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Discovery of "Pronghorn" and "Lewis and Clark" Fields:

Sweet-Spots within the Bakken Petroleum System
Producing from the Sanish/Pronghorn Member
NOT the Middle Bakken or Three Forks!

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Denver, Colorado USA



Forward-Looking Statements

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Acknowledgements



We thank Whiting management for permission to present this work, and of course all our Whiting colleagues of multiple disciplines who contributed immensely to turning the concepts described here into economic reality.

We are appreciative of the vast, unmatched core collection afforded by the North Dakota Geological Survey and to Julie LeFever and Kent Hollands of the ND Core Lab, in particular, for their support during our biannual "core trips" to Grand Forks, ND.

Summary



Remaining open-minded to a variety of sweet-spot factors is fundamental to tight oil exploration. Bakken Petroleum System sweet-spots:

- ✓ *source rock quality & maturity*
- ✓ *reservoir matrix quality & saturation*
- ✓ *fractures, pressures, etc.*

Low-accommodation setting following the 2nd-order angular unconformity (top Three Forks) controlled depositional and preservational patterns throughout the lowstand (Pronghorn Member of Bakken) to transgressive systems tracts of the lower, middle, and upper Bakken.

Regional log correlations, calibrated to core, are needed to adequately identify key surfaces and help demonstrate important provenance variation:

- *Northern Williston Basin, the basal transgressive Pronghorn member veneer has a northeastern-derived, siliciclastic provenance.*
- *Southern Williston was the locus of detrital dolomite derived from the Cedar Creek paleostructure. Subtidal, detrital dolomites form the main reservoir across Whiting's "Pronghorn" and "Lewis and Clark" Prospects.*

New productive zone identified between Bakken and Three Forks



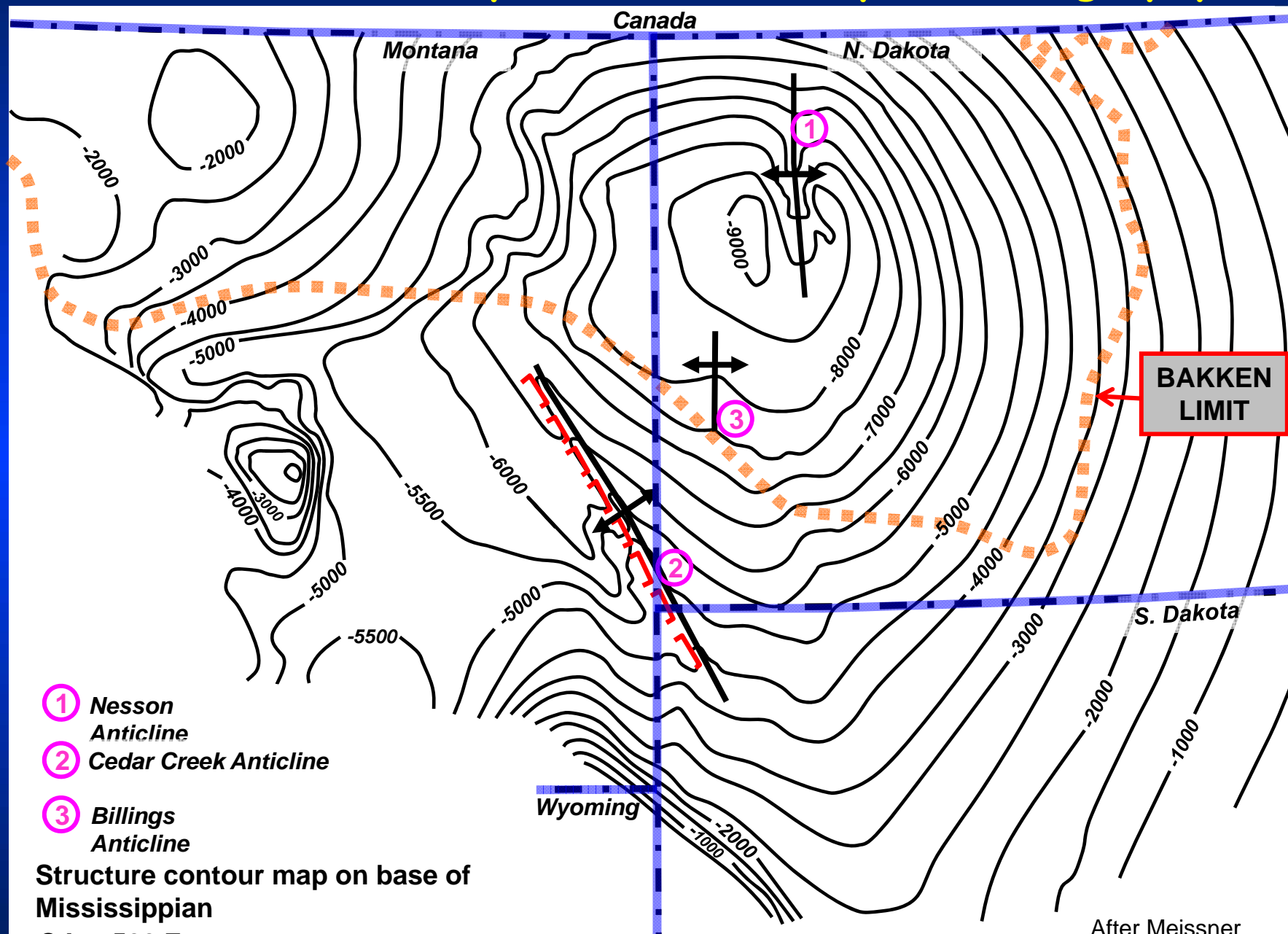
ERA	SYSTEM		FORMATION OR GROUP	
	TERTIARY		Fort Union Group	
MESOZOIC	CRETACEOUS	Upper	Montana Group	
			Colorado Group	Belle Fourche Shale-Niobara Fm
		Lower	Inyan Kara Group	Dakota Group
			JURASSIC	Morrison Formation
	Swift Formation			
	Rierdon Formation			
	Piper Formation			
	Nesson Formation			
	TRIASSIC	Spearfish Formation		
	PALEOZOIC	PERMIAN	Minnekahta Limestone	
Opeche Formation				
Minnelusa Formation				
PENNSYLVANIAN		Amsden Group		
		Tyler Formation		
MISSISSIPPIAN		Big Snowy Group	Heath Formation	
			Otter Formation	
			Kibbey Formation	
		Madison Group	Charles Formation	
				Mission Canyon Limestone
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			DEVONIAN	Bakken Formation
		Three Forks Formation		
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Dawson Bay Formation				
Prairie Formation				
Winnipegosis Formation				
SILURIAN	Interlake Formation			
ORDOVICIAN	Stony Mountain Formation			
	Red River Formation			
	Winnipeg Formation			
CAMBRIAN	Deadwood Formation			
PRECAMBRIAN			Pre-Beltian	

- Oil
- ☀ Gas
- Source rock

FOCUS
ZONES
FOR
TALK

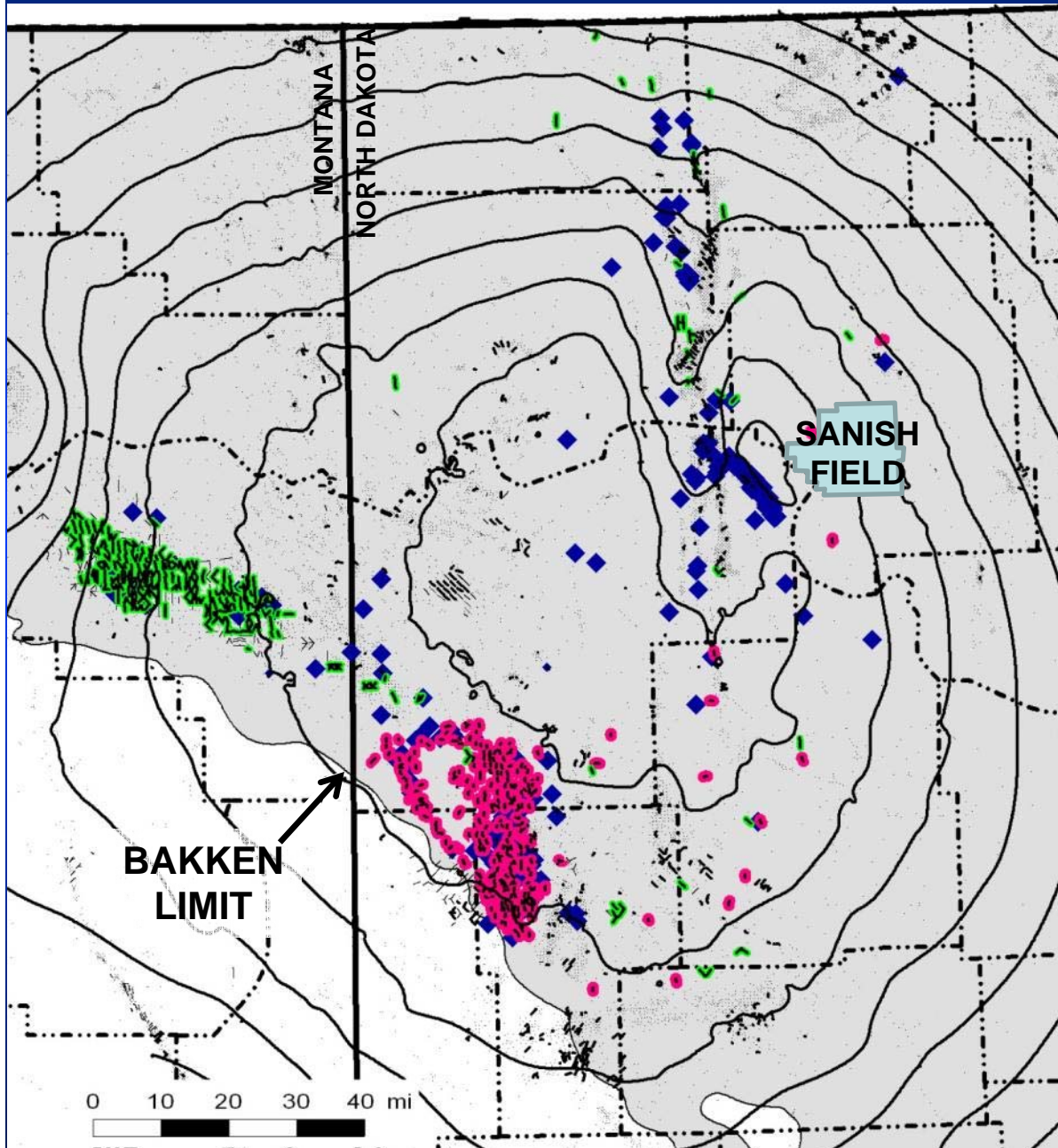


Williston Basin – simple structure/complex stratigraphy



After Meissner
1991

Bakken production at end of 2005



- 80's (unstimulated) horizontal play - *upper Bakken shale only*
- Early tests in ND Middle Bakken primarily tried to extend Elm Coulee trend and along the Nesson Anticline
- Mixed economic results with completion practices and limitations of the time



Vertical Bakken Production

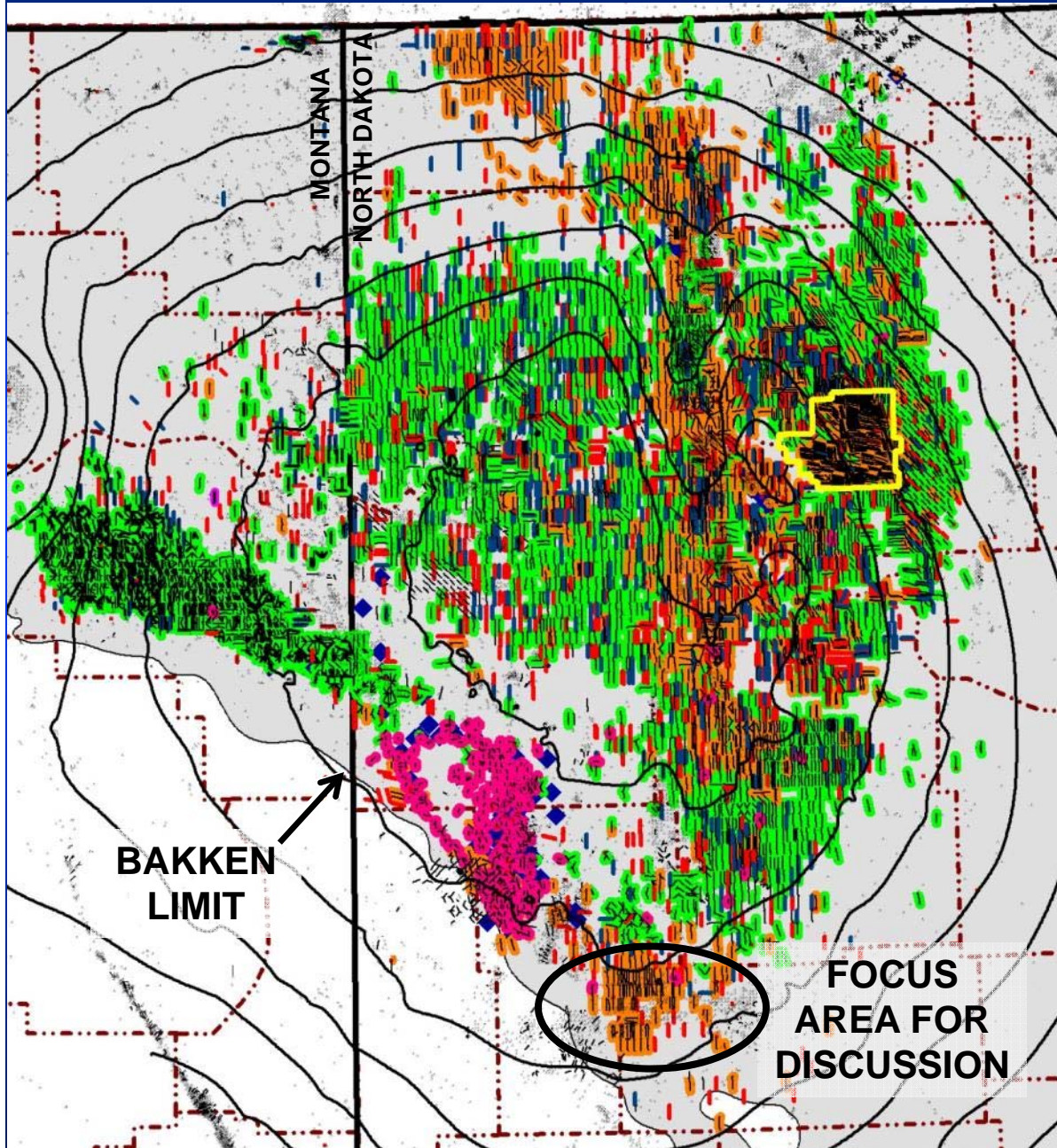


U. Bakken Shale Hz Production



M. Bakken Hz Production

Bakken Activity as of 10/1/12



- In 7+ years, play expanded to over 13,000 square miles
- Whiting currently at 20 rigs
- Whiting has operated 3.3 million linear feet of Bakken/Three Forks horizontal drilling (as of 4/12) and participated in another 1.9 million feet of non-op footage
- Whiting approaching 5 million linear feet of operated hz drilling by end of 2012



Vertical Bakken Production



Upper Bakken Shale Hz Production



Middle Bakken Hz Production



Three Forks Hz Production

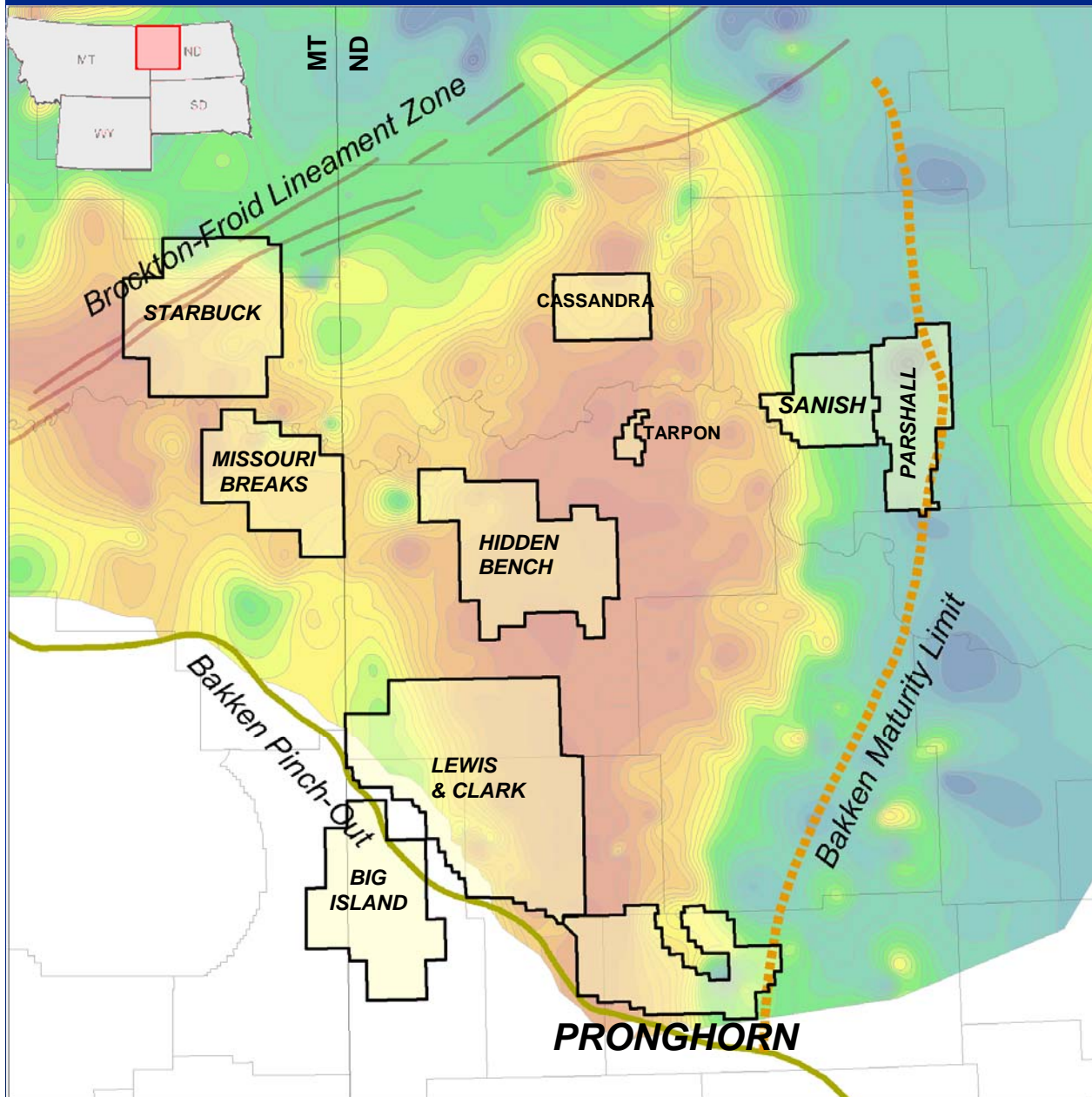


Bakken/Three Forks Hz Well Permit



Bakken/Three Forks Spud/Drilling Under Confidential status

Whiting Lease Areas within Williston Basin Plays (as of December 31, 2011)

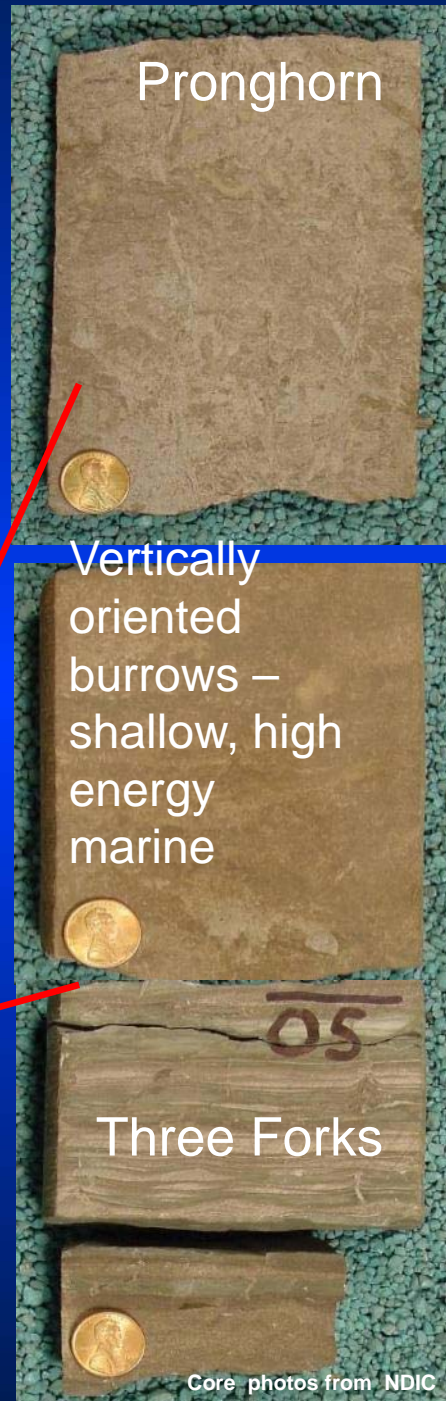
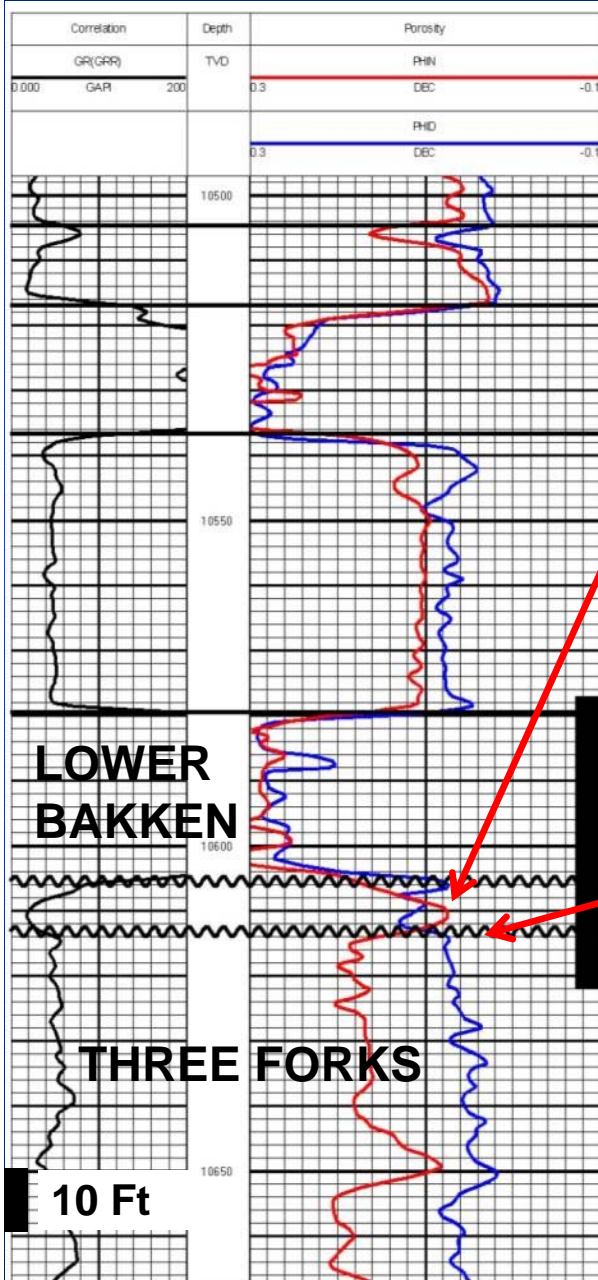


Whiting currently has over 1 million gross and 680,000 net acres - the majority of which are within the producing area of the Bakken petroleum system

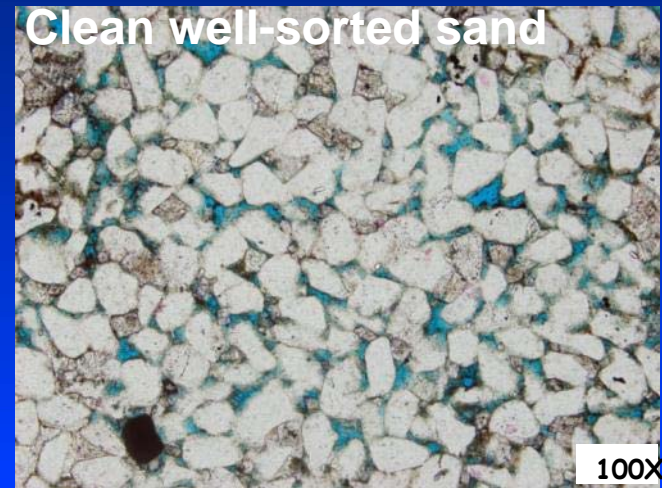
The colored map depicts the regional **Hydrogen Index** ("HI") of the upper Bakken Shale based on public domain data accessible from the USGS as compiled by the late Leigh Price, supplemented by in-house data.

Hot colors are low HI values indicative of greater levels of thermal maturity; cooler colors are higher HI values indicative of lower thermal maturity.

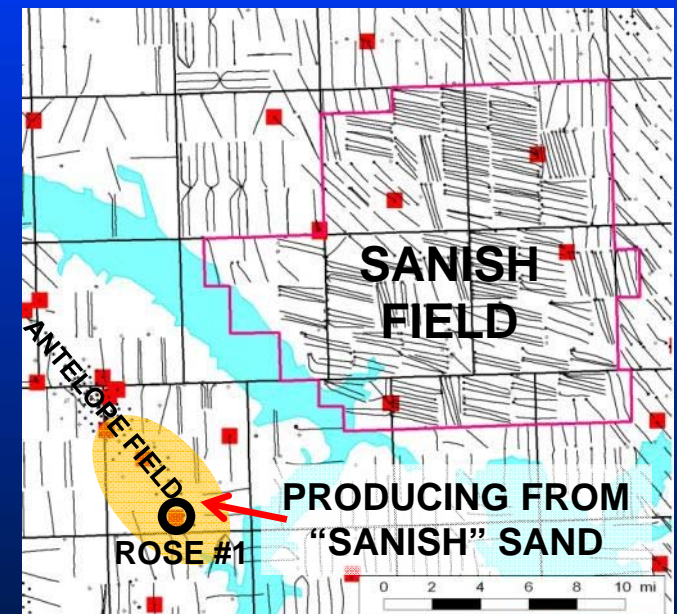
DUNCAN
Rose #1
33-T152N-R94W



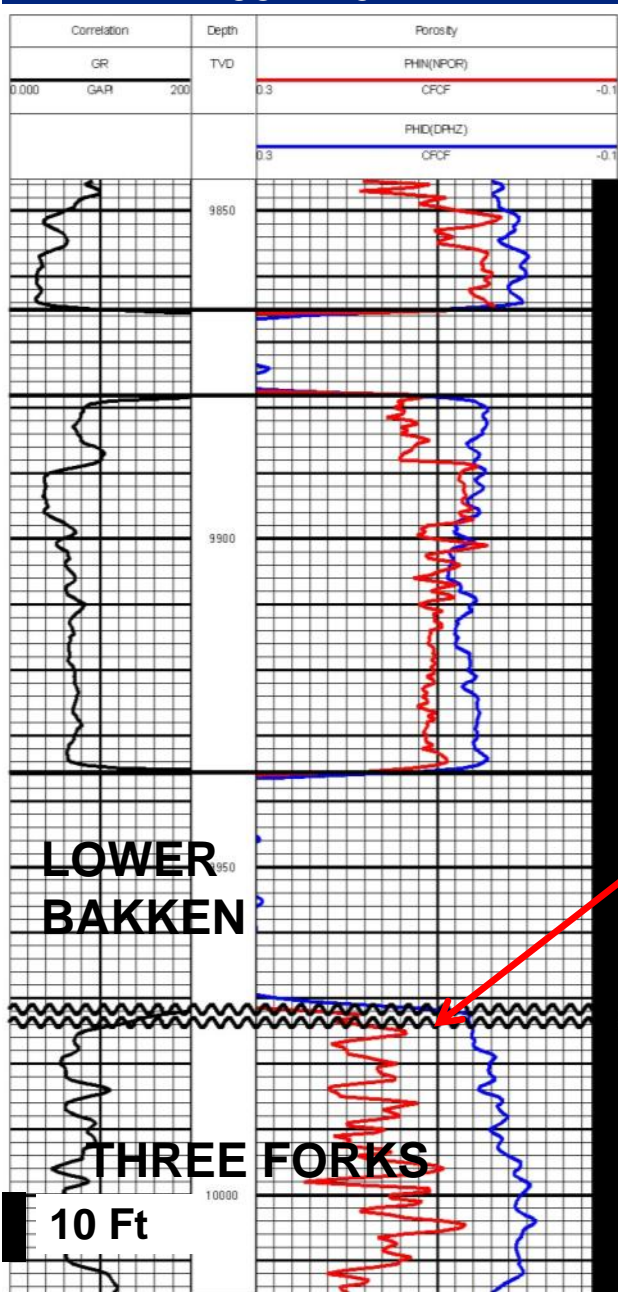
“Sanish” Sand
redefined as Pronghorn
Mbr. by LeFever, 2011



“Sanish” - Good quality qtz.- dominated reservoir – *but of limited extent!*



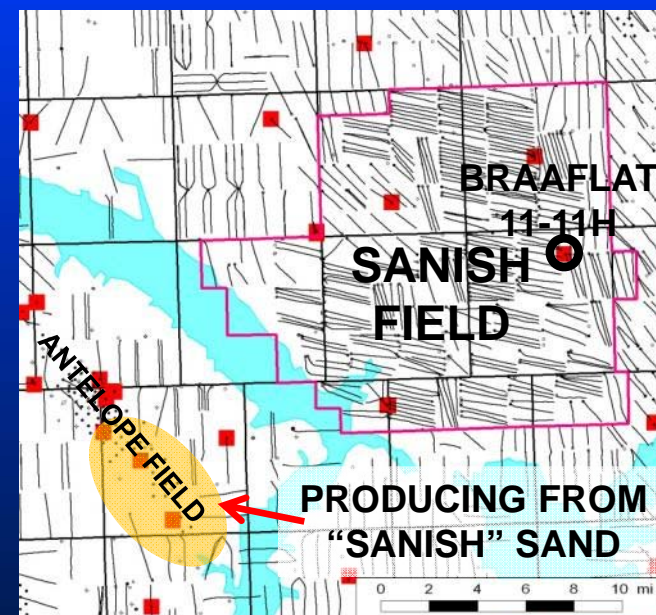
WHITING
Braaflat 11-11H
11-T153N-R91W



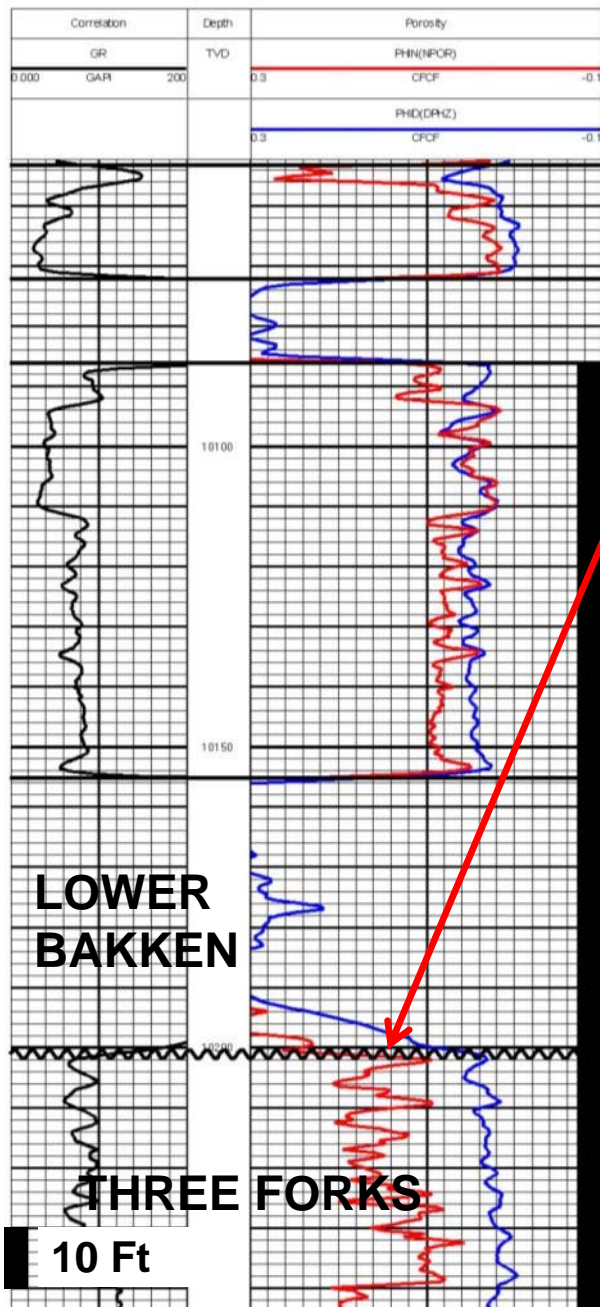
CORE



Less than 1 foot of bioturbated Pronghorn Facies forms a patchy, thin veneer overlying the Three Forks at Sanish Field



FIDELITY
DCR 43-28H
28-T154N-R92W



CORE

Lower Bakken
Shale

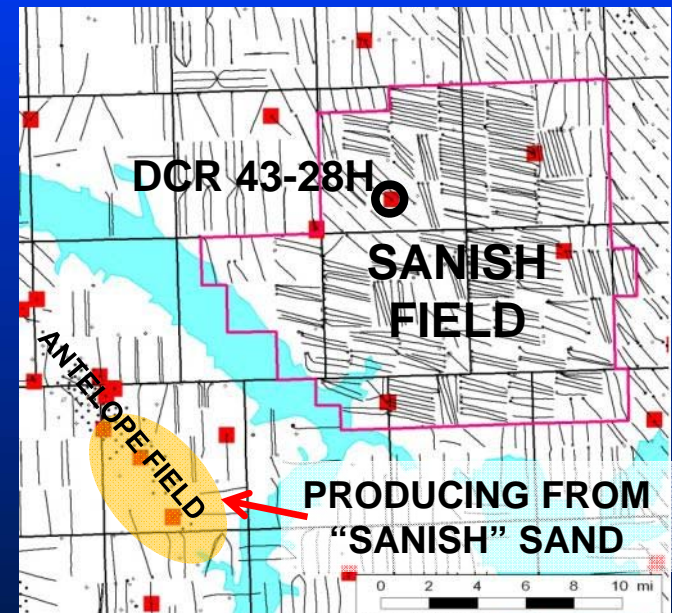


No Pronghorn beds
present -

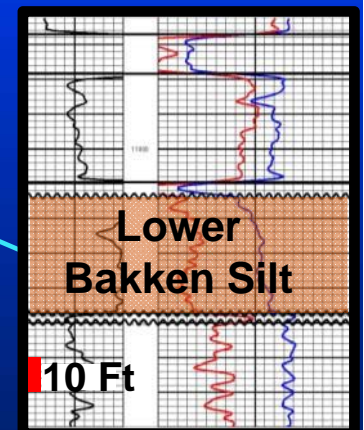
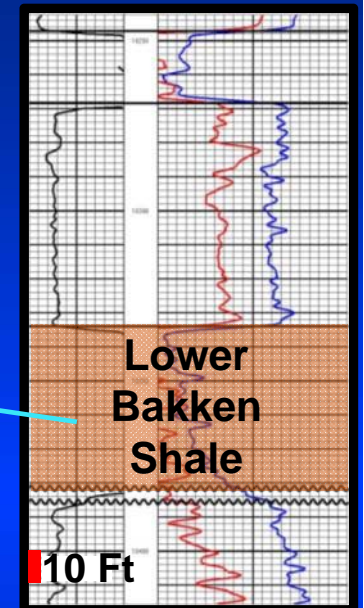
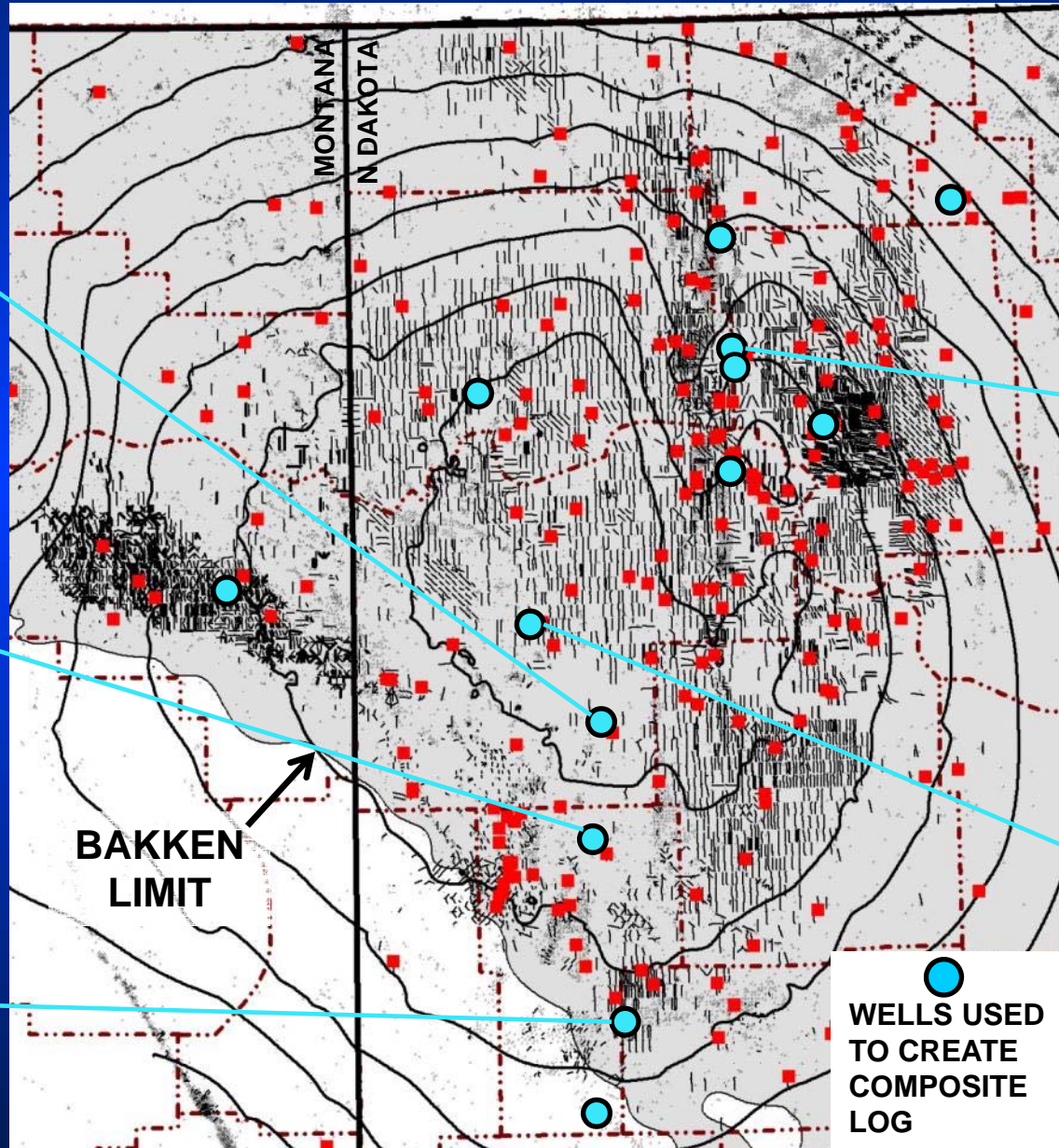
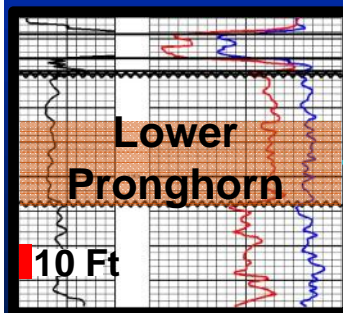
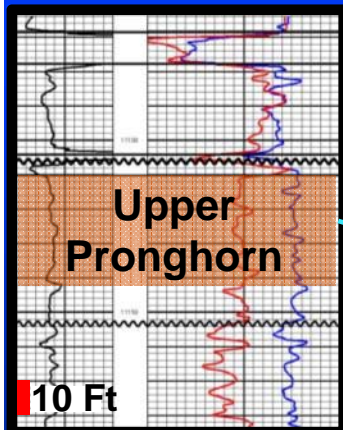
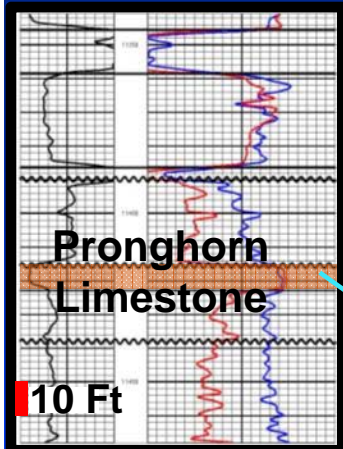


just rip-up clasts at
Lower Bakken Shale/
Three Forks contact

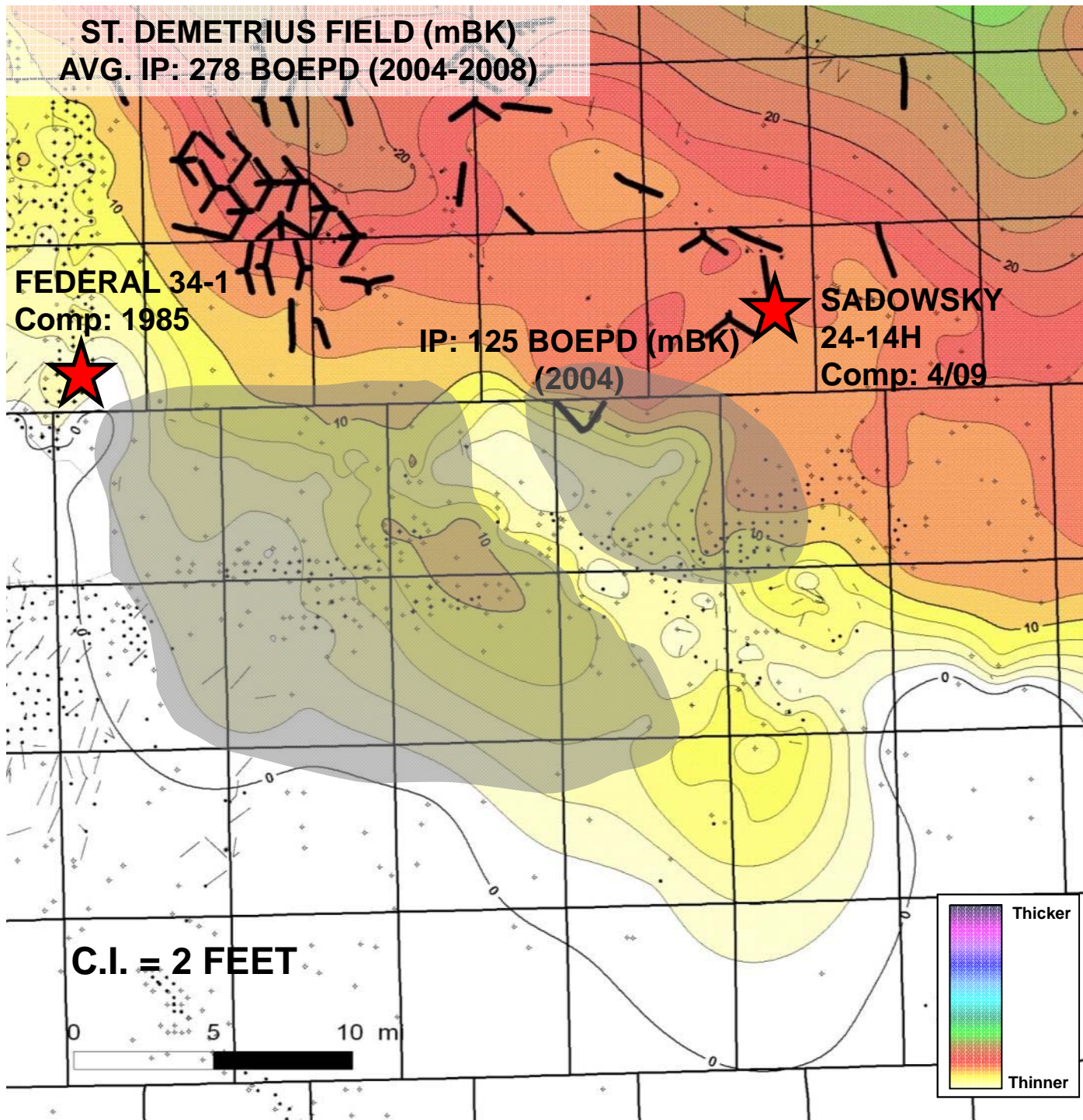
120 ft. of cumulative
thickness found elsewhere
in the basin is missing at
this contact



Bakken/Three Forks Core Control and the Challenges of Creating a Type Log



All logs shown extend 5 feet above Upper Bakken and 30 feet below the Three Forks top

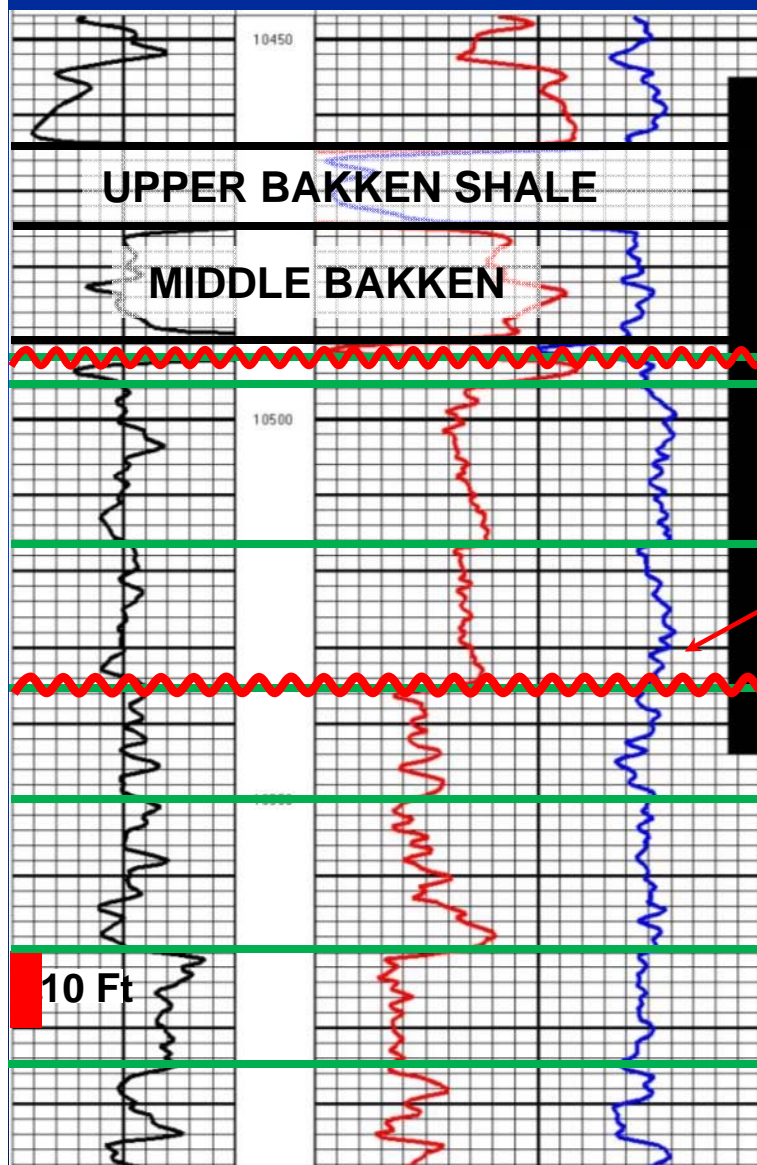


Middle Bakken Isopach with Bakken Hz. Wells Drilled prior to 2009

- Primary focus was for Middle Bakken
- Moderate to poor results and Middle Bakken only thinned to south – no additional industry interest for 4-5 years
- Several key cores were game changers
- Provided a new concept that ultimately ended up in a new focus area beyond where the Bakken was too thin and production was weak

Sadowsky 24-14H
14-T141N-R96W

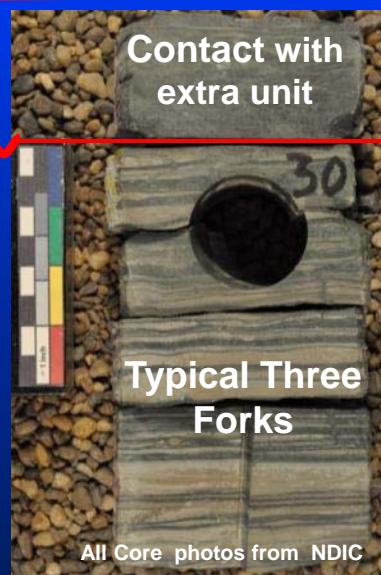
Unexpected units identified in
core ...



CORE



open marine limestone below
the Lower Bakken Shale with
lag deposit at contact



Three Forks
markers
(green) already
picked through
most of the
basin before
seeing this
core



Below the limestone and
above peritidal laminites
of the Three Forks were
diversely burrowed 1-3"
storm beds— **definitely
NOT Three Forks!**

All Core photos from NDIC

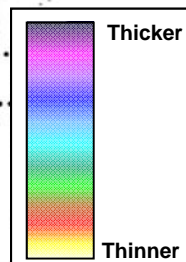
ISOPACH OF NEW UNIT C.I. = 5 Feet

"Sanish" Sand at
Antelope Field

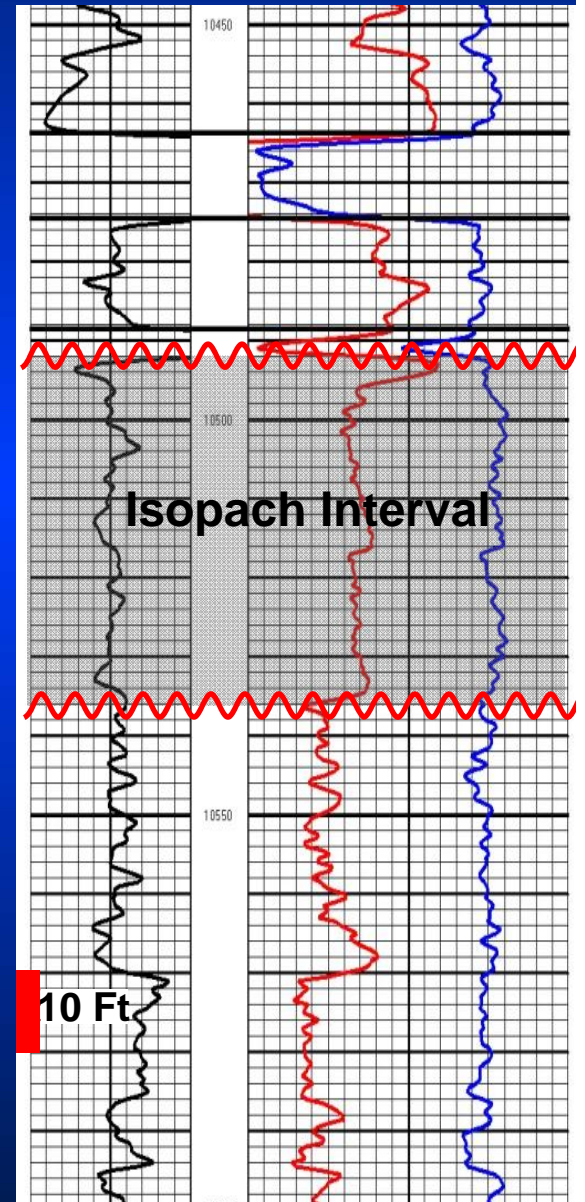
SADOWSKY
24-14H

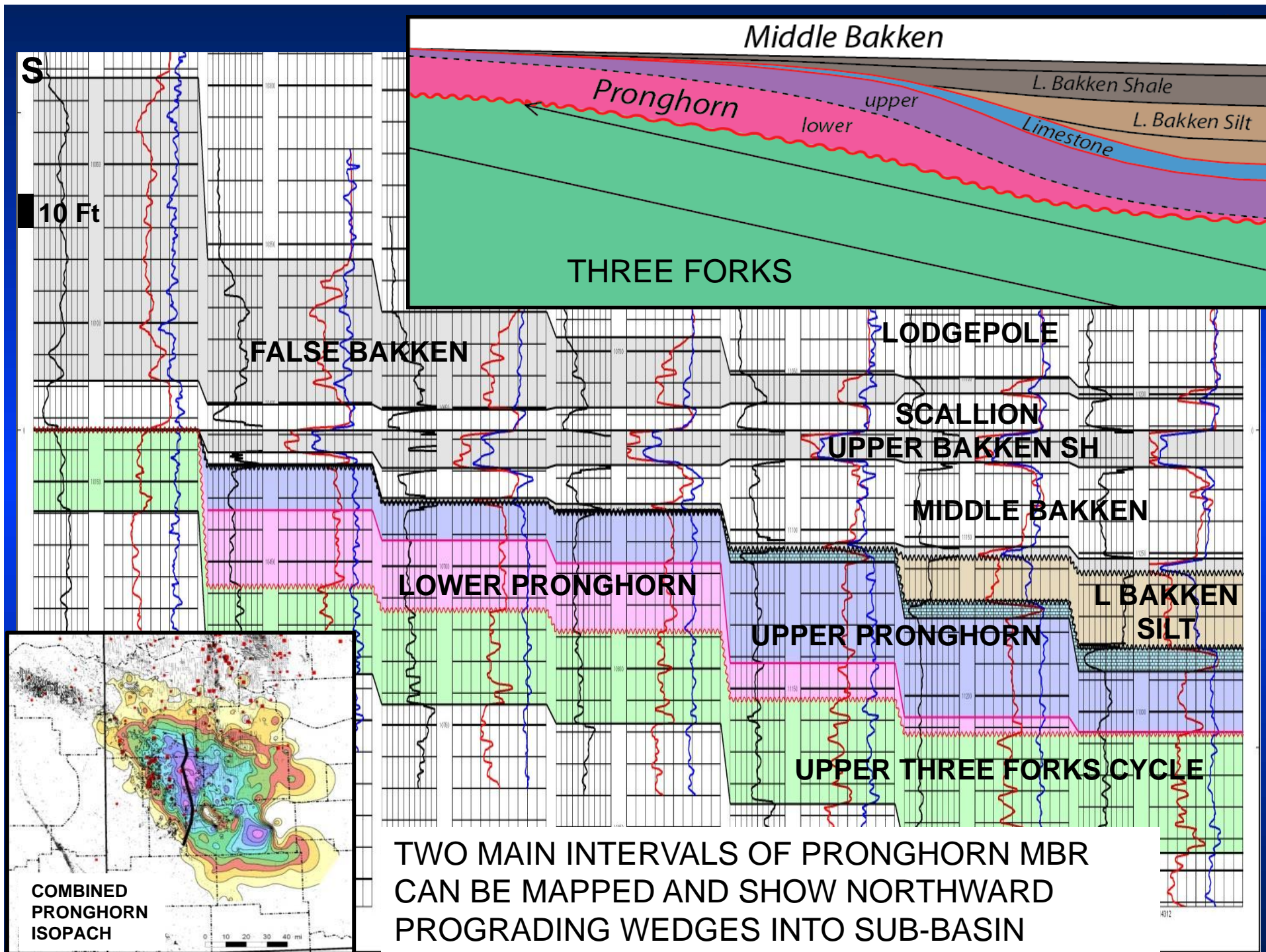
FED. 34-1

0 10 20 30 40 mi



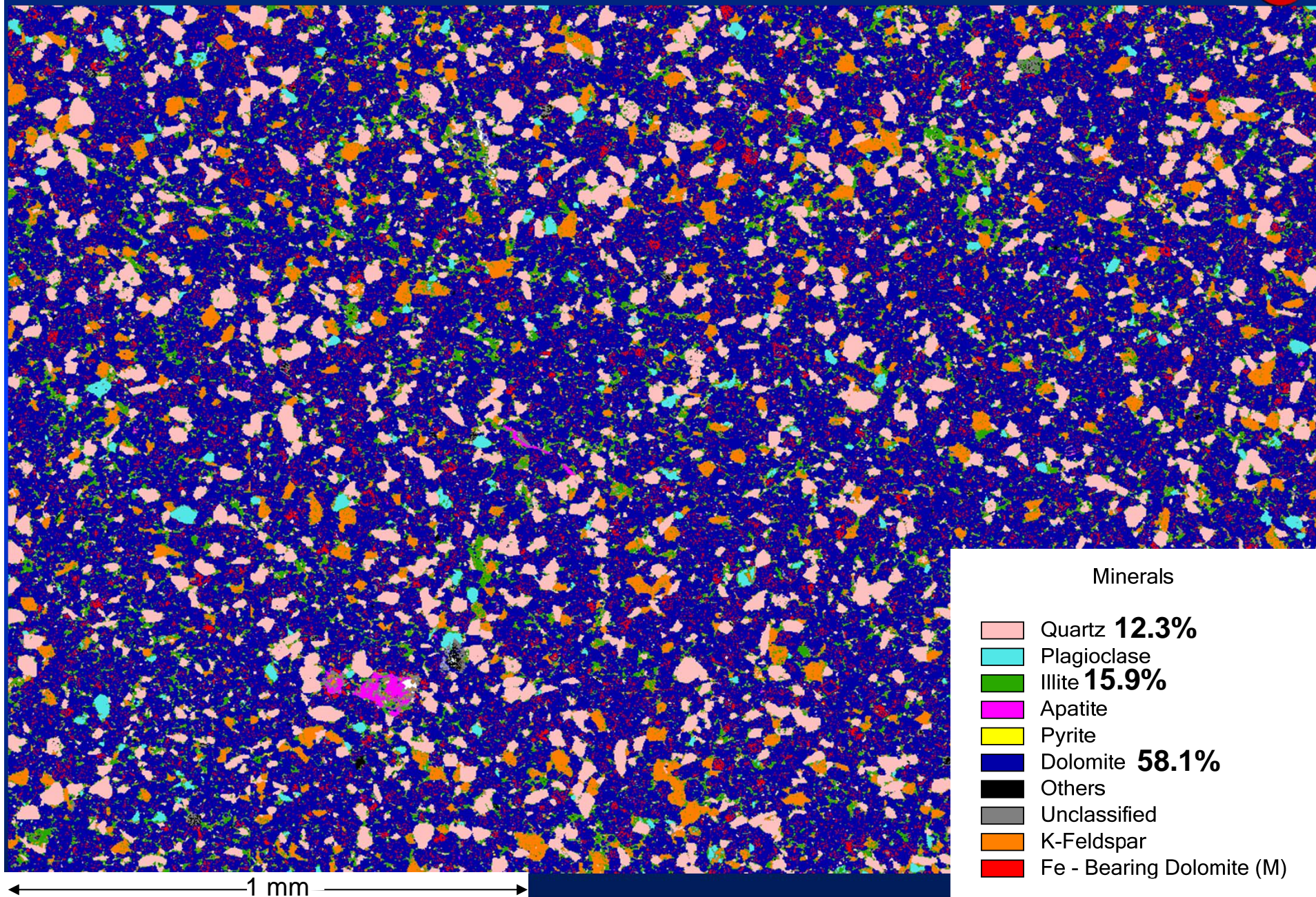
Sadowsky 24-14H
14-T141N-R96W





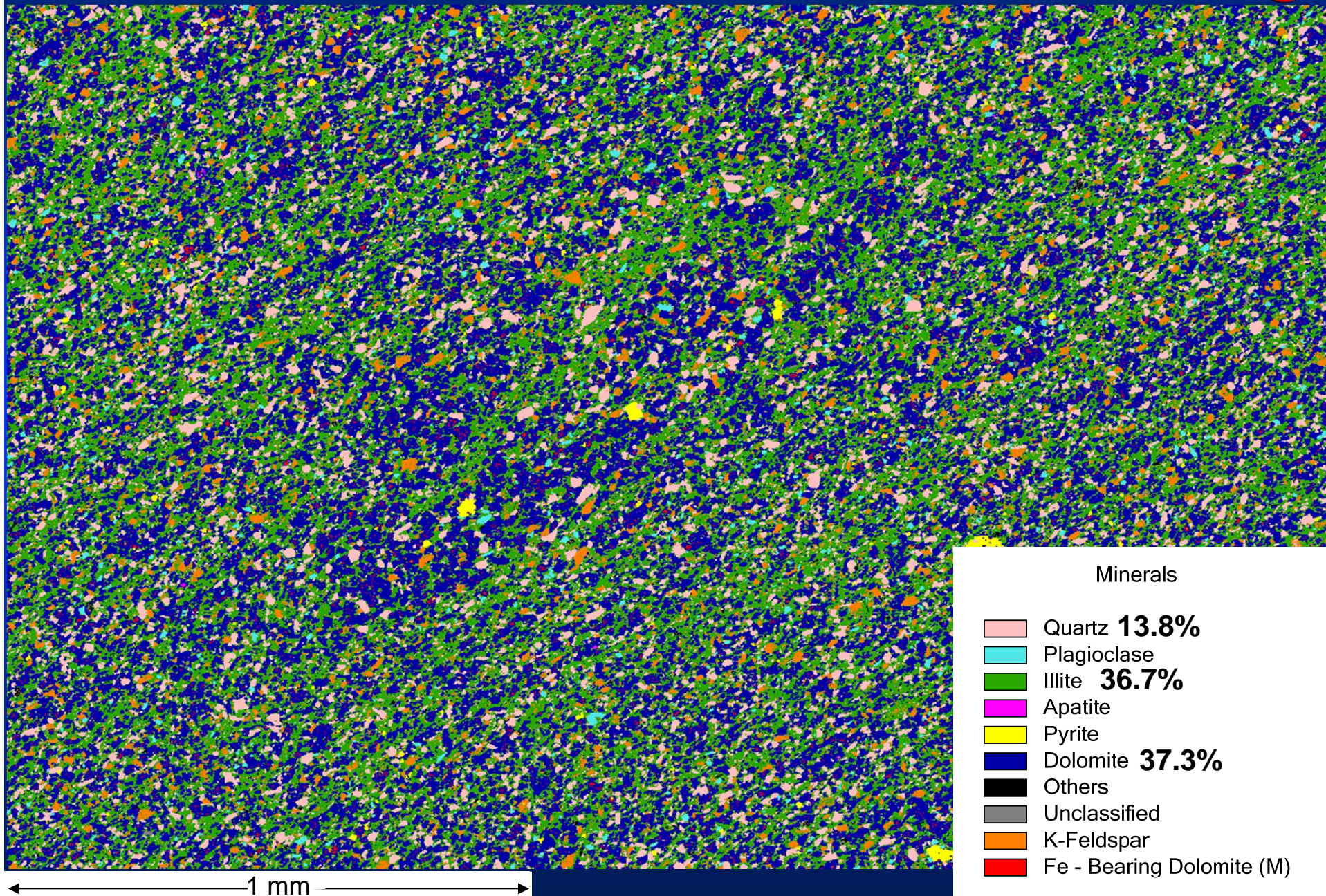
Qemscan Mineral Map - Pronghorn B Facies

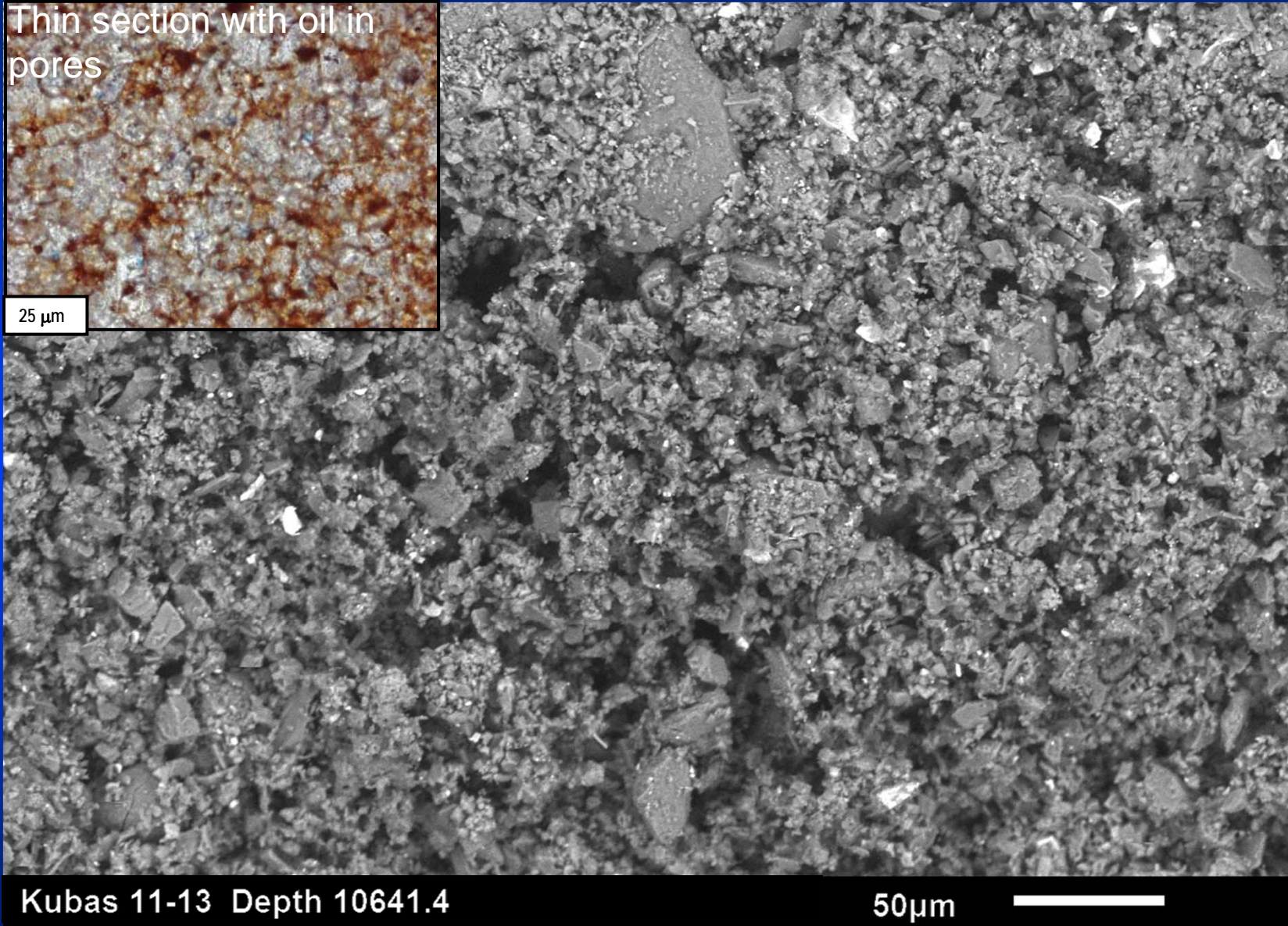
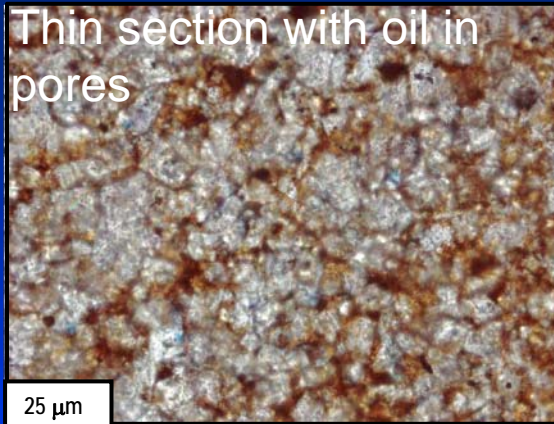
Detrital dolomite reservoir with quartz and illite



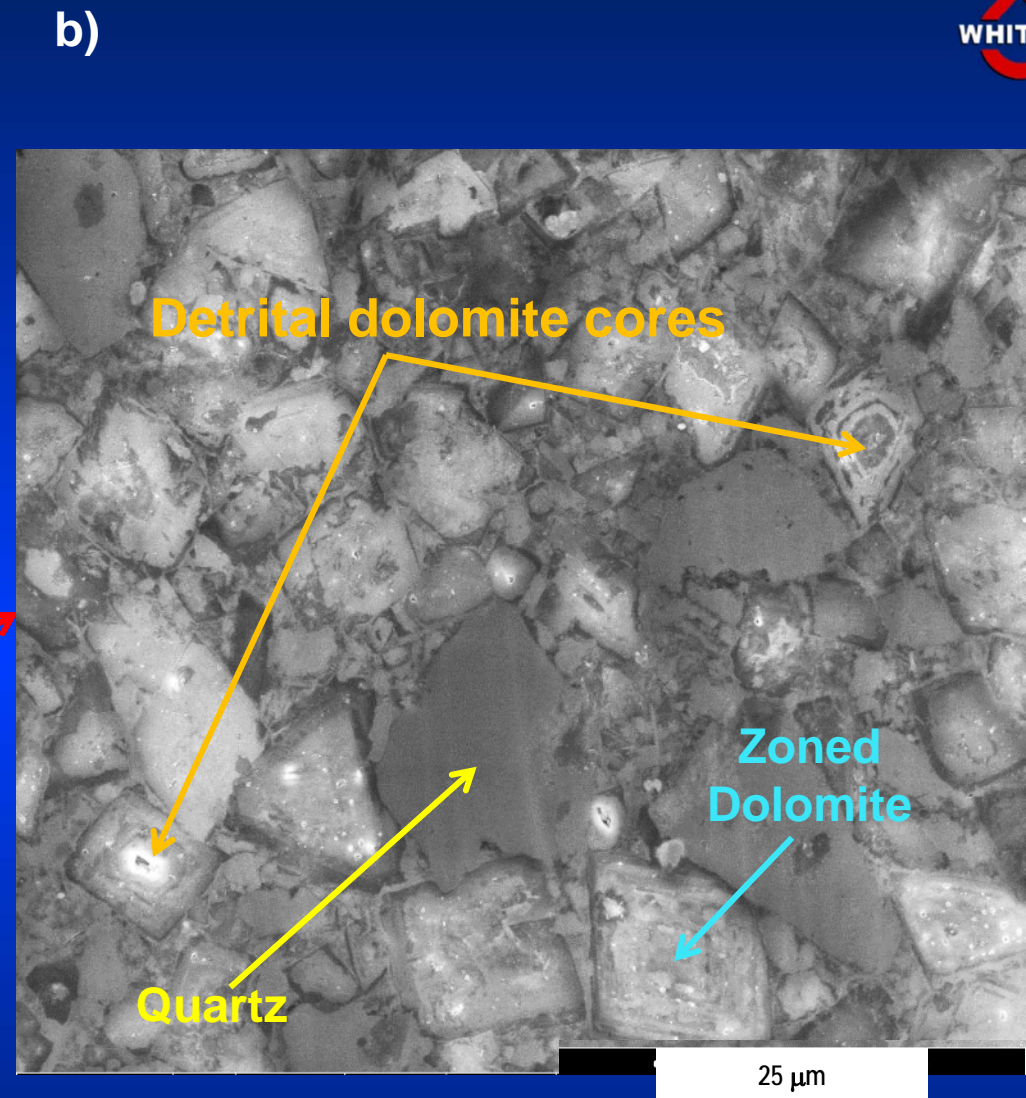
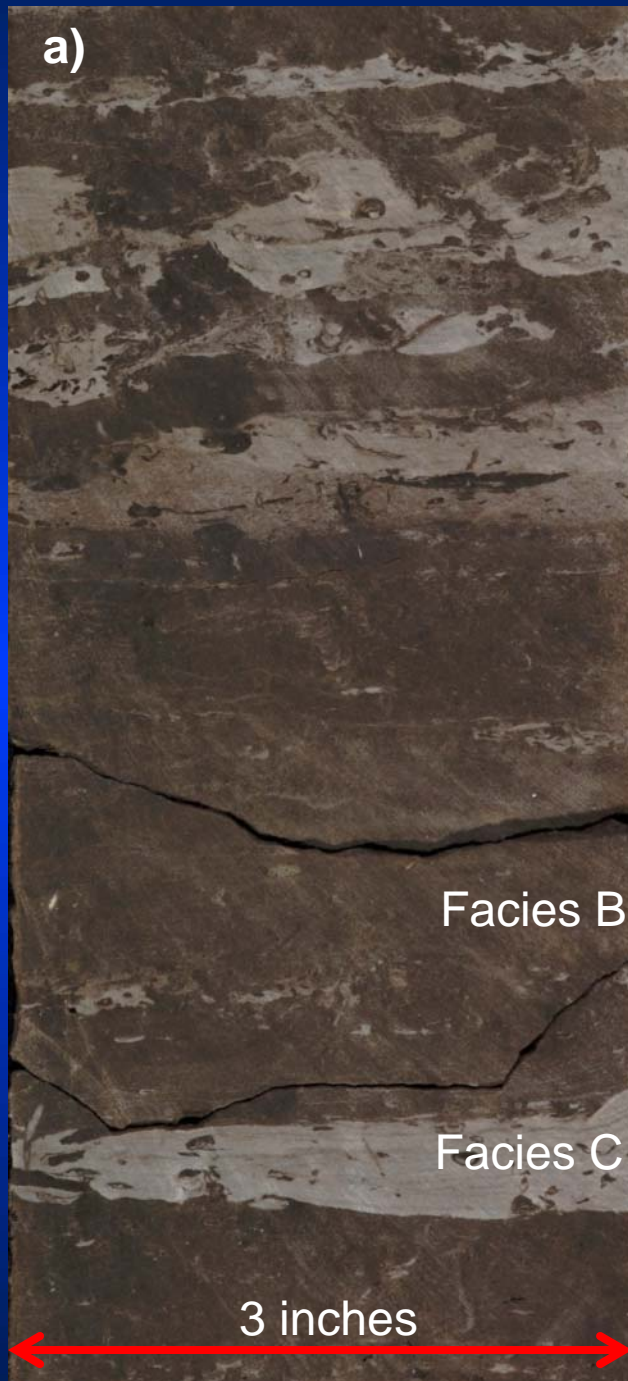
Qemscan Mineral Map - Pronghorn D Facies

Muddy Dolomite/Dolomitic Mudstone w/ significantly poorer reservoir quality





Thin section and SEM image at same scale - bi-modal dolo with intercrystalline pores

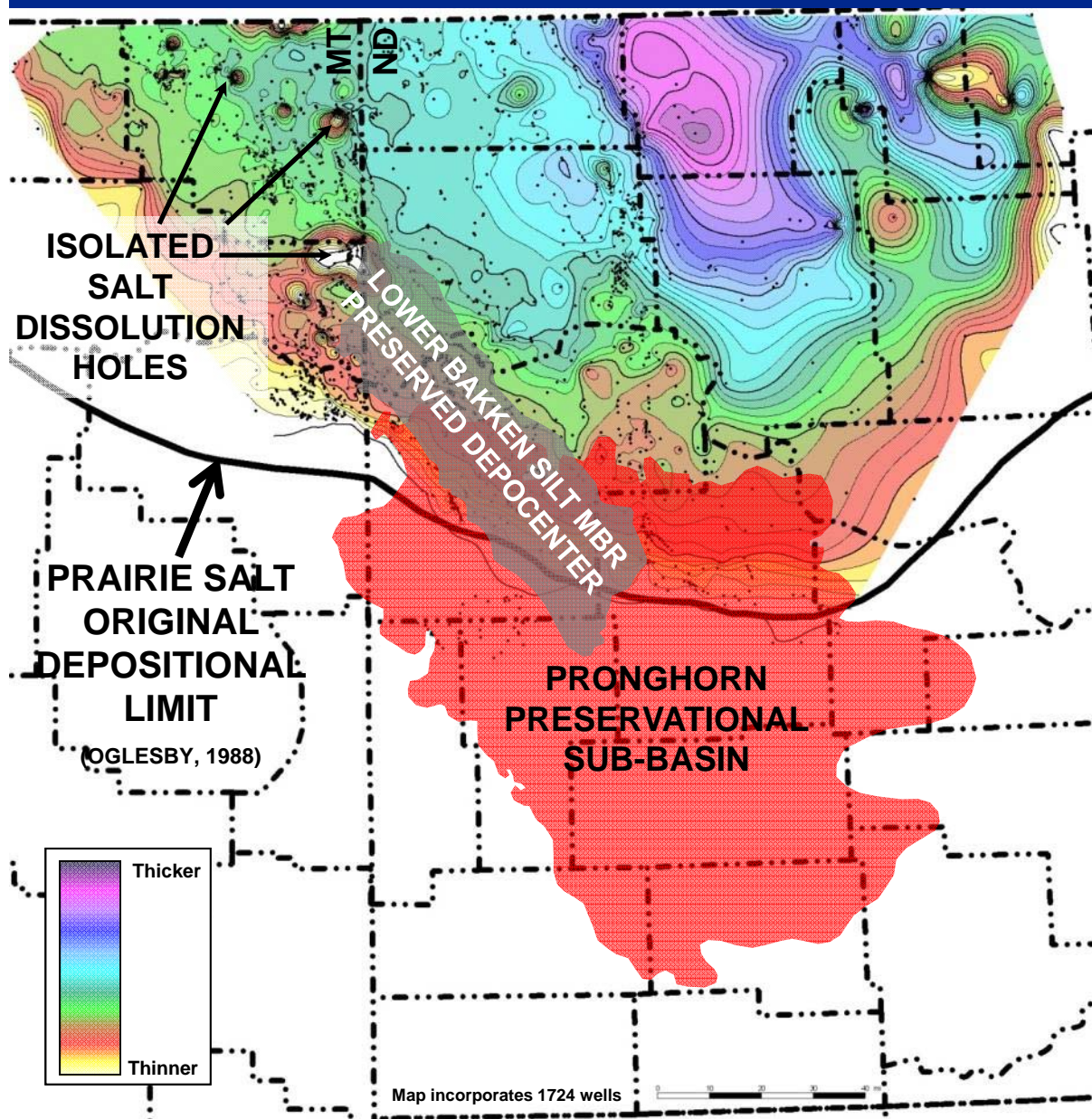


Pronghorn facies are detrital in origin

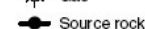
Cedar Creek high is likely source

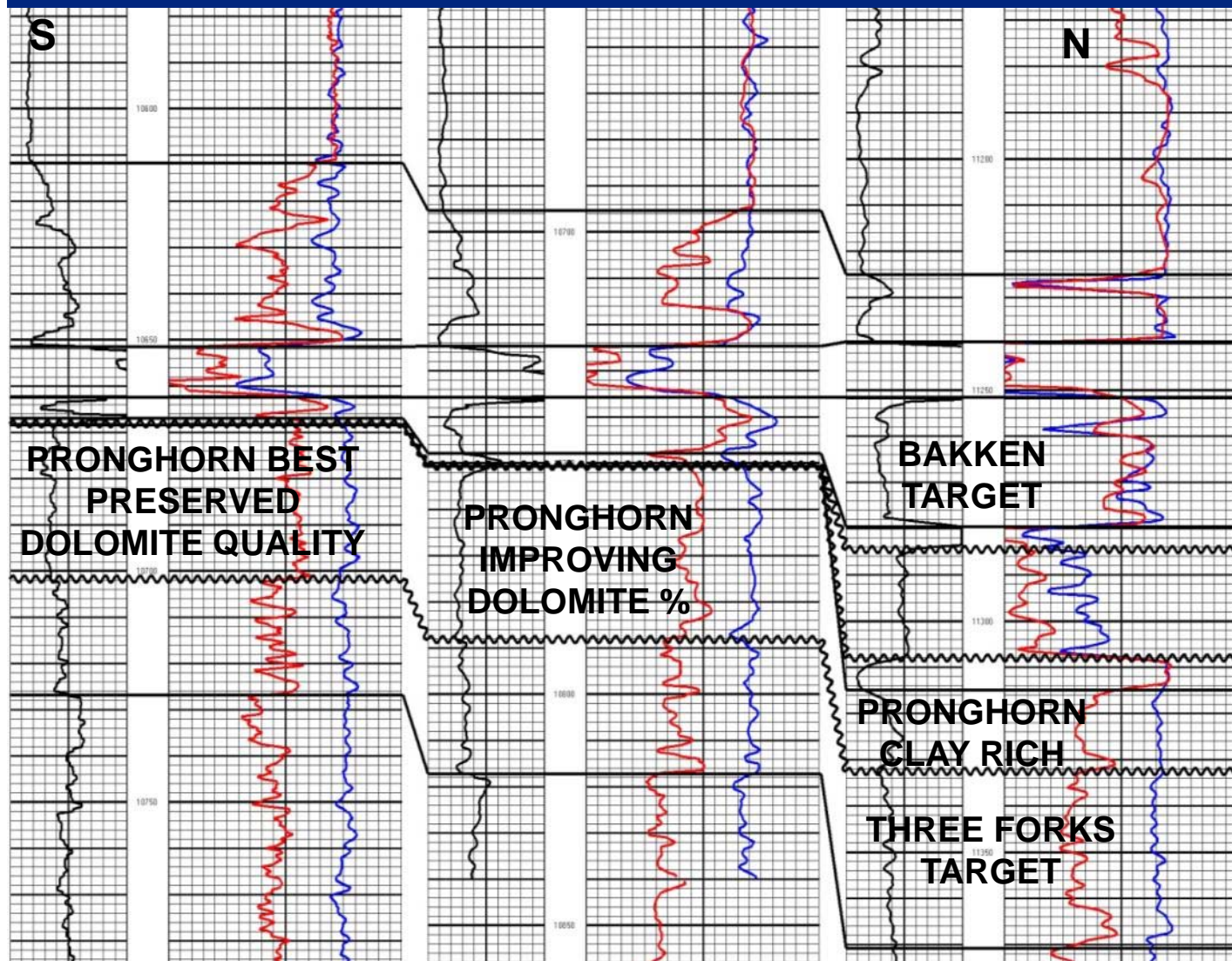
Devonian Prairie Salt Isopach (0-650 Feet)

C.I. = 20 Feet



ERA	SYSTEM	FORMATION OR GROUP
MESOZOIC	TERTIARY	Fort Union Group
	CRETACEOUS	Montana Group
		Upper
		Colorado Group
		Lower
		Inyan Kara Group
		Dakota Group
	JURASSIC	Morrison Formation
		Swift Formation
		Rierdon Formation
		Piper Formation
	TRIASSIC	Nesson Formation
		Spearfish Formation
PALEOZOIC	PERMIAN	Minnekahta Limestone
		Opeche Formation
		Minnelusa Formation
	PENNSYLVANIAN	Amsden Group
		Tyler Formation
		Big Snowy Group
	MISSISSIPPIAN	Heath Formation
		Otter Formation
		Kibbey Formation
		Charles Formation
		Mission Canyon Limestone
		Lodgepole Limestone
		Madison Group
	DEVONIAN	BAKKEN/THREE FORKS
		Birdbear Formation
		Duperow Formation
		Souris River Formation
		Dawson Bay Formation
		PRAIRIE SALT
		Winneposis Formation
	SILURIAN	Interlake Formation
	ORDOVICIAN	Stony Mountain Formation
		Red River Formation
		Winnipeg Formation
	CAMBRIAN	Deadwood Formation
	PRECAMBRIAN	Pre-Beltian





**GEOLOGY
MATTERS!**

IP: 2898 BOEPD

**Other Operator
Nearest Hz well
IP: 276 BOEPD**