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Characteristics and Modeling of Upper Jurassic Smackover Microbial Carbonate Facies and Reservoirs in the Northeastern Gulf of Mexico

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In the northeastern Gulf of Mexico, Upper Jurassic Smackover (Oxfordian) inner carbonate ramp, shallow-water microbial buildups developed on paleotopographic paleohighs (Paleozoic crystalline basement or Jurassic salt features) or on antecedent depositional topography in the Mississippi Interior Salt basin and in the Manila and Conecuh sub-basins. These microbialites included calcimicrobes, red algae, foraminifera, sponges, echinoids and bivalves and attained a thickness of 58 m. Buildups were best developed on a hard substrate during a rise in sea level under initial zero to low background sedimentation rates in low-energy and fluctuating environmental conditions. Extensive microbial growth occurred in response to available accommodation space. The demise of the microbialites corresponded to changes in environmental conditions associated with an overall regression of the sea.

Smackover carbonates are overlain by Haynesville (Buckner) anhydrite or argillaceous beds and unconformably overlie Norphlet sandstone beds or Paleozoic igneous and metamorphic rocks. Smackover lithofacies have been identified from the study of wireline logs, cores and thin sections. For buildups on Paleozoic paleohighs, these facies include, in descending order, (1) peritidal and lagoonal dolomudstone and dolowackestone, (2) shallow subtidal nearshore and shoal ooid dolograinstone and oncoidal and peloidal dolopackstone, and (3) subtidal peloidal doloboundstone. For buildups on antecendent depositional paleotopography, these facies include, in descending order, (1) peritidal silty lime mudstone and dolomudstone to wackestone, (2) shallow subtidal nearshore ooid, peloidal, bioclastic grainstone to wackestone, (3) subtidal fossiliferous lime mudstone, (4) subtidal microbially-influenced peloidal lime mudstone to packstone, (5) subtidal peloidal thrombolite boundstone, and (6) transgressive subtidal silty lime mudstone and dolomudstone and wackestone.

Although the principal control on reservoir architecture and geographic distribution of Smackover reservoirs is the fabric and texture of the depositional facies, diagenesis (mainly dissolution and dolomitization) is a significant factor that preserves and enhances reservoir quality. Porosity in the microbial boundstone facies is a mixture of primary shelter and fenestral porosity overprinted by secondary dolomite intercrystalline and vuggy porosity. Porosity in the nearshore/shoal grainstone and packstone facies is a combination of depositional interparticle and diagenetic moldic and dolomite intercrystalline porosity. The higher reservoir quality and productivity of the microbial boundstone is attributed to the higher permeability and greater interconnectivity of this facies because of the nature of the pore system (pore topology and geometry and pore-throat size distribution) instead of the amount of porosity. Pore-throat size distribution in the intercrystalline- and vuggy-dominated pore system of the dolomitized and leached boundstone is characterized by a higher percentage of large-sized pores having larger pore throats.

A successful exploration strategy to locate and define the distribution of reservoir quality microbial carbonate facies starts with detecting a petroleum trap. Initially, the identification of combination structural and stratigraphic traps through the use of 3-D seismic data proved highly successful. Petroleum traps consisted of Paleozoic basement paleohighs and favorable microbial boundstone and shoal grainstone facies that experienced depositional and diagenetic (dissolution and dolomitization) processes conducive to preserve and enhance reservoir quality. The development of recently discovered fields in the updip Smackover trend of the onshore northeastern Gulf of Mexico area has shown that this exploration strategy requires refinement. The petroleum trap for these fields is stratigraphic and the associated reservoirs are microbial boundstone characterized chiefly by vuggy pores and nearshore grainstone characterized chiefly by moldic pores resulting from leaching.