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Pore Type Characterization and Petrophysical Properties on Microbial Carbonate Reservoirs

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Carbonates and siliciclastics differ in mode of origin, mineralogical composition, dependence on biology, susceptibility to diagenesis, sequence stratigraphic character, and most importantly for reservoir characterization, in the variety of their pore types. Porosity in sandstones is almost exclusively intergranular; therefore, sandstone porosity and spatial distribution of the accompanying reservoir are governed mainly by depositional fabrics and facies geometry. As genetic pore types in sandstones vary within relatively narrow limits, the related petrophysical and reservoir performance characteristics are rather easily predictable compared to carbonate reservoirs. Porosity in carbonates may be depositional, diagenetic, or fracture in origin, and pore types such as intercrystalline, vuggy, moldic, fenestral, and reef-related (biogenically constructed) typical in carbonates, are generally absent in sandstones. Spatial distribution of porosity may or may not conform to depositional facies boundaries; it may have been modified more than once by burial diagenetic processes or it may have formed by brittle fracture under differential stress.

Our definition of flow units differs somewhat from Ebanks et al. (1992) version: "*A flow unit is a specific volume of a reservoir, which is composed of one or more reservoir quality lithologies and any non-reservoir quality rock types within that same volume, as well as the fluids they contain".* We define flow units as reservoir zones that combine high porosity and permeability with low capillary resistance to fluid flow. Flow units can be quality-ranked on the combined numerical values of porosity and permeability as measured in conventional core analyses and further evaluated by mercury capillary pressure measurements. In the absence of measured values, porosity is calculated from appropriate borehole logs and compared to baseline values from wells with both core analyses and calculated values from logs. Reservoir zones with lower porosity and permeability values that do not readily allow direct fluid transmission but do allow circuitous flow around low porosity and permeability segments are defined as baffles. True barriers to flow do not allow fluid flow vertically or horizontally. A fundamental problem in the analysis of all reservoirs is identifying flow units, baffles, and barriers and assessing which flow units have the greatest potential (highest quality) to produce economic quantities of hydrocarbons.

Relationships between pore and pore-throat geometries and how they relate to genetic pore type has not been studied in sufficient detail in microbial carbonates. Identifying and quantifying these relationships are essential for field development strategies such as predicting reservoir response to fluid injection, selecting infill well locations, or enhancing the profitability of other recovery methods by highlighting the spatial distribution of pore and pore-throat size distributions that influence reservoir performance characteristics.

Carbonate porosity is created or altered by depositional processes, diagenetic processes and mechanical fracturing (Ahr and Hammel, 1999; Ahr et al., 2005; and Humbolt and Ahr, 2008). These three main processes were plotted as end members on a triangular diagram (Figure 1) and the sides of the triangle represent hybrid pore types. The Ahr-Humboldt genetic pore classification is unique in its application to constrain porosity with primary rock properties such primary depositional texture and fabric and secondary diagenetic modifications.

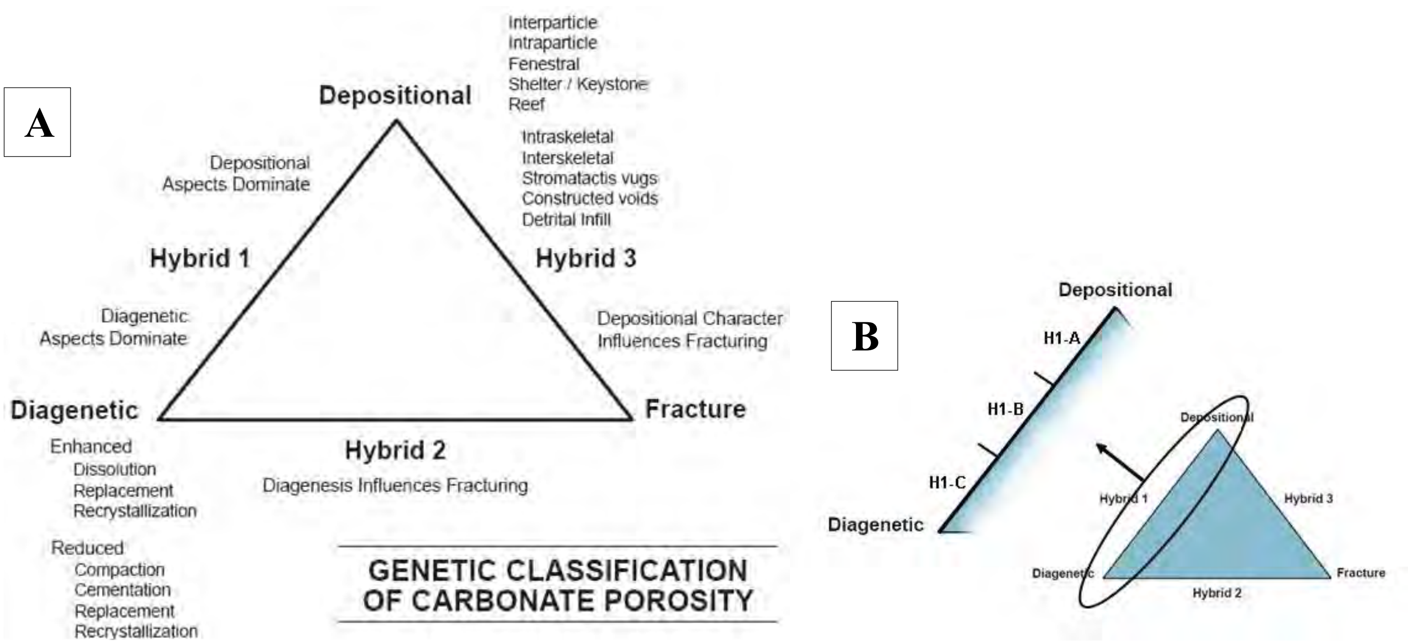

Figure 1 – A: Genetic classification of carbonate porosity, Ahr et. al. 2005, Ahr 2008. B: Modification of the genetic classification of carbonate porosity made by Humbolt and Ahr 2008, based on how much the porosity was modified by diagenesis (Hybrid 1 – A, Hybrid 1 – B or Hybrid 1 – C).

The technique of relating genetic pore types to petrophysical flow units has been applied to carbonate reservoirs with success, however it has yet to be rigorously tested in microbial carbonate reservoirs. Being biogenic in nature, the pore geometry of microbial carbonates fluctuates throughout a reservoir and creates difficulties when predicting reservoir quality. An expected complication of applying genetic pore typing to microbial carbonates is determining the amount of interplay between the depositional and diagenetic end members.

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