POROSITY AND PERMEABILITY CHARACTERISTICS IN A MIXED CARBONATE - SILICICLASTIC SEQUENCE: AN EXAMPLE FROM THE UPPER GUADALUPIAN (PERMIAN), WEST TEXAS AND NEW MEXICO

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ABSTRACT

Upper Guadalupian (Permian) reservoirs contain large resources of oil and gas, principally in sandstones of the Queen, Seven Rivers, and Yates Formations in the Permian Basin of West Texas and New Mexico. The 225 oil and gas reservoirs of this age have produced 1,576 million stock tank barrels (MMSTB) of oil (as of 1/1/90) from an estimated 6,830 MMSTB original oil in place. Of the remaining 5,254 MMSTB of oil, 1,834 MMSTB is mobile and 3,420 MMSTB is residual. In addition, 1,154 billion cubic feet of gas has been produced from these reservoirs.

Upper Guadalupian reservoirs rim both the Northwest Shelf of the Delaware Basin and the Central Basin Platform and occur discontinuously along the Eastern Shelf of the Midland Basin. The San Simon channel, which formerly separated the Northwest Shelf from the Central Basin Platform, was closed by late Guadalupian time. On the southern end of the Central Basin Platform, the Sheffield Channel, which formerly connected the Delaware Basin to the Val Verde Basin, was also closed. In addition, the Ozona Arch joined the Central Basin Platform. These events resulted in a contiguous strandline complex that now comprises a set of mixed carbonate-siliciclastic hydrocarbon reservoirs along the Delaware Basin margin of the Northwest Shelf and Central Basin Platform. Reservoirs have been found discontinuously along the entire margin of the southern half of the Midland Basin, the largest concentration being in the northwest. Before the deposition of the Queen Formation, the Ozona Arch and Central Basin Platform became one contiguous platform, causing the Midland Basin to become a highly restricted water body connected to the Val Verde Basin by only a small channel. Around the margin of this restricted basin, oil reservoirs of Queen age formed.

The facies stacking within the mixed carbonate-siliciclastic progradational parasequences, which made up upper Guadalupian reservoirs, differ between the Delaware Basin and the Midland Basin. A typical upward-shoaling cycle includes facies deposited in shallow subtidal lagoon, shoreface, mixed tidal channel and intertidal flat, and supratidal and red-bed sandsheet environments. Along the margin of the Delaware Basin, upper Guadalupian reservoir facies were deposited behind a rimmed margin. Reservoirs in this location contain this entire package of facies within a single parasequence. Younger formations are productive progressively basinward as a result of the overall progradational pattern, the majority of reservoirs producing from Seven River and Yates reservoirs. The larger and more numerous reservoirs in these formations are a product of increased siliciclastic sediment influx after the filling of the Midland Basin. At the margin of the Midland Basin, reservoir facies were deposited on a shallow ramp during Queen time. This deposition produced a parasequence in which the shoreface facies formed the base. Therefore, reservoirs rimming the Delaware Basin typically have shallow subtidal lagoon facies at the base of a parasequence while Midland Basin reservoirs typically have shoreface facies at the base.

Depositional facies and subsequence diagenesis have affected the amount and type of porosity and permeability and also the relationship between the two. For upper Guadalupian mixed carbonate-siliciclastic reservoirs the average reservoir porosity ranges from 8 to 27 percent with a mean value of 17 percent, whereas reservoir permeability ranges from 2 to 200 millidarcys (md) with a geometric mean of 30 md. In comparison to other sandstone reservoirs, upper Guadalupian mixed carbon-siliciclastic reservoirs have low permeability relative to porosity.

Three pore types identified in these mixed carbonate-siliciclastic parasequences are (1) interparticle, (2) moldic and intraparticle, and (3) microporosity. Interparticle porosity is most abundant in the shoreface and tidal-channel facies, due to sorting and smaller bulk volumes of cement. Moldic and intraparticle porosity appears most often in shoreface facies and is attributable to the dissolution of anhydrite and leaching of feldspar grains. Microporosity is most common in subtidal lagoon, tidal flat, and sandsheet facies. Microporosity occurs in dolomicrite, syndepositional grain-coating corrensite, dissolution-enhanced feldspar cleavage planes, and authigenic dolomite and feldspar.

Permeability is related to both depositional facies and to bedding type. Permeability is highest in the lower part of tidal-channel facies and in shoreface facies, ranging from 17 to 170 md, whereas the tidal flat facies is moderately permeable ranging from 1 to 10 md. Subtidal lagoon, supratidal, and red-bed sandsheet facies have very low permeabilities ranging from 0.01 to 1 md. Crossbeds associated with shoreface and tidal flat/channel

facies display permeabilities having the highest geometric mean of all bedding types. Planar and wavy laminations associated with shoreface and tidal flat/channel facies display the next highest permeability. Algal laminations and contorted bedding associated with subtidal lagoon, supratidal, and red-bed sandsheet facies have geometric mean values that are an order of magnitude lower than those of other bedding types.