Mud Volcanoes: A Dynamic Model Motivated by Observations Offshore Eastern Trinidad*

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The deepwater region of offshore eastern Trinidad is located in an area where the Orinoco delta overlaps the Barbados accretionary complex adjacent to the leading edge of the Caribbean plate. This dynamic geologic setting creates conditions amenable to elevated subsurface formation pressures and an active hydrodynamic system influenced by deltaic processes (expulsion of connate water through compaction due to rapid sedimentation), subduction processes (head-driven flux of fluids derived from high-pressure dehydration reactions), and the hydrocarbon system. Large seafloor expulsion features (mud volcanoes) are a recognizable surface expression of the active fluid system. To investigate the origin, evolution, and relationship to the petroleum system of these mud volcanoes, we carried out a study combining hydrocarbon systems analysis and seismic observations with data from a suite of drop cores collected on four mud volcanoes in offshore eastern Trinidad.

The mud volcanoes, as interpreted from the seismic data, are both spatially constant (associated with deeper structures) and punctuated by periods of active construction (development of lobate flows on the surface) and inactivity. A broad spectrum of surface morphology is associated with these features. The drop core pore fluid geochemistry reflects the interaction between methane dehydration, diagenetic reactions, and advective fluid mixing. Chloride concentrations exhibit a strong trend of increasing dilution with depth, an observation consistent with upward advection of dilute formation water and downward diffusion of seawater. Scaling analysis and transient analytical models of this process suggest the equilibration time scales are on the order of hundreds to thousands of years. The fluid composition records equilibration at cooler temperatures and shallower depths of burial than inferred for mud volcanoes elsewhere within the Barbados accretionary prism, perhaps reflecting the stronger influence of deltaic processes with proximity to the Orinoco delta.