DEPOSITIONAL ENVIRONMENTS AND RESERVOIR COMPARTMENTALIZATION WITHIN THE FRIO ZONE 21-B RESERVOIR, TIJERINA-CANALES-BLUCHER FIELD, SOUTH TEXAS

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ABSTRACT

Subsurface study of five sandstone units comprising the Frio zone 21-B reservoir at Tijerina-Canales-Blucher (T-C-B) field determined the environments of deposition and yielded a detailed three-dimensional portrait of the heterogeneous zone's reservoir compartments. Detailed isolith and log-facies maps, based on closely spaced production wells, integrated with maps of resistivity and determination of regional depositional setting, form the basis for interpretation of zone 21-B.

The 100-foot thick 21-B reservoir at T-C-B field is composed of two late-stage progradational events occuring within a larger-scale Lower Frio depositional episode which encompasses 800 feet of sediment. Zone 21-B occurs in the upper quarter of this depositional episode. The earliest depositional event is reflected in units 4 and 4a of 21-B which record the establishment of a barrier island/lagoon system based on the strike orientation of sand contours and SP-log-facies relationships. Reservoir facies include a complex mosaic of barrier core, backbarrier swale, shoreface, flood-tidal delta, tidal channel, crevasse-splay, washover fan, and barrier-flat facies.

The onset of the depositional episode's first-order, major transgressive phase is evident in the landward retrogradation of shore-zone deposition observed in unit 3. Analysis of five imbricately stacked sub-intervals composing unit 3 illustrates how shore-zone styles evolved from an early more landward, V-shaped, estuary-conformed chenier plain to a more seaward, dominantly marine-influenced, thin, broad beach-shoreface sand belt. Unit 2 records the establishment of two imbricately stacked barrier island systems and is notable for its preservation of shore-parallel, migrated tidal-inlet facies and the prominence of two fluvial systems which had progressed seaward from their position in unit 3 at the western limit of the field. By unit 1, as burial accommodation space became more constricted, the shore-zone evolved into a strandplain.

The shore-zone sand wedges of units 1, 2, 4, 4a, and parts of unit 3 pinch-out uniformly along a tectonic hinge-line in the center of the reservoir. Landward of this linear feature, an ancient estuary is apparent from funnelled, more dip-aligned sand contours, from the recognition of estuarine facies such as bayhead delta and fluvial systems, and from the relative percentages of mudstone throughout the field area.

Reservoirs west of this structural/stratigraphic hinge-line—including backbarrier deposits of units 4 and 4a, shore-zone bodies of unit 3, and fluvial/estuary sands of units 1, 2, and 3—are subject to greater heterogeneity than those in the eastern marine environment as a result of higher shale percentages and greater facies variability. Not surprisingly, overall resistivities are lower than in the eastern beach ridges which, in comparison, were subjected to greater and more sustained wave energies and should exhibit better reservoir qualities. In the western area, many infill wells drilled over 15 years after discovery of the field displayed high resistivities, signifying poor drainage of select reservoir facies.

In this study, contour maps of maximum resistivity (using deep-resistivity log values) and cross-sectional resistivity profiles (which illustrate the vertical and lateral continuities of resistivity intensities between wells), used in conjunction with isolith and SP-log facies maps, document proposed flow boundaries or discontinuities of the reservoirs. Because major shale intervals, which represent local transgressions, separate them, the five units behave, for the most part, as isolated, independent reservoirs. The eastern marine component of each unit is subdivided into offlapping subunits each of which averages seven feet in thickness. Based on comparisons of resistivity, structural elevation, and sand thickness, the subunits behave as separate reservoir compartments. Each of the subunits can be further differentiated into beach-ridge, back-beach swale, shoreface, ebb-tidal-channel- and-delta, and mud-flat facies. The best reservoir quality occurs in the upper section of a beach ridge at a fully developed position immediately down depositional dip from its landward pinch-out. The lower and basinward portions of beach ridges are gradational with shelf silts and muds which detract from overall reservoir qualities. Mapped contours of resistivity values parallel the depositional grain of barrier-core facies, reflecting greater homogeneity in this direction. In all units, barrier-core or beach-ridge facies exhibit consistently higher resistivities, hence, greater hydrocarbon saturations, than all other facies.

Subunits are separated by (permeability) barriers or baffles which define reservoir compartments. The most likely areas for interfacies fluid communications to exist are where beach-ridge (or barrier-core) facies of two subunits stack against

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each other. Conversely, intervening facies such as swales, shoreface, migrated tidal-inlet fill, and tidal channels should act as effective baffles to fluid migrations between beach ridge compartments. Shalier inter-ridge swales in units 1, 4, and 4a, and coastal mud flats in units 2 and 3 are the most important barriers to fluid migration within the marine environments. A single swale within unit 1 was proved by field-extension drilling by Exxon to have effectively isolated a beach-ridge compartment (containing several million barrels of recoverable oil) from updip perforations for the first 28 years of T-C-B's exploitation history.

Because of its huge volumes of initial oil and gas in place (157 million barrels of oil and 327.4 billion cubic-feet of gas), and because it is in the late stage of its productive life, T-C-B (zone 21-B) may be a candidate for a program of recompletions and infill drilling to capture bypassed reserves resulting from the complex reservoir facies architectures as delineated in this study.