed on aqueous NH4Cl solutions, with the salt forming the primary solid phase, yielding buoyancy-driven convection in the mushy layer and the development of chimneys. The lifetime of the chimneys increased with decreasing freezing rate; however, no steady-state chimneys have been observed. Rather, a convecting chimney appears to deplete the surrounding solution and is eventually extinguished. At freezing rates larger than about $5.5\,\mu$m/s a uniform mushy layer develops with no chimneys. However, at rates larger than about $5\,\mu$m/s a second mode of behaviour is observed in which the mushy layer is thin and there is significant supercooling and nucleation above it. There is hysteresis between the two modes.

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