Building a Deterministic Reservoir Model through Geologic Characterization to Optimize Production: A Case Study of the Permian (Leonardian) Upper Clear Fork and Glorieta Formations, Stockyard Field, Gaines County, Texas

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ABSTRACT

In today's petroleum industry, reservoir characterization is often undertaken to explain the geology of a reservoir in a mathematical language for engineers. This translation is used to input geologic parameters into a simulator to explain the dynamic production history of a reservoir and the associated hydraulic properties. However, the need for simulation is not always necessary. A high-resolution geologic model should, in the least, honor heterogeneity and hydraulic properties at the well log and micro-scale when core is available. To proceed to simulation, the geologic model must be upscaled (coarsened) to reduce computing time, thus heterogeneity is not preserved and the model is oversimplified. Therefore, in many cases (e.g., platform-top carbonates) the geologic model may prove to be a more accurate representation of the reservoir. Moreover, history matching through simulation is time intensive. This characterization study of the Permian, Upper Clear Fork and Glorieta Formations, has proven that, alone, a high-resolution geologic model can be created in a relatively short amount of time and provide tremendous economic upside.

The Permian basin of West Texas and southeastern New Mexico is a prolific hydrocarbon province that contains over 90 billion bbl of oil and 106 tcf of gas (Ward et al., 1986), and is ranked as a top-ten global petroleum province (Gautier et al., 1995)(Figure 1). The Permian (Leonardian) Clear Fork Group, the focus of this study, is a highly productive shallow marine platform carbonate reservoir within the Permian basin, containing approximately 4.4 billion bbl of in-place reserves (Galloway et al., 1983)(Figure 2). The highly stratified nature of the Clear Fork causes extreme reservoir heterogeneity, and therefore, primary oil recovery ranges from 6-15 % (Barber et al., 1983; Montgomery, 1998).

Although the majority of Clear Fork fields are in the twilight of oil production, small fields are occasionally still discovered. One such example is Stockyard field located on the northern portion of the Central Basin Platform in Gaines County, Texas (Figure 3). Oil is trapped within a doubly-plunging anticline, and is produced from 14 wells (40-acre spacing) that are completed in the Upper Clear Fork and lowermost Glorieta. Average porosity and permeability at Stockyard is 13 % and 14 md. Porosity and permeability range from 0.3 to 30 % and 0.01-280 md.

Hydrocarbon entrapment at Stockyard, is the result of structural drape of the reservoir interval over a basement uplift generated during the Marathon-Ouachita Orogeny. This pre-Permian structural high provided positive paleobathymetric relief that influenced the distribution of marine and peritidal environments during Clear Fork-Glorieta deposition. Peritidal and shoal

sediments were preferentially deposited across the crest of the structural high while subtidal sediments accumulated within the deeper waters of the adjacent structural lows (Figure 4). The reservoir interval is partitioned into a progradational set of eleven parasequences that reflect superimposed short- and long-term periods of accommodation change during deposition (Figure 5). Parasequences are comprised of a shallowing-upward facies succession that typically includes from base to top: non-reservoir subtidal, reservoir-prone shoal, and capping non-reservoir peritidal. Reservoir quality is controlled both by parasequence-scale facies discontinuity, and diagenetic overprint. The highest reservoir quality is associated with shoal facies that were preferentially subjected to a coarsely-crystalline phase of dolomitization. Future strategies of infill development, recompletion, and enhanced oil recovery should take into account parasequence-scale flow units to maximize recovery efficiency.

Bio

Chris Sembritzky currently works for Anadarko Petroleum Corporation in Houston, Texas, in the Enhanced Oil Recovery Division as a geologist. His work involves sequence stratigraphy, sedimentology, petrography and petrophysics in both carbonates and siliciclastics. His characterization projects focus on flow unit delineation, rock typing, and permeability prediction through capillary pressure analysis. He received his M.S. in geology from Baylor University in 2001.

Stacy Atchley is an Associate Professor of Geology at Baylor University, and coordinates the Applied Petroleum Studies program. For the past six years Dr. Atchley has served as Geological Advisor to Advantage Energy Services of Calgary, Alberta, Canada. Prior to joining Baylor in 1995, Dr. Atchley was employed by Exxon Production Research Company and Exxon Company, U.S.A.

Acknowledgements

I am grateful and sincerely appreciative of Dr. Stacy Atchley of Baylor University for his mentoring and guidance through such an encompassing petroleum study. Of course, much appreciation goes to Texland Petroleum for providing and funding this work. I benefited greatly from the geologists at Texland, Bryan Lee and Gary Phillips for sharing their knowledge of the field area. I am indebted to Ed Boutte of William, Cobb & Associates, for his patience and time as he brought me up to speed with PowerLog and general log analysis. And I would also like to thank Denny LeMar of Falcon Resources for providing his 2-D structural interpretations of the study area. Lastly, I want to acknowledge my wife, Tamara, for putting me through graduate school, without her, none of my work could have been possible.

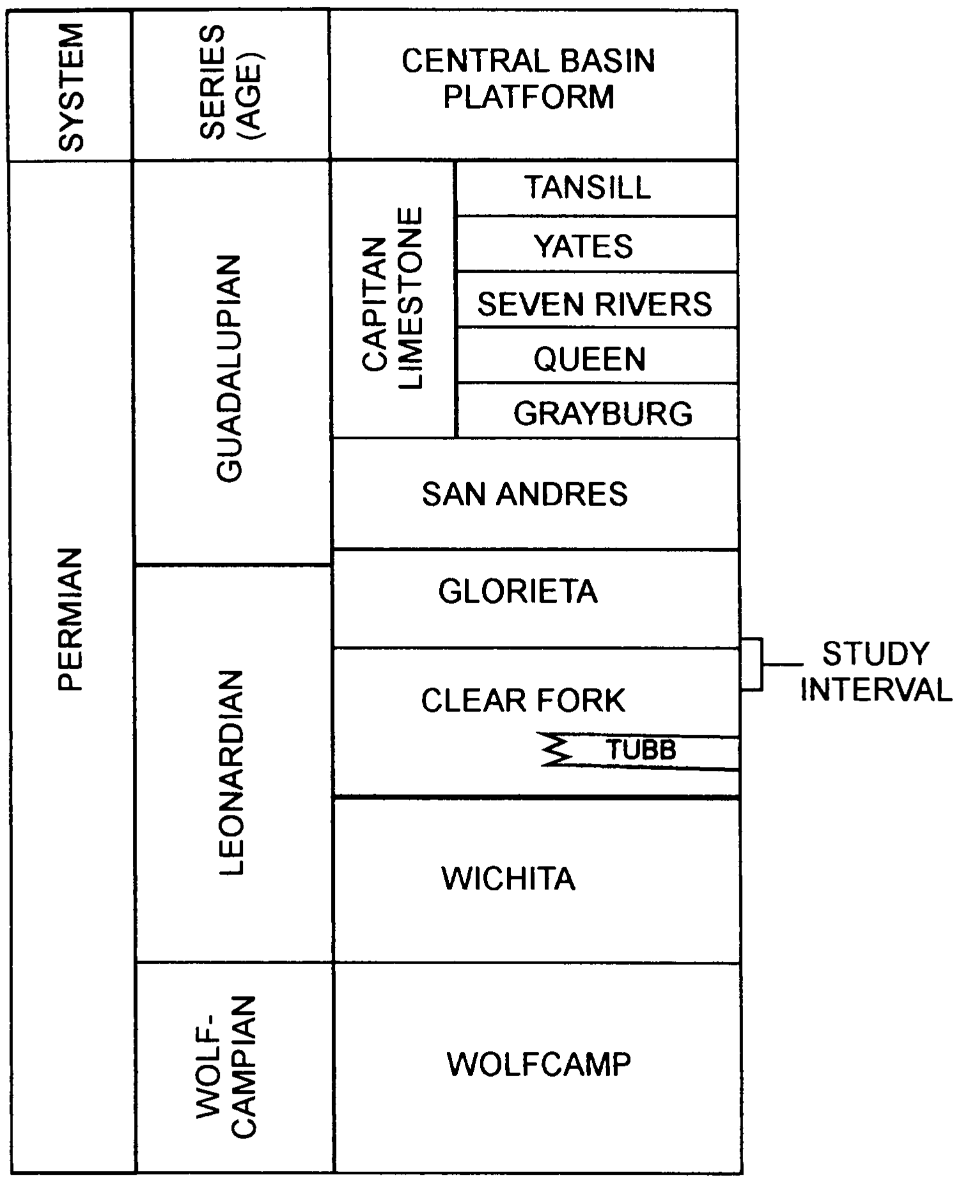

Figure 1. Stratigraphic column for the Central Basin Platform (modified from Montgomery, 1998).

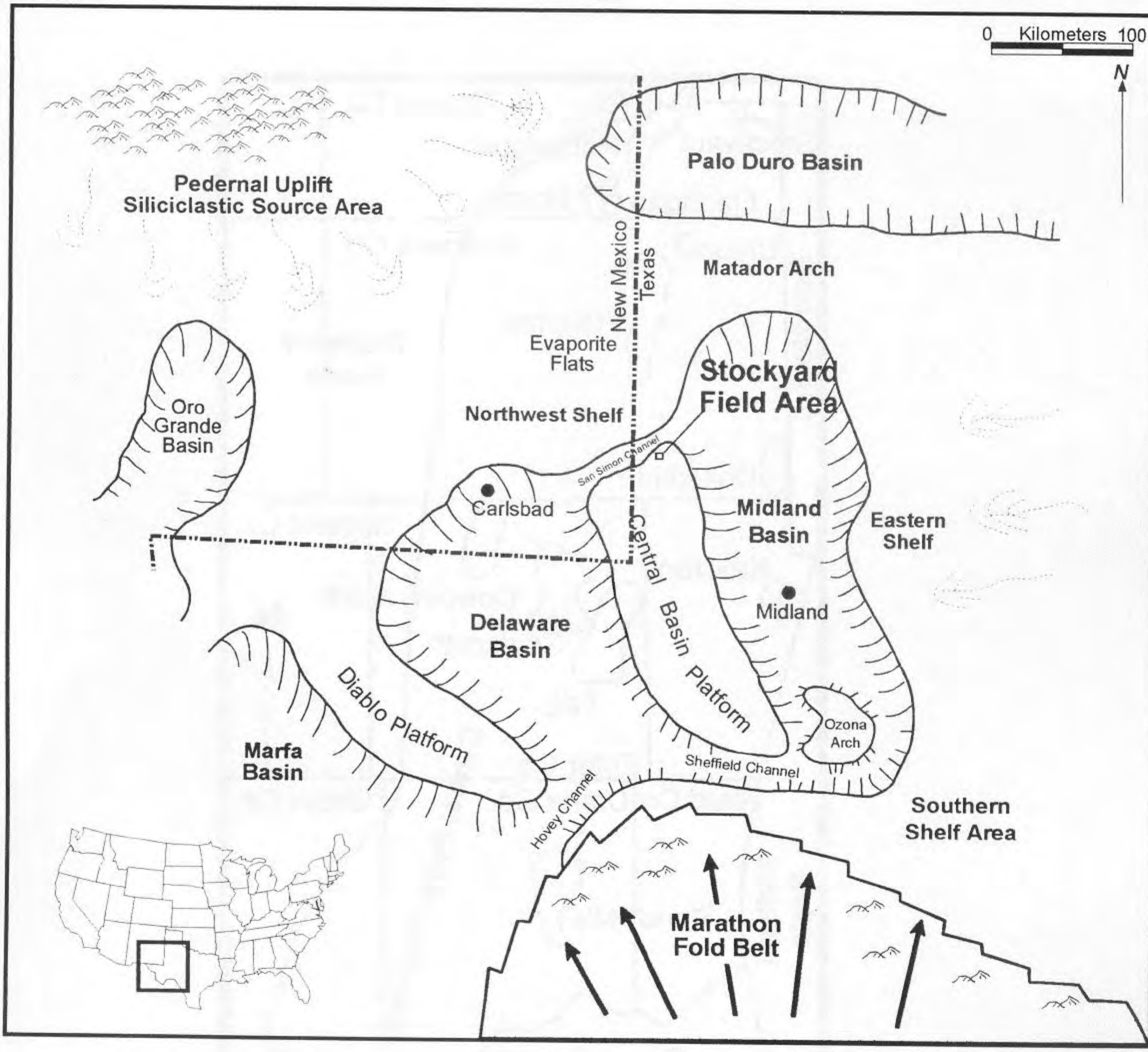

Figure 2. Permian paleogeographic map of West Texas and Eastern New Mexico. Stockyard field is located on the northern margin of the Central Basin Platform (after Atchley et al., 1999).

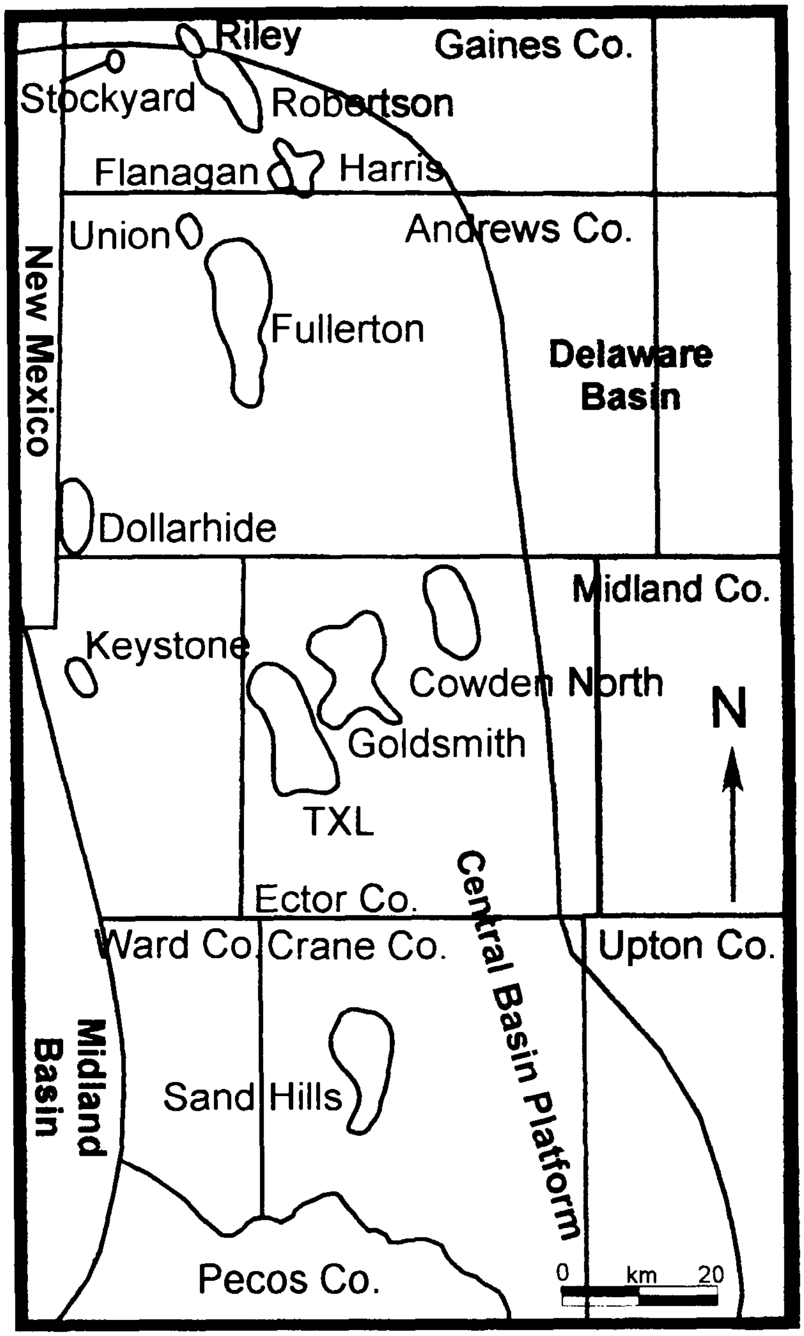

Figure 3. Regional Permian paleogeograhic map displaying Clear Fork reservoirs. Stockyard field is located in west-central Gaines County on the northern edge of the Central Basin Platform (after Galloway et al., 1983).

AAPG Search and Discovery Article #90023©2002 AAPG Southwest Section Meeting, Ruidoso, New Mexico, June 6-8, 2002 (2003)

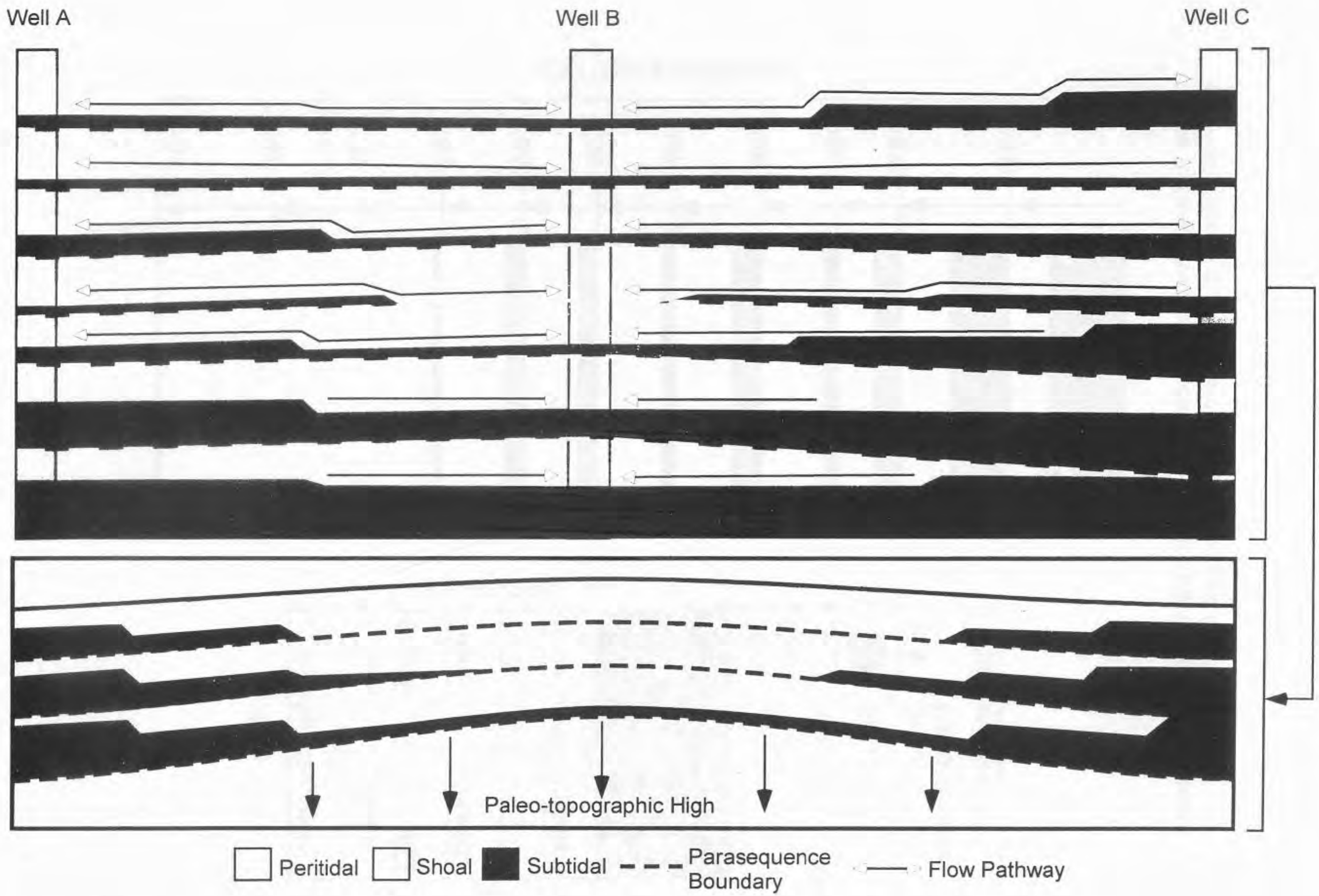

Figure 4. Diagrammatic cross-section across Stockyard field displaying facies distributions, stratal architecture, and related flow pathways. Facies distributions reflect paleotopography, and partition the reservoir into discrete flow units.

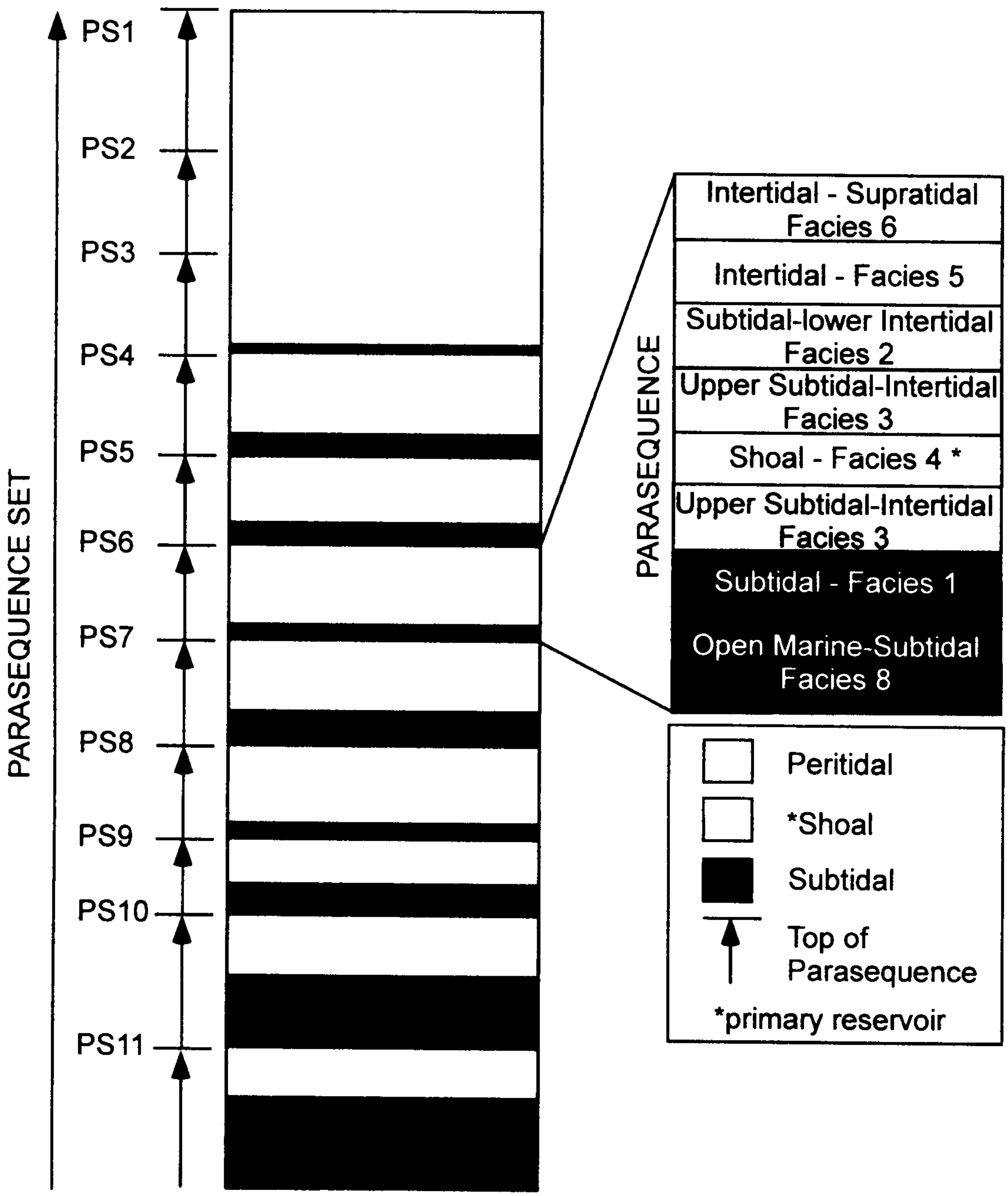

Figure 5. Diagrammatic representation of shallowing-upward parasequence set and individual parasequnce facies succession at Stockyard field.