PLENARY LECTURE

SOLIDIFICATION OF SOLUTIONS AND COLLOIDAL SUSPENSIONS

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Grae Worster is a Professor of Fluid Mechanics at Department of Applied mathematics and Theoretical Physics, University of Cambridge. He is actively involved in research which encompasses broad areas such as buoyancy-driven fluid flows, solidification and interactions between the two. He is particularly interested in the evolution of reactive porous media called *mushy layers* that commonly form during solidification of multi-component melts. The work includes the partially solidified regions formed during alloy production, solidification of magmas and the freezing of sea water to produce sea ice. Latterly, his research has been particularly focused on ice in our natural environment: sea ice, permafrost and glacial ice sheets.

ABSTRACT

Whenever a multi-component fluid is solidified there is potential for the components of the fluid to be segregated. In castings of metallic alloys, for example, micro segregation typically occurs on the scale of a few hundred microns, with the solidification front convoluted within a mushy layer: a reactive porous medium of solid crystals bathed in residual melt. Similar behaviour is seen when the oceans freeze to form sea ice. Both of these are examples of solutions, and the mushy layers that form are composed of dendrites or platelets aligned with the temperature gradient. A much richer variety of microstructures is seen when a colloidal suspension of solid particles is solidified: at fast solidification rates, these systems exhibit behaviour similar to that seen in solutions, with dendritic crystals of the solidified suspending fluid compressing the solid particles into their interstices; at slow solidification rates, ice lenses can form perpendicular to the temperature gradient; at intermediate rates, various polygonal or chaotic modes of segregation are seen. I shall describe laboratory experiments that illustrate these phenomena as well as mathematical models of the thermodynamic and fluid mechanical interactions that constrain micro segregation in colloidal systems and cause macro segregation in alloys and other solutions