Yeso Formation along the Northwest Shelf, Southeast New Mexico, USA; Conventional or Unconventional Reservoir Development?*

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Abstract

During the past decade, development of the Yeso Formation along the Northwest Shelf of the Permian Basin in Southeast New Mexico has progressed rapidly. The Paddock and Blinebry members of the upper Yeso Formation are the targets for this development. In 2011, ConocoPhillips began to develop the Yeso on a small acreage position near Maljamar, New Mexico. To date more than 70 vertical wells have been drilled on that acreage with maximum production reaching more than 3500 BOEPD. With the recent decline in oil price, development by vertical wells has become less attractive and horizontal wells have become the focus for many operators. The Yeso Formation was deposited on a shallow carbonate ramp during the Early to Middle Permian (Leonardian) (Ruppel and Ward, 2013). The Paddock and Blinebry members are composed of anhydritic dolomite with interbedded siltstones and fine-grained sandstones. The best reservoir facies were developed along the high-energy ramp crest to platform margin and are composed of peloidal grainstones to packstones with minor amounts of oolitic and fossiliferous grainstones. Historically, the conventional reservoirs of the ramp crest were identified and first drilled in the 1960's and are still under development today, particularly in Vacuum Field. Recent Yeso development, however, has focused on the inner to middle ramp deposits that are dominated by heavily bioturbated peloidal packstones and wackestones, with minor amounts of bioturbated to laminated mudstones. The inner to middle ramp deposits of the Yeso typically display poor reservoir quality when compared to the conventional reservoirs of the Permian Basin. The Paddock in the Maljamar area is a poor conventional reservoir with average porosity of 7.5% and permeability ranging from 0-350 md, while the Blinebry is a tight-carbonate unconventional reservoir (Bishop, 2014) with average porosity of 3% and permeability ranging from 0-15 md. Due to the paucity of rock data for the Yeso in the Maljamar area, much of the geologic analysis has focused on petrophysical and geophysical studies. Seismic attribute and waveform analyses have been used to identify reservoir sweet spots. While petrophysical studies have focused on the identification and mapping of pay and development of a detailed stratigraphy. Engineering studies have focused on understanding production trends, type-curve development, and optimizing the completions techniques to maximize production from these tight reservoirs.

References Cited

Bishop, J., Playton, T., Lipinski, C.J., Harris, P.M., Harris, F., and Landis, P., 2014, The Less Conventional Side of Carbonates: The Houston Geological Society Bulletin, v. 57, no. 1, p. 31-37.

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Ward, R.E., C.G. Kendall, and P.M. Harris, 1986, Upper Permian (Guadalupian) facies and their association with hydrocarbons-Permian Basin, West Texas and New Mexico: AAPG Bulletin, v. 70/3, p. 239-262.

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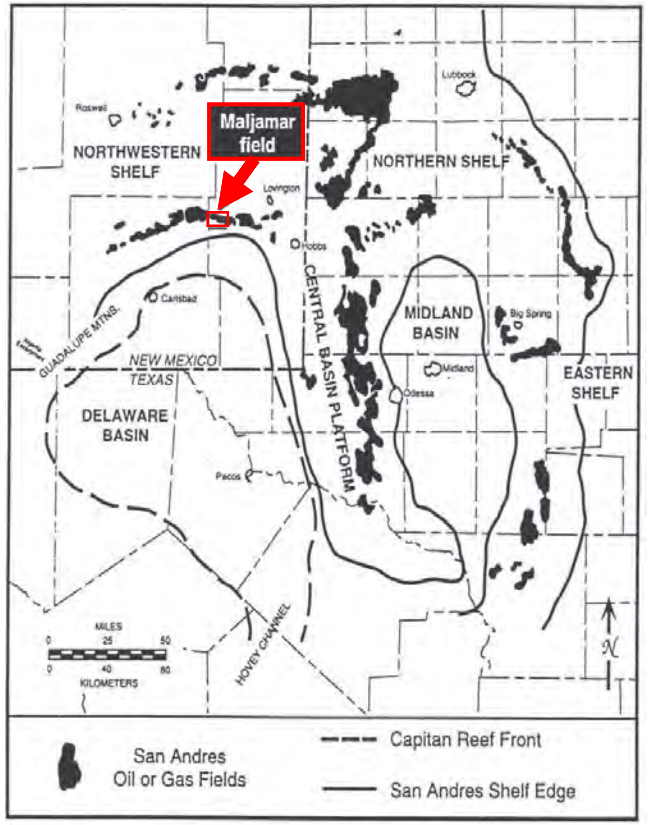
Outline

- Yeso Formation Geologic Setting and Depositional Model
- Yeso Production Information
- Data sources
- Log & core data
- Reservoir property mapping
- Paddock seismic interpretation
- Risk Criteria
- Risk mapping

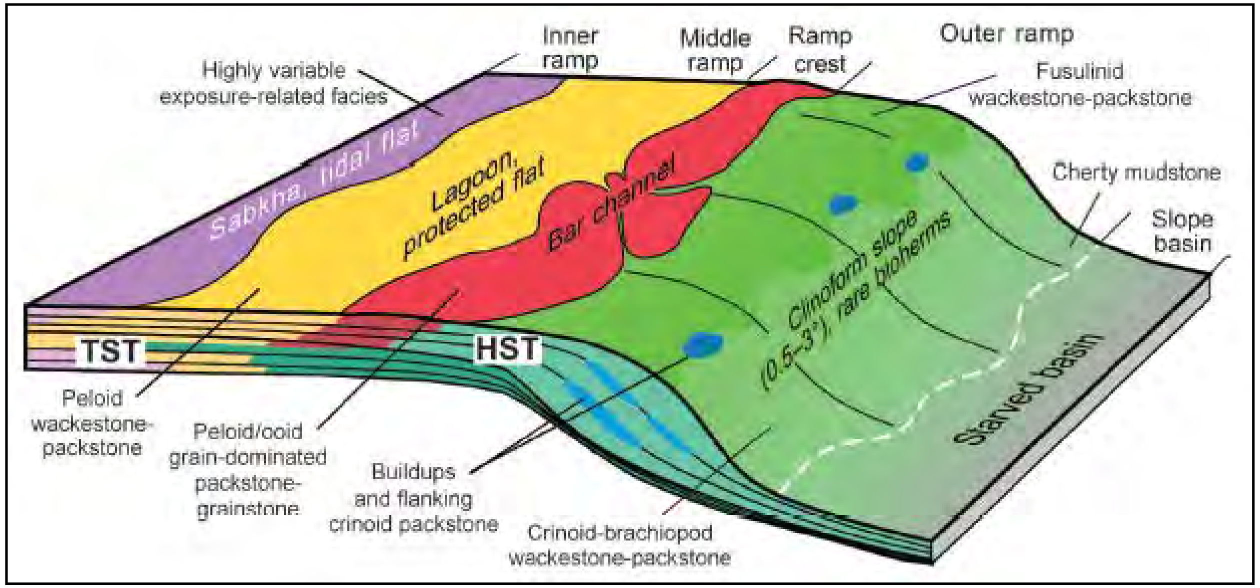
Field Location and Depositional Setting



Modified from Ward et al., 1986

- Yeso Group was deposited on shallow carbonate ramp
- Production comes from anhydritic dolomites of the Yeso Group
- Best reservoir facies typically found in ramp crest/platform margin – Where much of conventional production has been throughout history of Permian Basin
- Recent Yeso development in New Mexico confined to tight carbonate facies of the ramp/platform interior – mudstones to packstones with poor porosity and permeability, completions are critical to success of the program

Age			Unit Name	HC's
Permian 289-248 MYA	Ochoan		Rustler	
			Salado	
	Guadalupian		Tansill	
		Eumont	Yates	• ☼
		Eumont	Seven Rivers	• ☼
		Eumont	Queen	• ☼
			Grayburg	•
			San Andres	•
	Leonardian		Glorieta	•
		Yeso	Paddock	•
		Yeso	Blinebry	• ☼
		Yeso	Tubb	• ☼
		Yeso	Drinkard	• ☼
			Abo	• ☼
	Wolfcampian		Wolfcamp	
Pennsylvanian 320-289 MYA			Strawn	•
			Atoka	• ☼
			Morrow	☼



Ruppel et al., 1994

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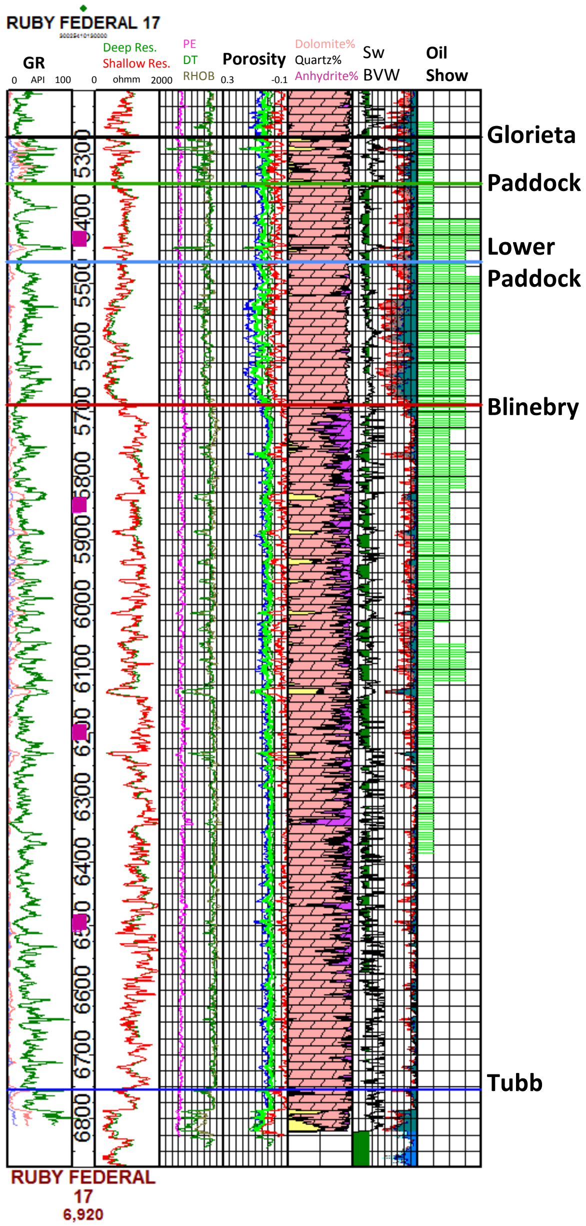
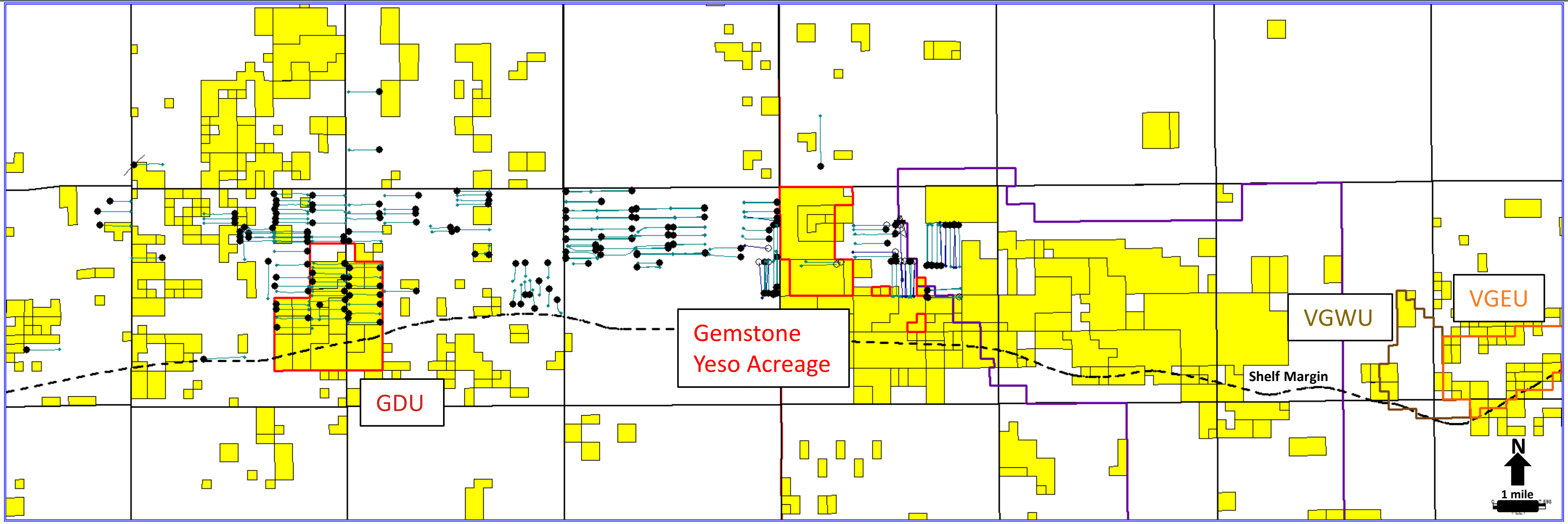
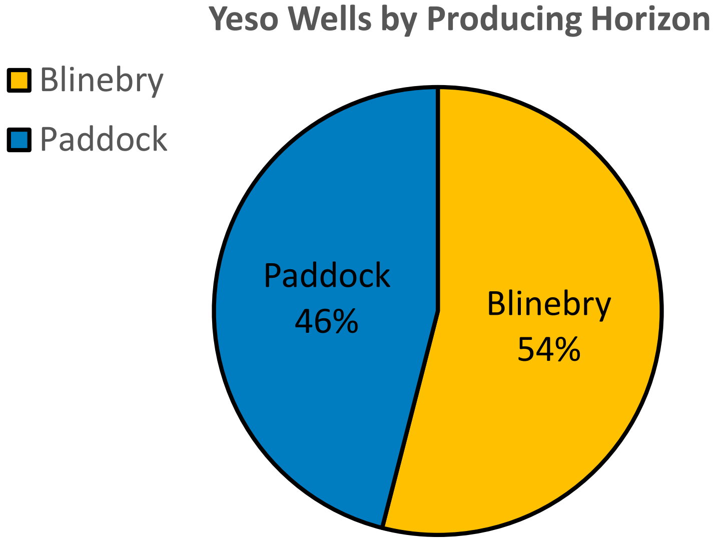
Yeso Reservoir Geology and Type Log

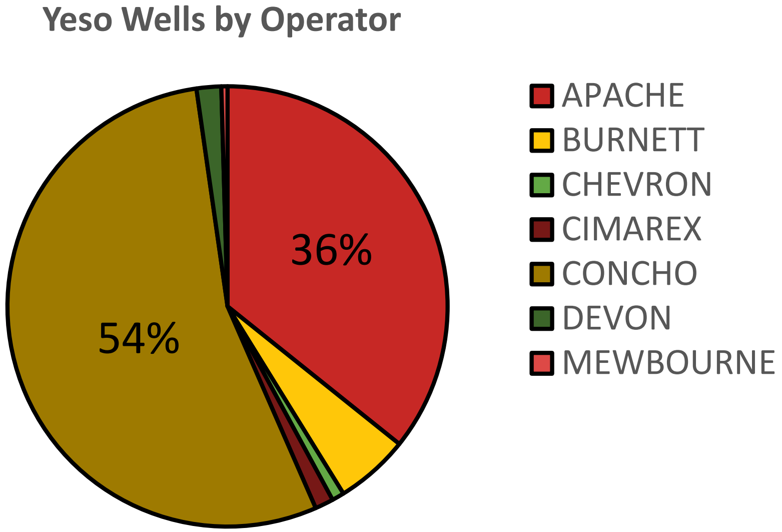


- Yeso Characteristics
  - Composition: anhydritic dolomite with minor sandstones
  - Gross thickness:
    - Paddock: 350 ft.
    - Blinebry: 1000 ft.
- Reservoir Properties
  - Initial pressure: 2800 psi
    - GORi: 1000 cf/bo
    - Pressure gradient: Normally pressured
  - Temperature: 120° F
  - Drive mechanism: solution gas drive
  - Reservoir Fluid Type: Black Oil
  - Porosity range for pay:
    - Paddock: 4-20% (7.5% Avg.)
    - Blinebry: 1-10% (3% Avg.)
  - Permeability range for formation:
    - Paddock: 0-350 mD (15 mD Avg.)
    - Blinebry: 0-15 mD (0.45 mD Avg.)
  - Gravity: 41° API

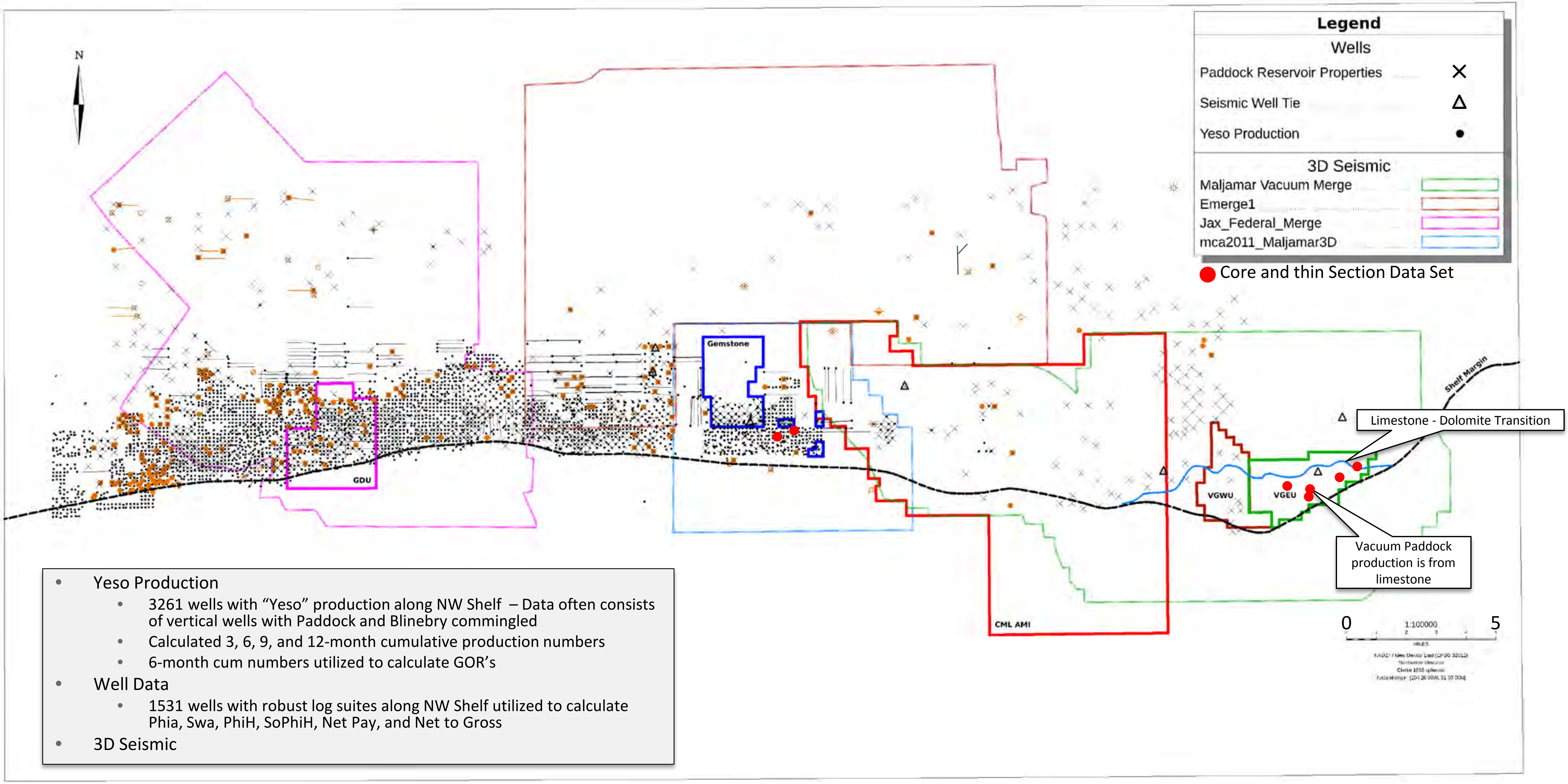
Yeso Horizontal Development along Northwest Shelf







Well Log, Production, and Seismic Data Sources



- Yeso Production
  - 3261 wells with "Yeso" production along NW Shelf – Data often consists of vertical wells with Paddock and Blinebry commingled
  - Calculated 3, 6, 9, and 12-month cumulative production numbers
  - 6-month cum numbers utilized to calculate GOR's
- Well Data
  - 1531 wells with robust log suites along NW Shelf utilized to calculate Phia, Swa, PhiH, SoPhiH, Net Pay, and Net to Gross
- 3D Seismic

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Depositional Environments and Facies Associations

Association	Facies	Description	Depositional Environment
A	8,11,13,14	Mud-dominated fabrics, peloidal, intermittent bioturbation/burrowing	Lagoonal, protected facies
B	1,2,3,12	Grain-dominated fabrics, ooids-peloids, only minor skeletal fragments	Middle Ramp
C	5,6	Grain-dominated fabrics, ooids-peloids, abundant skeletal debris, packstones to grainstones	Ramp Crest
D	4,7	Skeletal grain dominated wackestones to packstones	Outer Ramp
E	9,10	Siliciclastics - siltstone to fine grained sandstones, sometimes laminated	Sabkha siliciclastics
F	15	Brecciated and matrix filled assortment of various facies	Karst

Facies	Descriptive Name
1	Peloidal grainstone - grain dominated packstone
2	Mixed Ooid-peloids grainstone
3	Peloidal packstone
4	Fossiliferous packstone (crinoids, bryozoan, brachiopods)
5	Ooid dominated, peloidal, fossiliferous grain/packstone
6	Peloidal, fossiliferous grain/packstone
7	Fossiliferous wackestone (skeletal)

Facies	Descriptive Name
8	Mudstone
9	Very fine - fine grained sandstone
10	Siltstone - very fine sandstone, w/ lamination
11	Bioturbated/burrowed wackestones
12	Ooid-peloid packstone
13	Peloidal packstone w/ laminations
14	Peloidal wackestone
15	Brecciated zones

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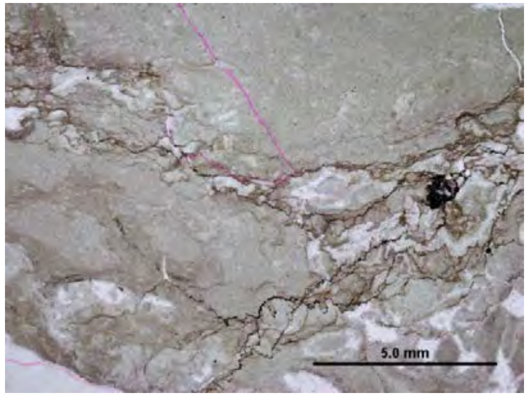
Core and Thin Section Examples of Depositional Facies

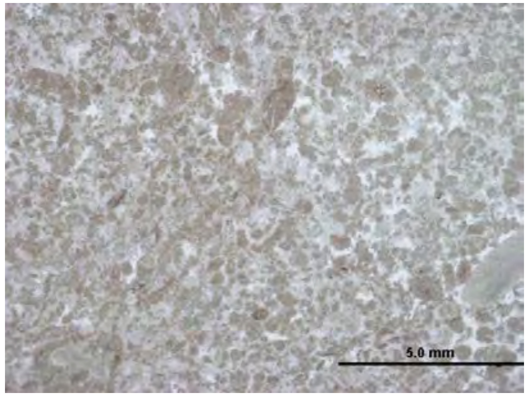
- Lagoonal-Tidal Flats

Facies
Mudstone
Bioturbated/burrowed wackestone
Peloidal packstone w/ laminations
Peloidal wackestone



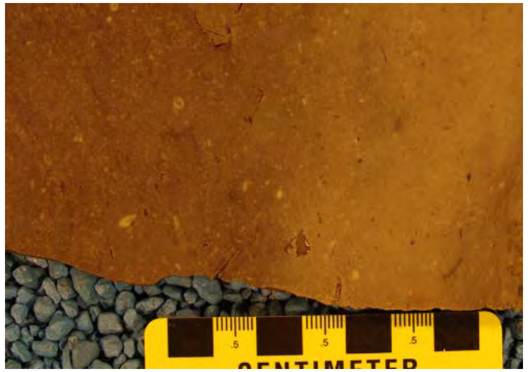
- Peloidal/Oolitic Middle Ramp

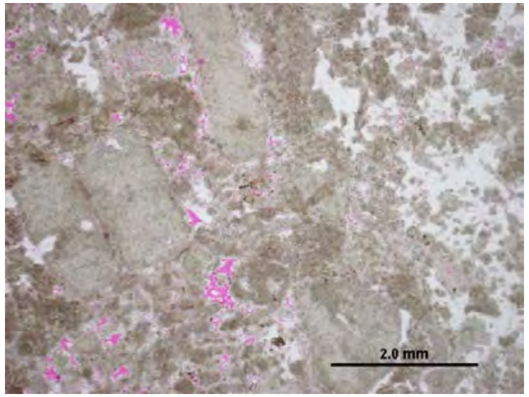
Facies
Peloidal grainstone to grain-dominated packstones
Ooid, peloidal grainstone
Peloidal packstone
Oolitic, peloidal packstone



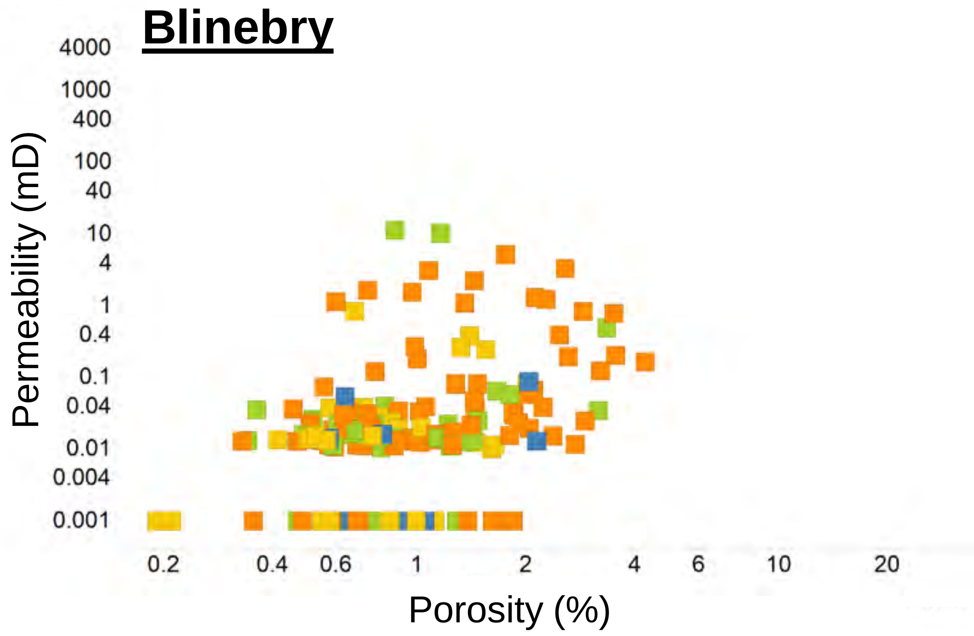
- Fossiliferous, Peloidal Ramp Crest

Facies
Ooid dominated, peloidal, fossiliferous grainstone
Peloidal, fossiliferous grainstone

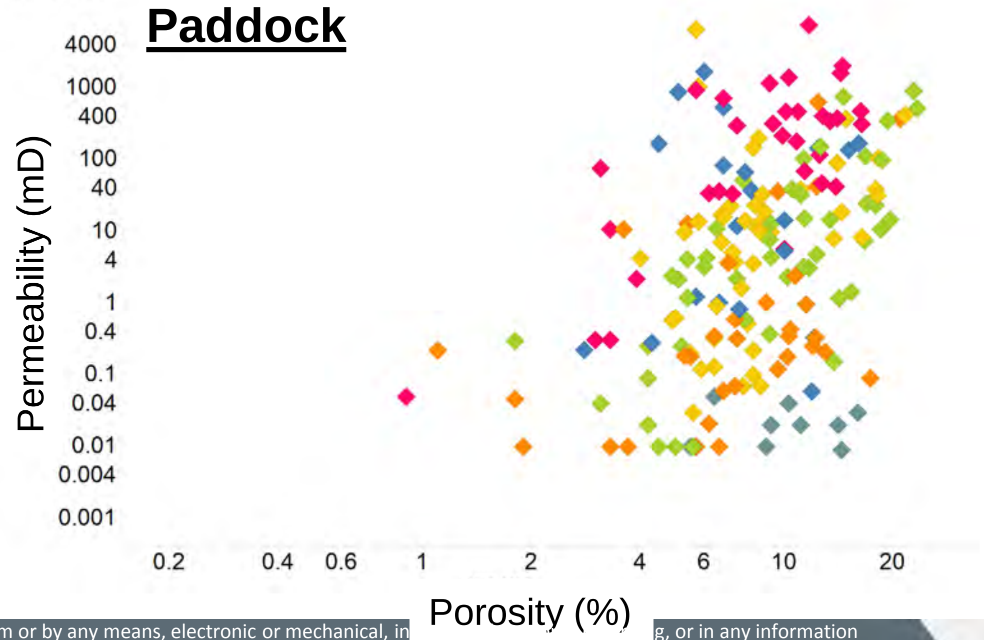




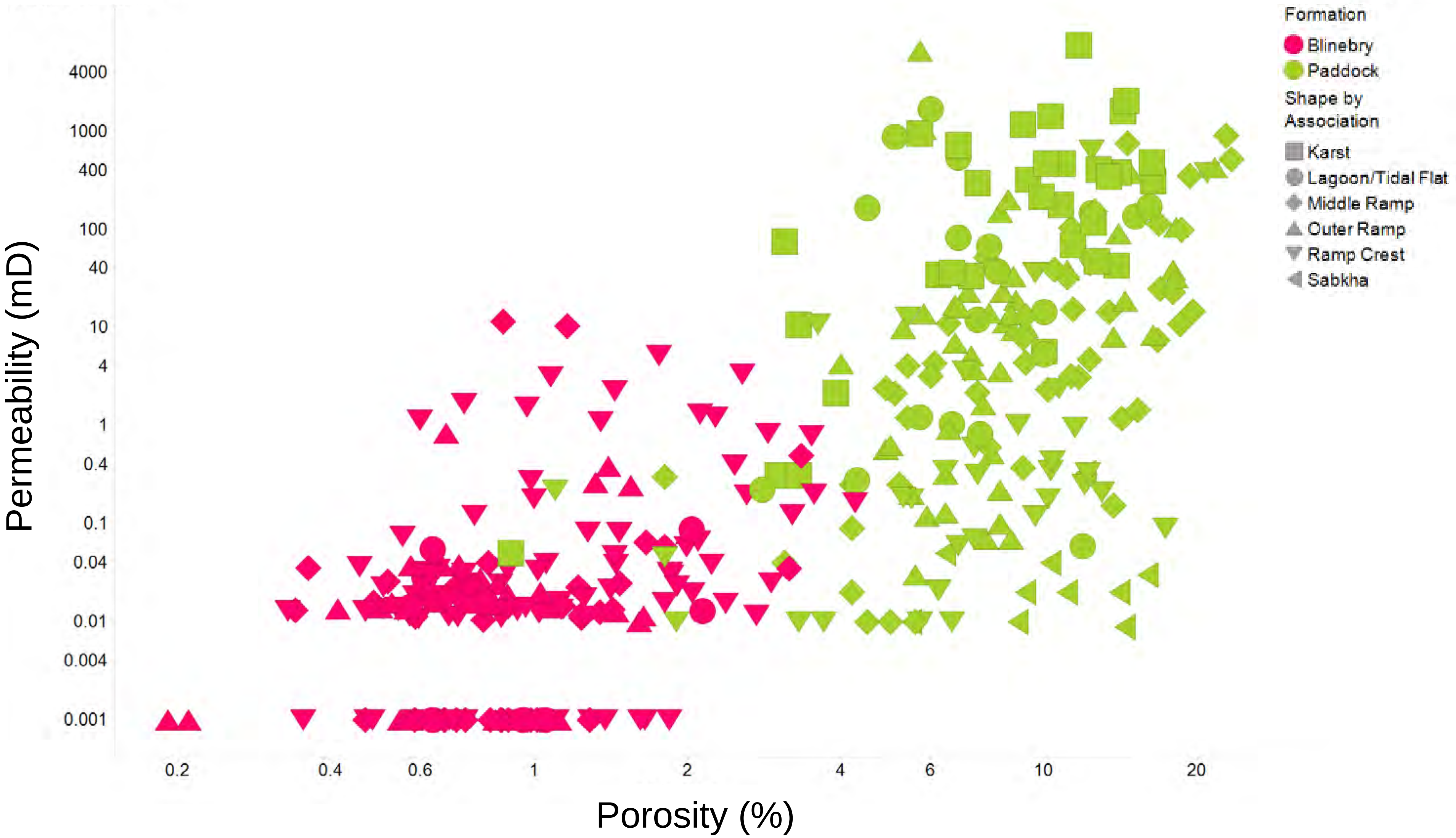
Depositional Facies Porosity vs. Permeability Trends



- Paddock best reservoir facies reside in the Middle Ramp to Lagoonal deposits
- Blinebry best reservoir facies reside in the Ramp Crest to Middle Ramp deposits



Paddock vs. Blinebry Reservoir Quality Comparison



- Paddock clearly displays better reservoir quality versus the Blinebry

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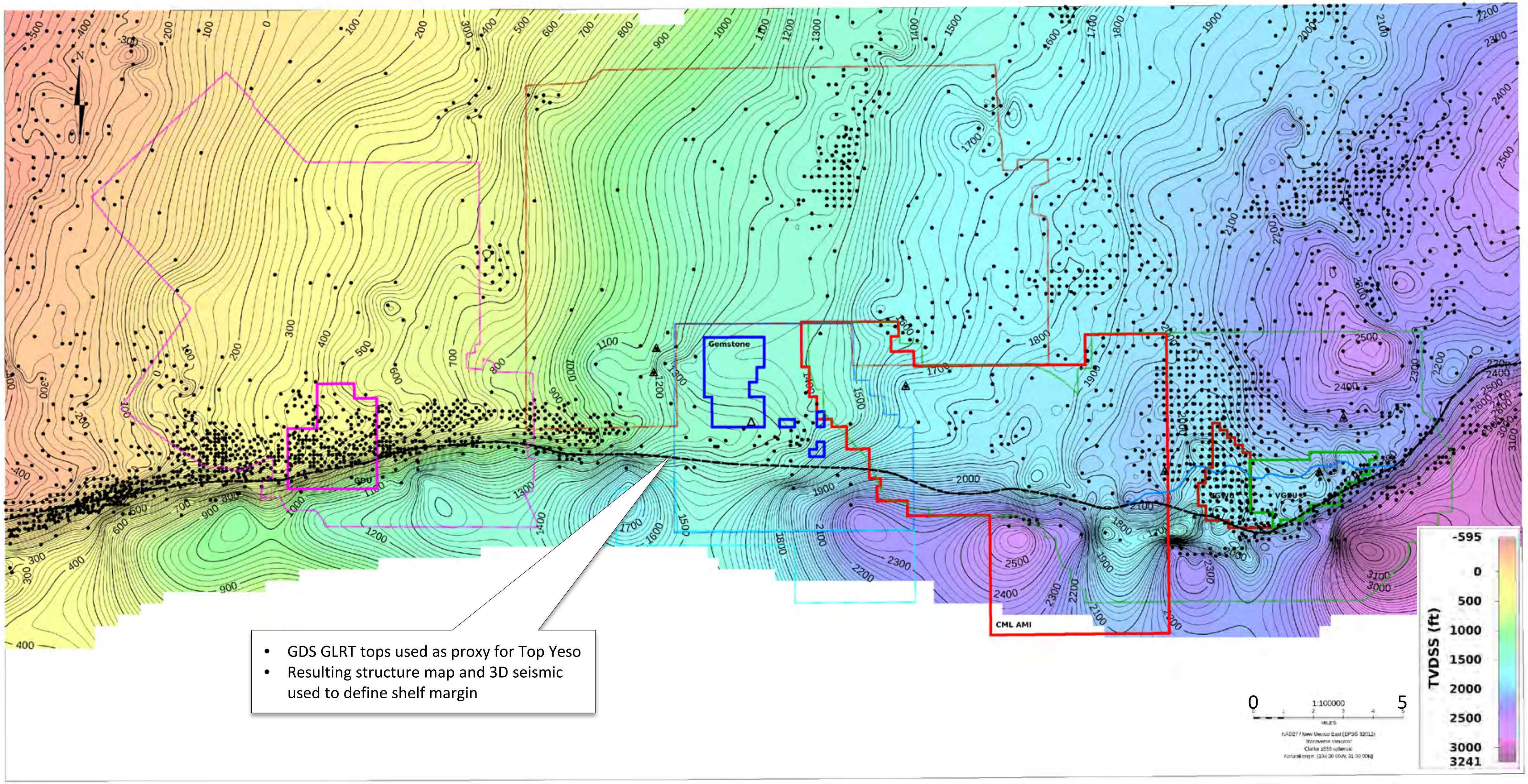
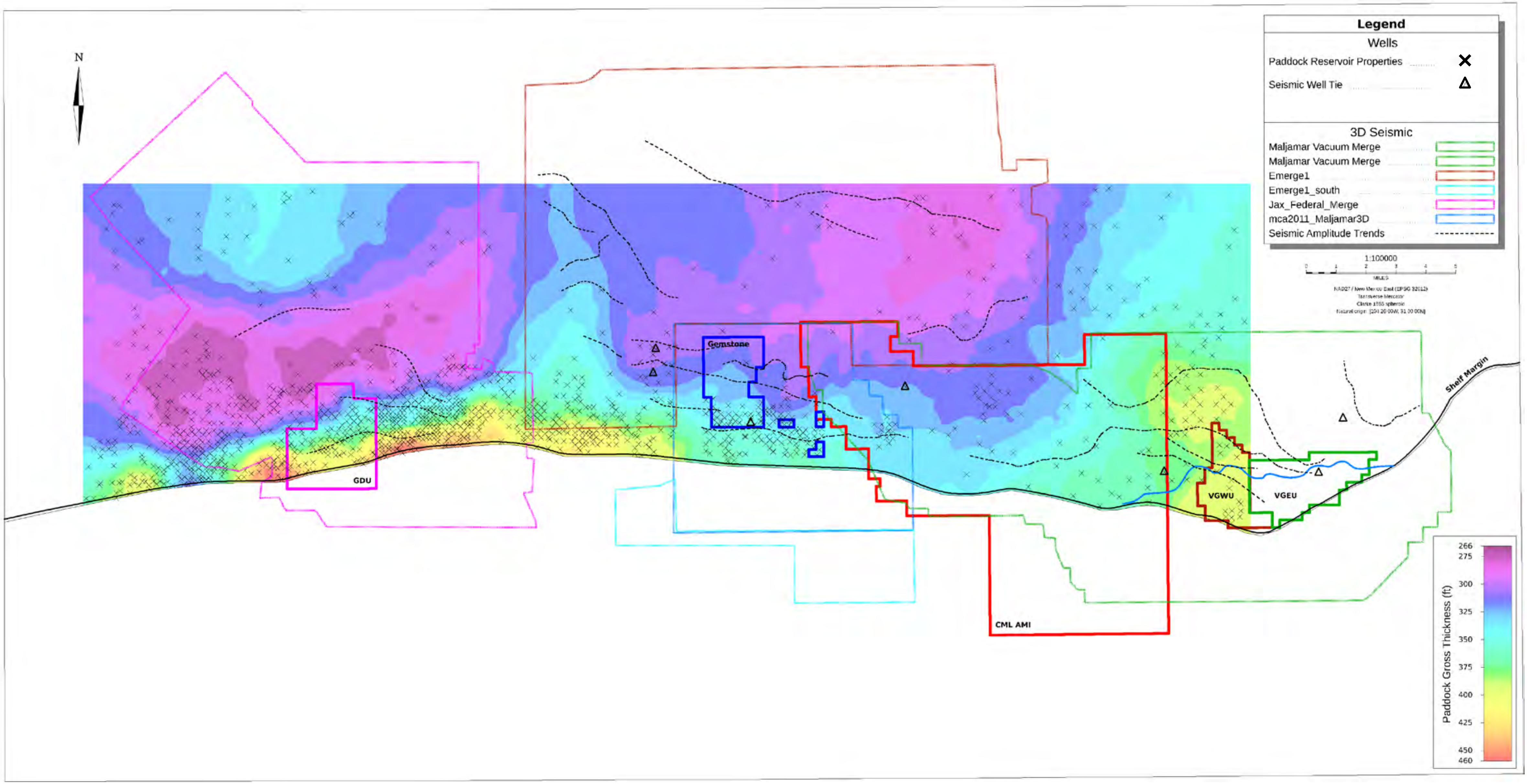
Yeso Structure and Shelf Margin Definition



- GDS GLRT tops used as proxy for Top Yeso
- Resulting structure map and 3D seismic used to define shelf margin

Paddock Gross Thickness



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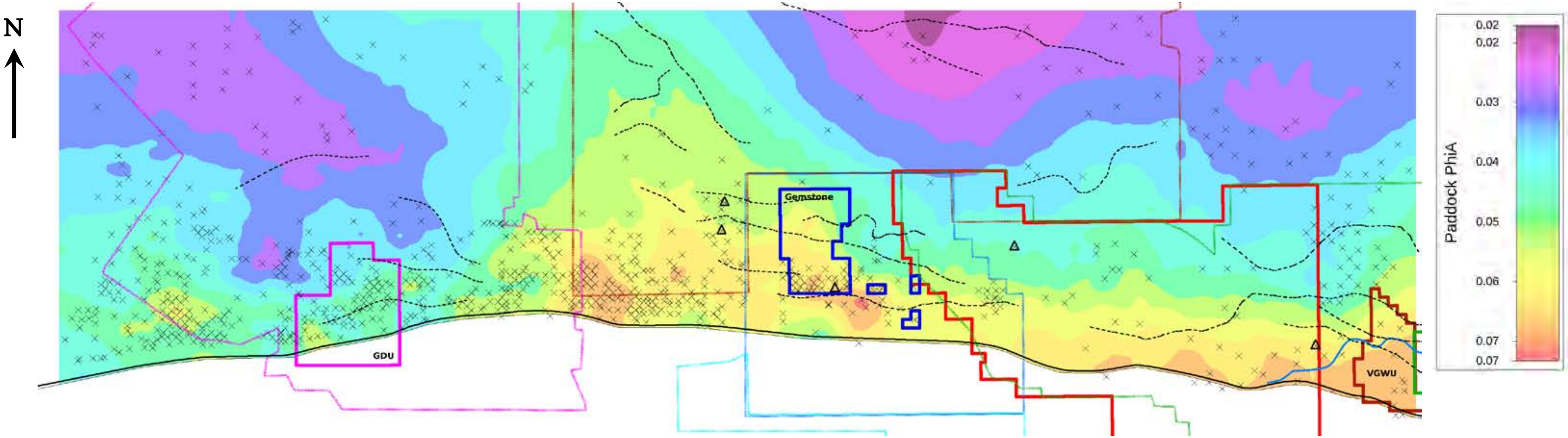
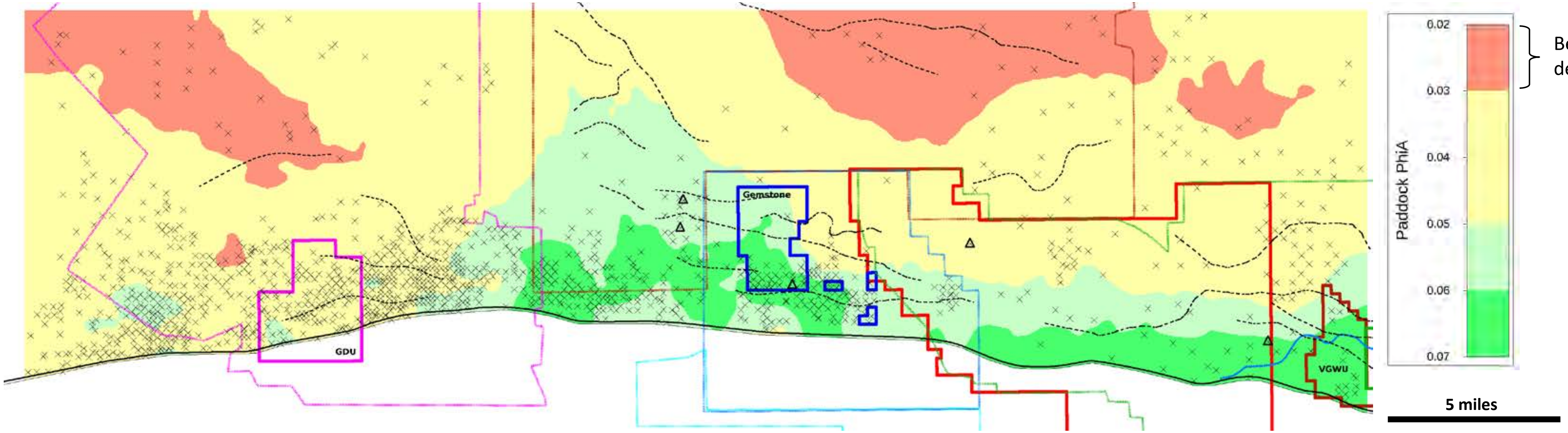
Paddock Average Porosity



Cutoffs
ϕ – 0-30%
Sw – 0-100%



Below minimum desired outcome

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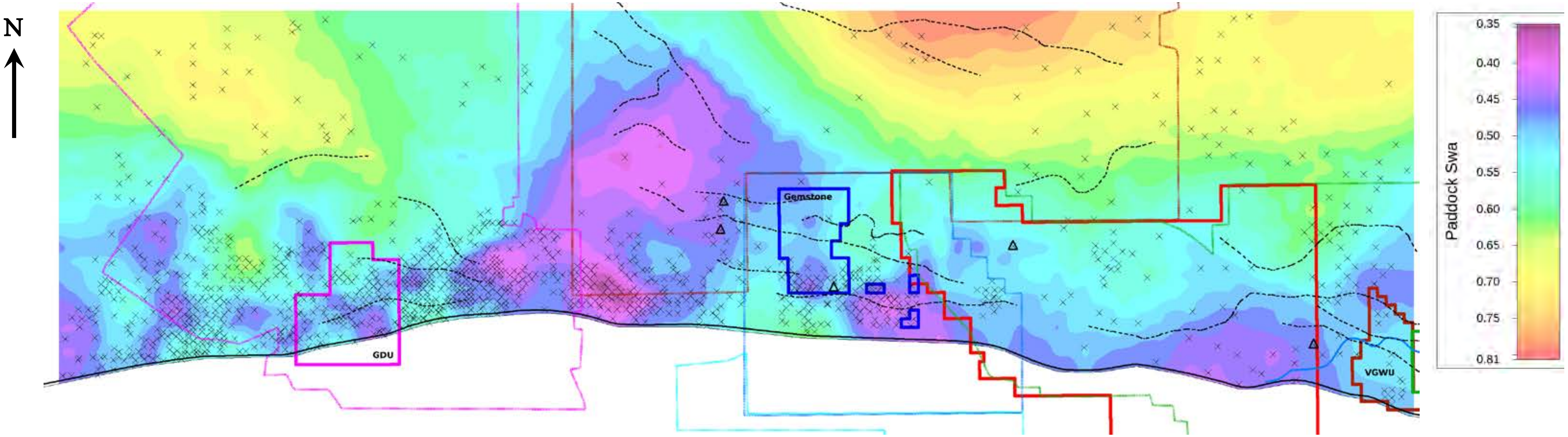
Paddock Swa



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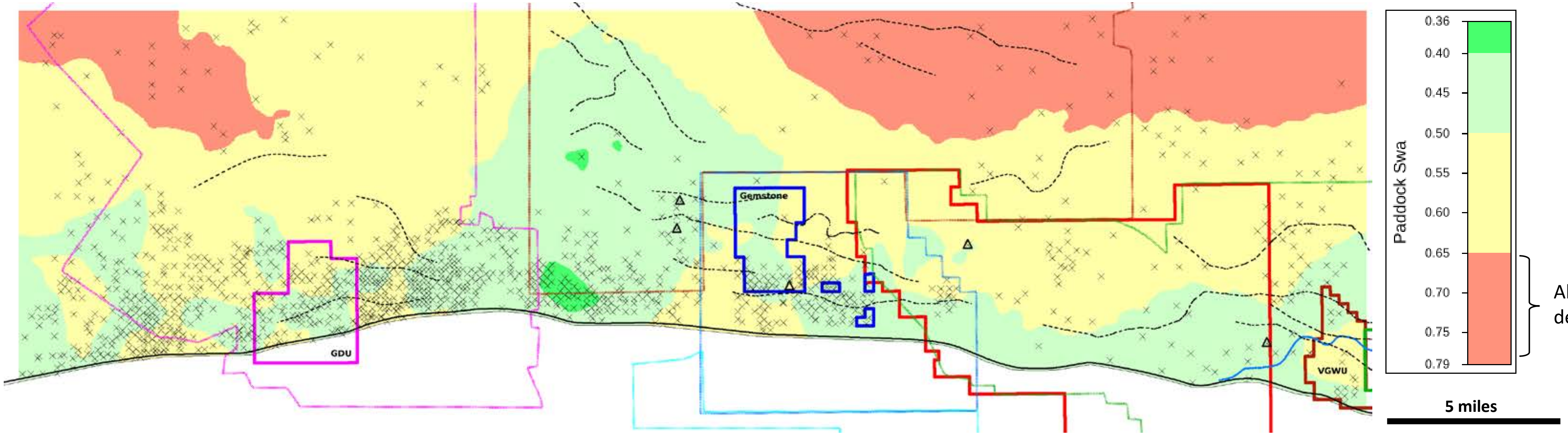
Sw – 0-100%



Above maximum desired outcome

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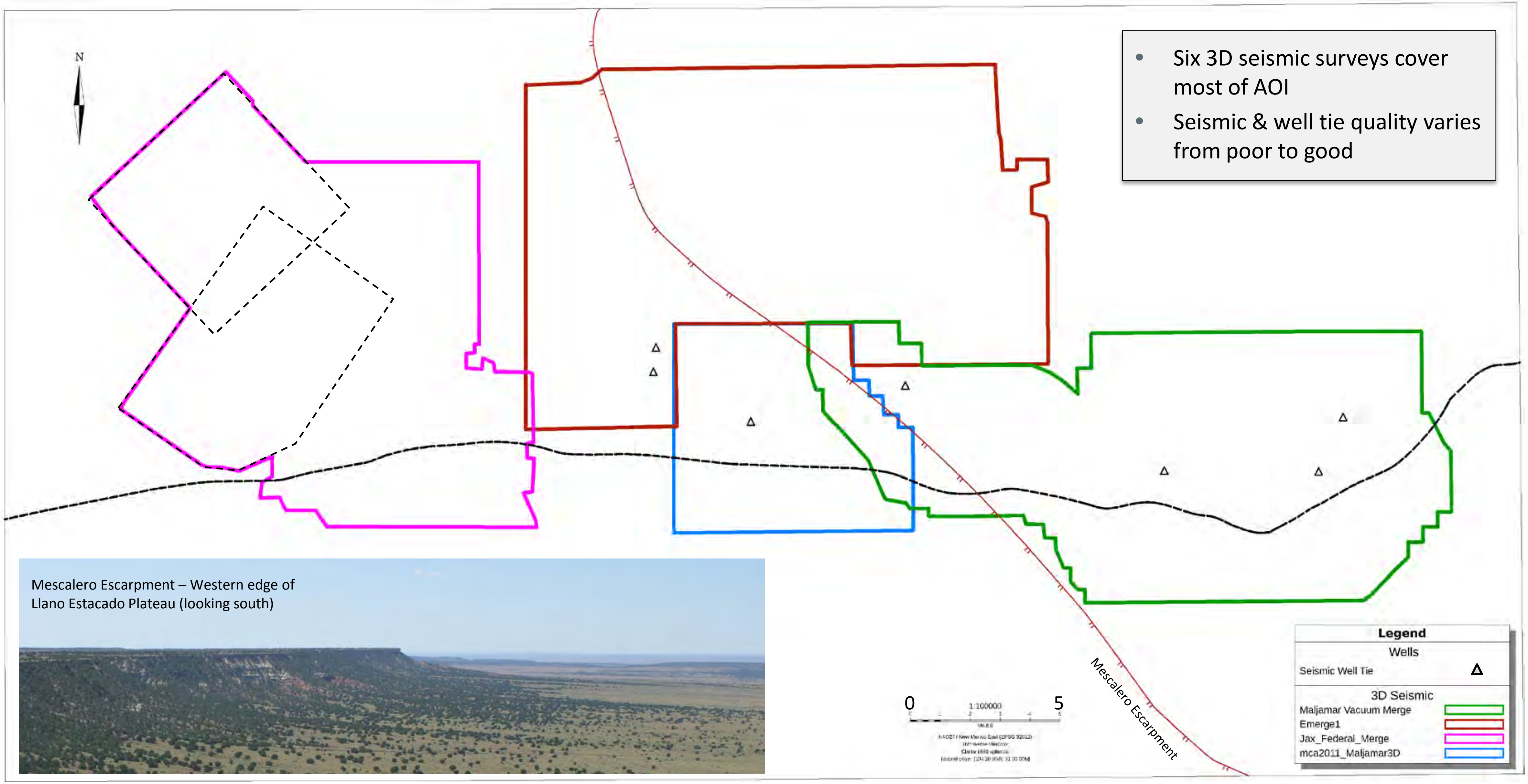
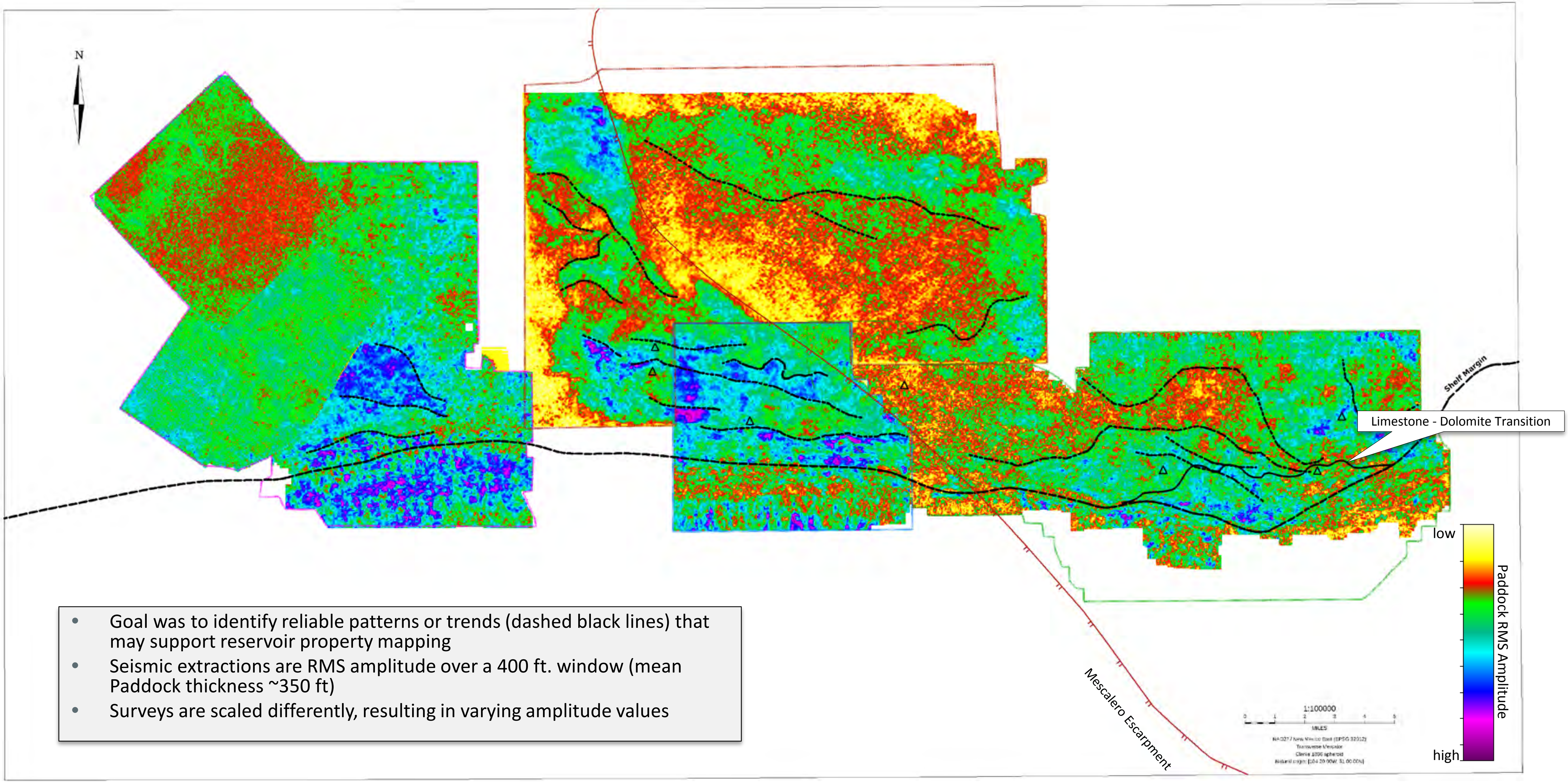
Paddock Seismic Interpretation - 3D Seismic Surveys

- Six 3D seismic surveys cover most of AOI
- Seismic & well tie quality varies from poor to good



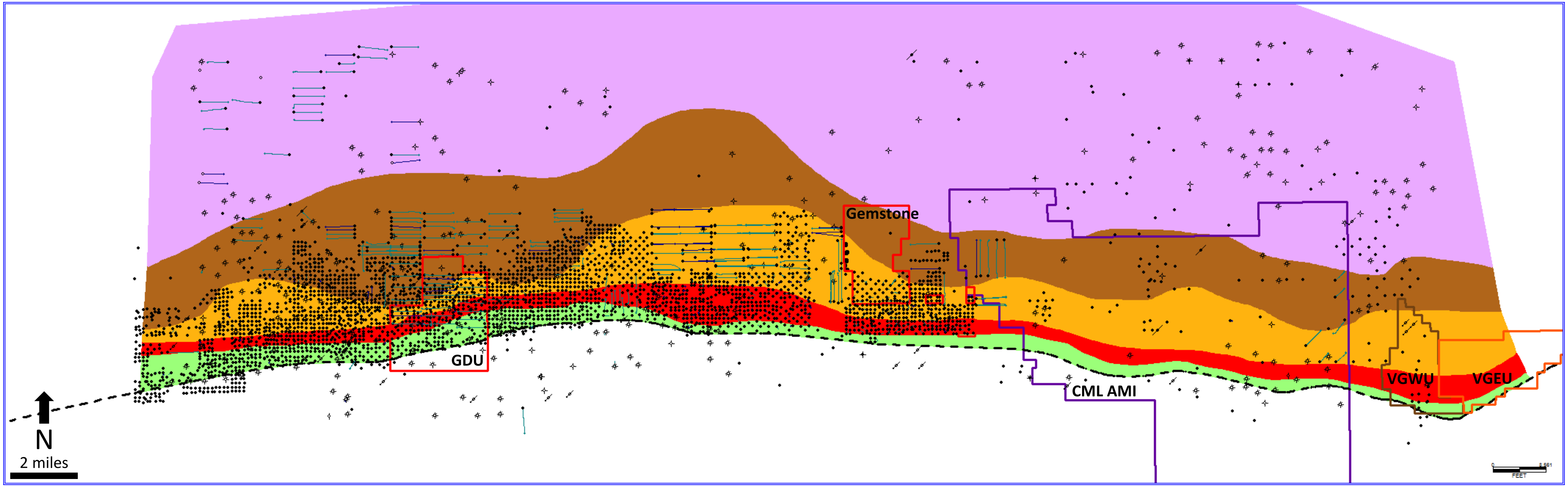
Mescalero Escarpment – Western edge of Llano Estacado Plateau (looking south)

Paddock Seismic Interpretation - Amplitude Extraction



- Goal was to identify reliable patterns or trends (dashed black lines) that may support reservoir property mapping
- Seismic extractions are RMS amplitude over a 400 ft. window (mean Paddock thickness ~350 ft)
- Surveys are scaled differently, resulting in varying amplitude values

Paddock Depositional Facies Map



Facies Key

- Ramp Crest – Ooid-peloid grain-packstones
- Outer Ramp – Fusulinid wacke-packstones
- Middle Ramp – Grain-dominated skeletal-peloid packstones
- Middle Ramp – Mud-dominated skeletal-peloid wacke-packstones
- Intertidal-Peritidal – Mud-dominated fenestral and pisolitic mud-packstones

(modified from Ruppel and Ward, 2013)

- **Vertical Yeso development along the shelf has historically focused on porous ramp crest grainstone facies to grain-dominated middle ramp facies**
- **Horizontal Yeso development has moved north to the transition area between grain-dominated to mud-dominated middle ramp facies**

- Facies belts constructed based on:
  - Published facies models for the Yeso Formation in Permian Basin outcrops (Ruppel et al., 1994; Ruppel and Ward 2013)
  - Paddock structure
  - Phia Maps for the Paddock
  - Porosity ranges from limited Paddock core in the Maljamar area
  - Paddock geologic risk maps

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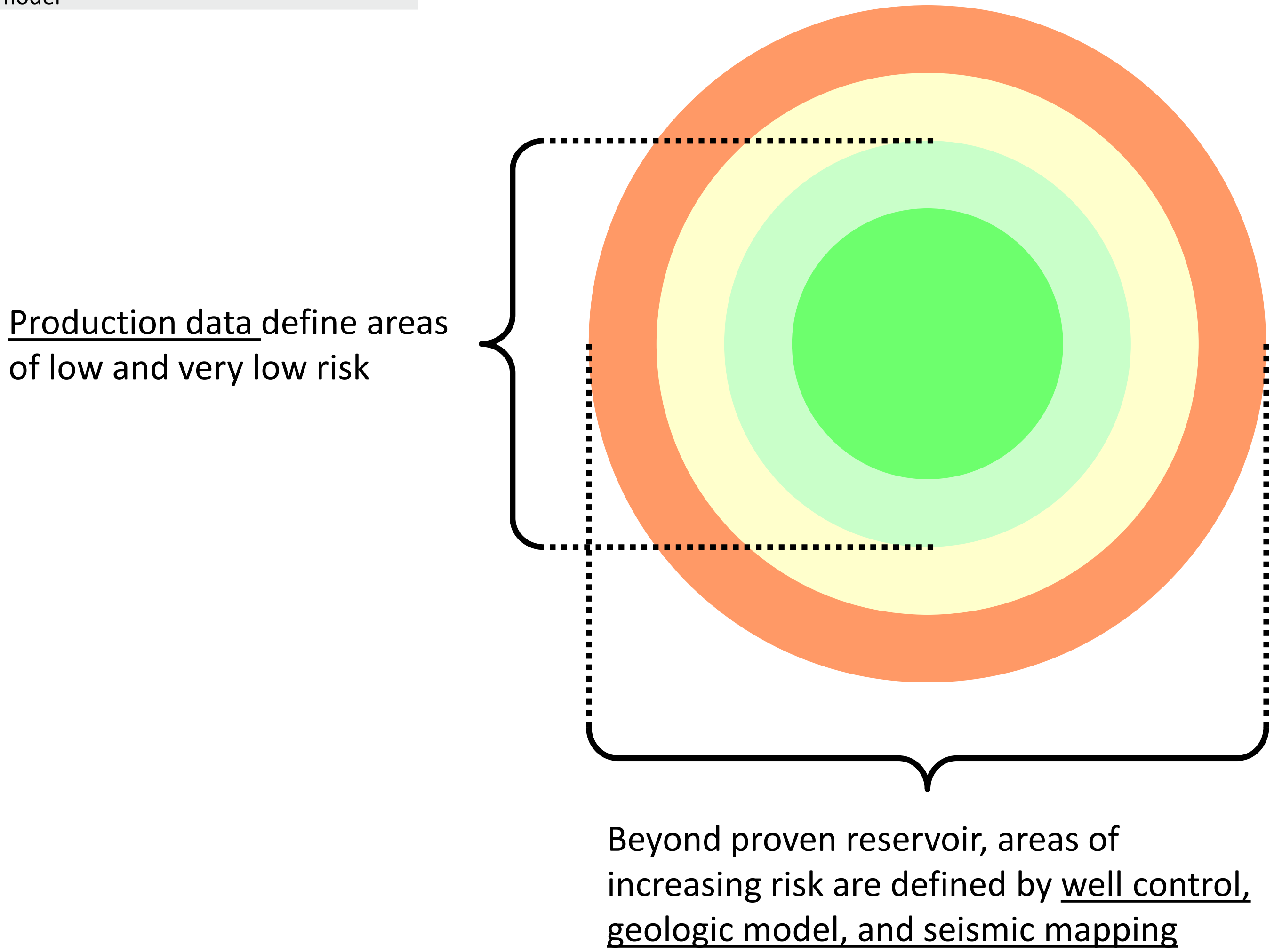
Paddock Reservoir Risk Criteria

Risk	Criteria
very low	proven and extensively drilled
low	proven "production envelope", but not extensively drilled
moderate	unproven, but supported by well control, geologic model, and seismic mapping
high	not supported by well control or geologic model



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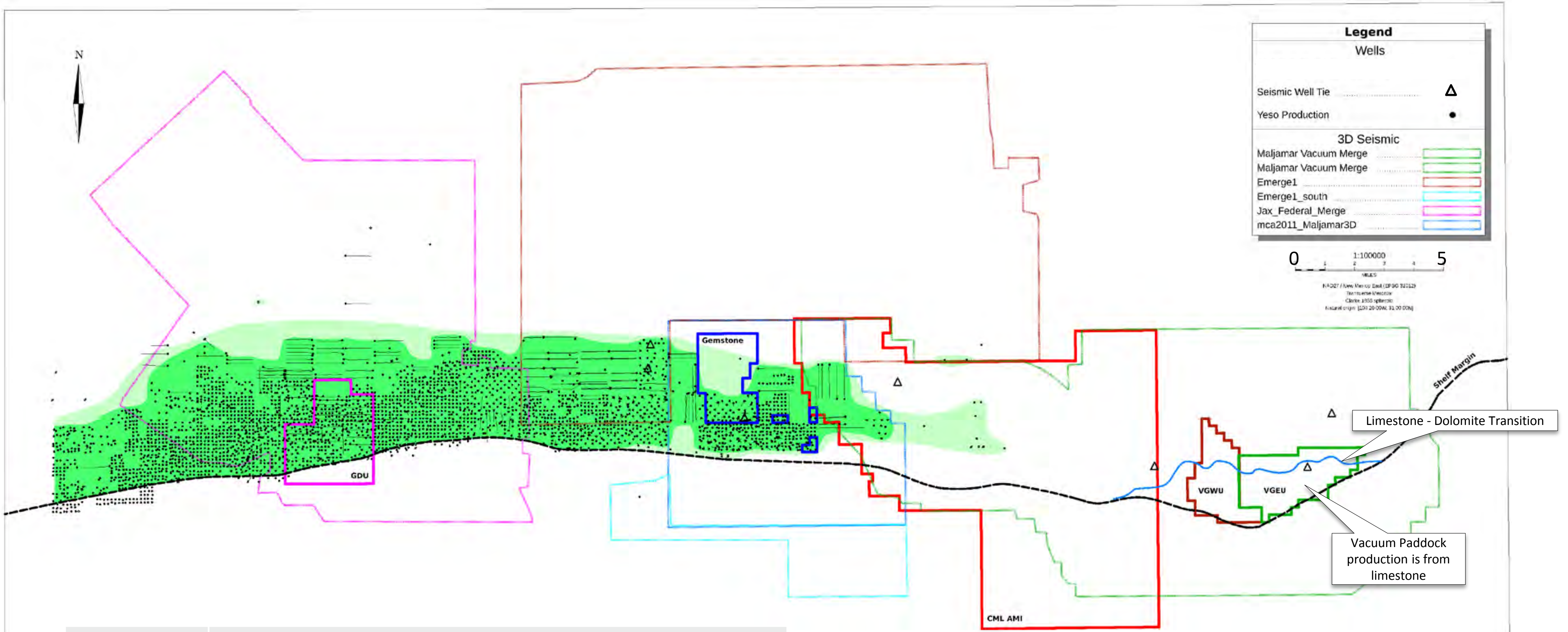
Paddock Reservoir Risk – Assembling the Pieces



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- Production data define areas of low and very low risk

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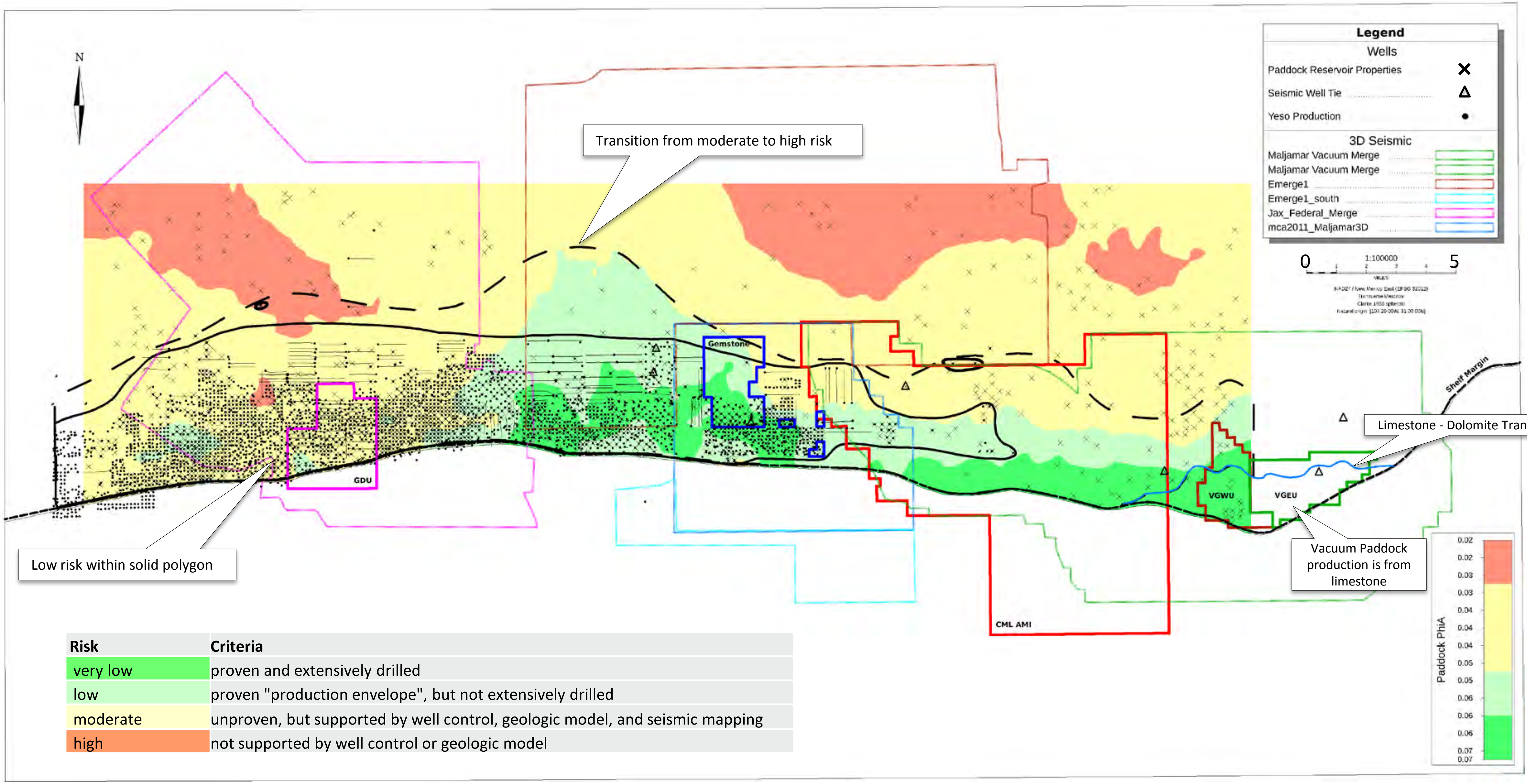
Paddock Reservoir Risk – Risk Polygons vs. Average Porosity



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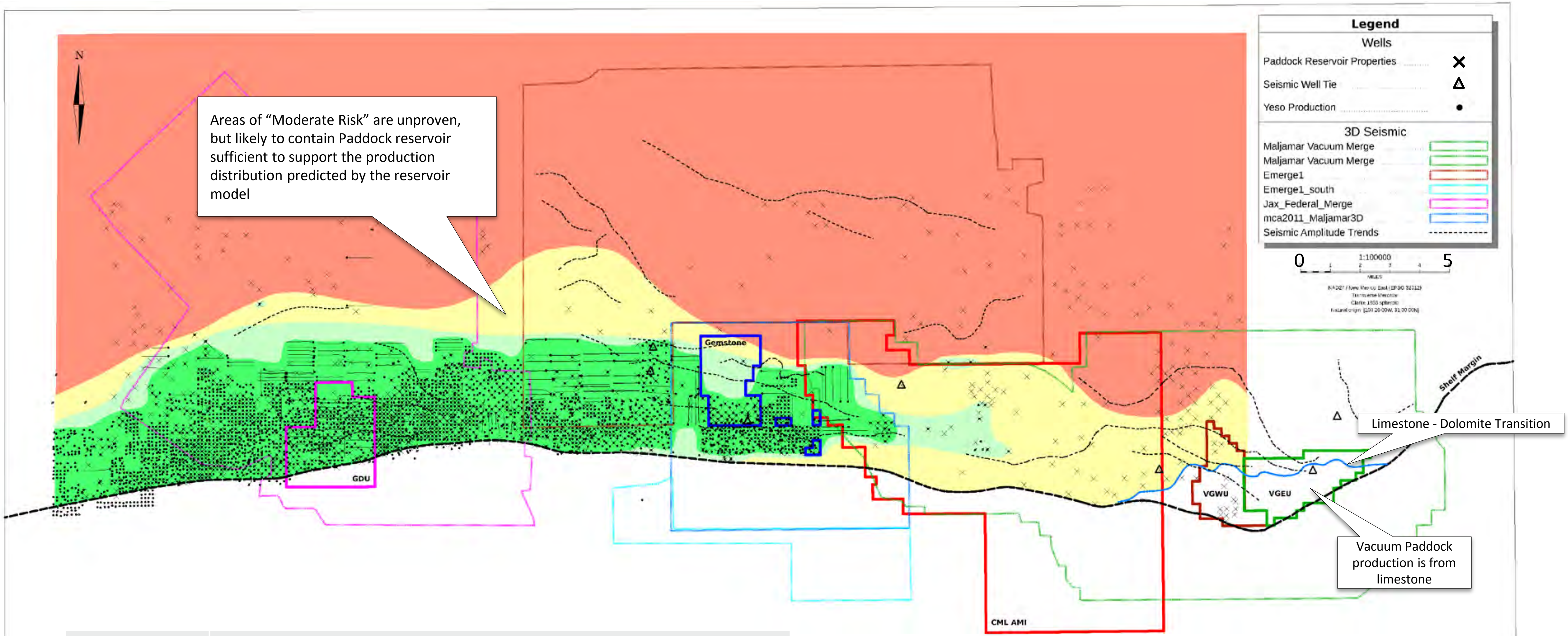
Paddock Reservoir Risk



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- <u>Production data</u> define areas of low and very low risk
- Beyond proven reservoir, areas of increasing risk are defined by <u>well control, geologic model, and seismic mapping</u>

Conclusions

- Conventional or Unconventional Reservoir Development? – Our answer: Both
- Horizontal development of the Yeso has become the preferred development methodology when compared to vertical wells.
- Reservoir quality in the Paddock is 1-2 orders of magnitude better than what is observed in the Blinebry in the Maljamar area.
- Recent horizontal development has focused on the Middle Ramp facies of burrowed peloidal packstones and wackestones deposited in a lagoonal environment.
- Risk analysis of the Paddock shows low reservoir risk within 3-4 miles north of the shelf margin with variations in that based on detailed petrophysical and geophysical analysis.

References

- Ward, R. E., C. G. Kendall, and P. M. Harris, 1986, Upper Permian (Guadalupian) facies and their association with hydrocarbons-- Permian Basin, West Texas and New Mexico: AAPG Bulletin, v. 70, no. 3, p. 239-262.
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