AAPG Search and Discovery Article #90049©2000 AAPG/EAGE International Research Conference, El Paso, Texas, October 1-5, 2000 (2005)

Mixed Carbonate and Evaporite Hydrocarbon Reservoir Systems: An Example from the Permian of NW Germany and the Cretaceous of NE Mexico

STEINHOFF, INGO, and CHRISTOPH LEHMANN, BP Amoco, P.O. Box 3092, Houston, Texas 77253–3092

Mixed carbonate and evaporite systems are important reservoirs around the world and occur throughout the geologic record. Major carbonate hydrocarbon reservoirs exist in the Ordovician, Silurian, Devonian, Permian, Jurassic, and the Cretaceous. Reservoirs associated with mixed carbonate and evaporite settings can be compartmentalized to various degrees by evaporite lithofacies interfingering with carbonate lithofacies. Data presented here introduce examples of the two end members of compartment complexity in carbonate reservoir systems: (1) the Permian of NW Germany, where carbonate sequences are generally not compartmentalized by evaporites, and (2) the Cretaceous of NE Mexico, where sequences are highly compartmentalized.

The main carbonate reservoir (Stassfurt Carbonate = Ca2) of the Upper Permian Zechstein is underlain by the Werra Anhydrite and sealed by the Basal Anhydrite, both of which reflect relatively clean sulfate depositional systems. The Ca2 reservoir consists of marginal marine to deep marine carbonate facies and can be subdivided into seven depositional cycles which generally do not contain any evaporite deposits that could act as flow barriers and thus compartmentalize the gross reservoir succession. Both the Werra Anhydrite and the Basal Anhydrite are composed entirely of sulfate lithology and can be subdivided into 10 facies types ranging from supratidal to deep marine ((1) karst, (2) sabkha, (3) algal tidal flat, (4) tidal flat, (5) beach, (6) salina, (7) sulfate arenite, (8) slope, (9) turbidites, and (10) basinal laminites). Each of these facies has characteristic seal qualities. Facies types (2) sabkha, (3) algal tidal flat and (6) salina serve as excellent seals, although other marginal marine and basinal facies can be good seals. Turbidites and slope deposits display the worst seal qualities within the Zechstein sulfate successions.

In NE Mexico, the carbonates and evaporites of the Albian Acatita Formation are interpreted to be deposited in a shallow lagoon separated by a grainstone shoal from the ancestral Gulf of Mexico. Meter-scale cycles are composed of basal fine-grained carbonates and evaporites with intercalated massive gypsum beds shallowing upward to bioturbated wackestones and miliolid/peloidal packstones and grainstones. The cycles are occasionally overlain by tidal flat laminites and are arranged into high-frequency sequences, which in turn comprise composite sequences. The transgressive parts of these genetic packages are composed of evaporite-dominated lithofacies, whereas the regressive parts are composed of carbonate-dominated lithofacies. This stratigraphic arrangement of carbonate and evaporite lithofacies creates highly compartmentalized carbonate reservoirs.

Although the Zechstein is a much more evaporitic system, the evaporite-prone parts of the sequences of the Acatita Formation in NE Mexico are interpreted to represent environments similar to those of the Zechstein salinas. Similar to the Zechstein, the salina evaporite successions measured in the Albian of NE Mexico are efficient regional seals compartmentalizing the carbonate reservoir facies. Recognizing the seal quality of mixed carbonate-evaporite systems plays an important role in assessing subsurface development where individual reservoir compartments are not in vertical communication. Compartmentalizing seals of various facies-dependent qualities and lateral extend have a major impact on the development of completion strategies in mixed carbonate-evaporite reservoir systems.