Integrated Model for Vadose Diagenesis of Carbonate Rocks

The composition, morphology, and distribution of vadose diagenetic features are related to extrinsic and intrinsic factors. Extrinsic factors include the total yearly precipitation, and its seasonal distribution, evapotranspiration, and temperature. These influence the total carbon dioxide supplied, and the relative time during which input (by vadose percolation) and loss (by degassing and evapotranspiration) occur. Intrinsic factors include rock type and composition, porosity and permeability, soil cover, and topography. These influence the rate of water infiltration, and the resulting rate at which descending waters become saturated. The interaction of the two factor groups determines the final character of the zones of vadose diagenesis. There results a land surface-, joint-, or fracture-related zone beneath which descending waters are generally saturated and little solution occurs. Also a zone exists beneath which pore fluids and gasses are unaffected by degassing or evapotranspiration, and within which vadose precipitational fabrics are confined.

As such, the zone of active vadose diagenesis may constitute only a small part of the total zone of percolation, much of the zone being characterized by fluids which pass through without altering their composition (i.e., causing no diagenetic alteration of rock fabric or mineralogy). Furthermore, because of the high wettability of most carbonate grains (in the absence of adsorbed organics), pores in the zone of slow degassing and high relative humidity may not display "typical" vadose meniscus cements, but may instead display coatings and fills of euhedral crystals. Consequently, the absence of vadose diagenetic features is probably the more common case (without indicating a lack of exposure). As such, periods of exposure may only be patchily recorded by the presence of vadose diagenetic zones.

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Exploration Strategies as Integral Part of Corporate Strategic Planning

With rising exploration costs, recent stabilization of world oil prices, and local surpluses of natural gas, the "bloom is off the sage" for just finding hydrocarbons as an exploration strategy. Now the explorationist must tie his exploration strategies to his company's strategic planning or, in smaller companies, to their long-term goals and objectives. Without these considerations, the company's exploration efforts will not be successful over the long term. The explorationist must now realize that exploration is a business, not merely a function.

There are two critical areas that need to be defined to combine exploration strategy and strategic planning. The planners' strategic criteria must be consistent and reasonable. Criteria should be designed so that the explorationist can clearly understand his responsibility. The explorationist will need to define his exploration environment. Questions like the following should arise in the explorationist's mind. Should I be exploring in this basin? What field sizes are left to be found? What is a realistic chance of wildcat success for a specific prospect, play, or basin? What mix of prospects will give my program a realistic chance of success?

Recent techniques and methods are available tools for defining the exploration environment. In the mature domestic areas, historical digital data bases can be used to describe the present environment and can project future environments. From these environments, along with geologic considerations, geophysical input and physical restraints such as capital and lease position, an exploration strategy can be created that will be compatible with the company's strategic planning.

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Facies Relationships and Paleoenvironments of a Tide-Dominated Delta—An Estuarine-Barrier Complex in a Mesotidal Setting, Upper Cretaceous, Drumheller, Alberta

The transition between the Bearpaw and Horseshoe Canyon Formations (100 m thick) near Drumheller represents an upward-coarsening deltaic sequence. A detailed field sedimentologic investigation of these rocks has led to the recognition of several distinct lithofacies. In stratigraphic order, the lithofacies of the subaqueous part of the delta are: (1) an offshore bar cross- and hummocky-stratified sandstone, (2) a prodelta marine shale and siltstone, (3) a distal mouth-bar shale, (4) siltstone and sandstone with *Chondrites*, and (5) a proximal mouth-bar sandstone and minor shale with *Teichichnus*, *Rhizocorallium*, *Lockeia*, and other burrows. The subaerial part of the delta and the interdeltaic shoreline sediments consist of 15 lithofacies that can be grouped as follows: estuarine distributary channel; barrier; back-barrier; tidal inlets; tidal channels and flats; peat swamp; and middle to upper delta-plain meandering rivers and overbank complexes. Trace fossils associated with these are: *Teredolites* borings, *Ophiomorpha*, *Teichichnus*?, *Cylindrichnus*, *Palaeophycus*, *Asterosoma*, and *Anemonechnus*?. Vertical lithofacies transitions suggest a few transgressive episodes. This sequence was deposited in a mesotidal, embayed shoreline, where a system of meandering distributary channels formed estuarine, tidally dominated deltas flanked by mesotidal barrier-island complexes. Minor transgressions of the sea interrupted the generation of a simple prograding sequence and resulted in formation of very complex facies relations.

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Facies Control of Carbonate Reservoir Properties

The relation between the depositional and diagenetic facies within a carbonate reservoir may affect the success of a secondary-recovery project in terms of the residual oil saturation following displacement of oil by water. Recognition of facies control on the evolution of porosity and permeability aids in the prediction of reservoir performance. Displacement tests, performed on vugular carbonate cores, illustrate this point.

Strongly wetting countercurrent imbibition tests, conducted on full-diameter cores from the Meekwap field in Alberta, reveal the effects of secondary porosity on the displacement of a nonwetting oil phase. In *Amphipore* sp. wackestones, dolomitization and dissolution of *Amphipore* segments have produced a random distribution of small moldic pores that are matrix connected. During water-wet displacement tests, poor displacement efficiency is realized in the high moldic porosity wackestones. Visual observations indicate that the nonwetting oil phase is preferentially trapped in the moldic pores. Reef-core boundstones, composed of a laminar stromatoporoid and algal assemblage, have a pore structure dominated by tabular vugs linked by vertical fractures. In contrast to the moldic pore system, displacement efficiency is maximized in the high porosity intervals as buoyancy forces allow oil to migrate through the vug-fracture system. Visual differentiation of the end-member pore systems will allow the development of a reservoir model that can predict oil recovery within various depositional facies within the reservoir.

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