

Fault Patterns in the Niobrara Formation—Examples from the Eastern and Central DJ Basin*

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Abstract

The Upper Cretaceous Niobrara Formation is the latest in a series of fractured plays at the forefront of exploration activity within the Rocky Mountain region. Prolific oil and gas production has been achieved through the use of modern exploration methods followed by advanced horizontal and vertical drilling and completion techniques.

Regional archival 2-D seismic data, as well as single fold seismic data, is used to target the more attractive exploration areas within the mature Denver Julesburg (DJ) Basin of eastern Colorado, southeastern Wyoming, and western Nebraska. The use of these reconnaissance data is followed by modern high-resolution 3-D seismic surveys that are used to identify Niobrara faults along with their orientation and throw.

McElvain Oil & Gas Properties, Inc. acquired a series of three proprietary 3-D surveys in Yuma County, Colorado, and they were merged into one 54.5 square mile continuous 3-D survey through the use of reprocessing. Subsequent interpretation techniques, including volume curvature, used to identify Niobrara fault trends, patterns, and fault displacements, reveal attractive structural exploration targets for the Niobrara Formation. These techniques led to the discovery of two new Niobrara fields within the Mildred combined-3-D-survey area. Two additional 3-D surveys, the 4.2 square-mile Krieger 3-D in Weld County, Colorado, and the 14.6 square-mile Cedar Creek 3-D in Cheyenne County, Nebraska, are shown to illustrate Niobrara faulting signatures in other portions of the DJ Basin. These surveys reveal that fault patterns within the Niobrara Formation are the result of both Laramide tectonism and post-Cretaceous dissolution of Permian salt beds.

Selected References

Blakey, R., 2011, North American Paleogeography, Late Cretaceous (85 Ma) (<http://www2.nau.edu/rcb7/namK85.jpg>)

Pollastro, R.M., and P.A. Scholle, 1986, Diagenetic relationships in a hydrocarbon-productive chalk—The Cretaceous Niobrara Formation, *in* F.A. Mumpton, (ed.) *Studies in Diagenesis: Geological Survey Bulletin*, v. 1578, p. 219-236.

Sonnenberg, S., 2010, Fracture Development in the Bakken Petroleum System, Antelope Field, Williston Basin, *in* L. Fletcher, Wyoming Geological Association Unconventional Energy Resources, 61st Field Conference Guidebook: Wyoming Geological Association (WGA), Casper, Wyoming.

Weimer, R.J., 1996, Guide to the petroleum geology and Laramide orogeny, Denver Basin and Front Range, Colorado: Colorado Geological Survey Bulletin, v. 51, 127 p.

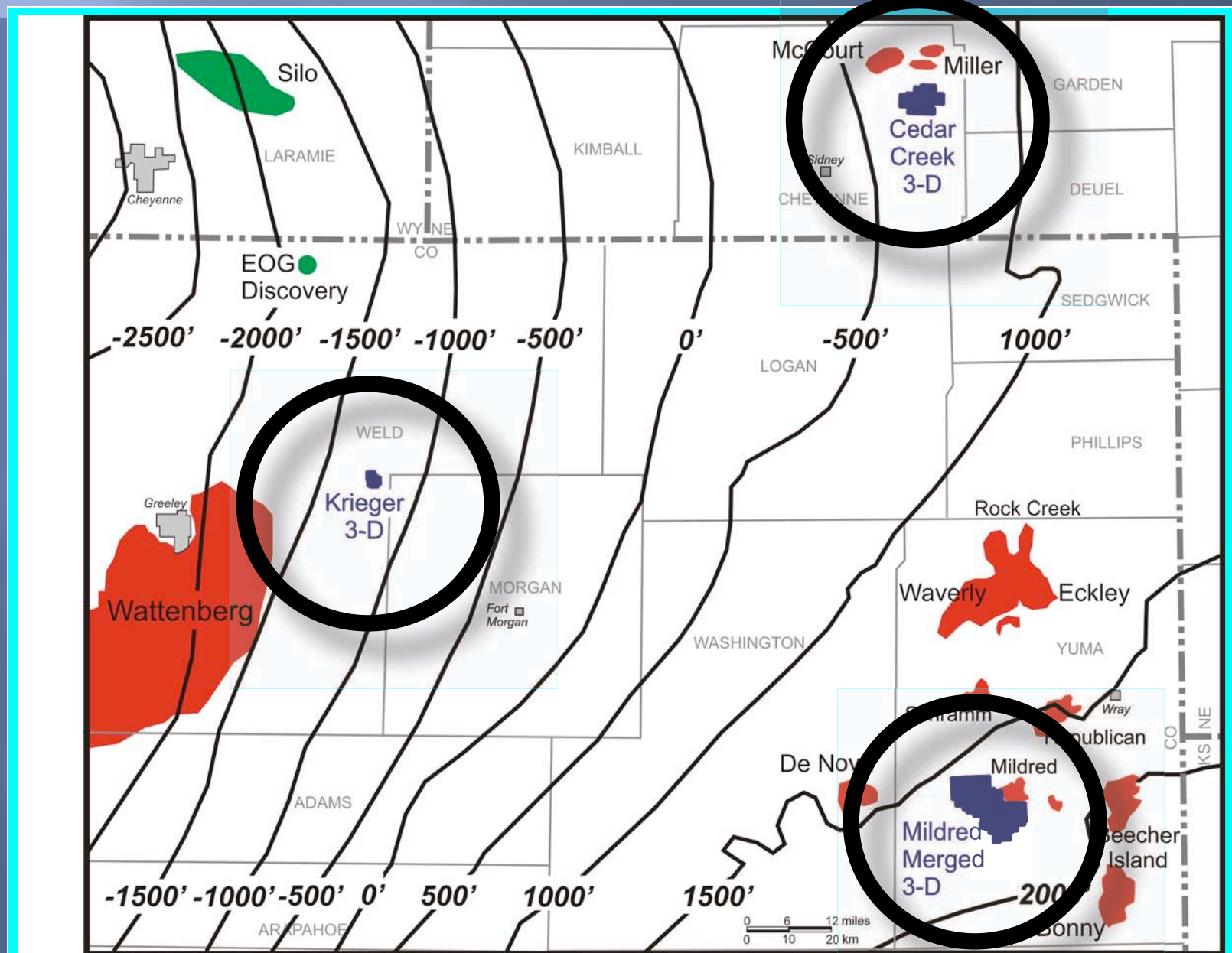
FAULT PATTERNS IN THE NIOBRARA FORMATION – EXAMPLES FROM THE EASTERN AND CENTRAL DJ BASIN

Note: This presentation is from the paper titled: "Fault Patterns in the Niobrara Formation – Examples from the Eastern and Central Denver Basin". This paper is included in the book: Revisiting and Revitalizing the Niobrara in the Central Rockies; published by the Rocky Mountain Association of Geologists (RMAG) in August 2011.

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Index Map



CI = 500 Feet

Adapted from Pollastro and Scholle, 1986

Niobrara Formation



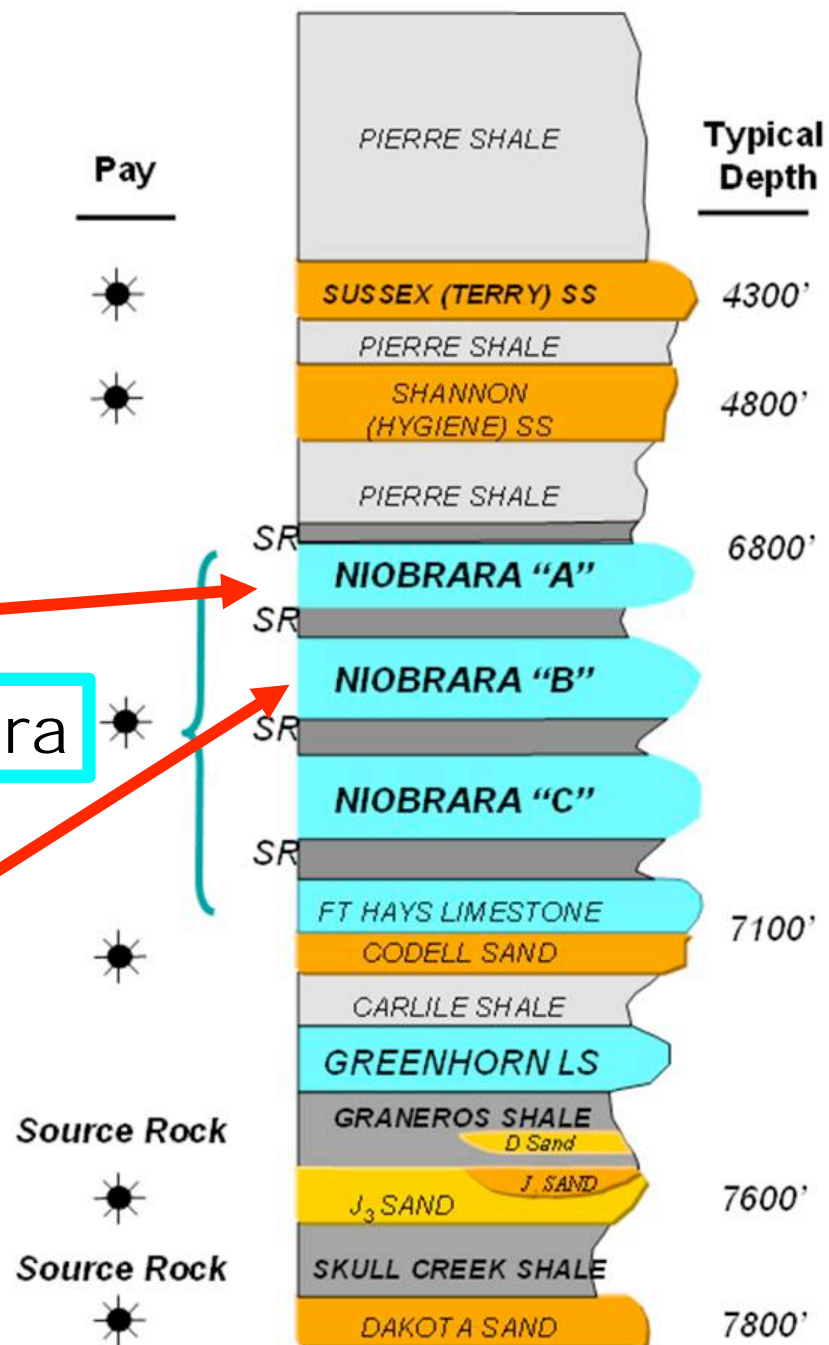
From Ron Blakey

Stratigraphic Column

Yuma County
Productive Zone
(Beecher Island)

Weld County
Productive Zone
(Niobrara B)

Niobrara



Geologic Setting – Thermally Mature Areas

Upper Cretaceous Niobrara Fm

- ◆ Chalk Beds = Hydrocarbons
- ◆ Matrix Porosities = 6 - 16%
- ◆ Permeability < .01 md
- ◆ Natural Fracturing/Hydraulic Fracturing

Geologic Setting – Eastern Flank

Upper Cretaceous Niobrara Fm (Beecher Island Zone)

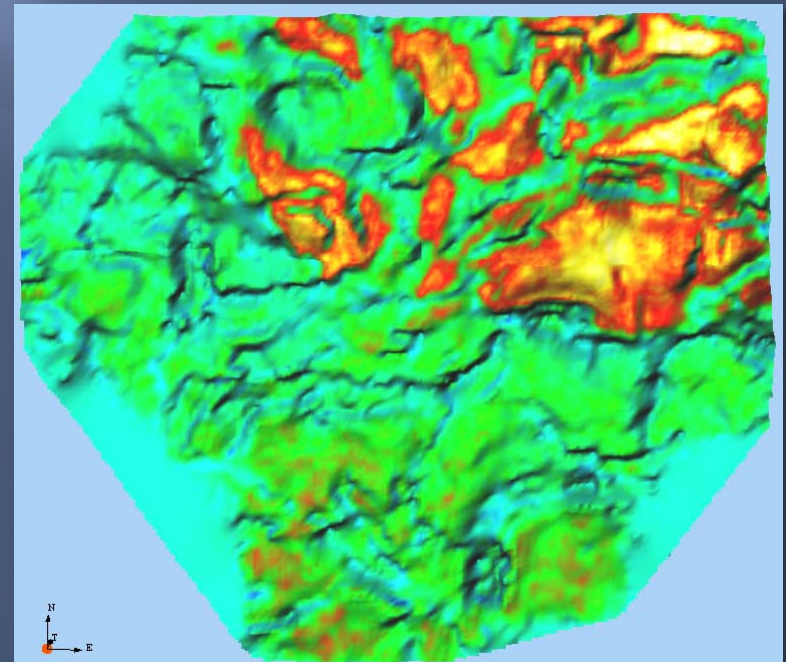
- ◆ Chalk Beds = Biogenic Gas
- ◆ Matrix Porosities = 30 - 45%
- ◆ Permeability < .1 md
- ◆ Rely Less On Natural Fracturing
- ◆ Production established in 1919 at Beecher Island Field, Yuma County

Geophysical Exploration History

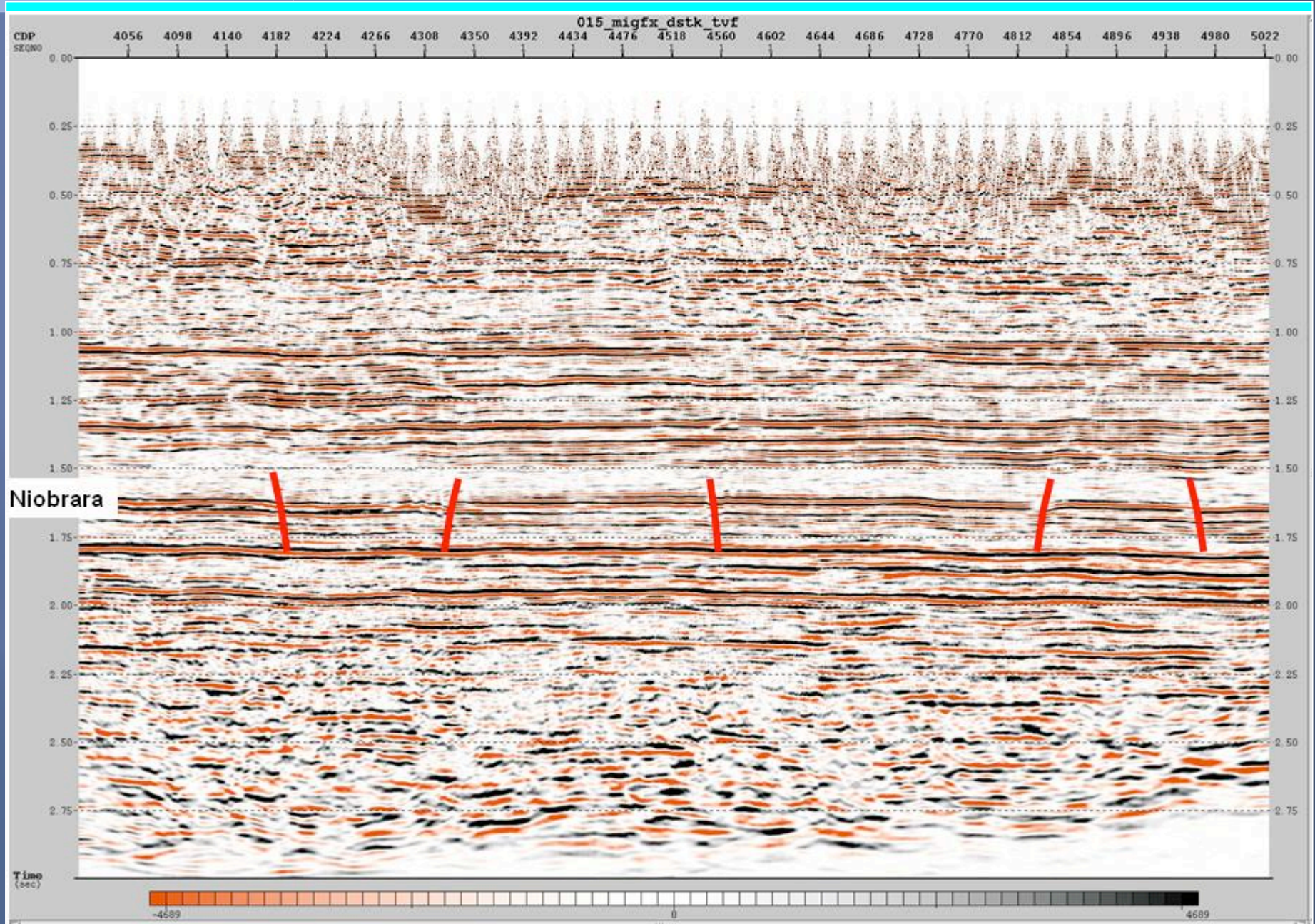


Single Fold (100%) Seismic Data

3-D Seismic Data



Single Fold Seismic Data



3-D Exploration Method

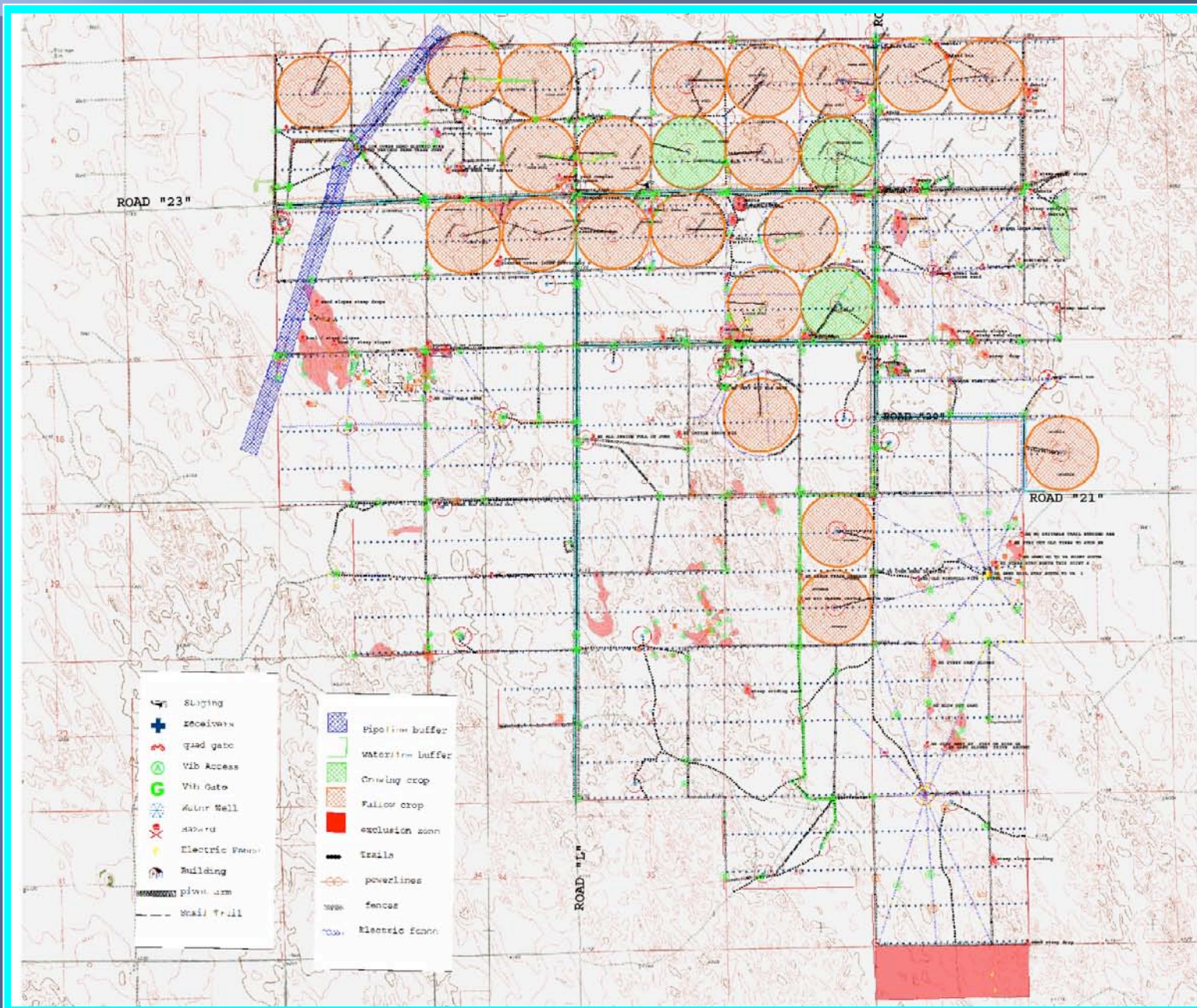


3-D Acquisition Parameters

Survey:	Mildred 3D	West Mildred 3D	Dune 3D	Cedar Creek 3D	Krieger 3D
Contractor:	Lockhart	CGG-Veritas	CGG-Veritas	CGG-Veritas	Lockhart
Bin Size:	110' x 110'	110' x 110'	110' x 110'	110' x 110'	82.5' x 82.5'
VP Spacing:	220'	220'	220'	220	165'
Source Line Spacing:	220'	220'	220'	220'	1155'
# Vibrators:	1	1	1	1	2
# Sweeps/VP:	8 x 2	1	1	1	8
Receiver Spacing:	220'	220'	220'	220'	165'
Receiver Line Spacing:	660'	1320'	1320'	1320'	495'
Patch:	12 x 50	8 x 60	8 x 60	8 x 60	14 x 60
Nominal Fold:	54	120	120	120	36
Sample Rate:	2 ms	2 ms	2 ms	2 ms	2 ms
Year:	2006	2008	2009	2008	2009

**Mildred Merged
3-D**

Hazard Map



Mildred Merged 3D Surface



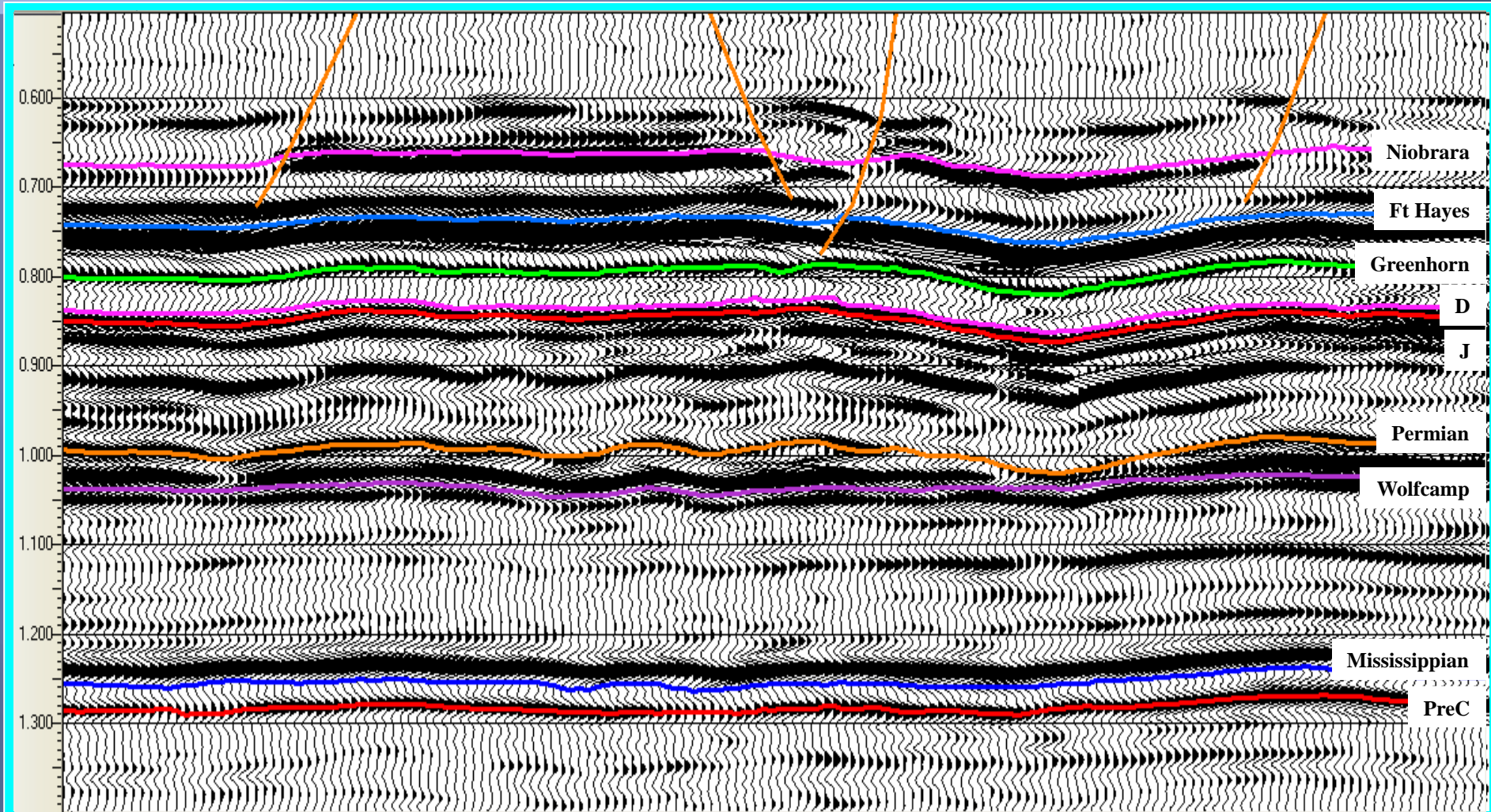
Vib Tracks in Summer



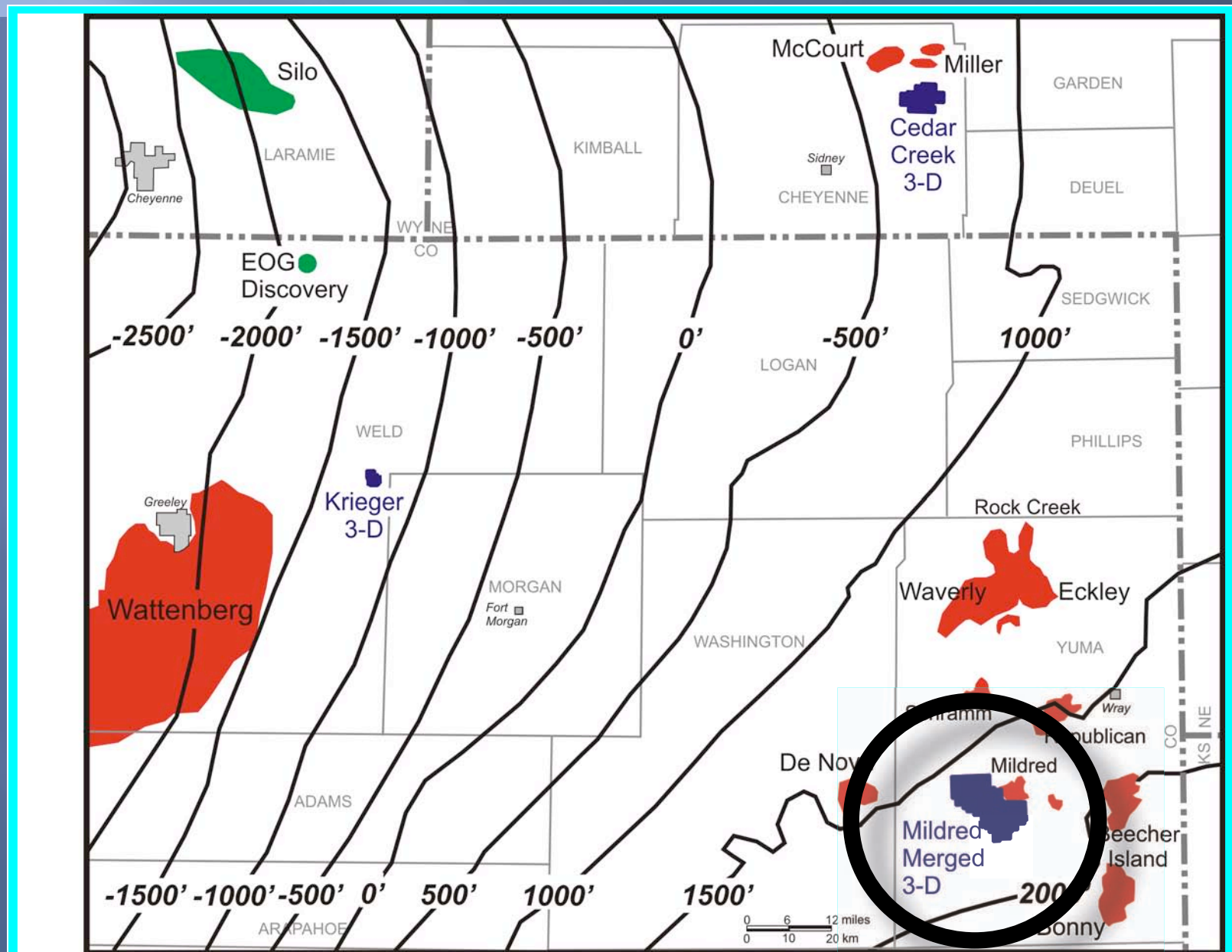
Vib Tracks in Winter



InLine Across Mildred Merged 3-D



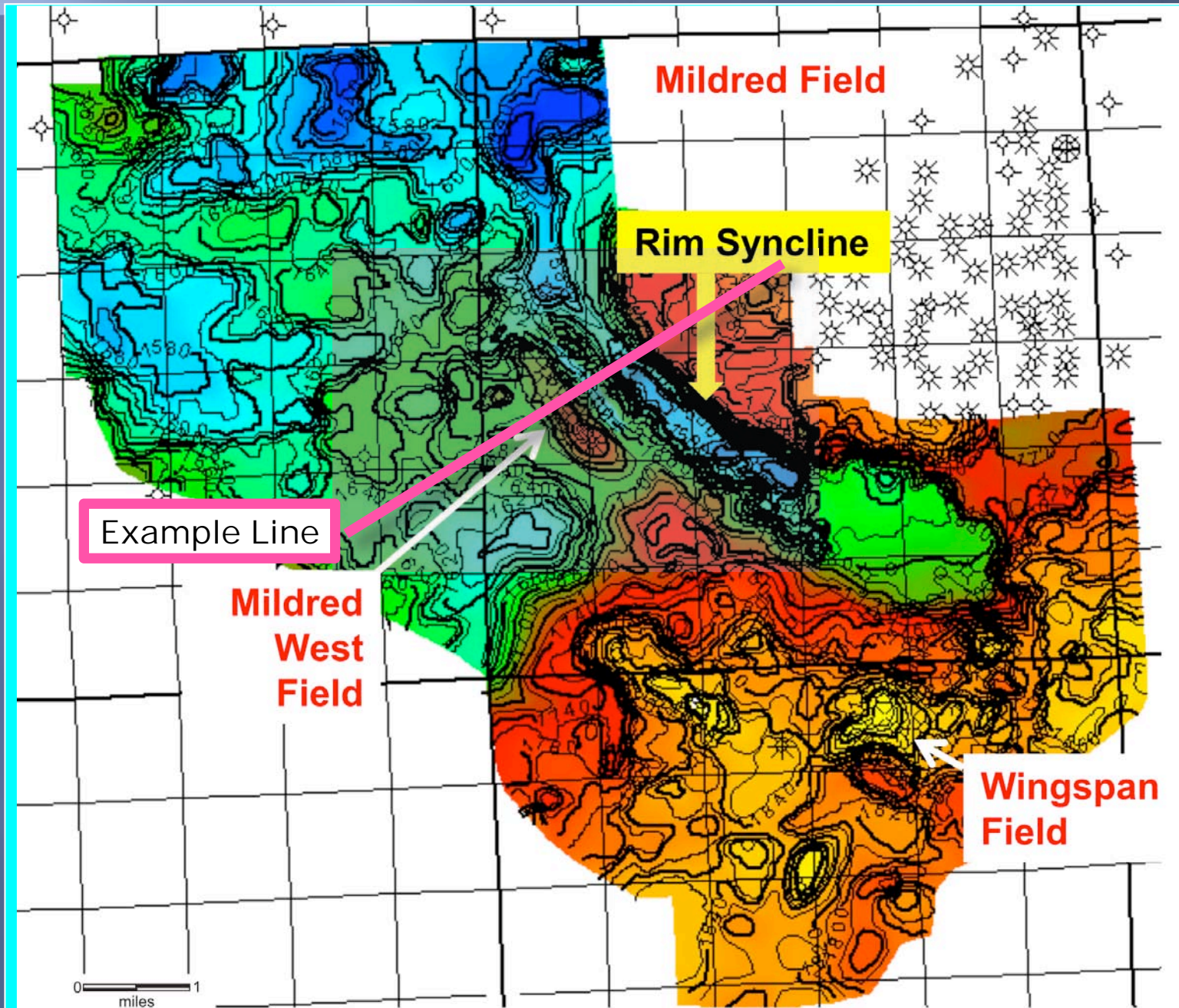
Index Map



CI = 500 Feet

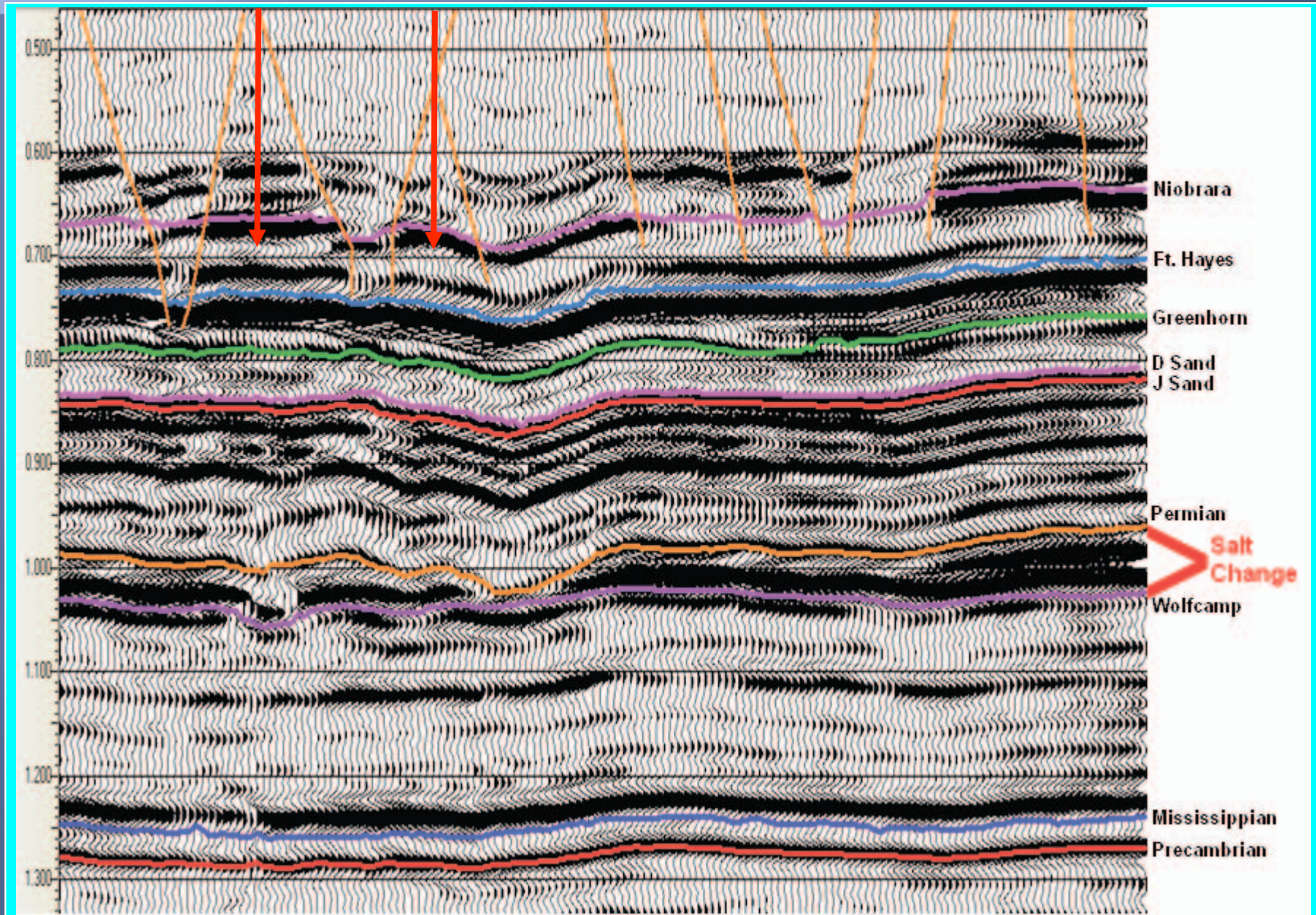
Adapted from Pollastro and Scholle, 1986

Niobrara Subsea Depth Structure Map

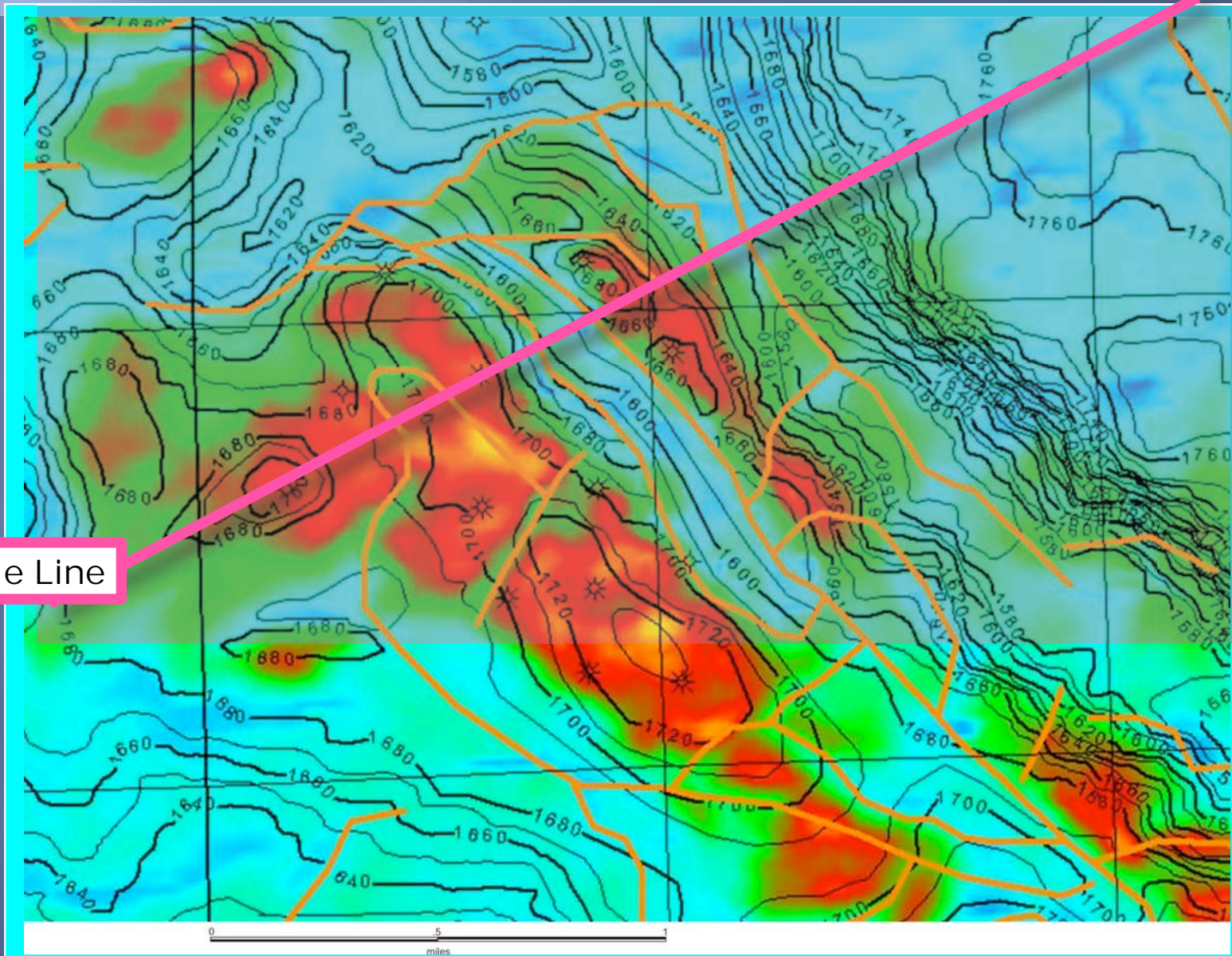


CI = 10 Feet

Arbitrary Line Across Mildred West Field



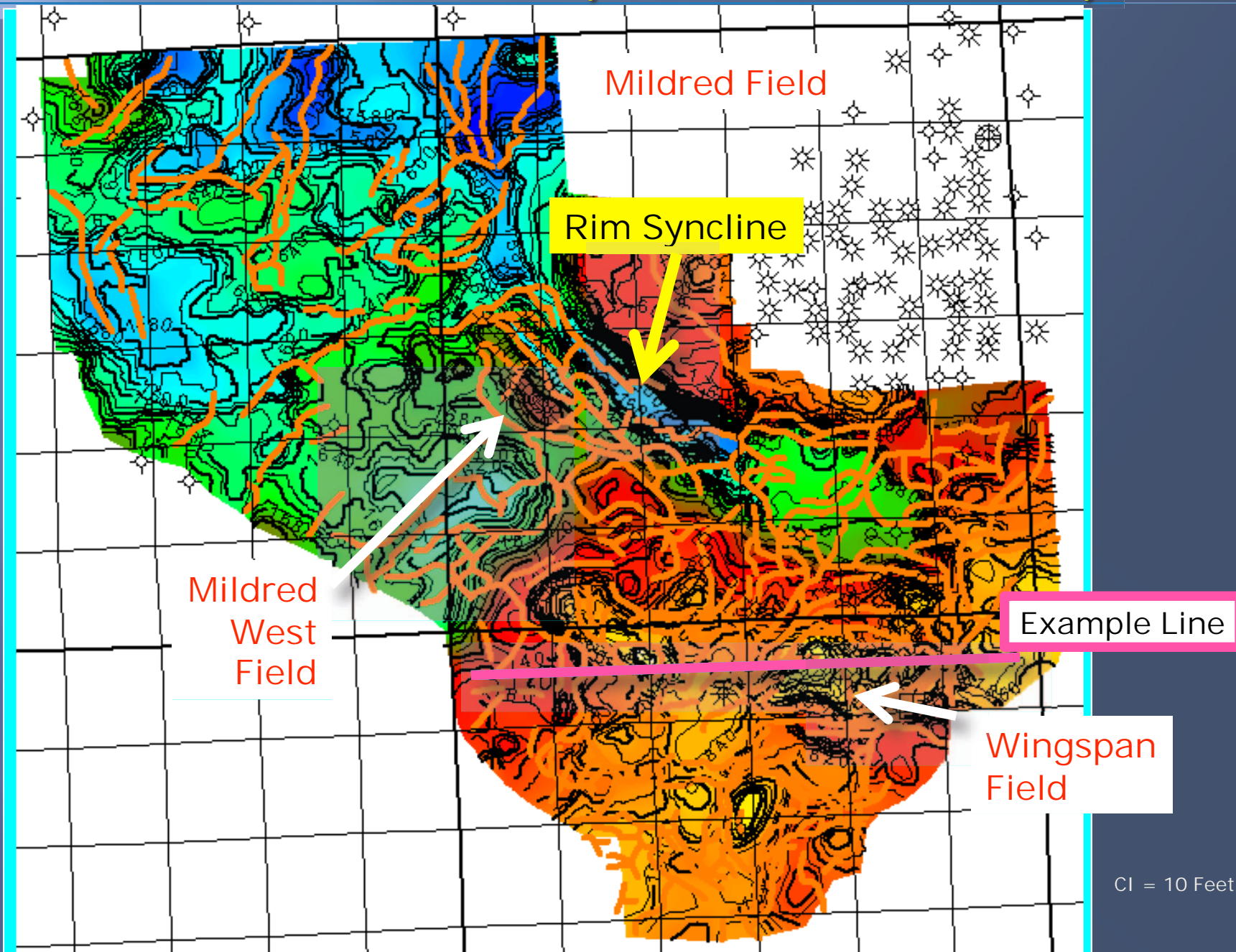
Mildred West Field; Niobrara Structure Map



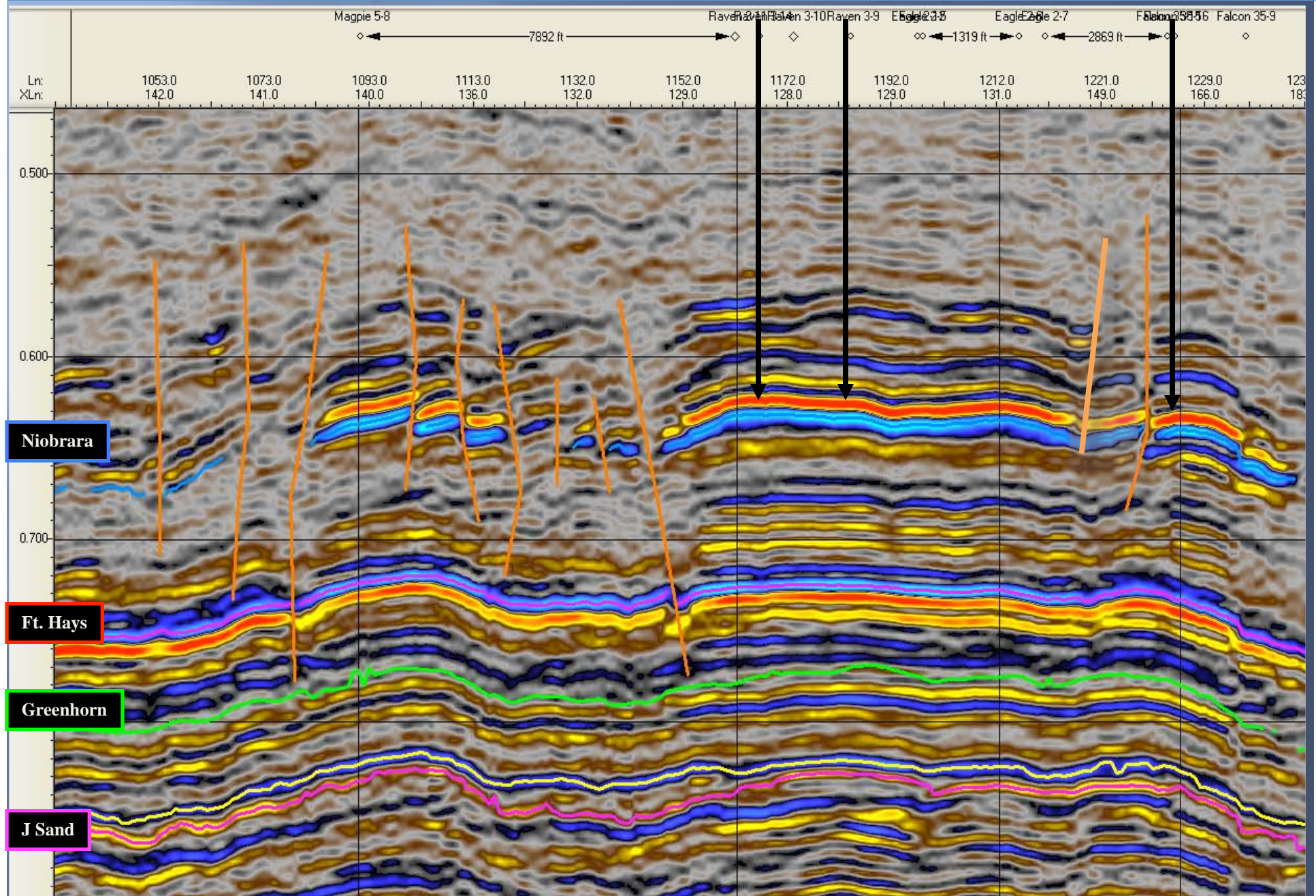
Example Line

CI = 10 Feet

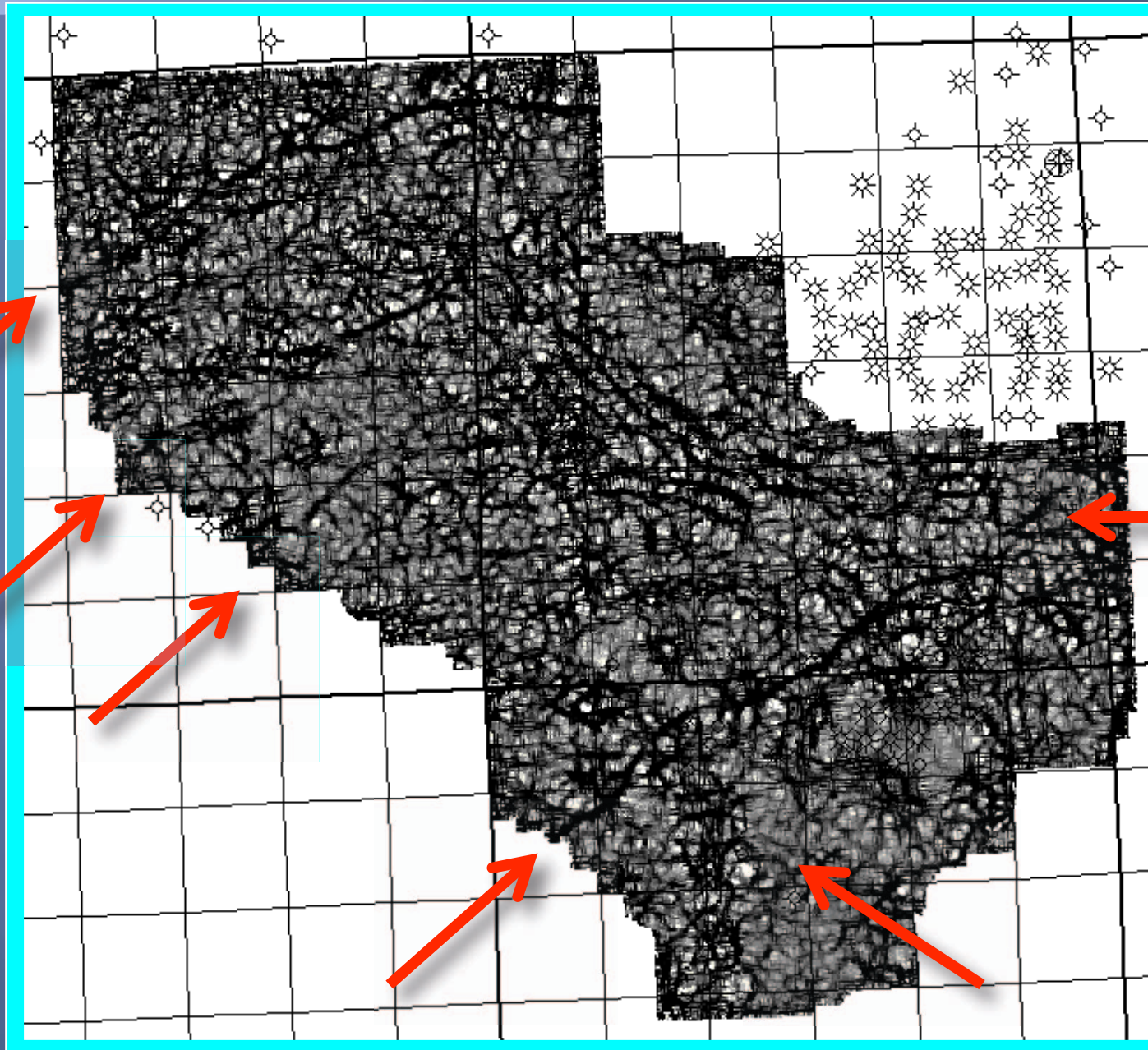
Niobrara Subsea Depth Structure Map



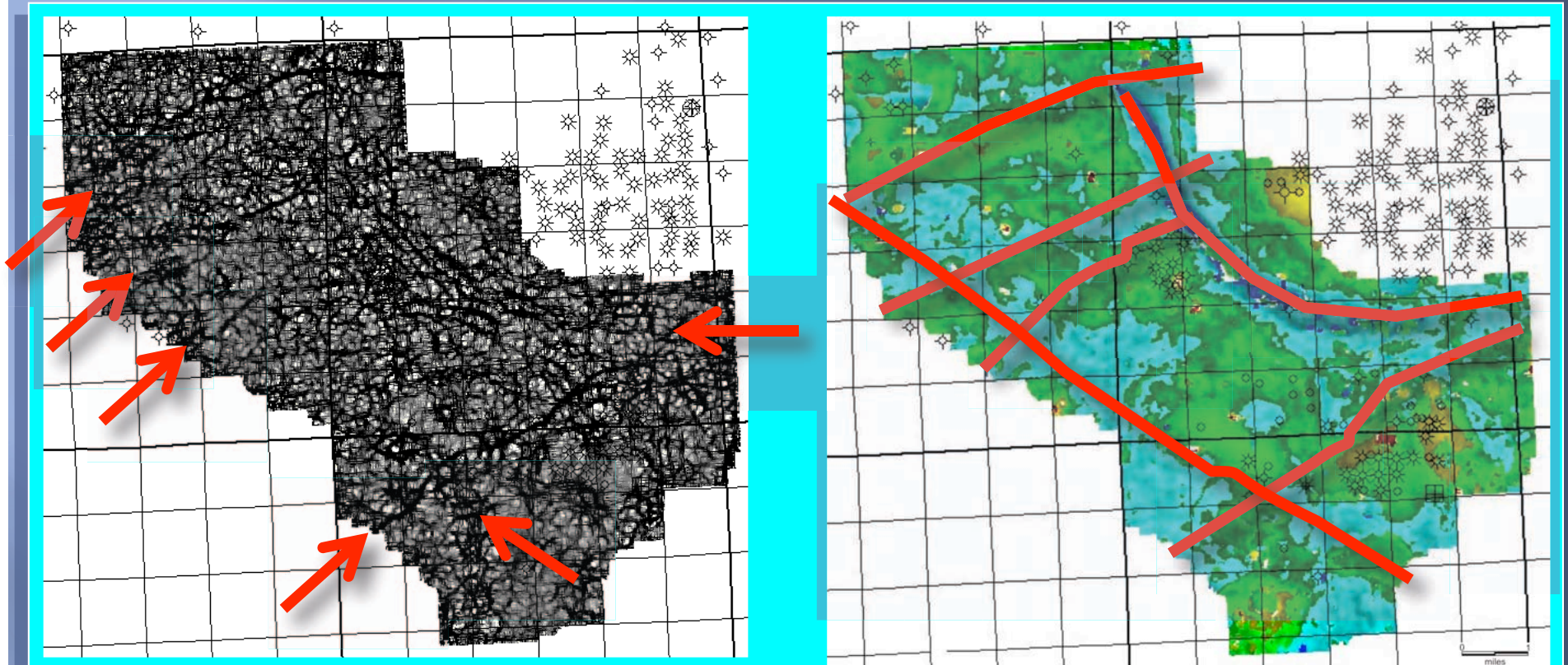
Arbitrary Line Across Wingspan Field



Pre-Cambrian Most Negative Curvature



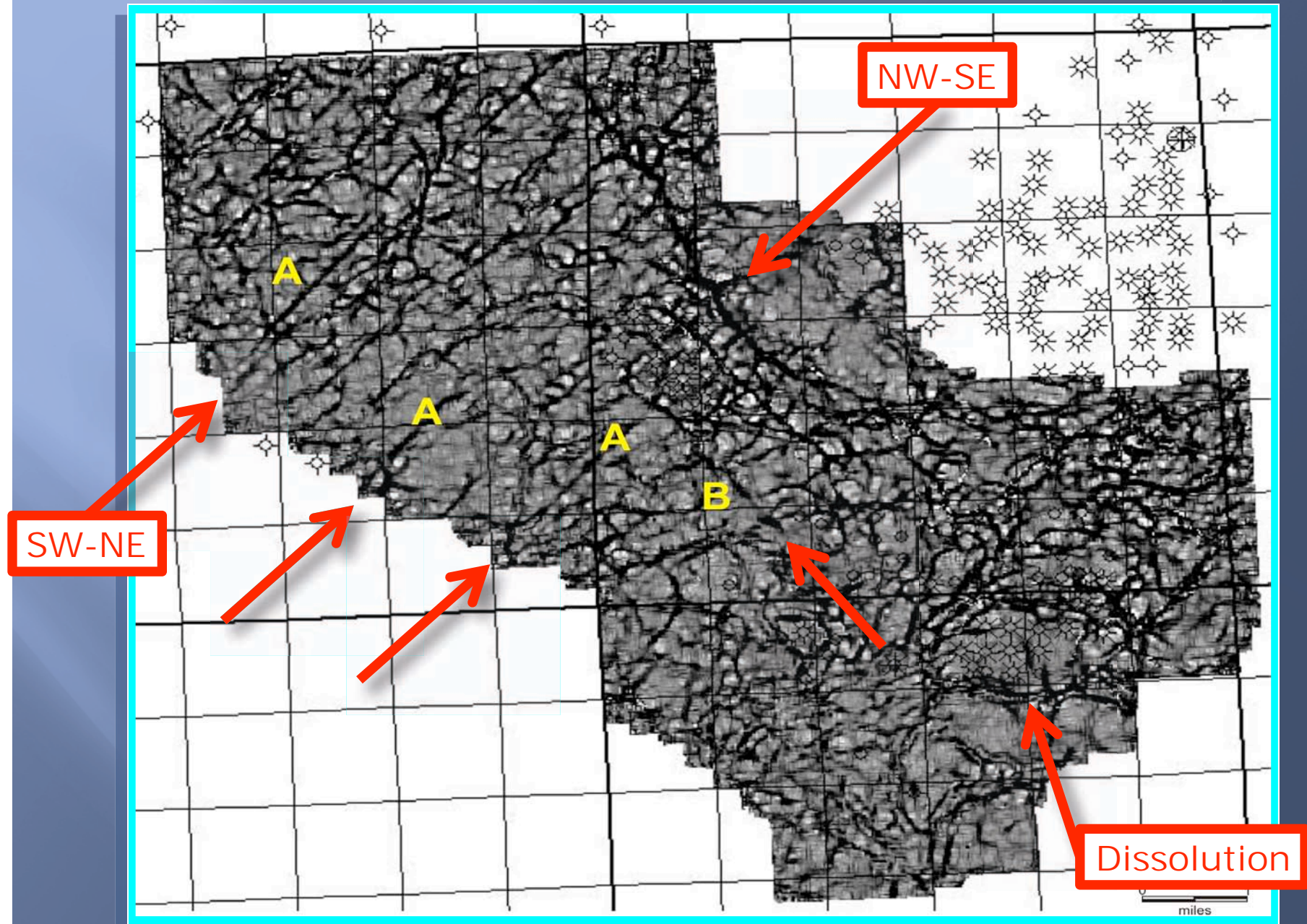
Pre-Cambrian Most Negative Curvature



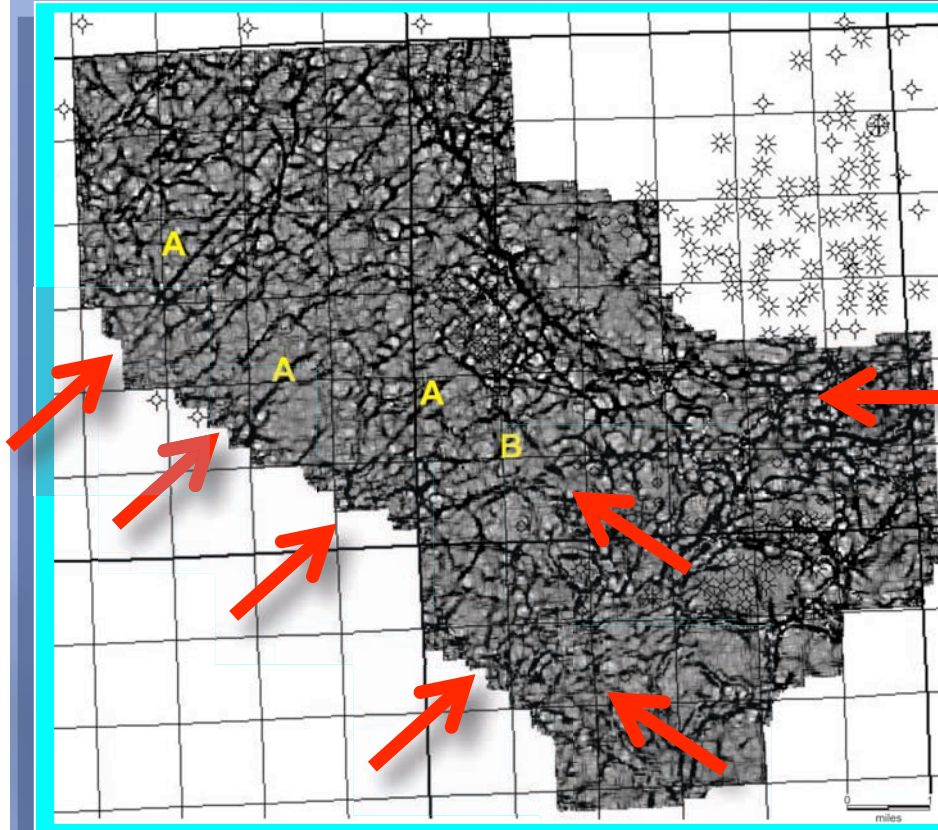
Pre-Cambrian Curvature

Isochron: Permian - Wolfcamp

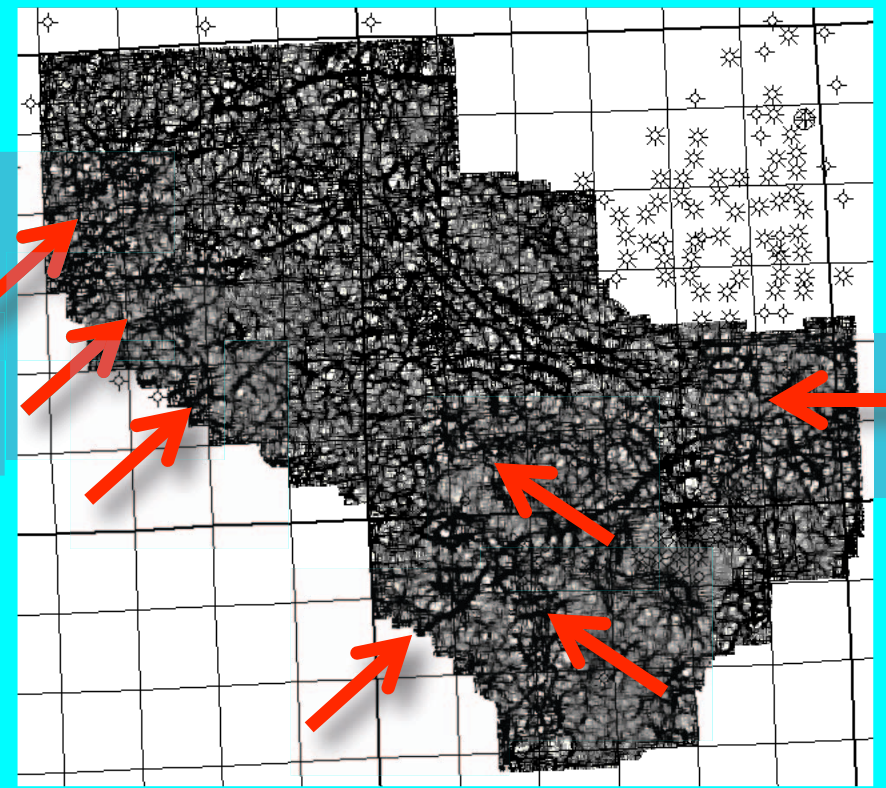
Niobrara Most Negative Curvature



Niobrara Most Negative Curvature

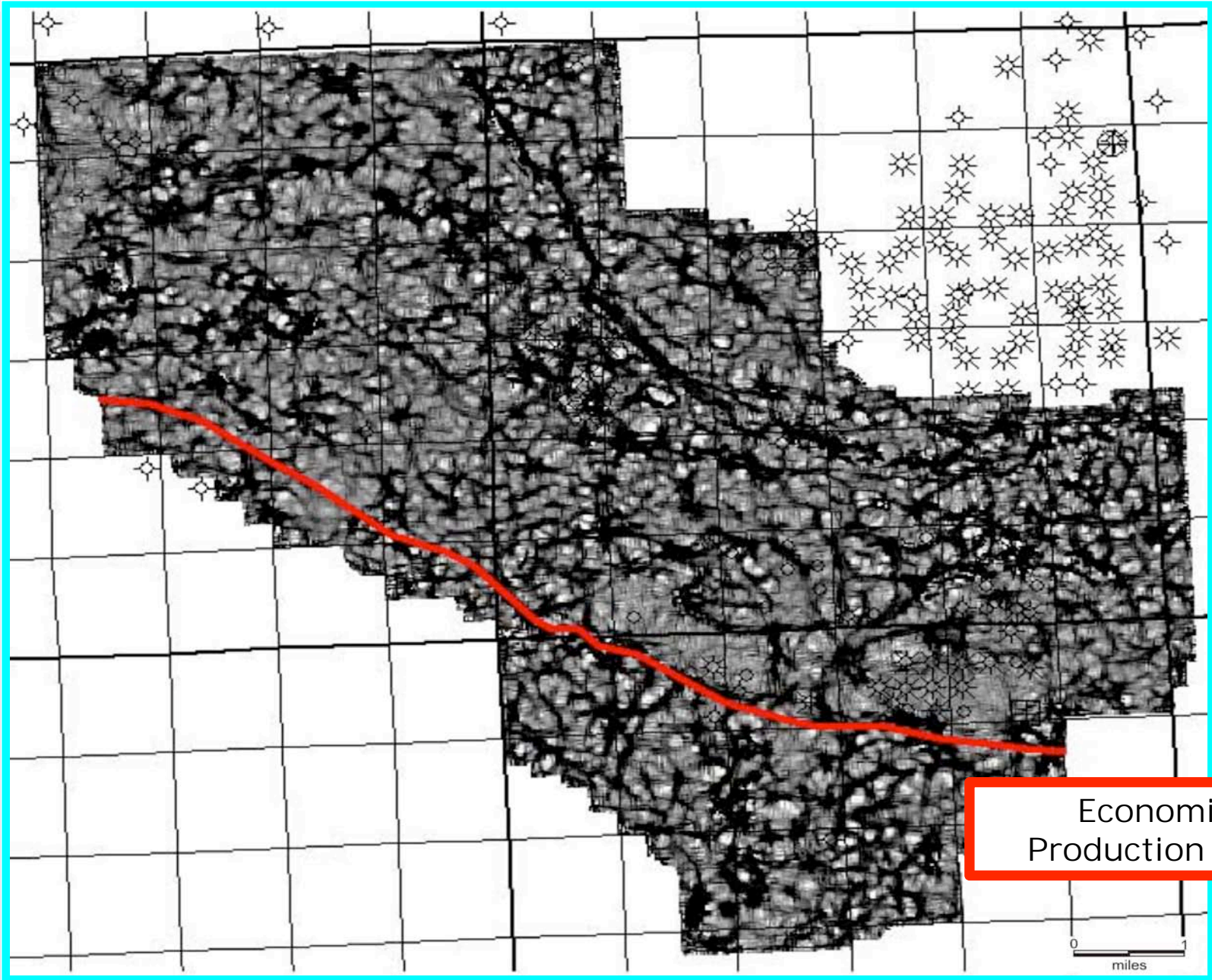


Niobrara Curvature



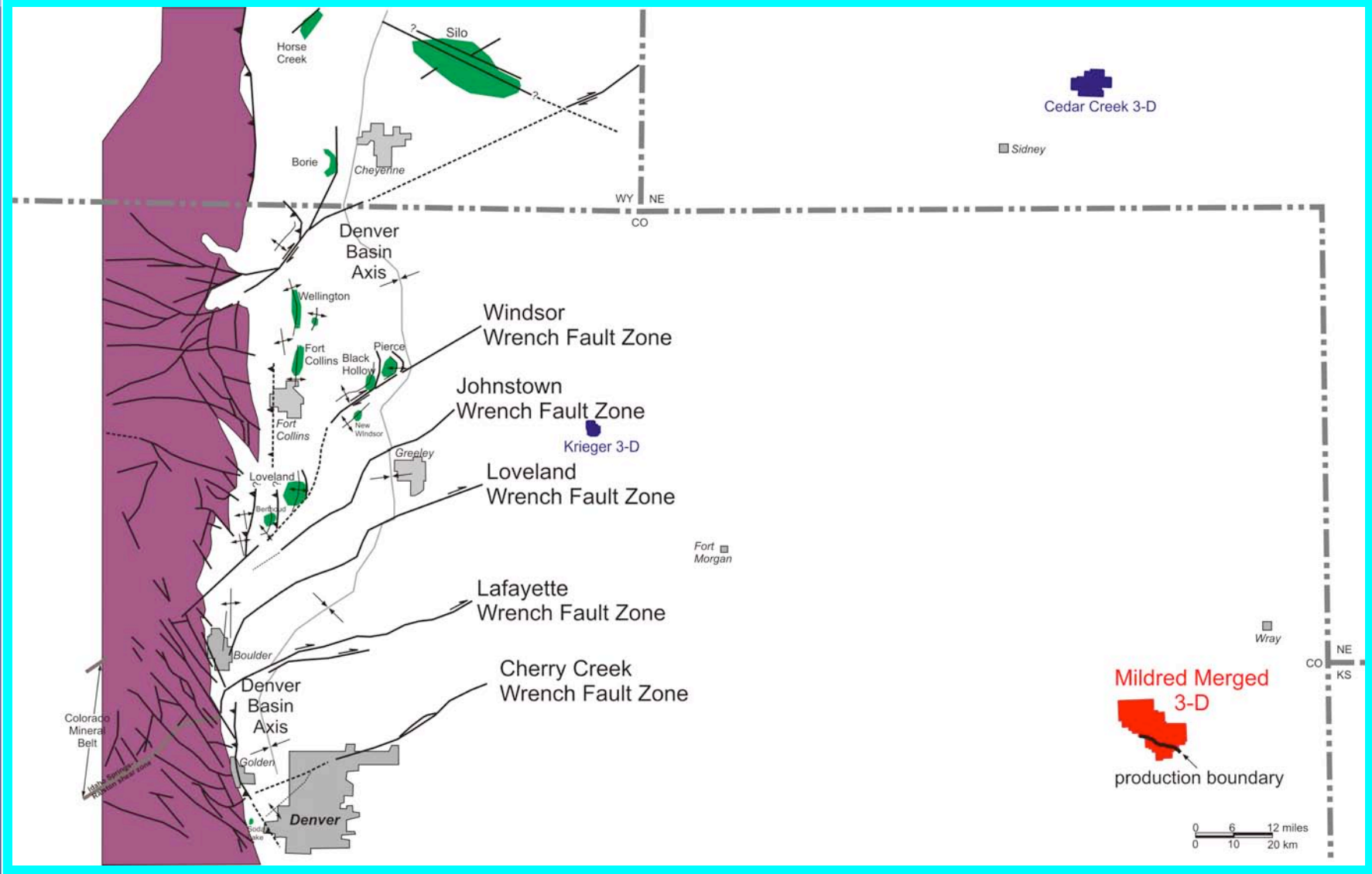
PreCambrian Curvature

Permian Most Negative Curvature

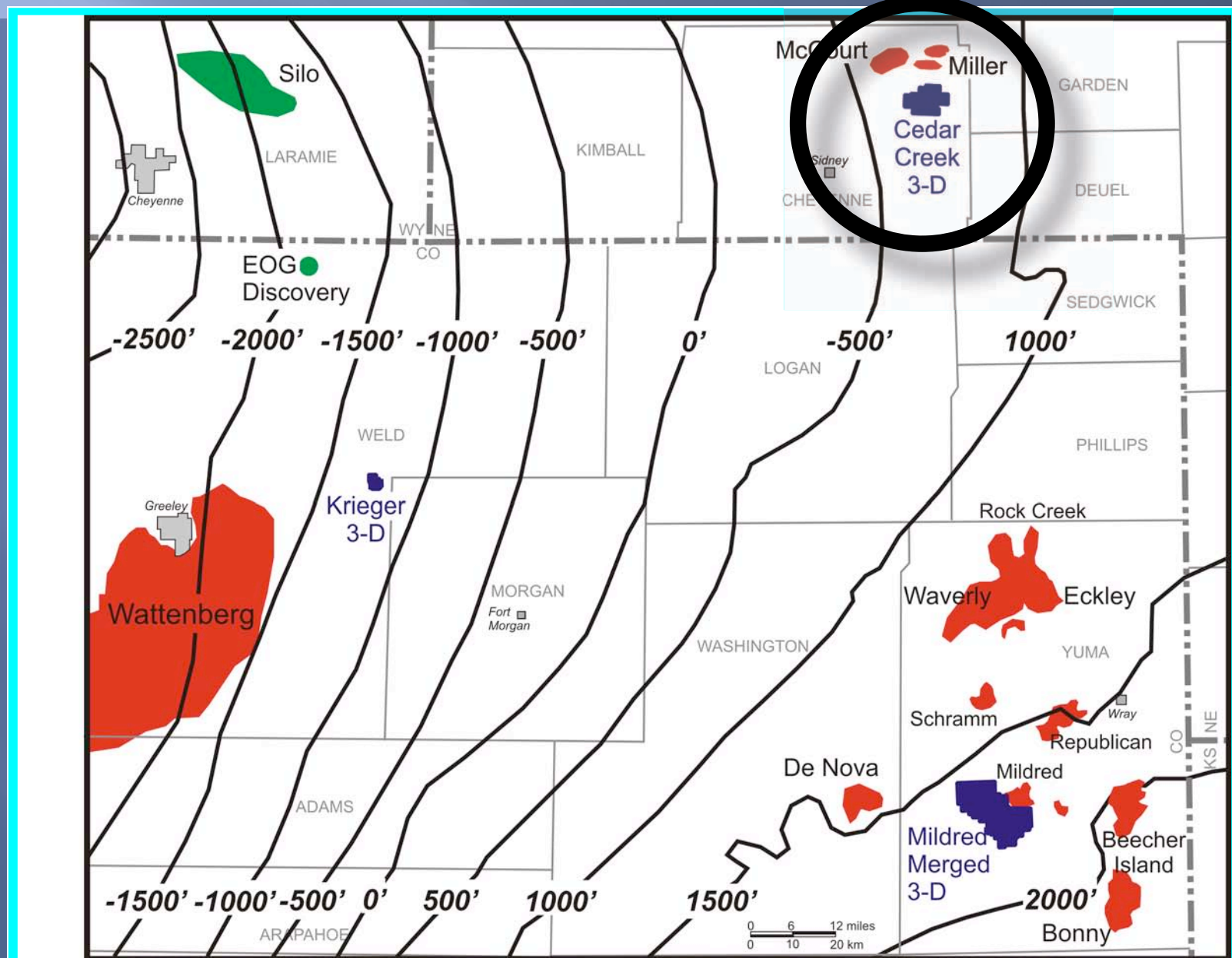


Economic
Production Line

Major Wrench Fault Zones



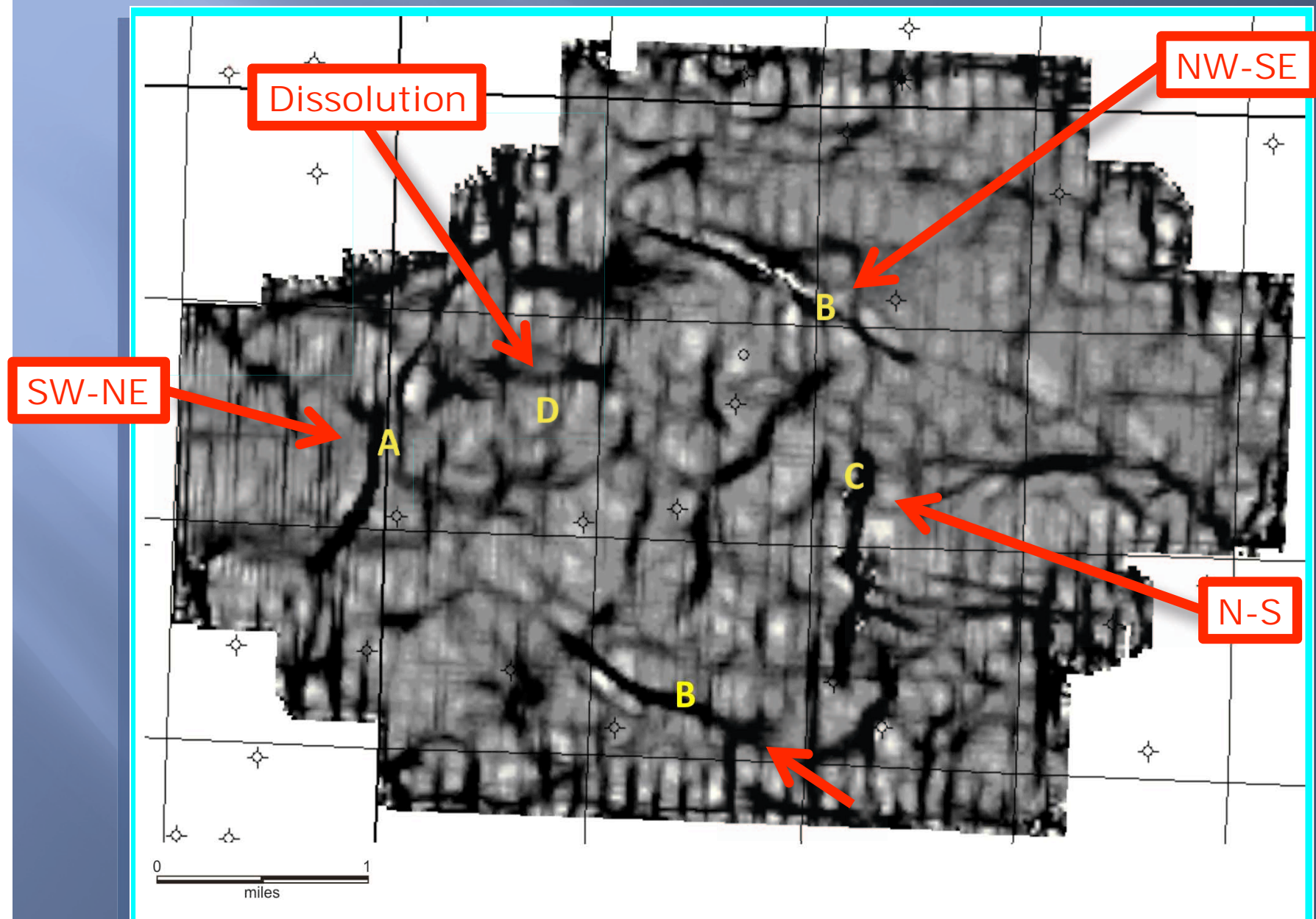
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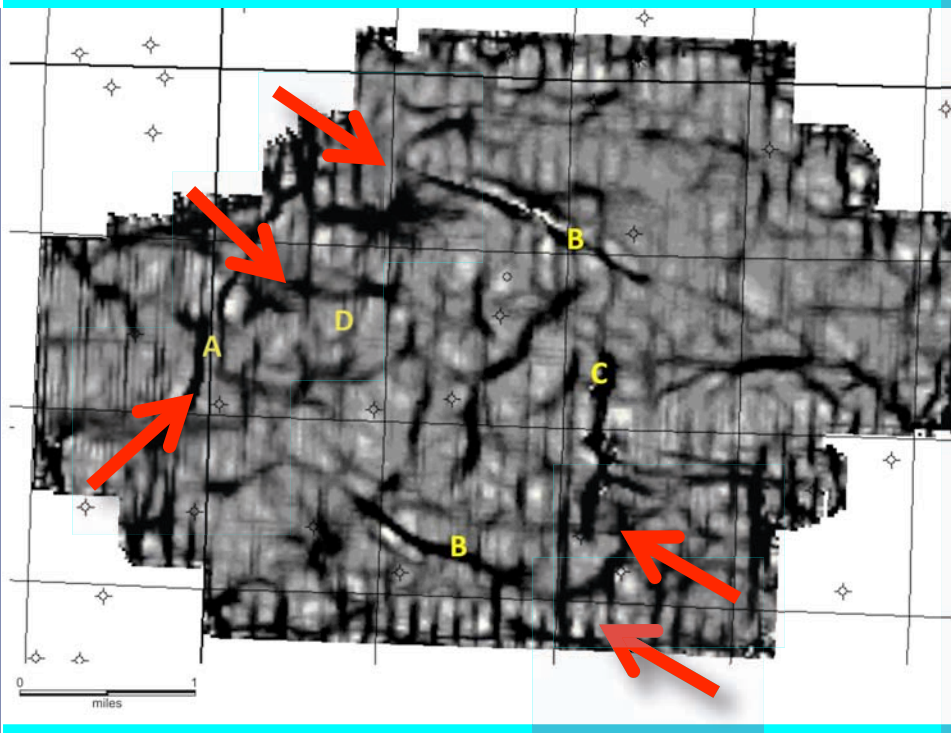
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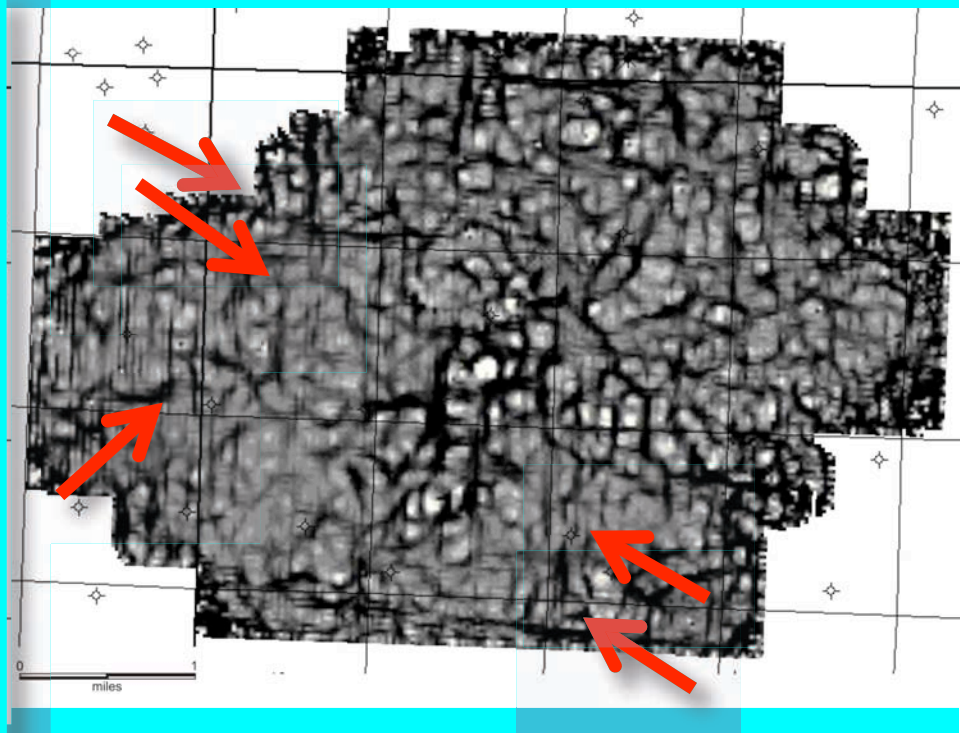
Cedar Creek 3D – Niobrara Curvature



Cedar Creek 3D – Curvature

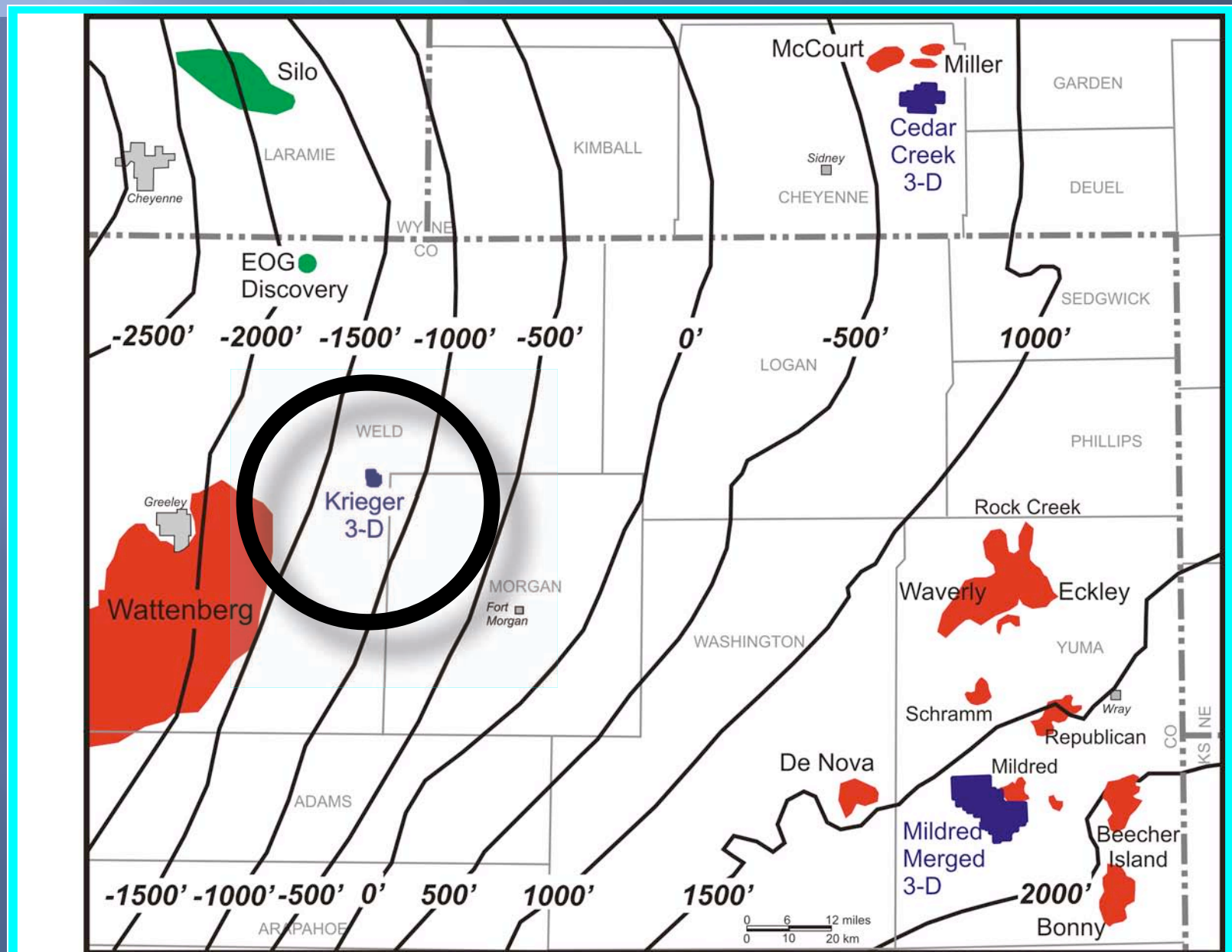


Niobrara Curvature



Pre-Cambrian Curvature

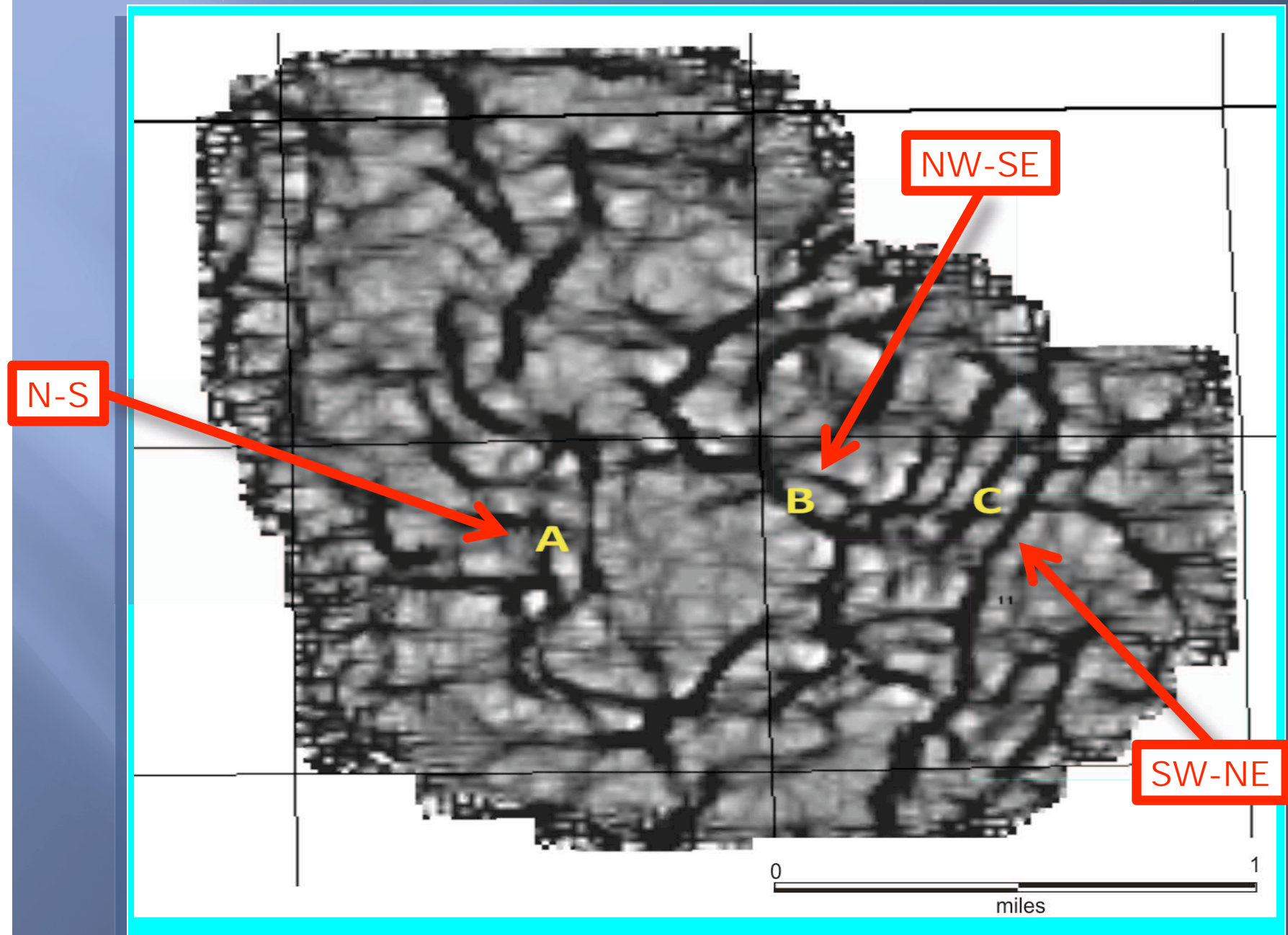
Index Map



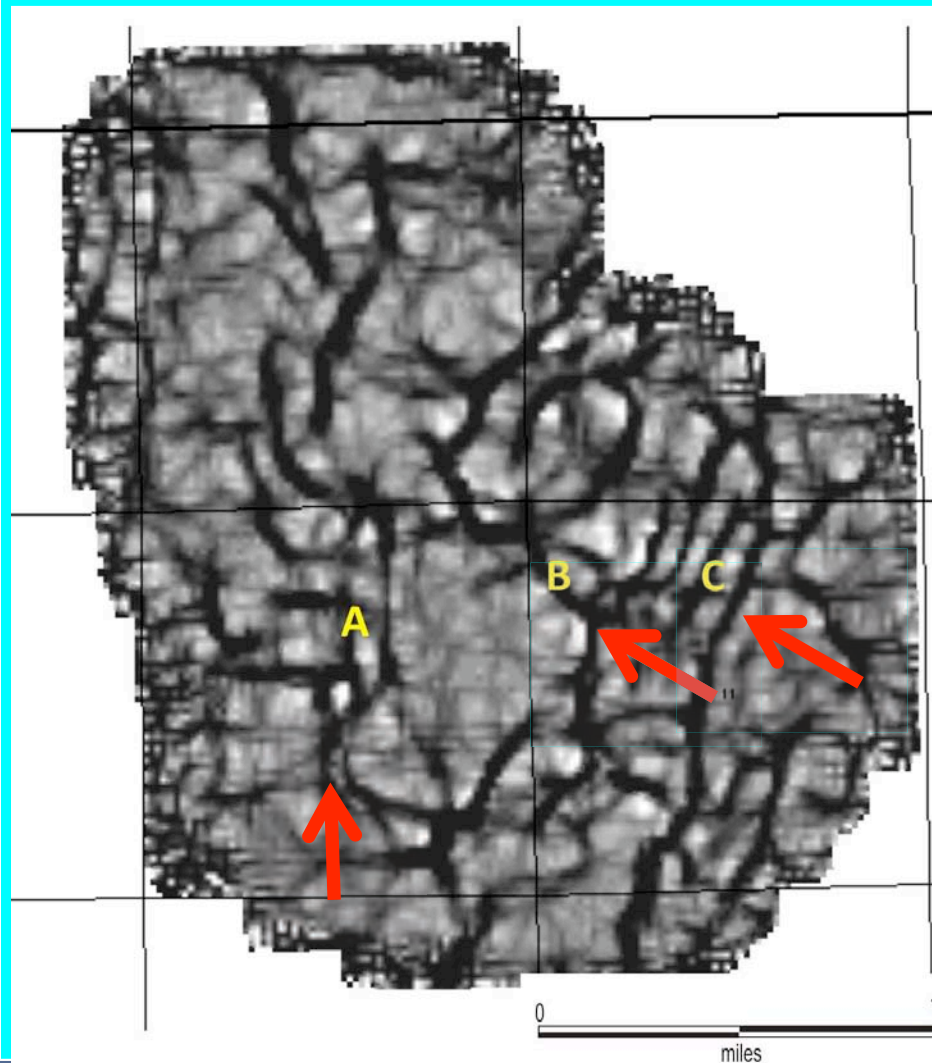
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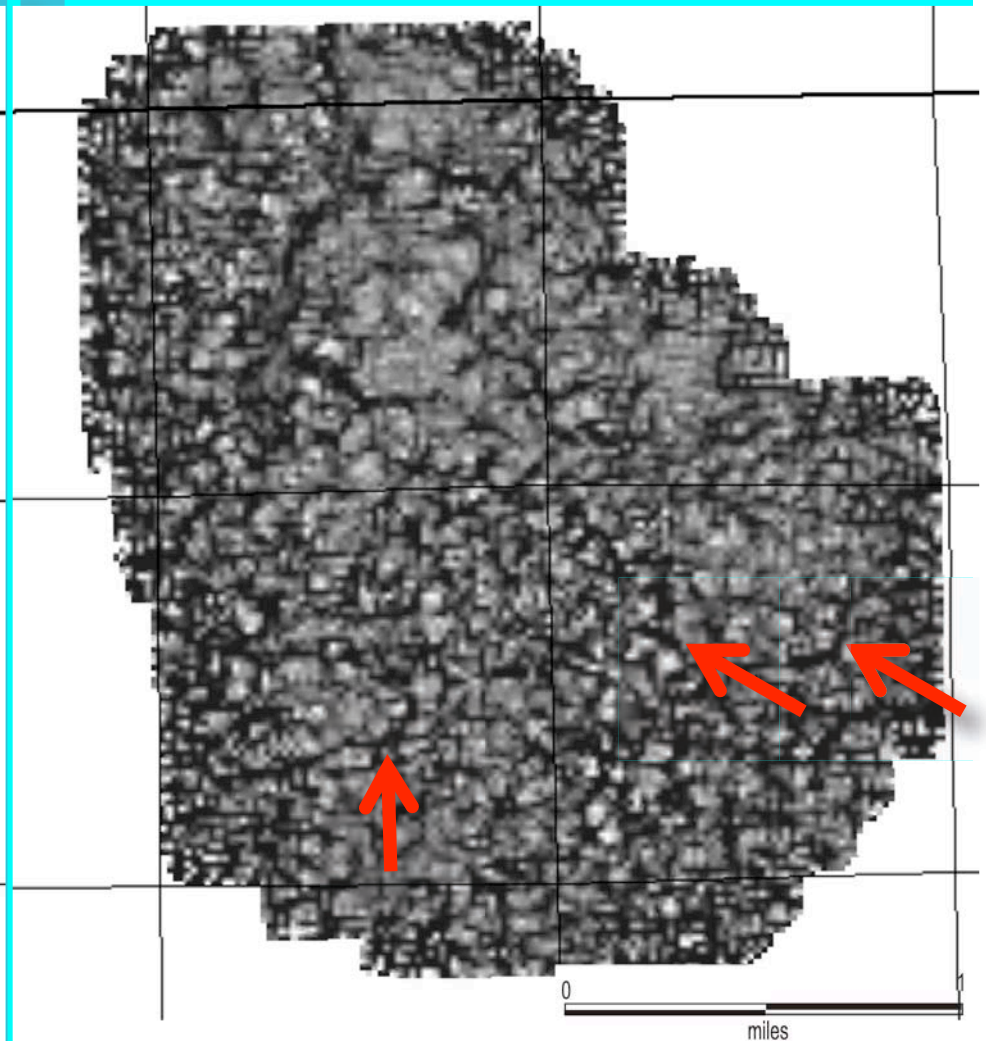
Krieger 3D – Niobrara Curvature



Krieger 3D – Curvature



Niobrara Curvature



Pre-Cambrian Curvature

Summary

14 Successful Wells in Wingspan Field and 7 Successful Wells in Mildred West Field

- ◆ 100% and 2-D data for reconnaissance mapping
- ◆ 3-D data for:
 - ✓ Accurate fault definition
 - ✓ Shear zone identification
 - ✓ Salt tectonics / structural mapping
 - ✓ Amplitude analysis
- ◆ Curvature to analyze Niobrara fault patterns reflecting two structural events:
 - ✓ Laramide reactivation of shear zones in Pre-Cambrian basement
 - ✓ Curvilinear faults resulting from post-Cretaceous dissolution of Permian salt beds

Acknowledgements

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Properties, Inc

SEISCO, Inc

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