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Some Aspects of Multiphase Fluid Flow, Chemical Mass Transport, and Alteration in Sedimentary Basins

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Ground water table topography, compaction, buoyancy, and positive volume chemical reactions can all induce fluid flow, chemical mass transport and alteration in sedimentary basins. In the overpressured parts of active basins the last two are of primary importance because overpressuring provides both a barrier to hydrostatic (topography-driven) flow and inhibits compaction. Flow below the top of overpressure is chemically zoned and fluids generated in each zone interact. Oil is generated at depths where temperatures reach ~80ºC, dry gas is generated at temperatures greater than ~130ºC, and, as in steamflooding (Cathles, et. al., 1990), CO_2 is generated where temperatures exceed ~320ºC. Upward-migrating CO_2 reacts with Fe, Mg, and Ca aluminosilicates higher in the section producing carbonates from these cations. CO_2 is buffered at very low fugacities so long as Ca-aluminosilicates are present. When the Ca-aluminosilicates are reacted, Fe- and Mg-aluminosilicates buffer CO_2 fugacity to intermediate levels providing the characteristic temperature-dependence of reservoir CO_2 mole fraction noted by Smith and Eherenberg (1989). When all the aluminosilicates are reacted, buffer control on CO_2 is lost and reservoir CO_2 mole fractions can approach 100%. We have found that dry gas generated at ~12km depth in the offshore Louisiana Gulf of Mexico interacts with and alters oil near the top of overpressure higher in the section. The intensity of this "gas washing" increases from the coast toward deep water in an extremely regular fashion. Near the Louisiana coast nearly 90wt% of the oil has been stripped, midway to the shelf (at South Eugene Island Block 330) 15% has been stripped, whereas off the shelf (at Joliette) none has been stripped. CO_2 stripping is not a factor in the offshore Louisiana area because basin sediments have not been heated above 320ºC. CO_2 stripping could be a factor in areas with thick sediment accumulations and higher heat flows, however. Finally, decompression of waters and gases propelled across the pressure transition zone that separates the overpressure interior and hydrostatically-pressured shallow zones in a basin produces alteration of particular interest. Because the intensity of this alteration is directly related to the amount of fluid driven across the pressure transition, it potentially provides a map of fluid movements in a basin. We have constructed computer models of all these processes. The models will be described and illustrated with applications to field observations in the offshore Louisiana Gulf Mexico and basins in Southeast Asia.

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