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Solidification and Compositional Convection of a Ternary Alloy

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In an experimental study where an aqueous solution of potassium nitrate and sodium nitrate were cooled from below, two distinct mushy layers formed separated by a nearly horizontal interface. Fluid in the melt and the upper, primary, mush was kept well mixed due to compositional convection originating in the primary mush. Convection reduced the vertical concentration gradient in the primary mush layer allowing the cotectic mush to overtake the primary mush. At this point convection stopped and the growth of the single mush layer (cotectic) that remained was governed by diffusion. Concentration measurements showed good agreement with the evolution predicted by use of the linearized equilibrium phase diagram. We develop a global conservation model in this regime that accurately predicts the two mush interface positions when forced with empirical heat and solute fluxes. The identification of a density reversal in this system begins to address the complexities of solidifying multi-component alloys.

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