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Topographic controls on the propagation of carbon dioxide in geological reservoirs

Sam Pegler (1), Herbert Huppert (1,2,3), and Jerome Neufeld (4)

(1) Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Cambridge, UK, (2) Faculty of Science, University of Bristol, Bristol, UK, (3) School of Mathematics and Statistics, University of New South Wales, Sydney, Australia, (4) BP Institute and Department of Earth Sciences, University of Cambridge, Cambridge, UK

The propagation of carbon dioxide (CO_2) in saline aquifers can be controlled by the topography of the caprock along which it flows. The influence of topographic trapping in basin-like structures, such as that of the Sleipner Field, is central to understanding the long-term flow and containment of CO_2. We present a theoretical and experimental study of the flow of gravity currents in porous media with variations in the topography along which they flow. Our results provide a general assessment of the role of topography in the entrapment of CO_2. We consider cases where the height of the topography forms an anticline from a line or point source. In all cases, it is found that the flow of CO_2 transitions towards a long-term regime controlled by the shape of the caprock. We identify an intrinsic time scale before which the flow is controlled by gravitational spreading due to gradients in hydrostatic pressure, and beyond which the variations in topography are dominant. Our theoretical predictions compare well with data from a new series of laboratory experiments. Comparison between our mathematical solutions and seismic data gathered from the Sleipner Field indicates that topographic control is unlikely to explain the observed non-axisymmetric flow of CO_2 plumes.