Geophysical Research Abstracts
Vol. 13, EGU2011-6338, 2011
EGU General Assembly 2011

Modelling Submarine Turbidity Currents

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The collapse of continental shelves leads to the spreading of sediment across the deep ocean through particle laden flows known as turbidity currents. Turbidity currents are driven by gravitational forces associated with a density difference caused by the presence of suspended particles. This generates a flow which transports the suspended particles, but which progressively slows as they sediment to the underlying boundary. The surrounding fluid is also entrained into the current, further decelerating the flow by reducing the density difference between the current and the ambient fluid. The deposits from turbidity currents, known as turbidites, are of key importance to understanding sedimentary rock formations and present new opportunities for hydrocarbon reservoirs. Numerical modelling of the deposits from turbidity currents presents an opportunity for comparison with field data from turbidites, allowing the structure and size of the event that formed the deposit to be determined.

The distance travelled by a turbidity current over the ocean floor is much larger than the height of the flow and thus to model the motion we adopt a shallow layer model in which vertical accelerations are neglected. The model we employ is a three equation system that expresses the conservation of fluid and particulate and formulates a balance of momentum for a current flowing down an incline. Importantly we include the effects of surrounding fluid being engulfed into the flow in our expression for conservation of fluid through the entrainment law of Parker (1987). For sufficiently dilute flows a settling law is employed in which the settling velocity is determined through the balance of gravitational and drag forces on a single particle in the suspension. However for suspensions with higher particulate concentrations the settling velocity of a single particle will be reduced by the effect of an increased viscosity due to the presence of nearby particles and by the motion of interstitial fluid opposing the gravitational settling of the particle due to the motion of surrounding particles. Hence we employ a 'hindered settling' law for the rate at which particles sediment out of the current.

Through steady, time independent solutions to the governing equations we find that varying the initial conditions leads to two distinct regimes with two different shapes of deposit. Employing a hindered settling law we find that the steady solutions lead to deposits with interior maxima. Time dependent solutions are constructed using numerical means and they reveal the dynamical controls upon these flows.