Abstract Submitted
for the DFD12 Meeting of
The American Physical Society

Trapped subsurface oil plumes and critical escape phenomena[1]

CHUNG-NAN TZOU, ROBERTO CAMASSA, ZHI LIN, RICH MCLAUGHLIN, KEITH MERTENS, BRIAN WHITE, University of North Carolina — A critical phenomenon concerning the escape/trap of buoyant miscible plumes rising through strongly stratified fluids is presented experimentally and theoretically. The criticality is determined by the distance between plume release height and depth of ambient density transition. For fluid released closer to the background density transition than this critical distance, the buoyant fluid escapes and rises indefinitely. For fluid released further than this critical distance, the buoyant fluid is forever trapped within the fluid. Two new mathematically exact formulas will be presented for the cases of linear and sharp ambient stratification and they show quantitative agreement with experiments. The new solution for linear stratification is analyzed in the limit of vanishing transition layer thickness. The analytic solution for sharp stratification is shown to accurately estimate the depth at which subsurface plumes trapped during the Deepwater Horizon oil disaster. Also, a dimensional analysis argument is presented which captures the essential physics to provide a simple understanding of this phenomenon.

[1]We gratefully acknowledge support from NSF CMG ARC-1025523, NSF RAPID CBET-1045653, NSF DMS-1009750 and NSF RTG DMS-0943851.

Keith Mertens
University of North Carolina

Date submitted: 03 Aug 2012 Electronic form version 1.4