EXTRUSIVE SHALE MASSES: NEW GULF COAST EXPLORATION FRONTIER

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ABSTRACT

Many Gulf Coast shale masses are extrusive deposits formed by the processes of "sedimentary volcanism." "Sedimentary volcanic" deposits have only recently been recognized in Tertiary strata of the Gulf Coast. Diagnostic evidence for this phenomenon is found at outcrops of the Catahoula Formation (Middle Tertiary) in the South Texas counties of Live Oak, McMullen, Duval and Webb. The absence of *active* "sedimentary volcanism" in the Gulf Coast and the difficulty of recognizing this phenomenon in ancient rocks are causes for a general omission of this subject from the American geologic literature; consequently, explorationists are overlooking diapiric and possibly extrusive origins for numerous Gulf Coast shale masses.

The ultimate relationship of a buried extrusive shale mass with adjacent and overlying beds is determined by the amount of mudflow buildup and preservation during the time of deposition of the nearby normally deposited beds. If the sum of mudflow deposition (with accompanying erosion) greatly exceeds the sedimentation of the adjacent beds, large mudflow domes and ridges may form prominent topographic features. Conversely, if the rate of sedimentation of adjacent beds equals or exceeds that of the mudflow accumulation, an ill-defined mudflow facies is formed. Most thick, extrusive shale bodies probably are composite masses of both rapidly and sporadically extruded mudflows inter-fingered with normally deposited beds.

Growth of an extrusive dome is attained by a sequence of mudflows extruded from clusters of mudcones. Dips of mudflow layers increase as each succeeding layer is extruded and a domal topographic feature forms. Slopes of active mudcones are commonly 30-40 degrees, depending upon the mud viscosity; cones are known to exceed 1500 feet in height. Commonly, mudflows range in thickness from several inches to 50 feet and extend as much as two miles from their parent vent. Mudflow extrusions may take place simultaneously for many miles along a fault system. Active mudflow ridges 20 miles long are known in West Pakistan. These flat-topped ridges are hundreds of feet thick and have steep sides with 40-70 degree slopes.

Erratic rocks are commonly brought up thousands of feet stratigraphically by mudflows. Erratics up to three feet in maximum dimensions are common and rarer occurrences of blocks with 50 foot dimensions are known. Microfossils, thousands of feet out of place, commonly occur within extrusive mudflows or shale masses. Diagnostic evidence of diapiric clastic rocks includes: erratic fossils, churned shale pellets, gas bubbles, and disrupted rock frameworks.

Revised exploratory thinking is required to successfully search for and recognize subsurface diapiric shale masses. Diapiric shale masses are formed in specific basins, along certain trends, and during favorable geologic times. Although intrusive shale plugs exhibit the same pronounced structures as salt plugs, buried extrusive shale masses are generally not associated with pronounced radial faulting, sharply upturned beds or other commonly recognized structural attributes of intrusive masses.

Diapiric shales produce negative gravity anomalies because of low densities. Density logs show densities to be almost as low as salt. Low velocities (indicated by sonic logs) cause shale-mass structures to be mapped seismically as "lows" instead of "highs," unless correct velocity functions are used.

A common clue to subsurface diapiric masses is half-ohm resistivity (IES log) caused mainly by high water content of the shale. Few correlations, if any, can be made within the diapiric mass. An abnormal microfaunal sequence is nearly always encountered, as is high-pressure shale gas. Because of their greater magnitude and distinguishable direction, mudflow dips within an extrusive mass can often be recognized by a dipmeter survey. Dips recorded within an intrusive shale plug or a "shale sheath" should be random in both magnitude and direction. Sidewall cores within a diapiric mass reveal churned shale pellets and gas bubbles in the shale units; and disrupted sand-grain frameworks in the sandstones.

Sandy, water-filled, gas-churned mudflows are high porosity, low permeability masses that serve as barriers to hydrocarbon migration. Intrusive structures have had a timely injection in order to trap migrating hydrocarbons whereas extrusive shale masses are unique barriers because the barrier is present before or during deposition of the adjacent beds.

Systematic recognition and delineation of extrusive shale masses in the Gulf Coast by both conventional and improved exploration methods will open new frontiers to Gulf Coast petroleum exploration.