PS Stratigraphic Variability of the Marmaton Group Across the Lips Fault System in the Texas Panhandle Granite Wash, Southern Anadarko Basin*

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Abstract

The Desmoinesian Marmaton Group, located along the southern portion of the Anadarko Basin in the Granite Wash, contains over 2,000 feet of stacked tight-sand and conglomerate unconventional reservoirs. Facies variability and lateral continuity within reservoirs represent the biggest challenges to reservoir characterization due to laterally restricted alluvial fan systems. A high-resolution stratigraphic hierarchy mapped across fault blocks should identify previously undocumented syndepositional faults. These fine-scale time sequences should constrain reservoir thicknesses and frame facies changes near sub-seismic faults. Twenty-one stratigraphic surfaces were enveloped into a scalar stratigraphic hierarchy used for estimating fault timing and duration. Well log trends were calibrated to core descriptions, which enable interpreting depositional environments directly from well logs across the 810 square mile study area. The well log trends in non-cored wells were calibrated to cored wells to extrapolate depositional environments over the study area. This interrelationship between structure and stratigraphy provides tools to optimize the placement and design of lateral wells.

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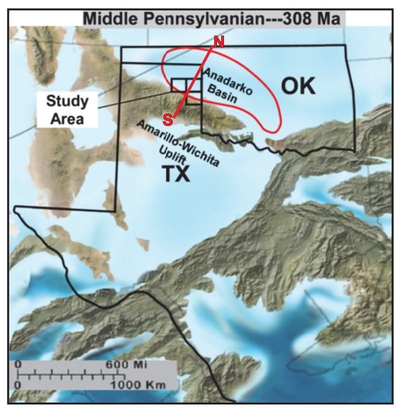
Introduction and Regional Setting

Abstract

The Desmoinesian Marmaton Group, along the southern portion of the Anadarko Basin in the Granite Wash, comprises over 2,000 feet of stacked tight sandstones and conglomerates, containing unconventional reservoirs. Uncertainty around facies variability and lateral continuity of these reservoirs represents challenges to accurate reservoir characterization due to laterally restricted submarine fan systems, and mountain-front faulting. This study examines 206 wire-line well-log suites and nine icehouse flooding surfaces across an 810-square mile study area to frame fine-scale sequences, track facies changes, and estimate fault timing and duration. This high resolution stratigraphic framework comprises a hierarchy of cycles: one third-order, three fourth-order, and eight fifth-order cycles; these were mapped across fault blocks. Mapping at the fifth-order scale documented previously un-published faults, and showed that movement occurred during two separate fifth-order cycles. Within the stratigraphic framework, well log trends, calibrated to core descriptions, enabled prediction of depositional environments in uncored wells.

1. Paleogeographic Setting and Present-Day Structure of the Southern Anadarko Basin



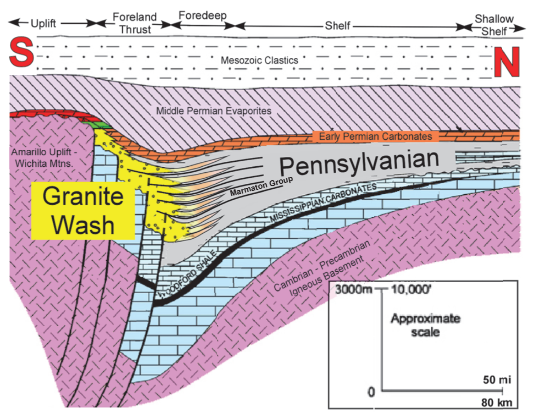


Figure 1. Paleogeographic map of the Desmoinesian mid-continent region (modified after Blakey, 2013). The Anadarko foreland basin was an intracratonic seaway that received episodic deposition from the uplifting Amarillo-Wichita mountain chain.

Figure 2. South to north cross section across the Anadarko Basin. Several millions of years of transpressional faulting deposited the up to 1500' thick Marmaton Group (after Pippin, 1970; Dutton and Garnett, 1989; and Johnson, 1989). See inset map Figure 1 for cross section location.

2. Depositional Model

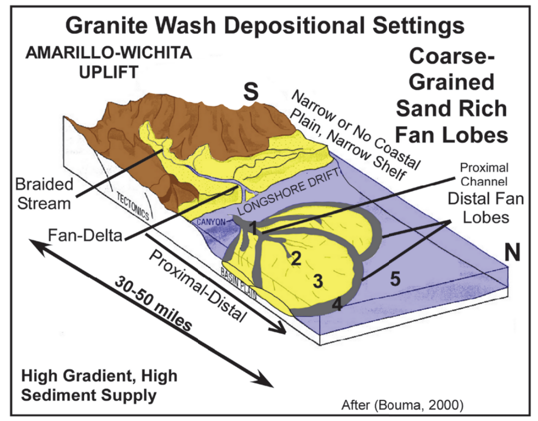


Figure 3. Many cycles of coarse-grained fan-deltaic, and sand-rich submarine fan comprise the many stacked reservoirs in the southern Anadarko basin. Facies Associations 1-5 were interpreted from core. See core analysis section.

What is the Granite Wash?

10,000 feet thick sedimentary column, which contains multiple stacked unconventional reservoirs (tight sands and conglomerates).

Comprised of Pennsylvanian age clastics eroded from uplifted Precambrian/Cambrian basement of the Amarillo-Wichita Uplift (Ball and others, 1991).

Reservoir characterization can be challenging due to: lateral discontinuities of reservoirs, differentiation of reservoirs from non-reservoirs, and hydrocarbons are difficult to distinguish from water.

3. Stratigraphic Framework

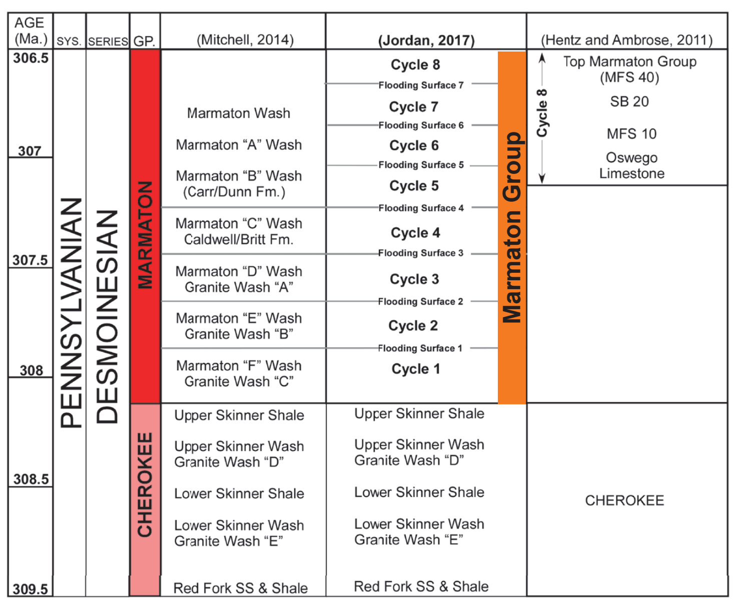


Figure 4. Stratigraphic nomenclature chart for the Marmaton Group modified after (Hendrickson, Smith, and Williams, 1996; Hentz and Ambrose, 2011; and Mitchell, 2014).

The stratigraphic framework in this study is comprised of eight base level cycles, which are divided by regionally extensive flooding surfaces.

Hypothesis

Assuming faulting was active during deposition of the Marmaton Group, a high resolution stratigraphic framework constructed across documented fault blocks will highlight fault timing and duration.

Question

When did faulting occur and how did it impact facies distribution and sequence thickness?

Marmaton Group Study Area and Dataset

4. Regional Study Area

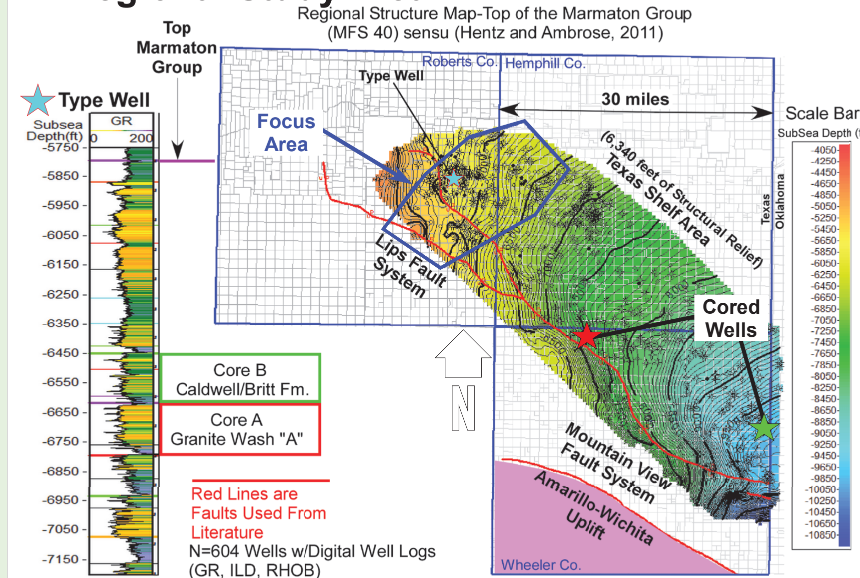


Figure 4. Regional data map contains 604 wells with high quality digital log curves (GR, ILD, RHOB), and cored wells with 87 feet of core (red and green stars). Faults adapted from (Evans 1979; McConnell, 1989; and LoCricchio, 2012).

5. Focus Area: Data Map

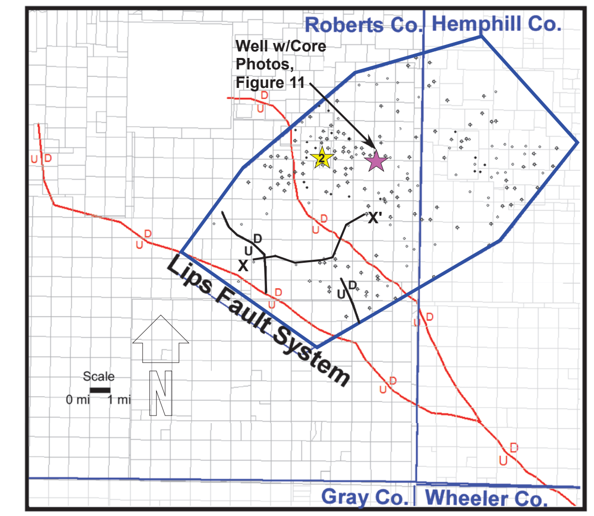
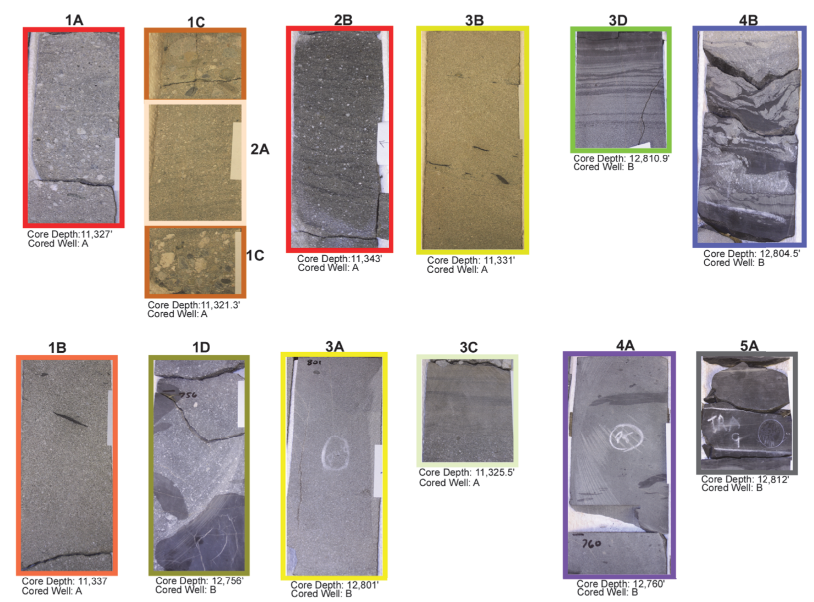


Figure 5. Zoomed in view of the focus area. The focus area is a subset of the regional dataset, which contains 206 wells that penetrate the Marmaton Group along with the digital well log suite used for mapping (GR, ILD, and RHOB).

Sedimentology: Process-Facies and Associations

7A. Core Derived Lithofacies



7B.

- **1A** Very coarse grained sandstone to pebble; structureless w/very poor to moderate sorting
- **1B** Coarse to very coarse grained sandstone; exhibits graded bedding w/poor to moderate sorting
- **1C** Pebble lag deposits; coarse grained sandstone matrix w/very poor sorting
- **1D** Very coarse grained sandstone to pebble; very poorly sorted, contains mud clasts 1-5 cm thick and cobbles greater than 20 cm
- **2A** Coarse grained sandstone; moderate to poorly sorted
- **2B** Coarse grained sandstone w/ laminations; dish structures
- **3A** Medium to fine-grained sandstone; structureless w/moderate to poorly sorted
- **3B** Fine to medium grained sandstone; 1-10 cm beds with organic material
- **3C** Very fine-grained sandstone; Inter-laminated, 2-5 cm bed caps
- **3D** Inter-laminated very fine-grained sandstone and silt
- **4A** Very fine-grained SS-Siltstone, Clay Clasts; 1-5 cm
- **4B** Clay, w/sand lenses; 1-5 cm thick beds
- **5** Black clay with/without laminations

Figure 7. Photos of core facies (7A) and descriptions of thirteen lithofacies identified in 87 feet of core (7B).

8. Core B: Core Box Photographs

Top of Core

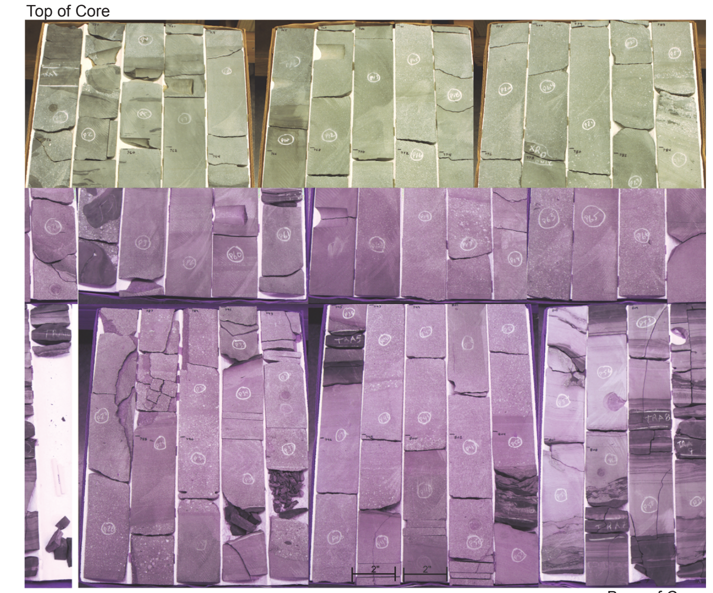


Figure 8. Core box photographs from core "B."

Base of Core

9. Facies Associations

- **1** Proximal Axial Submarine Fan, Proximal to Channel
- **2** Proximal Off-Axis Submarine Fan, Distal to Channel
- **3** Medial Submarine Fan Lobe
- **4** Distal Submarine Fan Lobe
- **5** Distal Fan Drape/ Hemipelagites

Five facies associations were defined based on how rocks were formed by genetic sedimentary processes (e.g. process facies). Facies groupings are divided by grain sizes, sedimentary structures, bed thicknesses and process interpretations (1) coarse-grained debrites; (2) thick-bedded turbidites; (3) thin-bedded turbidites; (4) fine-grained debrites; and (5) hemipelagites.

Depositional Environments: (1) proximal fan lobe channel; (2) proximal fan lobe interchannel; (3) medial fan lobe; and (4) distal fan lobe deposits. Hemipelagites (5) are deposited in still water settings and can be unrelated to fan delta deposits or could be distal fan drapes.

Coarse-grained debrites and thick-bedded turbidites are predicted to contain the best reservoir quality due to coarsest grain size and lowest clay content. Figure 3. shows where each of these depositional environments can be found within a fan-delta facies model.

Figure 9. Lithofacies associations.

Log-to-Core Calibration and Log Trends

10. Log Calibration - Fan Delta Cycle

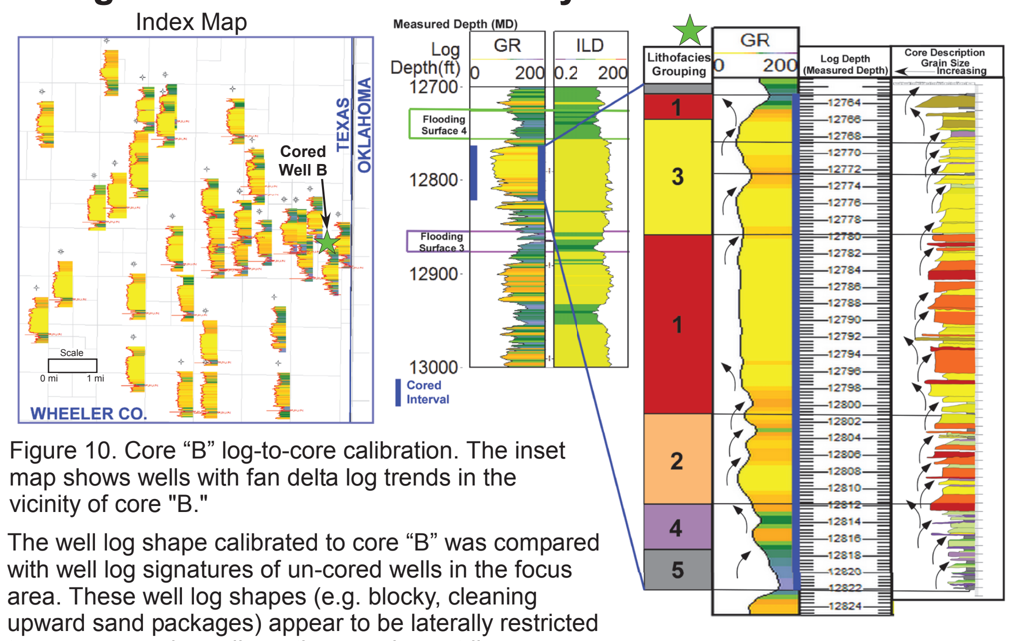


Figure 10. Core "B" log-to-core calibration. The inset map shows wells with fan delta log trends in the vicinity of core "B."

The well log shape calibrated to core "B" was compared with well log signatures of un-cored wells in the focus area. These well log shapes (e.g. blocky, cleaning upward sand packages) appear to be laterally restricted to one area and are discontinuous along strike.

11. Log Calibration: Flooding Surface

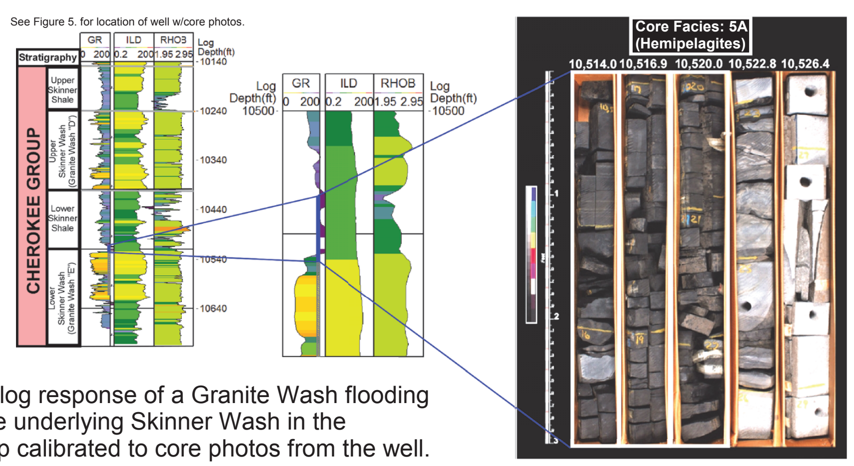


Figure 11. Well log response of a Granite Wash flooding surface from the underlying Skinner Wash in the Cherokee Group calibrated to core photos from the well.

12. Extrapolation of Fan Delta Log Trends to Focus Area

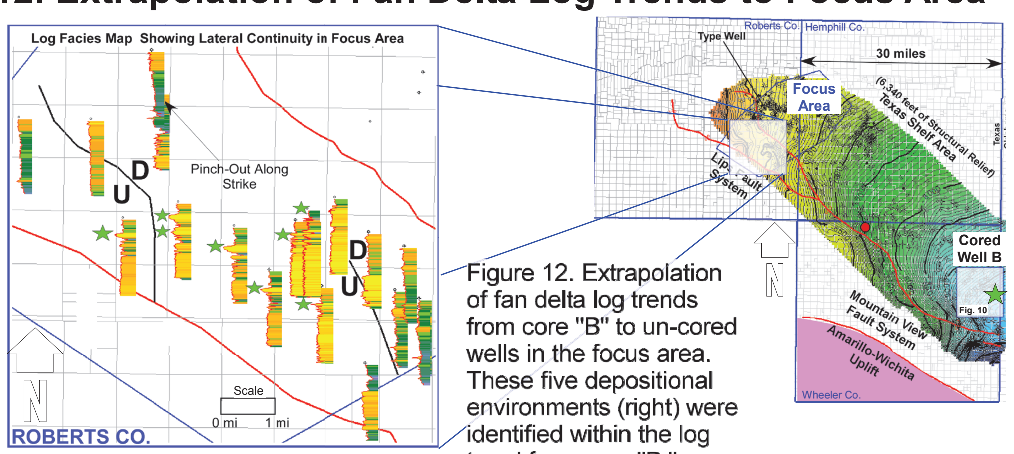


Figure 12. Extrapolation of fan delta log trends from core "B" to un-cored wells in the focus area. These five depositional environments (right) were identified within the log trend from core "B."

Stratigraphic Framework

13. Type Well: Stratigraphic Hierarchy

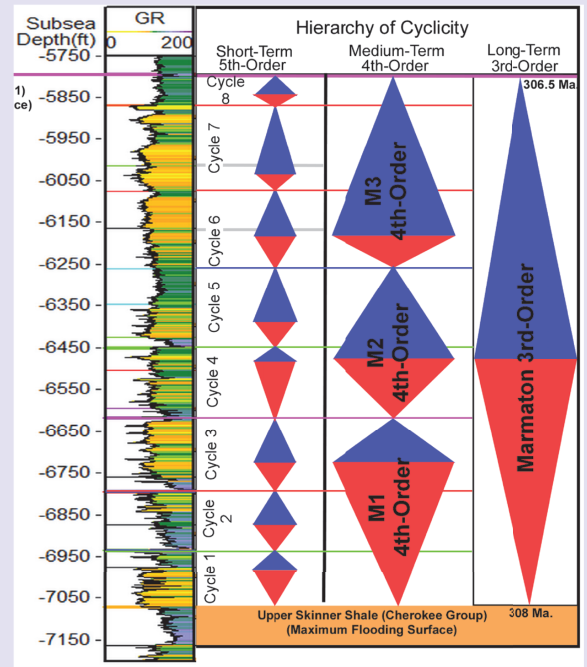


Figure 13. Three-fold stratigraphic hierarchy of the Marmaton Group based on detailed correlations in 600 wells (sensu Mitchum and Van Wagoner, 1991).

Sequence Thickness Across Faults

14. Isopach Maps: Highest-Resolution Sequences

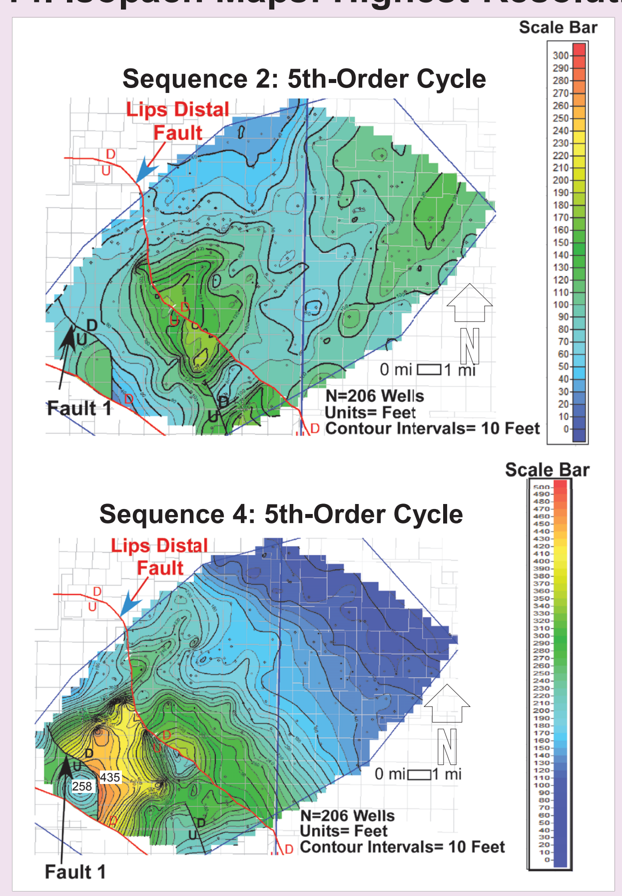


Figure 14. Cycle two and four isopach maps.

Increased thickening of cycle four is expressed as channels and fan apron shaped depocenters on downthrown fault blocks, while upthrown fault blocks could have been eroded and are thinner.

In response to fault movement due to nearby tectonic uplift, sediments eroded and aggraded on the downthrown side of fault one. As a result of uplift and denudation, a large drop in base level occurred during cycle four.

Sand Thickness Across Faults

15. Gross Sand Isolith Maps

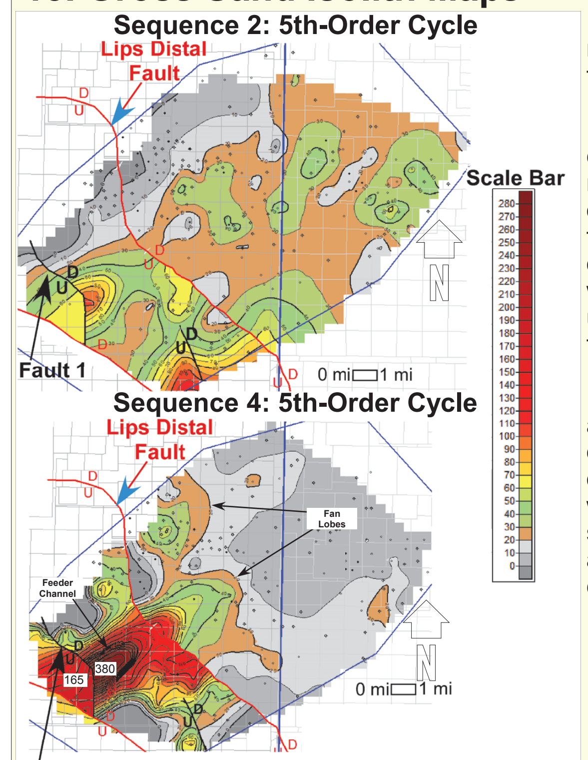


Figure 15. Sand maps for cycles two and four.

Cycle four contains twice as much sand on the down thrown fault side of fault one, where the upthrown side is thinner.

Faulting provided accommodation during deposition of cycle four, which allowed for sand to aggrade and stacked channels.

Un-Published Faults

16. Sequence 4 Structure Map

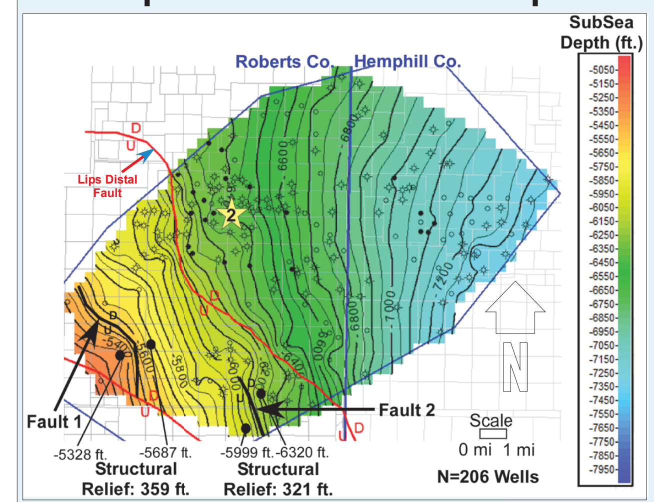


Figure 16. Structure map contoured on flooding surface four.

17. Sequence 4 Slope Angle Map

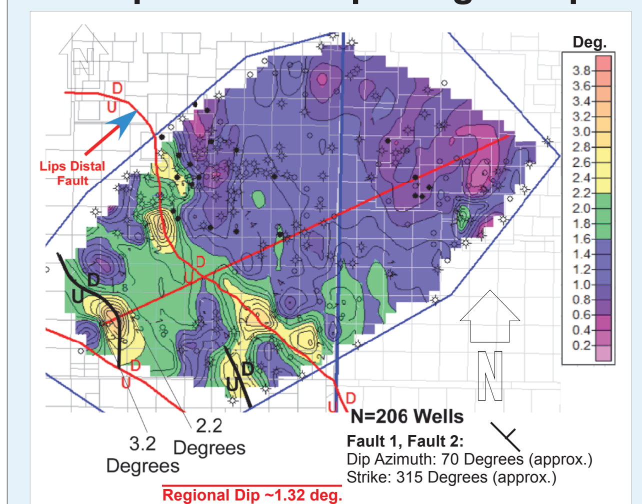
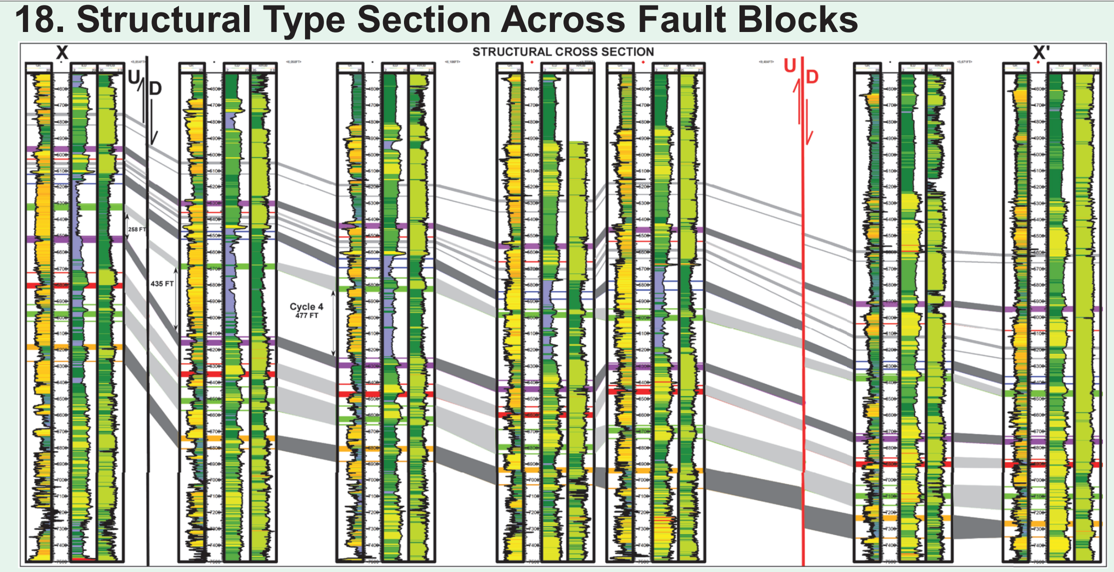


Figure 17. Dip angle curvature map calculated from flooding surface four structure map. Dip angle curvature calculations based on (Wood, 1996).

Figure 18. Structural cross section (refer to Figure 5 on first poster for location of cross section) across fault blocks showing increased thickening of sequence four across fault one.

Structural Type Section

18. Structural Type Section Across Fault Blocks



Conclusions

- A high-resolution chronostratigraphic framework was constructed in over 200 wells to delineate fault movement
- Fault movement likely occurred episodically during two separate 5th-order cycles (Cycle 2, Cycle 4), which may be related to uplift during a 3rd-order cycle.
- Cycle 2 was thicker on up thrown fault blocks, whereas Cycle 4 was thicker on down thrown fault blocks.

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