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FLOW CHANNELS IN SOLIDIFYING MATERIAL

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We have investigated the dynamics of flow channels in a flowing liquid while it cools and solidifies. The region separating melt and solid is a nonequilibrium *geodynamic structure*. The characteristics of drainage channels and their dynamics permeates earth science and many examples are known such as localization of volcanic eruptions, localization of sea floor hydrothermal vents, gas hydrate formation, gas hydrate dissolution along sedimentary continental margins, groundwater flow through calcareous sediments and surface drainage patterns from water. However, our strongest motivation has been stimulated by our petrologists who want to know how melt moves from a place where it was first formed by crossing a threshold in temperature and pressure space, to the place where it is picked up and brought back to a laboratory for measurement.

The final product of this research is the text **Lava Tube Instability** by Miranda C. Holmes, (Courant Institute of Mathematical Sciences, New York, NY), Myself, and Caleb J. Mills, e-Joint Program and eScription Inc., Needham, MA). The text is to be submitted to JGR.

Abstract: Long-lasting lava tubes are found in many settings for igneous flows. We ask, 'how far can the fluid flow and remain liquid?' Our laboratory experiments show that when a liquid flows in a container with the boundary temperature below freezing, a tubular drainage channel is surrounded by solidified material and the tube size changes in the flow direction. Also, when the flow rate drops below a fixed value the tube freezes shut. Pressure drop across the tube reaches a maximum near the freeze point. A theoretical model similar to a number of studies of injection molding is constructed. If the flux of fluid is imposed, then the tube can be infinitely long, but in that case there is a minimum pressure as flux is varied. For fixed pressure drop across the tube, this minimum determines the length of a stable tube of melt. However, in the common case where the upstream reservoir region is compressible and a relation between pressure and flow rate exists, a stable tube exceeds this length. This seems to explain the experimental pressure maximum near freezing. In the unstable range, the growing instability is oscillatory, which is not found in previous theories with more restrictive upstream conditions. This may help explain why such freezing flows become complicated easily, since the final freezing might happen at different phases of the cycle for nearly the same conditions. Therefore the distance traveled by melt in a lava tube is very sensitive to the conditions that govern pressure and flow rate at the upstream end.