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Controls of the Behavior of Marine Turbidity Currents

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As the offshore industry continues to expand operations in deep water, on and below the continental slope, they are increasingly challenged to evaluate the risk associated with locating sea floor facilities in the path of potential turbidity currents. Fortunately, this growing need parallels the development of sophisticated surveying and sea floor sampling equipment that support detailed mapping of sea floor features and deposits shaped by historic turbidity current events. These data can be used with robust numerical models to recreate, or at least reasonably estimate the speed, width, heights, densities and other details of the past flows. If sufficient data are available, a population of events can be recreated so that a statistical parameterization can be made of this geohazard.

We have developed a robust three-dimensional numerical model that can reproduce many of the morphological features and sea floor deposits from sequences of turbidity current flow events. The model (a version of M3D) is an unsteady, process-based, three-dimensional model specifically designed for simulating gravity-driven sediment transport in deep water environments. It simulates sediment erosion, transport, deposition, and bed elevation changes for arbitrary initial bed profiles in response to gravity-driven flows due to sediment suspension (i.e. turbidity currents) or other gravity flows created by temperature and salinity variations. It includes representations of a) modification of flow turbulence by gradients in the vertical suspended sediment concentration, b) bed armoring, c) multiple grain sizes, d) both suspended and bed load sediment transport, and e) morphological change that is fully coupled with the forcing.

We have applied this model, and our experience with a number of detailed deep-water surveys, to systematically explore the role of major controlling parameters on the development and characteristics of turbidity current flows. Primary controls on the scale of the flow are created by the size of the bottom feature that contains the flow, the scale

and duration of the triggering event, and whether the flow is channelized or spreading. More immediate controls come from the slope of the bottom, the grain size distribution of the transported load and the underlying bed and the relative erodibility of the sea bed. A series of simplified modeling scenarios have been created to systematically explore the role of these parameters on the stability and growth of the flows, the maximum speed profile along the flow lengths and both the vertical and lateral spreading. The results are presented graphically so that they can be used to judge approximate flow characteristics in areas that have not been studied or modeled.