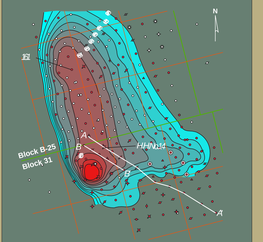
DISTAL CHERT RESERVOIRS
University Waddell Field

STRUCTURAL SETTING

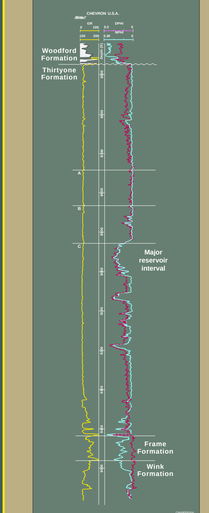


University Waddell field is developed over a simple anticline that is probably fault controlled along it's western margin.

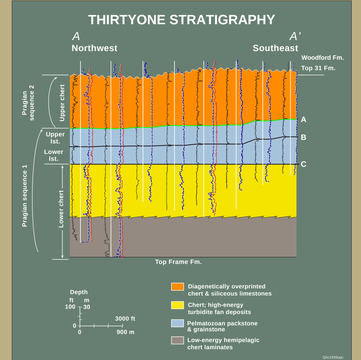
RESERVOIR CHARACTERISTICS AND VOLUMETRICS

Discovery date:	1949
Average depth:	8,600 ft (2,620 m)
Area:	8,700 acres (3,510 hectares)
Well spacing:	20–40 acres (8-16 hectares)
Top seal:	Woodford Formation
Bottom seal:	Frame Formation (Silurian/Devonian Wristen Gp.)
Trap:	Anticline
Hydrocarbon source:	Woodford Formation
Producing unit:	Thirtyone Formation (Lower Devonian)
Reservoir lithology:	Chert
Oil-water contact:	-6,650 ft (2,030 m) subsea elevation
Average gross pay:	900 ft (27 m)
Average net pay:	100 ft (21 m)
Average porosity:	9 percent
Average permeability:	1 md
Water saturation:	0.37
Residual oil saturation (Sor):	0.23
Oil gravity:	44°API @ 60°F
Original bottom-hole pressure:	4,200 psia
Temperature:	140°F (60°C)
Formation volume factor:	1.73 (at original bottom-hole pressure)
Oil viscosity:	0.475 centipoise (at original bottom-hole pressure)
Solution gas-oil ratio	1,330 SCF/STB (original)

THIRTYONE TYPE LOG



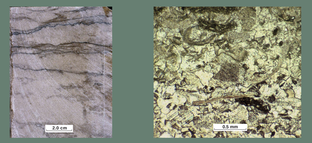
THIRTYONE STRATIGRAPHY



Interpreted sequence stratigraphy and gross packaging of chert and carbonate lithologies in the University Waddell Thirtyone chert reservoir.

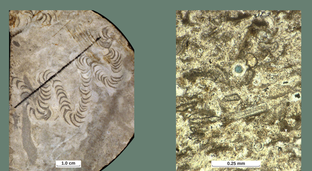
Thirtyone chert reservoir intervals in University Waddell field are developed in the middle and top of the formation.

PLATFORM-DERIVED SKELETAL CARBONATE



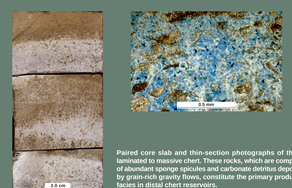
Paired core slab and thin-section photographs of thin-bedded to massive skeletal packstone. These rocks contain crinoids, brachiopods, and other minor skeletal debris. Pore space is occluded by syntaxial cement and carbonate mud.

DISTAL CHANNEL MARGIN BURROWED CHERT



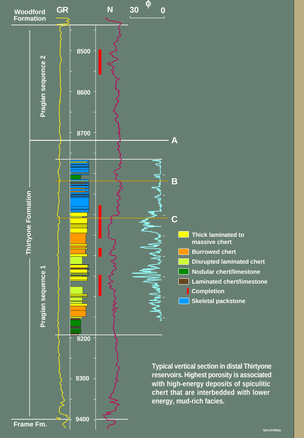
Paired core slab and thin-section photographs of burrowed chert. Laminations, graded bedding, and fluid escape structures are locally common. Although minor spicule-moldic pore space exists, these rocks are mostly nonporous.

CHANNELIZED GRAIN-RICH CHERT



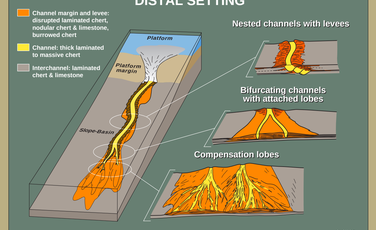
Paired core slab and thin-section photographs of thickly laminated to massive chert. These rocks, which are composed of abundant sponge spicules and carbonate detritus deposited by grain-rich gravity flows, constitute the primary productive facies in distal chert reservoirs.

RESERVOIR FACIES



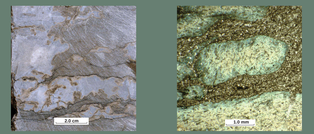
Typical vertical section in distal Thirtyone reservoirs. Highest porosity is associated with high-energy deposits of spiculitic chert that are interbedded with lower energy, mud-rich facies.

THIRTYONE DEPOSITIONAL MODEL DISTAL SETTING



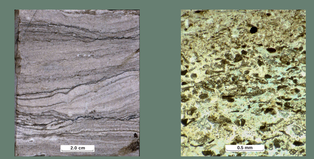
Grain-rich spiculitic cherts are channelized grain-rich debris flows that display evidence of rapid, high-energy deposition. Marginal facies are highly burrowed, reflecting slower deposition in low-energy, moderately well oxygenated conditions. Laminated muds document interchannel to distal hemipelagic deposition.

CHANNEL MARGIN INTERBEDDED CARBONATE AND CHERT



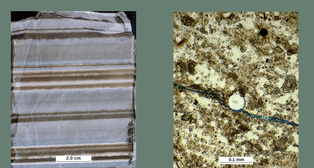
Paired core slab and thin-section photographs of nodular chert and limestone formed by burrowing and soft sediment deformation of interbedded and interlaminated chert and carbonate. Minor porosity exists in chert layers; carbonates are nonporous.

CHANNEL MARGIN DISRUPTED LAMINATED CHERT



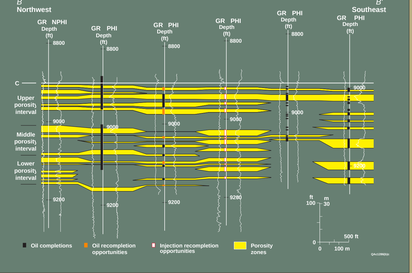
Paired core slab and thin-section photographs of laminated chert with convolute and disrupted laminations caused by soft sediment deformation and burrowing. These rocks, which are nonporous, contain siliceous mud and very fine grained peloidal/skeletal debris deposited by episodic transport of fine-grained carbonate platform detritus into a deep-water, outer ramp to slope setting.

HEMIPELAGIC LAMINATED CHERT



Paired core slab and thin-section core slab photographs of laminated chert and lime mudstone. These rocks are hemipelagic deposits that represent the most distal phase of Thirtyone deposition. They contain no porosity.

THIRTYONE RESERVOIR ARCHITECTURE DISTAL SETTINGS

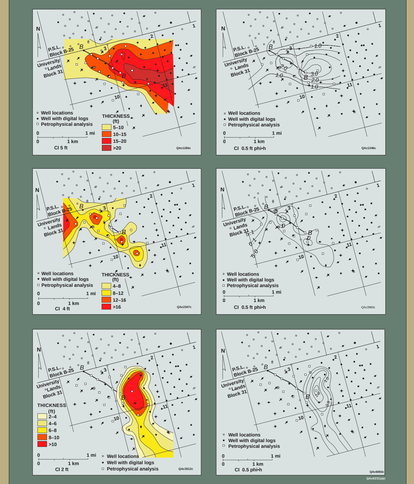


Architecture of grain-rich, cycle-base chert reservoir units. Note marked differences in thickness and continuity.

SUMMARY OF HETEROGENEITY IN DISTAL THIRTYONE RESERVOIRS

In contrast to proximal Thirtyone chert reservoirs where there is a single, continuous porous chert reservoir, distal chert reservoirs contain numerous separate and discontinuous stacked porous chert units. In distal reservoirs, lack of continuity is the primary contributing factor to heterogeneity and low recovery efficiency. The distribution of porous chert in distal settings is a function of sediment geometries associated with submarine fan and debris-flow deposition. Episodic downslope transport of siliceous spiculitic sediment along the margins of the carbonate platform has resulted in vertical segregated and laterally discontinuous chert reservoir intervals. These deposits are interbedded with and grade laterally into lower energy mud-rich sediments that typically have low porosity and permeability. Although these muddy rocks are not flow barriers, they do act as baffles to flow and impact recovery efficiency. Detailed correlation and mapping of individual porous chert layers is critical for establishing a reservoir framework that can serve as a basis for defining recompletion and infill drilling targets. Such an approach has led to the identification of several drilling and recompletion prospects in Waddell field.

FLOW UNIT CONTINUITY



CONCLUSIONS

Devonian chert reservoirs in West Texas contain a large remaining oil resource that is a target for more efficient exploitation techniques based on a better understanding of the geological controls on heterogeneity. Because these controls differ systematically between chert reservoirs developed in updip, proximal settings and downdip, distal settings, it is crucial that both regional and local geologic controls be examined and integrated into modern reservoir characterization and exploitation efforts. The Three Bar and University Waddell fields provide fundamental models of the styles of heterogeneity expected in proximal and distal settings, respectively.

Maps of individual grain-rich, cycle-base chert flow units. Note highly variable patterns among units in thickness and ϕh reflecting the control on reservoir architecture of depositional style.