Sedimentologic and Stratigraphic Controls on Reservoir Sweet Spots in Wolfcamp 'A,' Howard County, Midland Basin

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Significance

- Deep-water carbonates can comprise conventional and unconventional hydrocarbon reservoirs and non-reservoir rocks.
- Such deposits are complex, and not as well understood as siliciclastic deposits and shallow-water carbonates.
- The economic potential warrents further exploration of the controls on the distribution of reservoirs in order to create predictive models that are widely applicable.

Overview

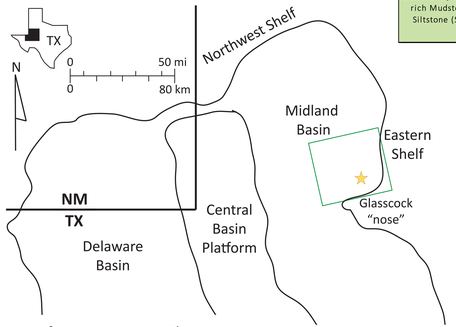
- Deep-water deposits of "Wolfcamp A" are investigated as a case study to understand the sedimentologic and stratigraphic controls on 'sweet spots' within basinal settings of the Midland Basin.
- This project will provide an understanding of the compositional, sedimentologic, and stratigraphic characteristics of sweet spots in the Wolfcamp A.

Methods

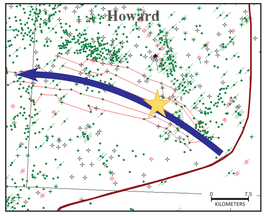
1) Compare petrophysical, XRD, and pyrolysis data in Wolfcamp A to determine what variables control reservoir quality.
2) Decipher depositional processes of units.
3) Determine the vertical and lateral stratigraphic architecture of Wolfcamp A.
4) Generate a stratigraphic and sedimentologic conceptual model to locate reservoir sweet spots.

TIME INTERVAL			FORMATION	
Permian	Leonardian	Upper Leonardian	Spraberry	Upper Spraberry
				Lower Spraberry
		Lower Leonardian	Dean Sandstone	
	Wolfcampian		"Wolfcamp"	Wolfcamp A
				Wolfcamp B
				Wolfcamp C
				Wolfcamp C Clastic
Pennsylvanian				Wolfcamp D

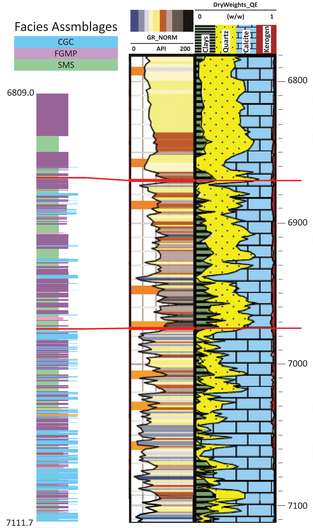
Stratigraphic chart of basinal late Paleozoic strata in the Midland Basin.



Map of Permian Basin. The study area is ~ 72.1 by 56.2 km. (green polygon), located in Howard County, western Texas. Study area contains basinal and slope depositional settings of the "Wolfcamp A." Gold star shows location of the cored Sparky-1 well. Inset map of study area shows the preferred transport route for Wolfcamp A sediments into the basin.



Facies Assemblage	Facies	% of Wlfcp A in Core		Dominant Grains	Grain Size & Sorting	Contacts	Bedding & Sedimentary Structures	Interpreted Depositional Mechanisms
Coarse-Grained Packstone - Rudstone (CGC)	Echinoderm & Foram Rudstone – Packstone (RP)	22%	4%	Echinoderm fragments, foraminifera	0.05 mm – 4 cm; Poorly to very poorly sorted	Sharp or gradational upper & lower contacts	Massive, normally graded, inversely graded	Hyperconcentrated to concentrated density flows, turbidity flows
	Massive Echinoderm & Foram Floatstone (MF)		6%	Echinoderm fragments, foraminifera	0.05 mm – 4 cm; Poorly sorted	Sharp upper & lower contacts	Massive	Hyperconcentrated density flows
	Echinoderm & Foram Packstone (CP)		12%	Echinoderm fragments, foraminifera	0.05 mm – 2 cm; Very poorly to poorly sorted	Sharp or gradational upper & lower contacts	Massive, normally graded, rarely inversely graded	Hyperconcentrated to concentrated density flows, turbidity flows
Dominantly Calcareous Mudstone – Wackestone (FGMP)	Calcareous Md-Wk, w/ <10% Quartz-rich Mud-Slt (FGC10)	49%	36%	Echinoderm fragments, foraminifera	0.005 mm – 4 mm; Poorly to well sorted	Sharp or gradational upper & lower contacts	Laminated (massive, normally graded, prominent to vague), rarely structureless	Turbidity flows, concentrated density flows
	Calcareous Md-Wk, w/ <40% Quartz-rich Mud-Slt (FGC40)		14%	Echinoderm fragments, foraminifera	0.005 mm – 4 mm; Poorly to well sorted	Sharp or gradational upper & lower contacts	Laminated (massive, normally graded, prominent to vague)	Turbidity flows, concentrated density flows
Dominantly Quartz-rich Mudstone – Siltstone (SMS)	Quartz-rich Mud-Slt, w/ <10% Calcareous Md-Wk (S10)	27%	14%	Detrital quartz, siliceous spicules	0.005 mm – 4 mm; Poorly to well sorted	Sharp or gradational upper & lower contacts	Laminated (massive, normally graded, prominent to vague), rarely structureless	Turbidity flows, concentrated density flows
	Quartz-rich Md-Slt, w/ <40% Calcareous Md-Wk (S40)		12%	Detrital quartz, siliceous spicules	0.005 mm – 4 mm; Poorly to well sorted	Sharp or gradational upper & lower contacts	Laminated (massive, normally graded, prominent to vague)	Turbidity flows, concentrated density flows



▲ Descriptive table of lithofacies covering 98% of Wolfcamp A core, and their interpreted depositional mechanisms. Facies dominated by carbonate minerals are shaded blue, and facies dominated by quartz are shaded yellow. Facies assemblages are colored to coordinate with figure below.

Unit 3: relatively quartz-rich, lower porosity

◀ Comparison of facies assemblage log developed from core analysis and associated well logs (gamma ray and modeled mineralogy).

Unit 2: relatively clay-rich, organic-rich

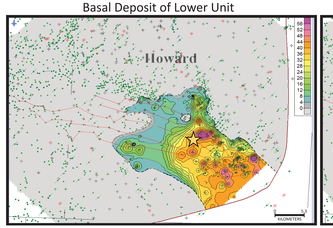
Vertical changes in composition and sourcing of sediment gravity flows into the area.

Bold red lines separate the three major units (U1, U2, U3), distinguished by dominant composition and facies assemblage prevalence.

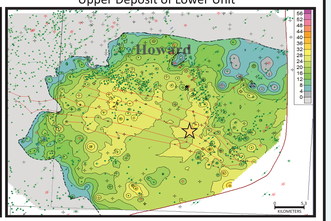
Unit 1: relatively carbonate-rich, porous and tight

Well logs from Rock Oil.

Basal Deposit of Lower Unit

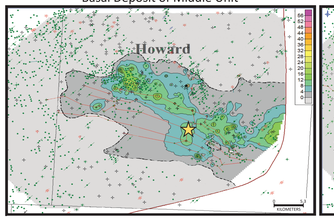


Upper Deposit of Lower Unit

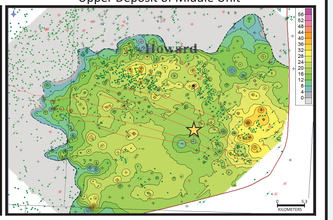


Isopach maps of two intervals in U1 of Wolfcamp A. Both the carbonate-rich deposits have lobe-shaped distributions, with indications of bifurcation and post-depositional erosion. Initial U1 deposits are backstepped towards the platform margin. Subsequent U1 deposits prograde towards the basin. Gold star in each map shows location of the Sparky-1 well.

Basal Deposit of Middle Unit



Upper Deposit of Middle Unit



Isopach maps of two intervals in U2 of Wolfcamp A. Map of the quartz- and organic-rich basal deposit (left) has a channel-shaped distribution. Map of the quartz- and carbonate-rich upper deposit (right) has a lobe-shaped distribution, with indications of bifurcation and post-depositional erosion. Initial deposits of U2 are backstepped towards the platform margin. Subsequent U2 deposits prograde basinwards. Gold star in each map shows location of the Sparky-1 well.

Key Findings To Date

- Eleven carbonate- or quartz-rich lithofacies, interpreted to represent sediment gravity flow deposits from multiple platform sources.
- Quartz-rich mudrocks form most promising unconventional reservoirs, and grainy resedimented carbonates form reservoirs with macropores.
- U1 is dominated by carbonates, and deposits have lobe-shaped distributions extending basinward.
- U2 basal deposits are dominated by quartz-rich mudrocks occurring in channels, backstepped towards the platform margin. Subsequent mudrock deposits are lobe-shaped and extend basinwards.
- A preferred transport route for sediments into the basin originates at the intersection of the Eastern Shelf and Glasscock "nose."

Implications

- The vertical change in dominant composition from carbonate to quartz, progradational geometries punctuated by backstepping of deposits between major units, and their regional natures suggest external controls, such as relative sea-level fluctuations.