Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

A phase-field model for capillary bulldozing LIAM MORROW, OLIVER PAULIN, MATTHEW HENNESSY, CHRISTOPHER MACMINN, University of Oxford — The invasion of non-wetting gas into a horizontal, liquid-filled tube or Hele-Shaw cell is a classical problem in fluid mechanics that has been studied extensively from a variety of perspectives. However, the addition of a sedimented granular material to the defending liquid phase can fundamentally change the mechanics of the problem by introducing friction, leading to a class of "multiphase frictional flows" that remain relatively poorly understood. For example, recent experiments [Dumazer et al., 2016, PRL] show that, in a capillary tube, the motion of the gas-liquid interface will bulldoze the granular material, accumulating a pile of grains on the liquid side of the interface that will grow until it forms a plug and clogs the tube. Here, we present a thermodynamically consistent phase-field model for capillary bulldozing. The model involves three phases – gas, liquid, and liquid-solid mixture – and takes the form of a coupled pair of nonlinear conservation laws and a linear elliptic equation for the velocity of liquid-solid mixture. We solve our model numerically for a variety of different scenarios to develop insight into the roles of sliding friction, rearrangement, capillarity, viscosity, and plug formation during capillary bulldozing.

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Date submitted: 02 Aug 2020 Electronic form version 1.4