Traverse Group Reservoirs in the Michigan Basin: A Second Look*

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Abstract

Traverse Group reservoirs have been a prolific source of hydrocarbons in the Michigan Basin since the 1930's. Early exploration targeted structural traps in these relatively shallow reservoirs (300 to 900 meters). The reservoirs in these fields consists of dolomitized, vuggy carbonates sealed by argillaceous and organic shales of the overlying Antrim Shale. The Traverse Group in the subsurface of Michigan includes the argillaceous shales of the Bell Shale, and shales, dolomites and limestones of the Traverse Limestone. The facies of the Traverse Limestone reflect a shallow water carbonate bank present over much of the Lower Peninsula of Michigan. Facies include grainy oolitic and skeletal sand shoals, patch reefs and reef-associated rubble, muddy lagoonal carbonates, and open shelf deposits consisting of interbedded tempestites and bioturbated, cherty carbonates.

Overlying the Traverse Limestone are argillaceous carbonates and dolomitic shales of the Squaw Bay Formation. The contact between the Traverse Limestone and the Squaw Bay Formation is a hardground with pyrite mineralization marking a period of relative sea level rise in the basin. The Squaw Bay Formation was deposited in the outer shelf under more reducing conditions. Up section, the Squaw Bay Formation becomes more argillaceous and exhibits higher gamma ray signatures. This zone transitions into the overlying Antrim Shales. In productive reservoirs, dolomitization preceded up to the Squaw Bay Formation, which acted as a partial seal to these fluids.

Dolomitization generated significant secondary porosity including vuggy and intercrystalline porosity (up to 12% in the Smith-Gerard #1). Grainy carbonates (reef rubble; skeletal, pelletal and oolitic sands) provided permeable pathways for dolomitizing fluids to migrate through the Traverse Limestone if not cemented early. Historic Production in Traverse Group reservoirs through 1986 was 115 million barrels of oil. Renewed interest in overlooked hydrocarbons is already driving exploration and speculation on the underlying Dundee-Rogers City Formations. These Middle Devonian Reservoirs were exploited prior to modern advances in technology and geologic principles – perhaps it is time to look at Traverse Group reservoirs again as well!

Selected References

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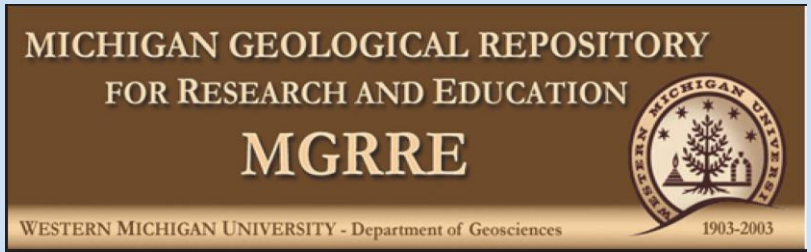
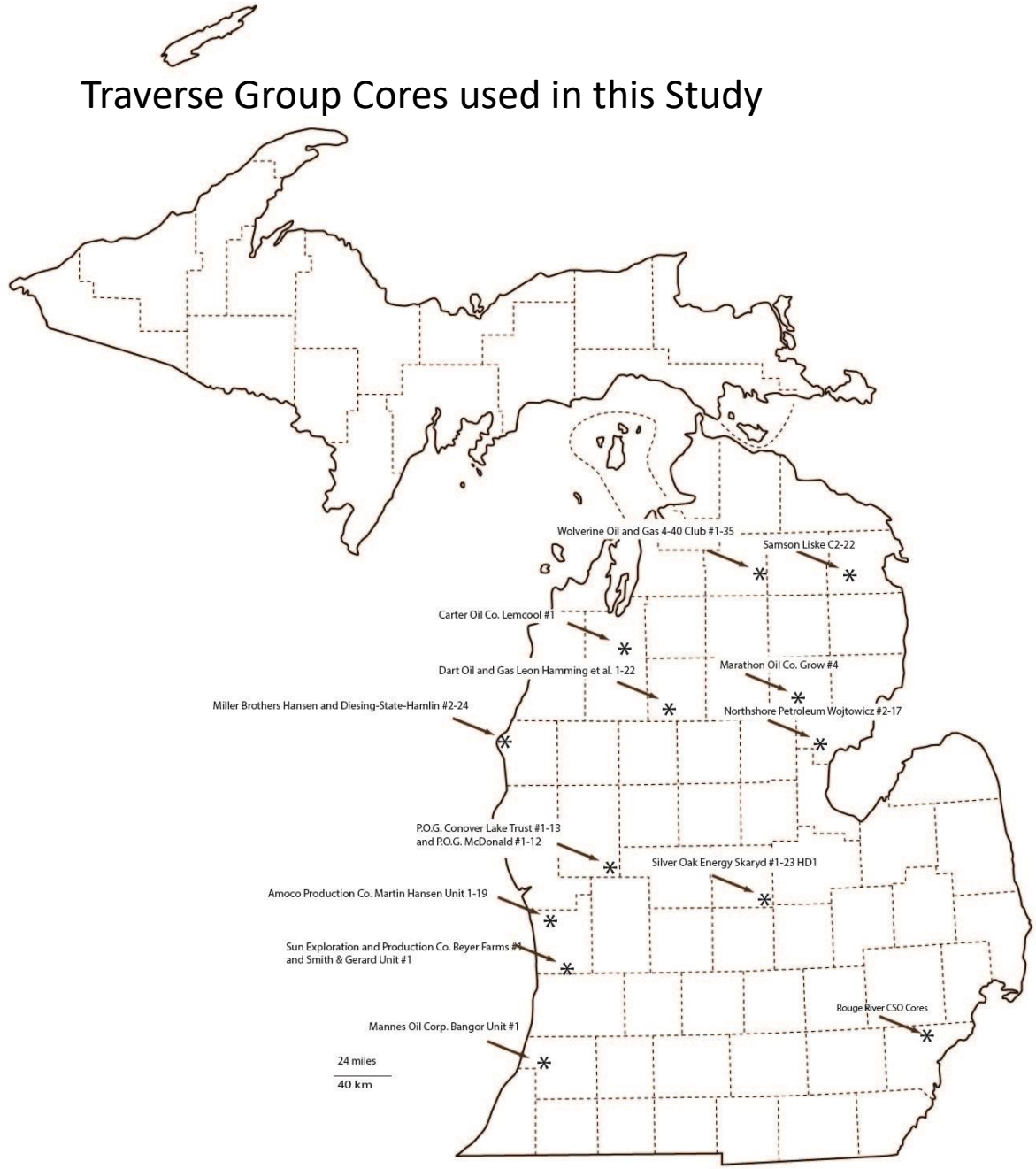




Traverse Group Cores used in this Study

General Observations:

- Increasing Shale content to East
- Increasing dolomite content toward the contact with the overlying Squaw Bay Formation
- Contact with Squaw Bay – hardground –pyritized, phosphatic and glauconitic pellets, erosional surface
- Cored interval:
  - Generally upper 20-40 ft of Traverse Limestone
  - Contact with Squaw Bay Formation
  - Some to all of the Squaw Bay Formation
  - Then into overlying Antrim Shale

Regional Stratigraphic Terminology

NW MI:

Antrim Shale

Traverse Group
- Jordan River Formation
- Whiskey Creek Formation
- Petoskey Limestone
- Charlevoix Limestone
- Gravel Point Formation
- Bell Shale

Rogers City Formation

Dundee Formation

Subsurface:

Antrim Shale

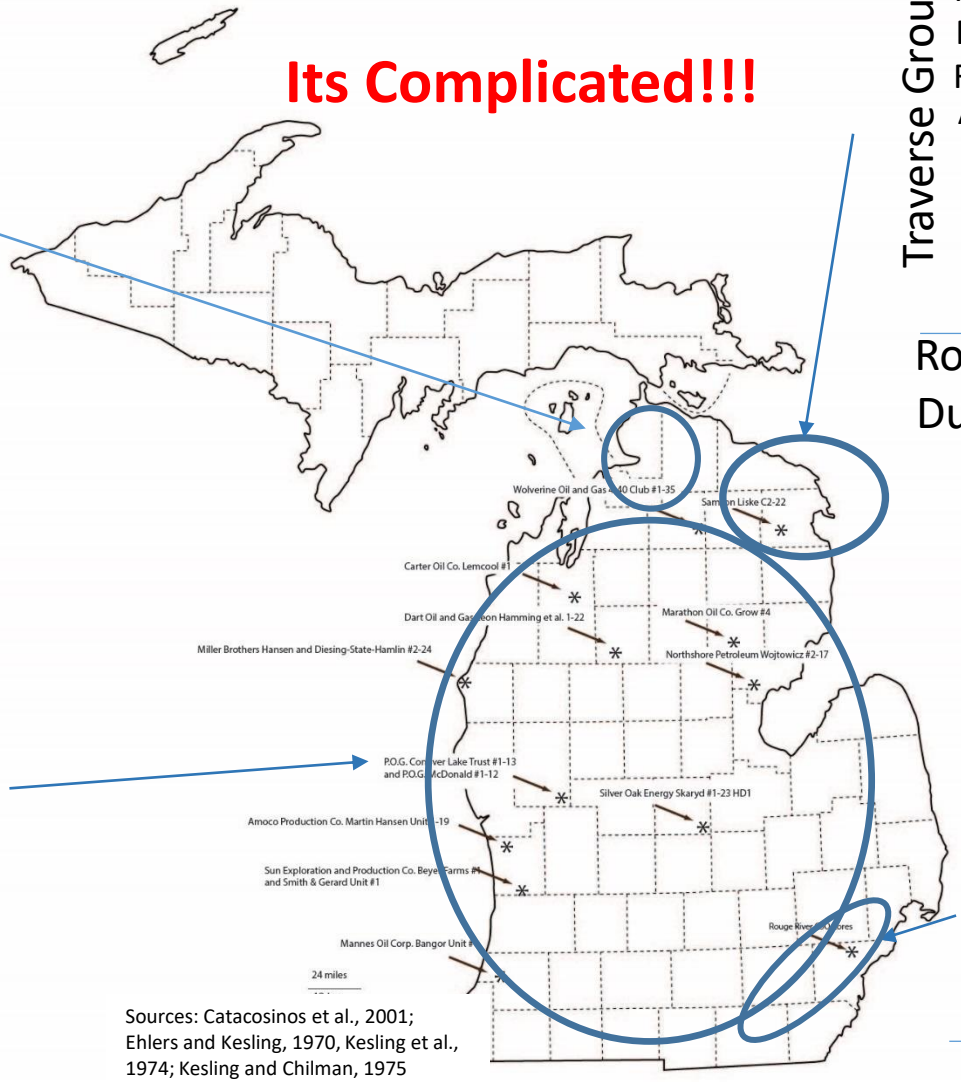
Squaw Bay Formation

Traverse Group
- Traverse Limestone
- Bell Shale

Rogers City Formation

Dundee Formation

Its Complicated!!!



Sources: Catacosinos et al., 2001; Ehlers and Kesling, 1970, Kesling et al., 1974; Kesling and Chilman, 1975

NE MI:

Antrim Shale

Squaw Bay Formation

Traverse Group
- Thunder Bay Formation
- Potter Farm Formation
- Norway Point Formation
- Four Mile Dam Formation
- Alpena Limestone
- Newton Creek Limestone
- Genshaw Formation
- Ferron Pt. Formation
- Rockport Quarry Limestone
- Bell Shale

Rogers City Formation

Dundee Formation

SE MI:

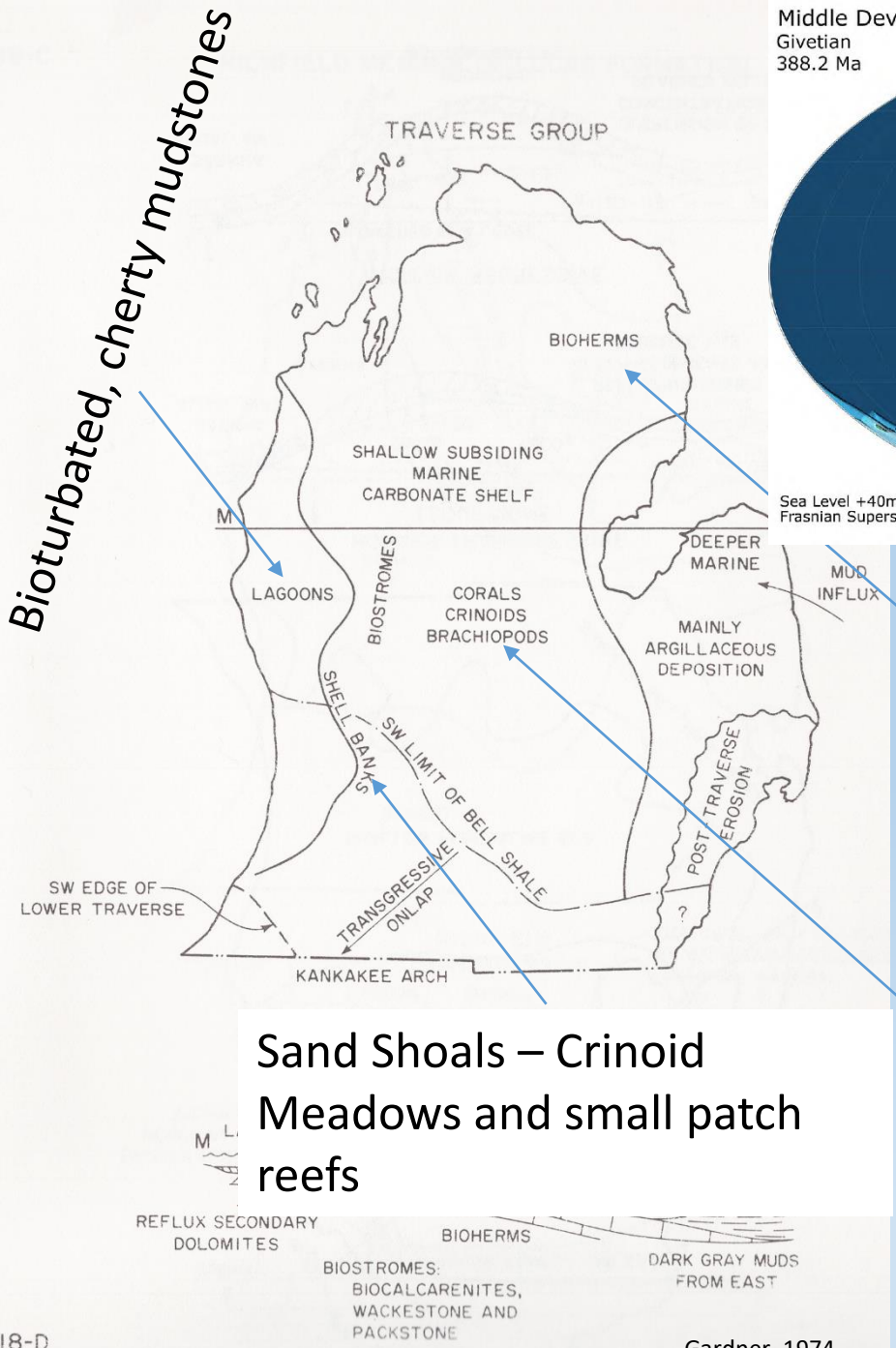
Antrim Shale

Squaw Bay Formation

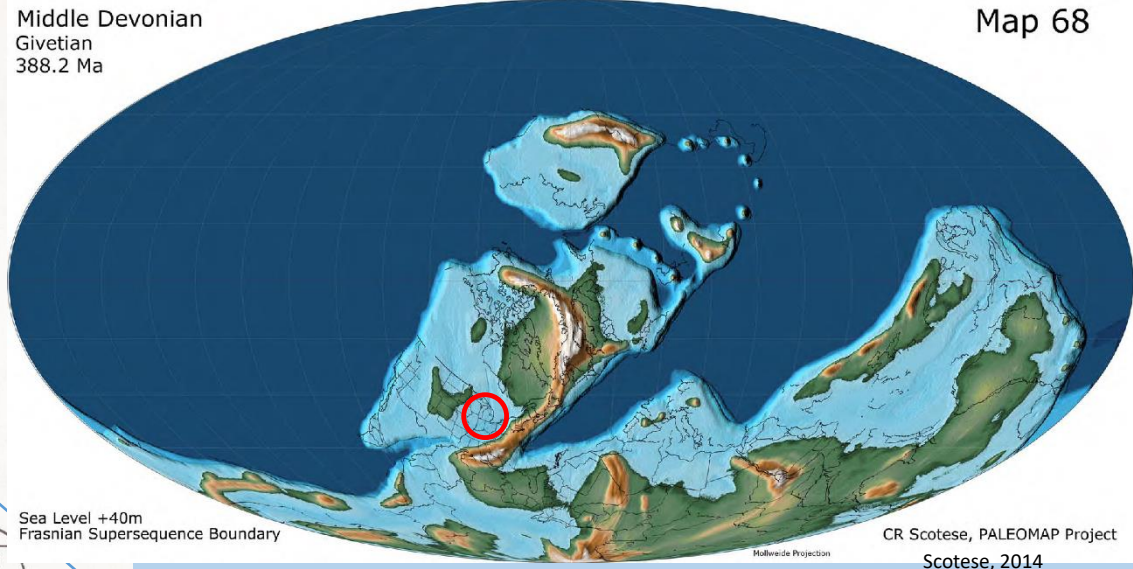
Traverse Group
- Ten Mile Creek Dolomite
- Silica Formation

Dundee Formation

Bioturbated, cherty mudstones



Gardner, 1974



Scotese, 2014

Patch Reefs and interbedded lagoonal, open shelf, and rubble deposits (Outcrop-Quarry Cuts)

Sand Shoals – Crinoid Meadows and small patch reefs

Open Shelf – muddy/pelletal carbonates, storm beds

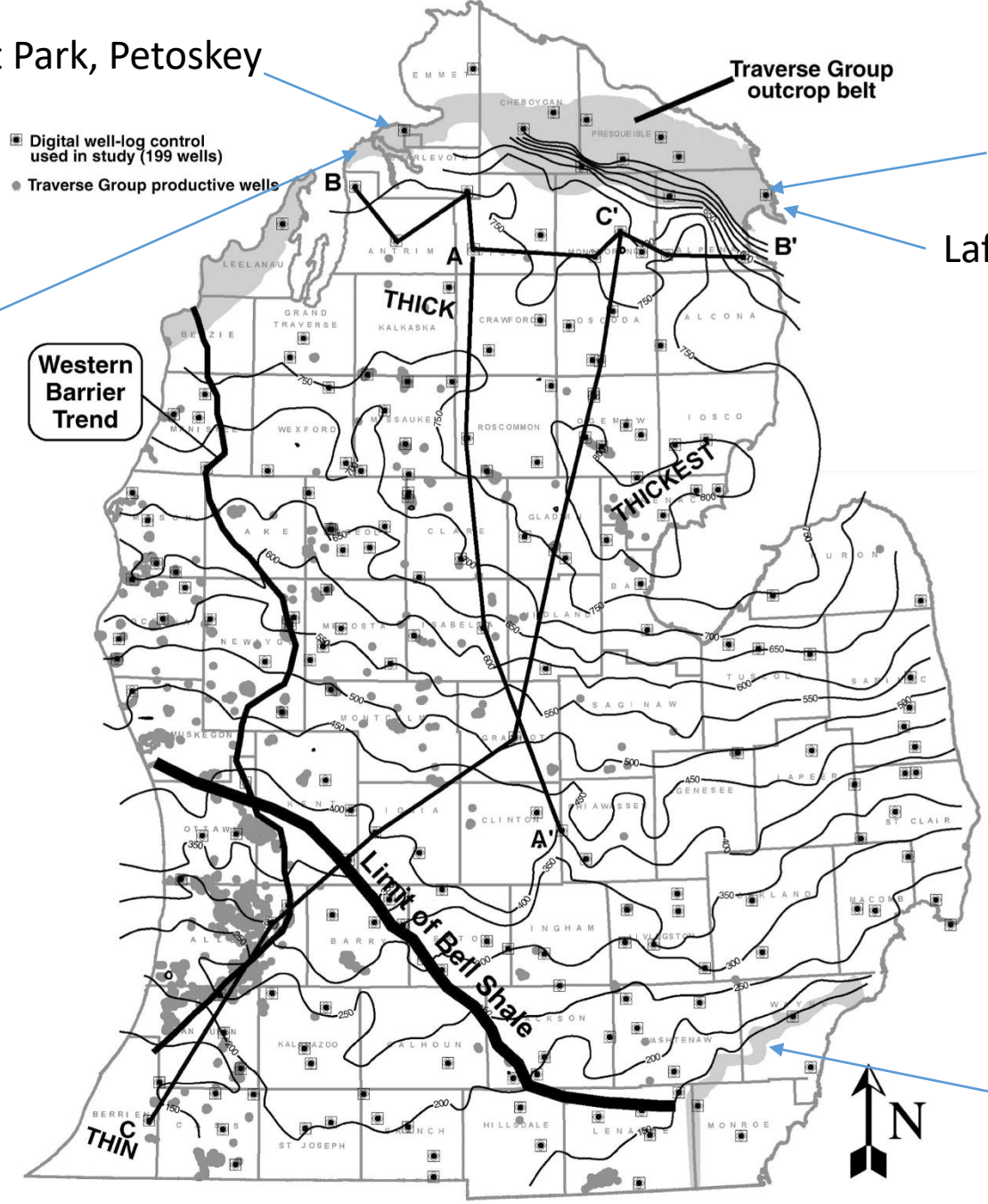
Sunset Park, Petoskey

Fisherman's Island State Park And St. Marys Cement

Rockport State Recreation Area

Lafarge Alpena Quarry

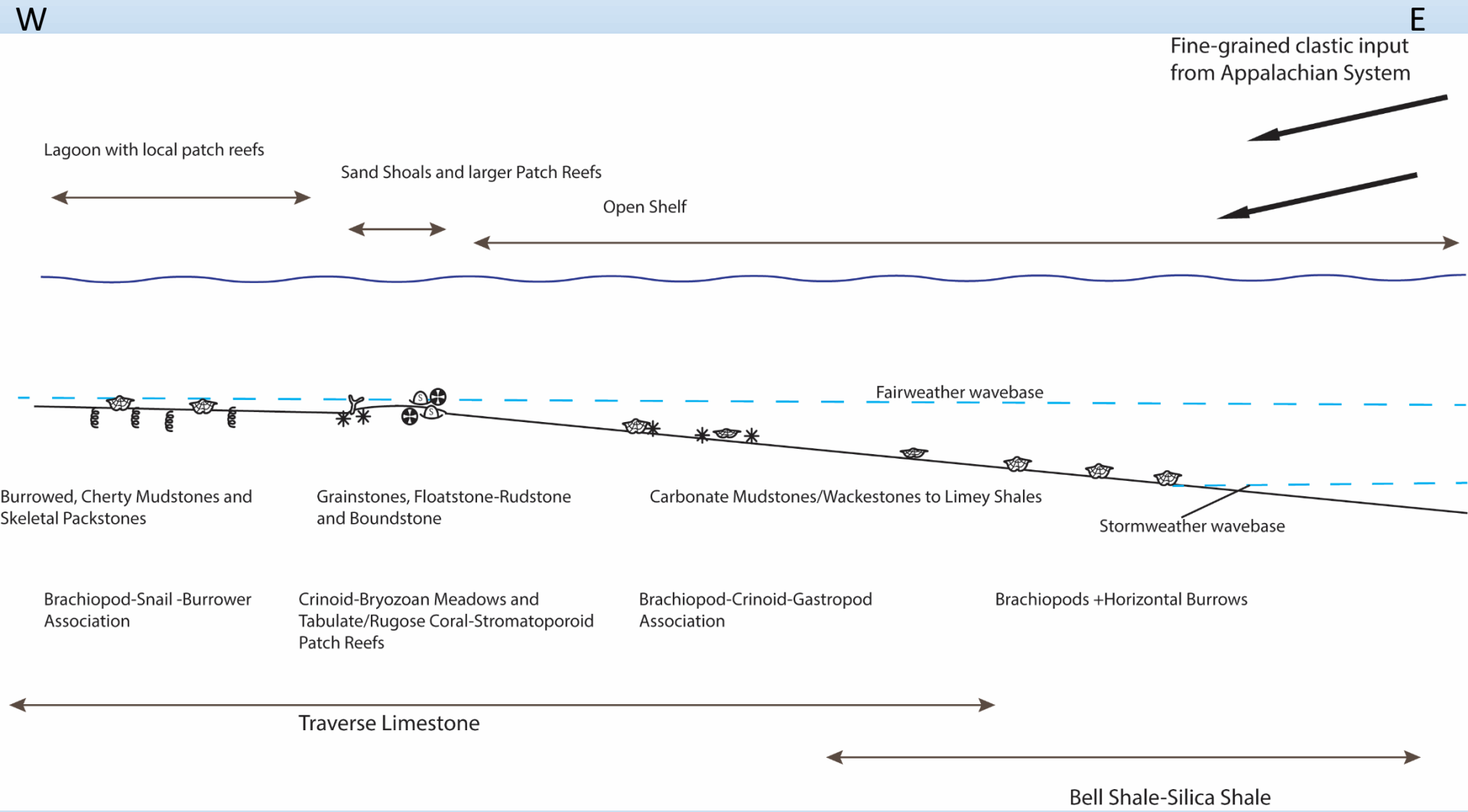
Traverse Group outcrop/subcrop



Gross Isopach Map of Traverse Group
C.I. 50 ft

Wylie and Huntoon, 2003

Upper Traverse Group Depositional Model



The lagoonal facies – stretches at least to eastern Wisconsin (Milwaukee Formation).

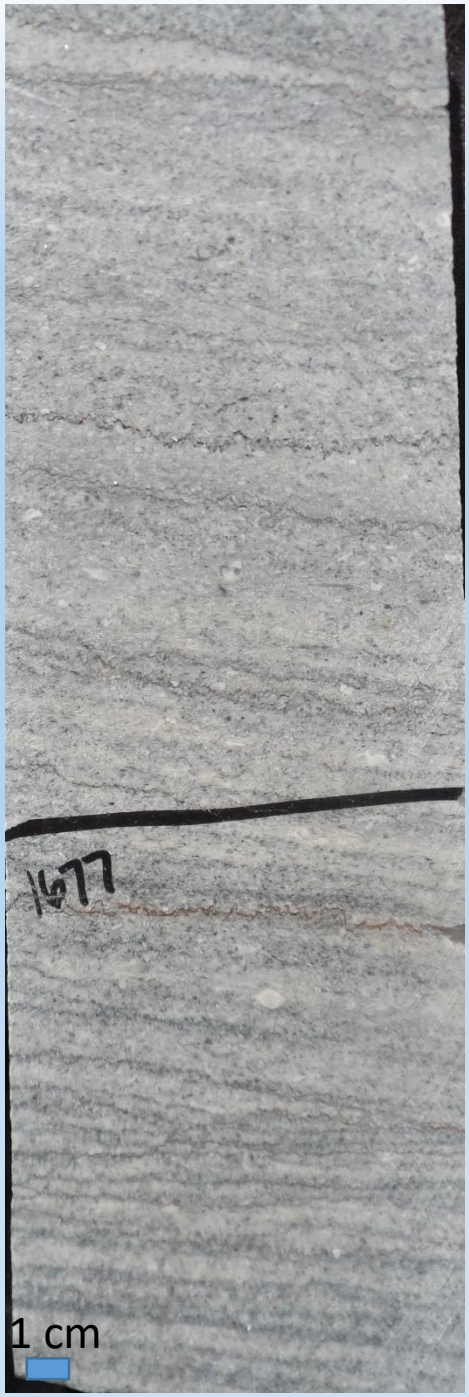
P.O.G. Conover Lake Trust #1-13
PN: 37265, Newaygo Co. 2678 ft.

Sun Oil Co. Smith & Gerard Unit #1
PN: 38732, Allegan Co. 1559 ft.

Lagoonal Facies

- Muddy or pelletal – lime mudstones and wackestones
- Dispersed skeletal material – dominantly brachiopods ± tabulate corals, crinoids, rugose corals, trilobites, gastropods, stromatoporoids
- Large, irregular burrows? Filled with chert cement

Lagoonal carbonates – Gravel Point Formation Fisherman's Island State Park



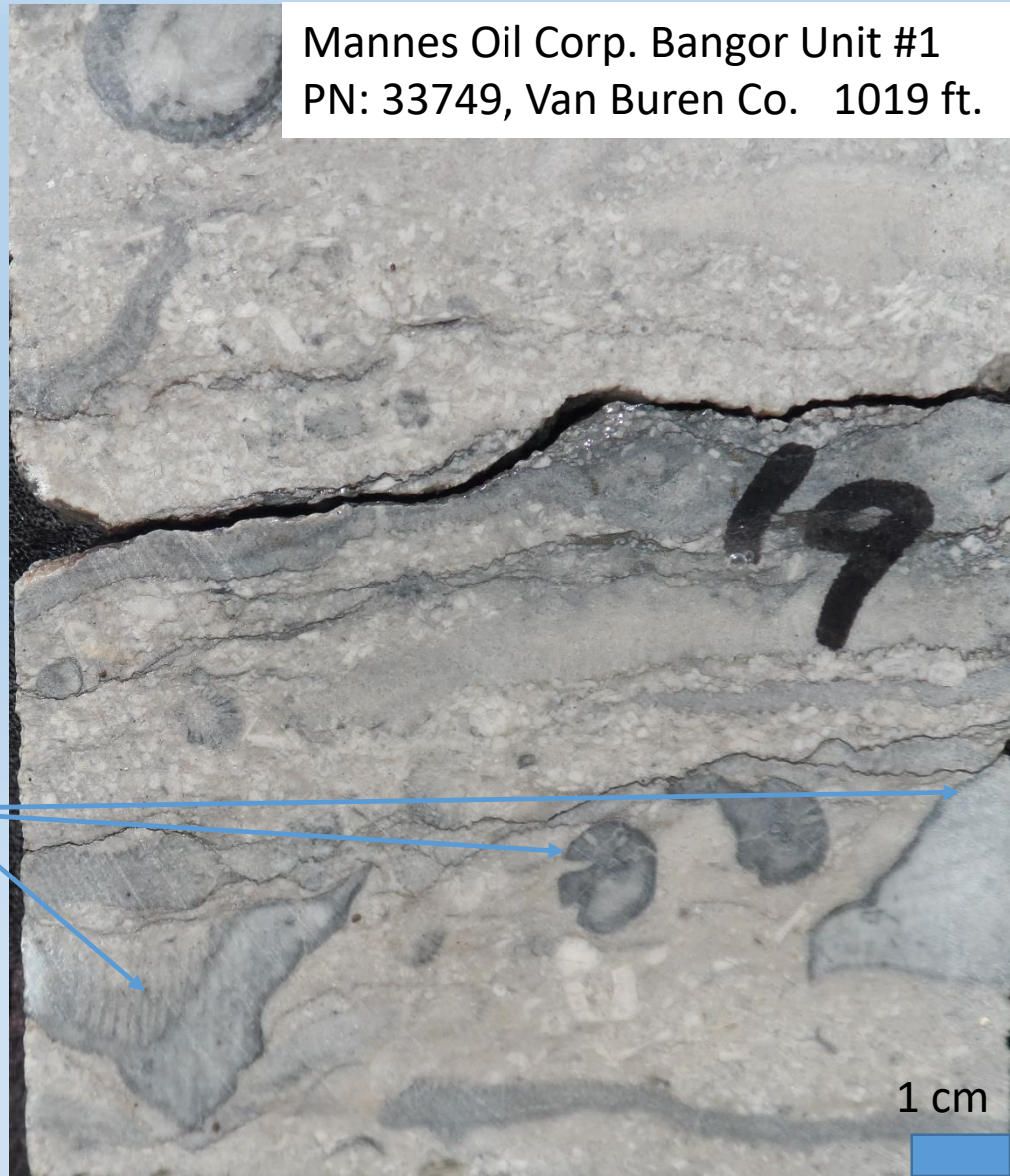
Sun Oil Beyer Farms #1
PN: 38726, Allegan Co.
1677 ft.

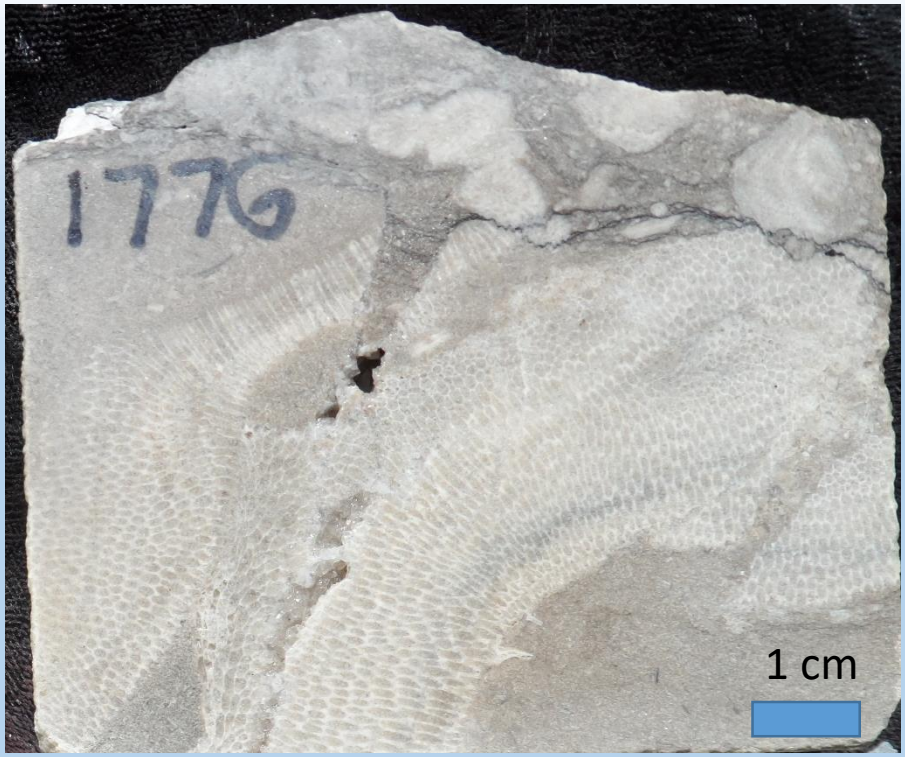
Cross-bedded skeletal sands – likely **cemented up early**; Mostly crinoidal debris. Fining upward cycles. Digitate stylolites.

Sand Shoal Facies

Influx from local reefs? – rugose and tabulate corals

Mannes Oil Corp. Bangor Unit #1
PN: 33749, Van Buren Co. 1019 ft.



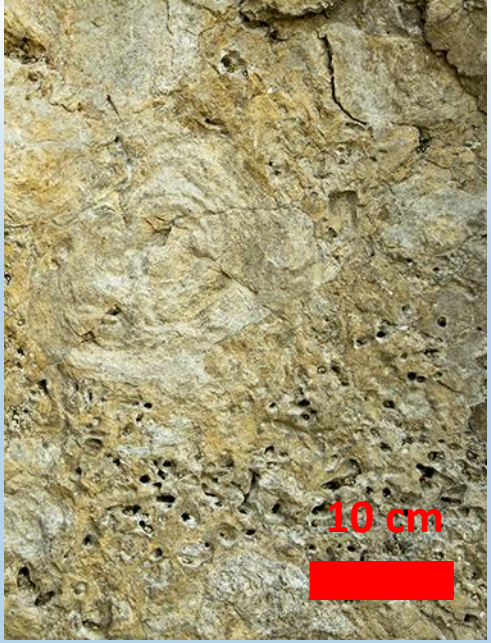


Patch Reef Rubble – Mix of large clasts of tabulate corals, stromatoporoids, and rugose corals with associated reef dwellers (brachiopods, crinoids) in mud matrix

Amoco Martin C. Hansen Unit 31-19
PN: 30814, Ottawa Co. – 1749 and 1776 ft.

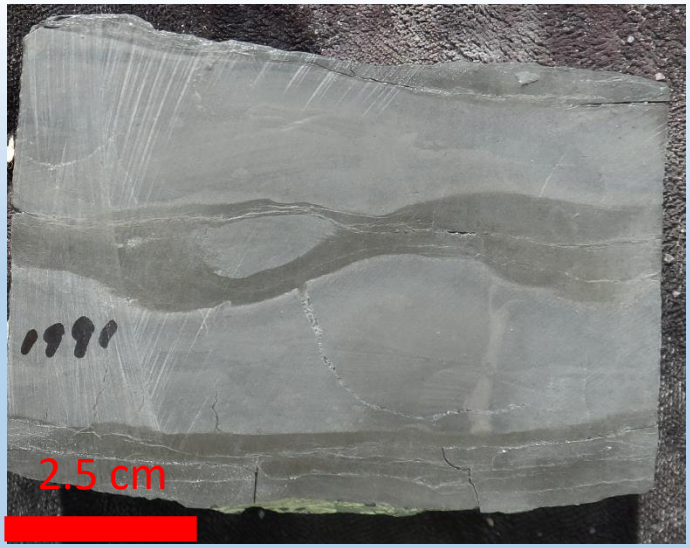
Small Patch Reef, Genshaw Formation
Quarry Wall – LaFarge Quarry
Alpena, MI

Reef- outlined in red dashed line

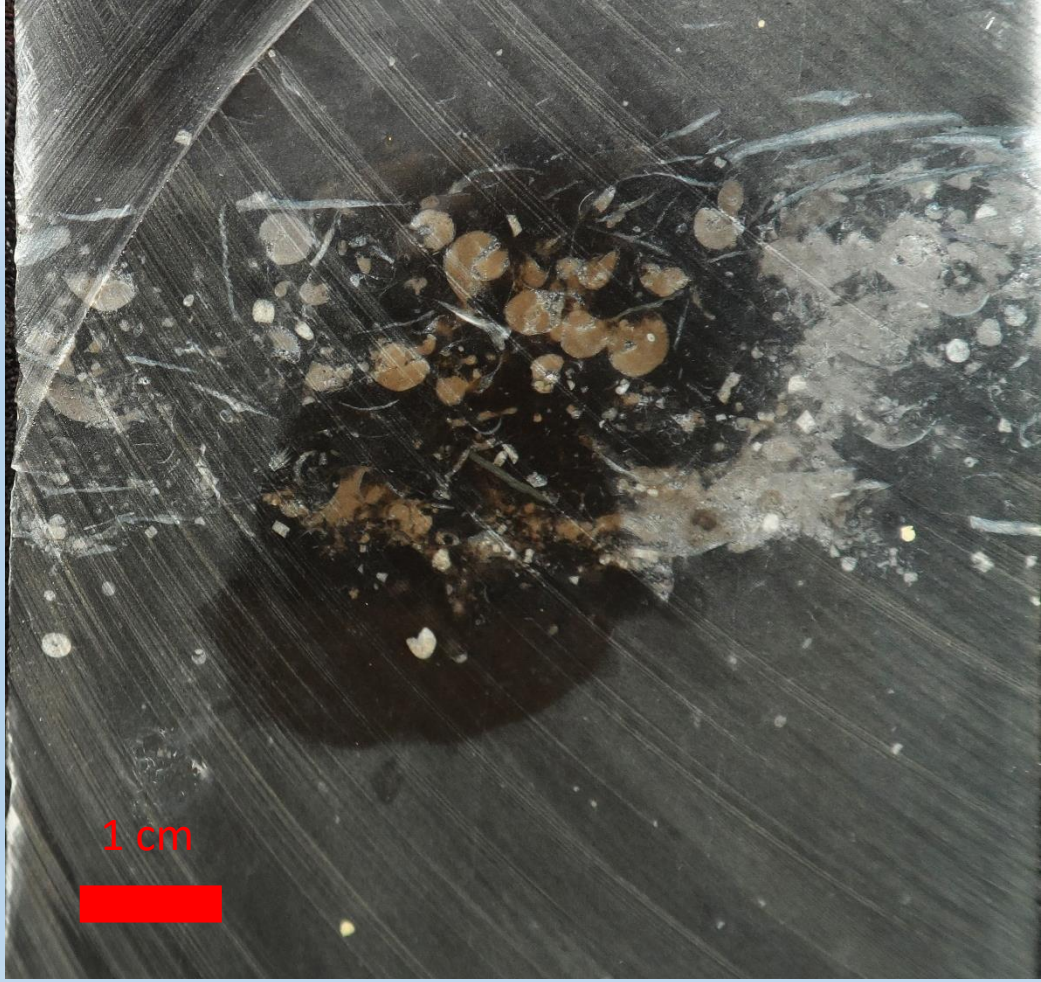


Stromatoporoid Rudstone
Sunset Park, Petoskey, MI
Picture Courtesy of Linda Harrison

Large Corals – Rockport Quarry Limestone
Rockport State Recreation Area
Alpena County, MI



Northshore Wojtowicz #2-17
PN: 58235, Arenac Co.
1991 ft



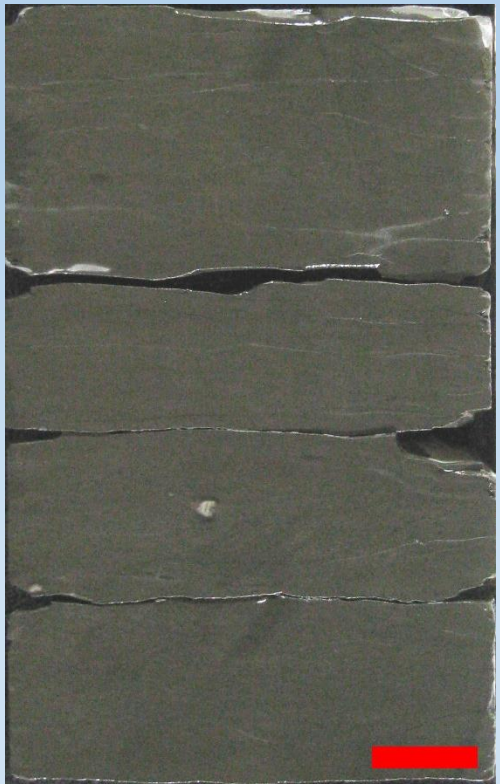
Dart Leon Hamming et al. #1-22
PN: 31448, Missaukee Co.
3251 ft.

Open Shelf Carbonates – muddy, nodular wackestones with skeletal-rich storm beds. Lower diversity (thin-valved brachiopods, crinoids, gastropods).
When dolomitized – vuggy porosity

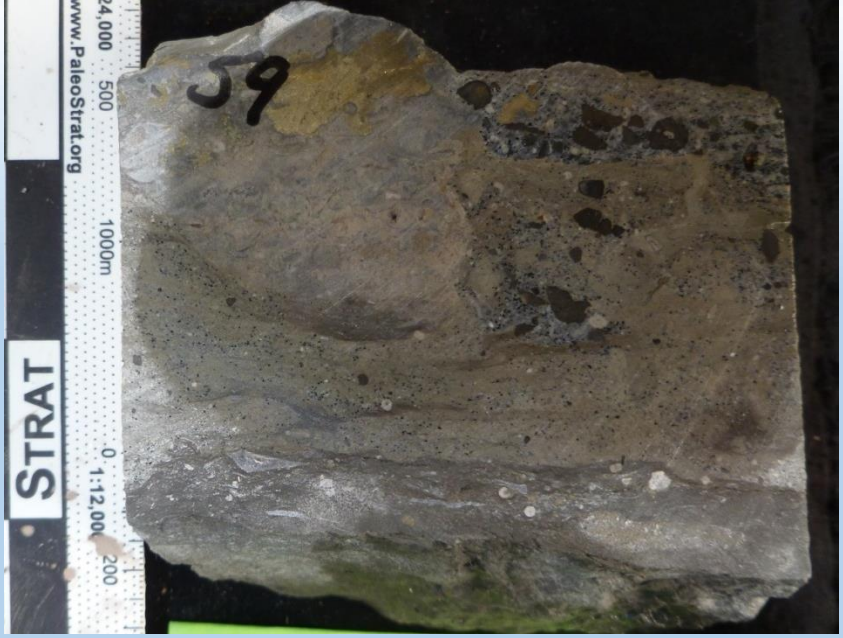
Southeastern Mi – more dominantly argillaceous – shales to argillaceous carbonates.

Upper Traverse Gp – brecciated carbonates with chert.
In places oil-stained – but no seal!

Ten Mile Creek Dolomite – vuggy, skeletal carbonates with argillaceous seams. Rouge River CSO Project, well BH-107A at 55.5 ft.



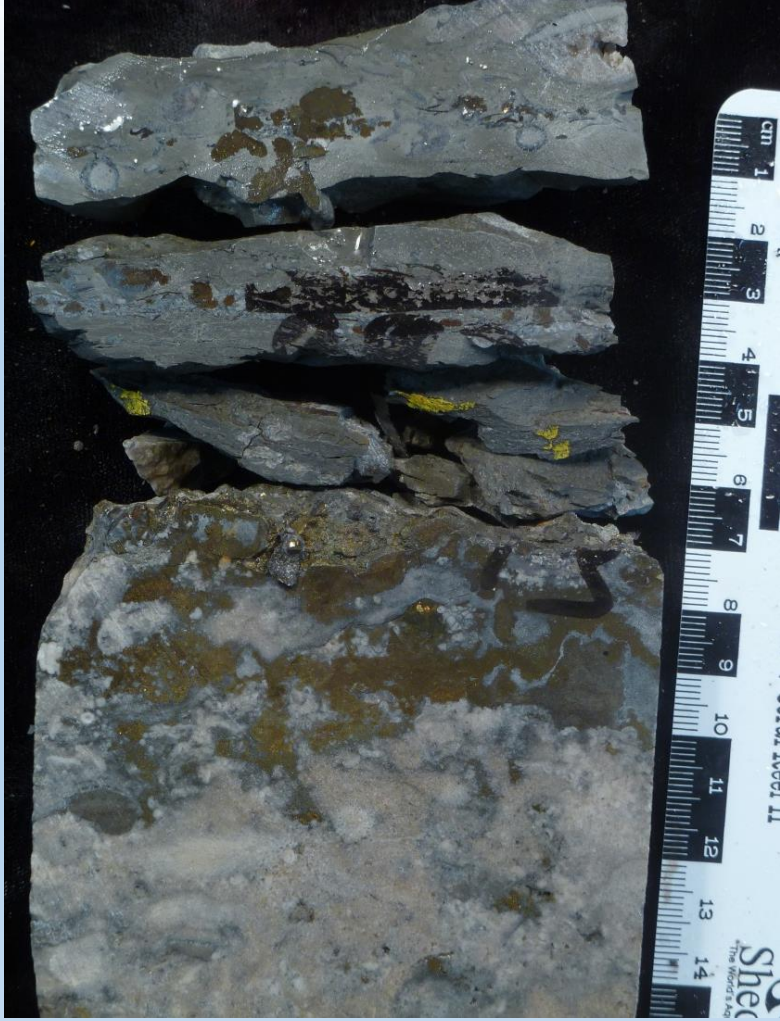
Silica Formation ranges from fossiliferous, argillaceous carbonates to massive shales. Rouge River CSO Project, well BH107A, upper image at 138 ft, image on right at 163 ft.



Wolverine 4-40 Club #1-35
PN: 33405, Otsego Co.
1359 ft.

Traverse Limestone-Squaw Bay Contact

- Hardground with irregular topographic relief
- Borings
- Pyrite nodules, glauconite and phosphatic pellets
- Shell lag deposits above contact – with switch to more argillaceous carbonates of Squaw Bay Formation

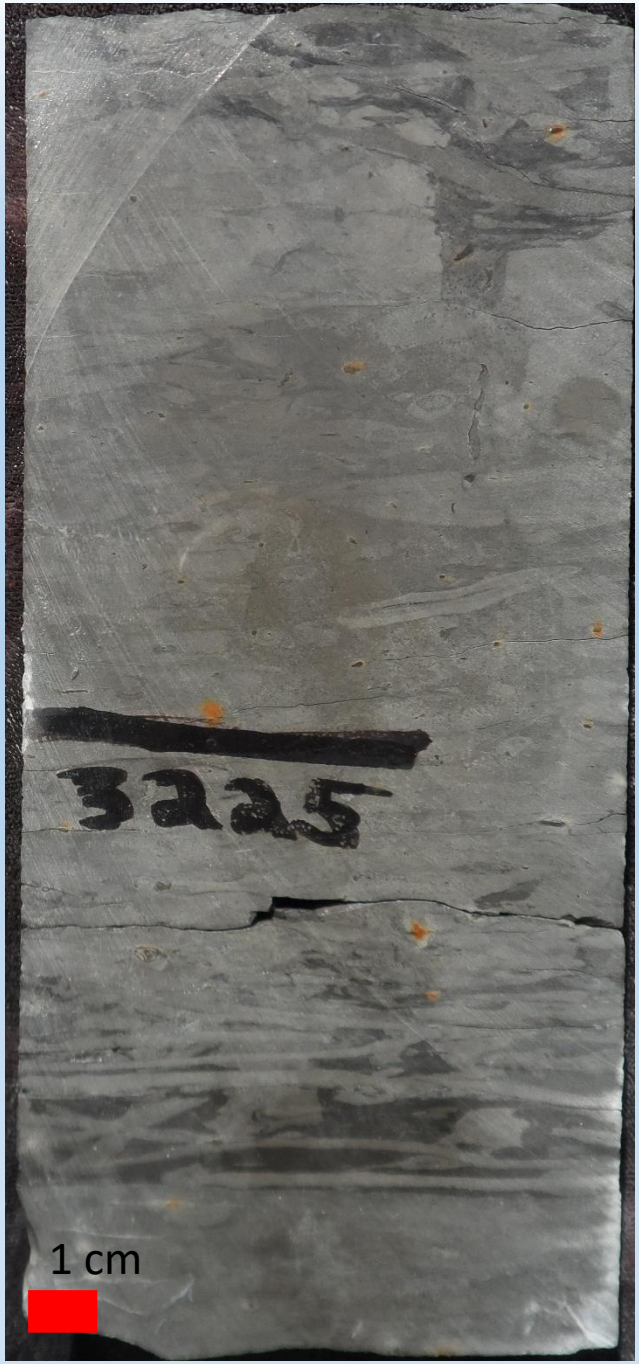


Mannes Oil Co. Bangor Unit #1
PN: 33749, Van Buren Co.
993’

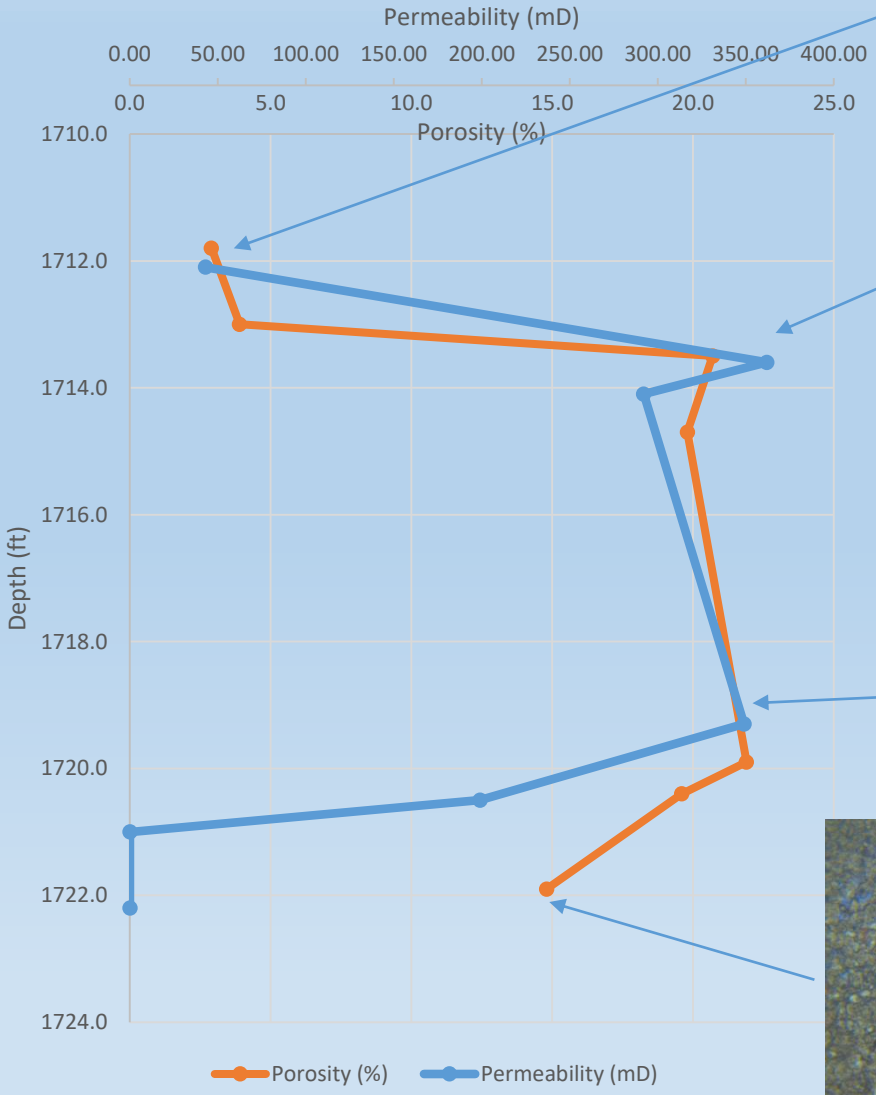
Pictures courtesy of Kyle Cox (from Cox et al. 2014 – NC GSA Presentation)

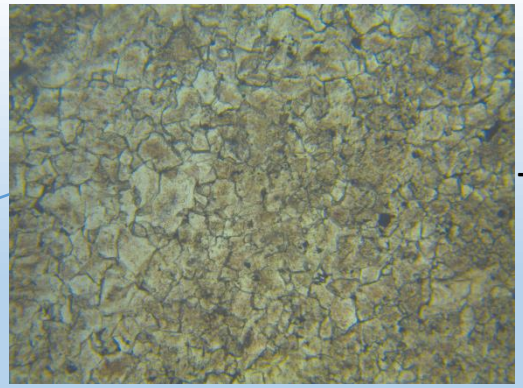
Squaw Bay Formation

- Bioturbated to laminated argillaceous mudstones and limey shales
- Low diversity fauna – some brachiopods, gastropods, and crinoids
- Low organic content
- Seal

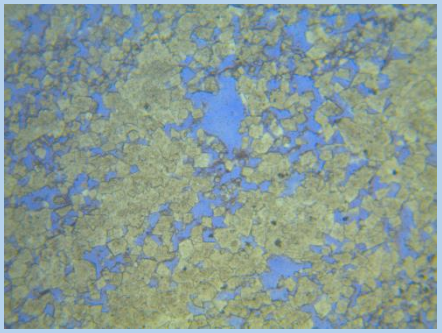


Porosity and Permeability in the upper Traverse Limestone, Marathon Grow #4

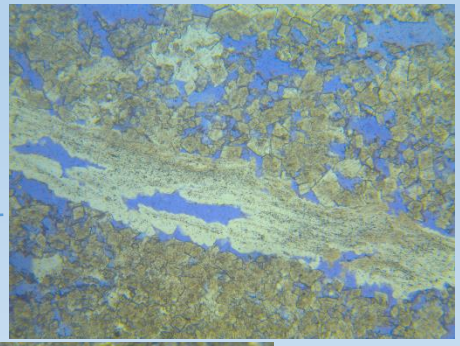




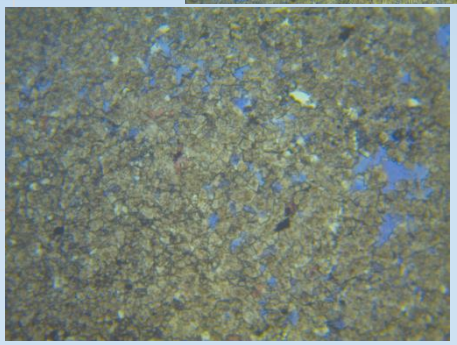
Tight matrix



Intercrystalline porosity

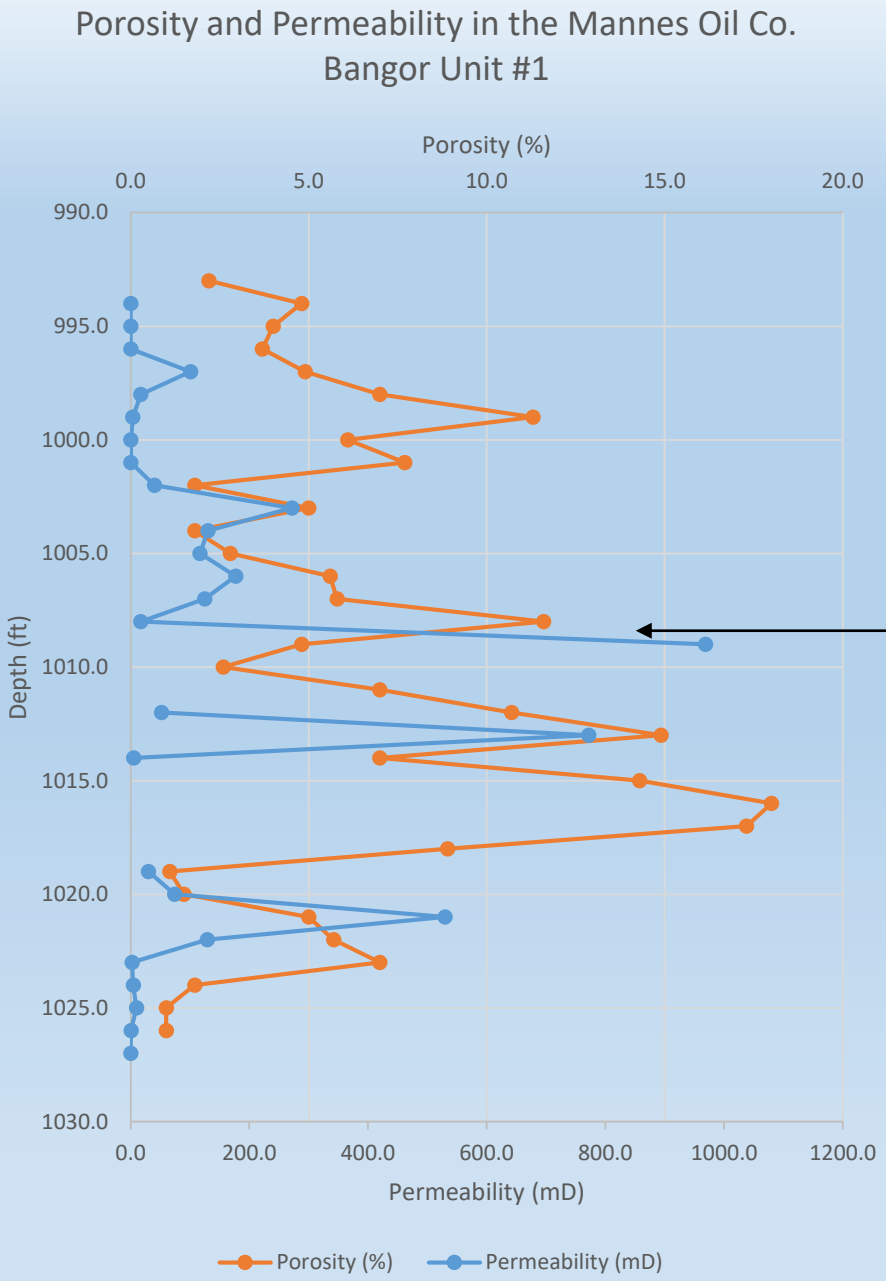


Intercrystalline and moldic porosity



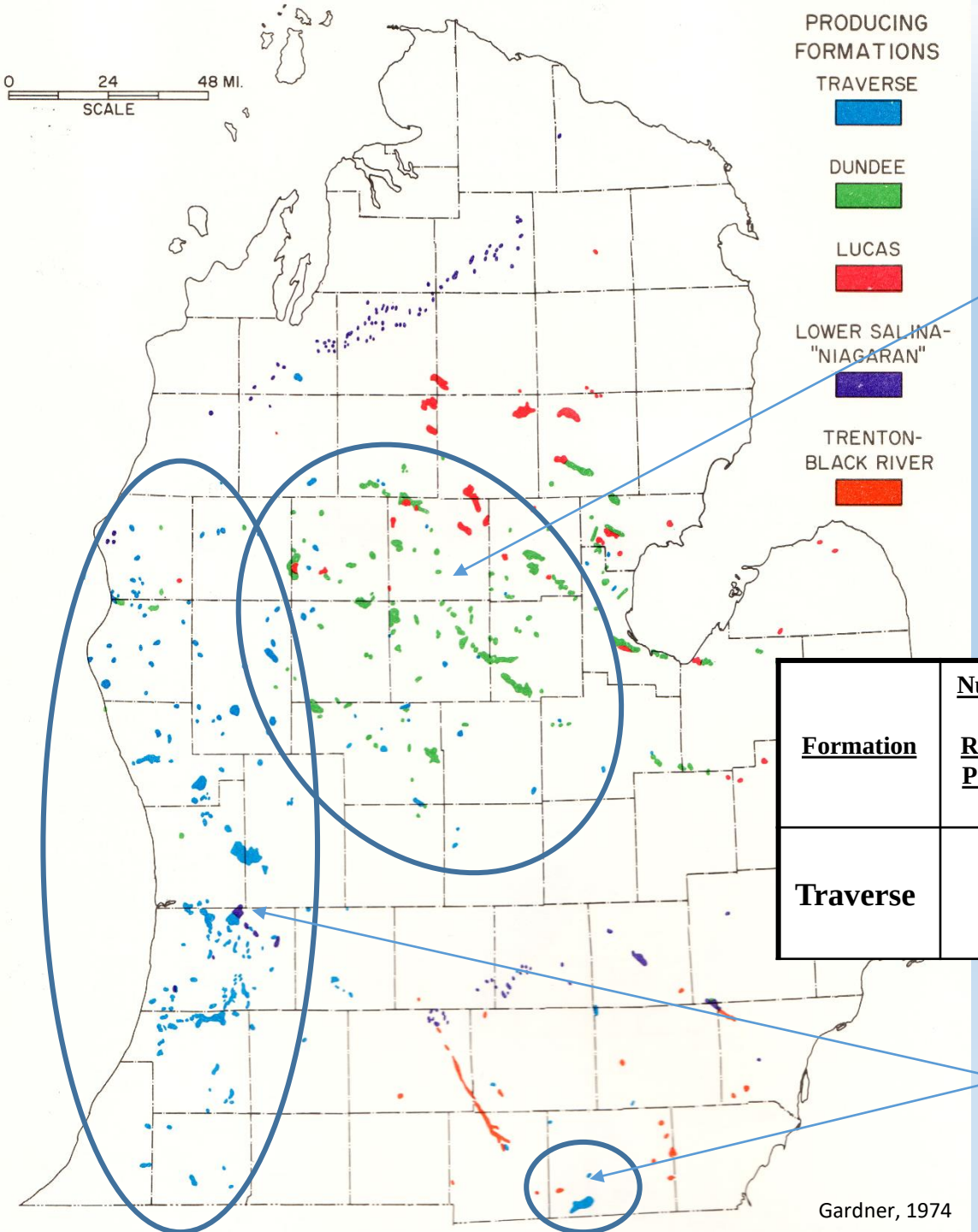
Intercrystalline porosity

Each slide ~ 2mm


Porosity and Permeability in the Mannes Oil Co.
Bangor Unit #1
Porosity (%)
0.0
5.0
10.0
15.0
20.0
990.0
995.0
1000.0
1005.0
1010.0
1015.0
1020.0
1025.0
1030.0
Depth (ft)
0.0
200.0
400.0
600.0
800.0
1000.0
1200.0
Permeability (mD)
Porosity (%)
Permeability (mD)


1 cm

At 1008 ft



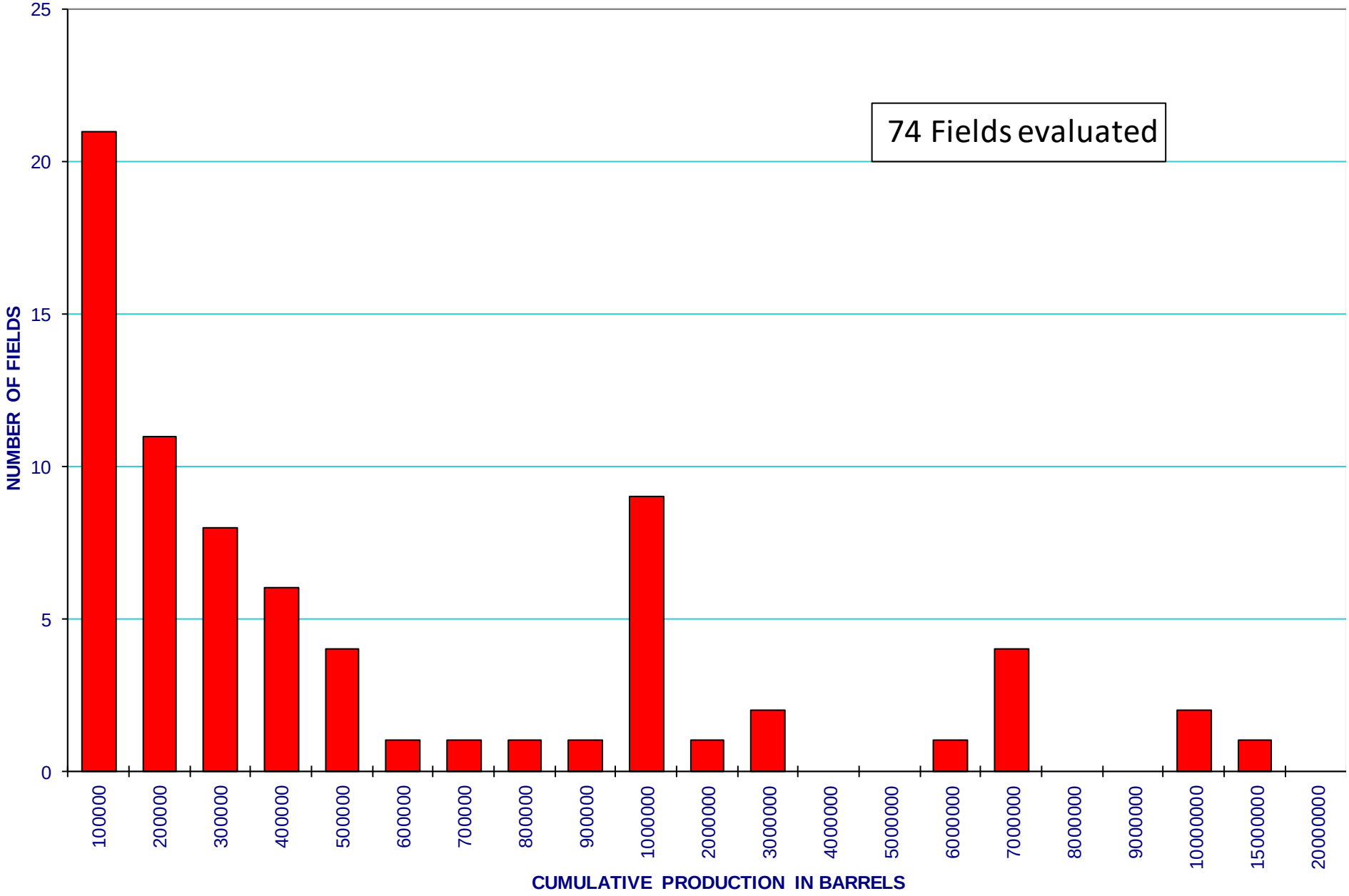
Some Dundee Fields also producing from Traverse

Dolomitized Reservoirs; Structural Controls

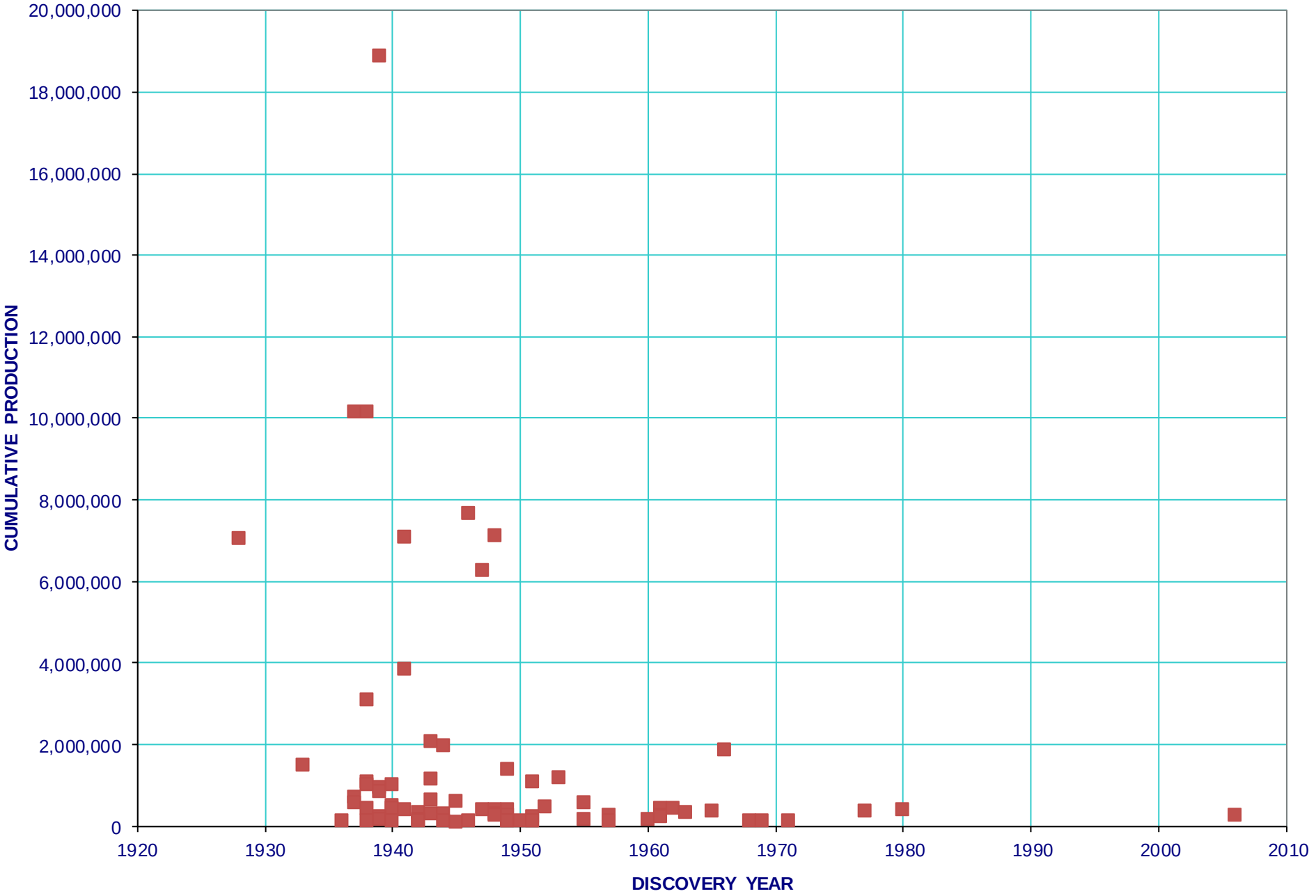
Formation	Number of Fields Reporting Production	Cumulative Oil Produced	Cumulative Gas Produced	Average Depth and Depth Range
Traverse	260	110 Million BBLS	13 BCF	2000 600 to 3400

Primarily Traverse Production
Both primary and second ϕ.
+/- Structural Controls – mainly shallow reservoirs

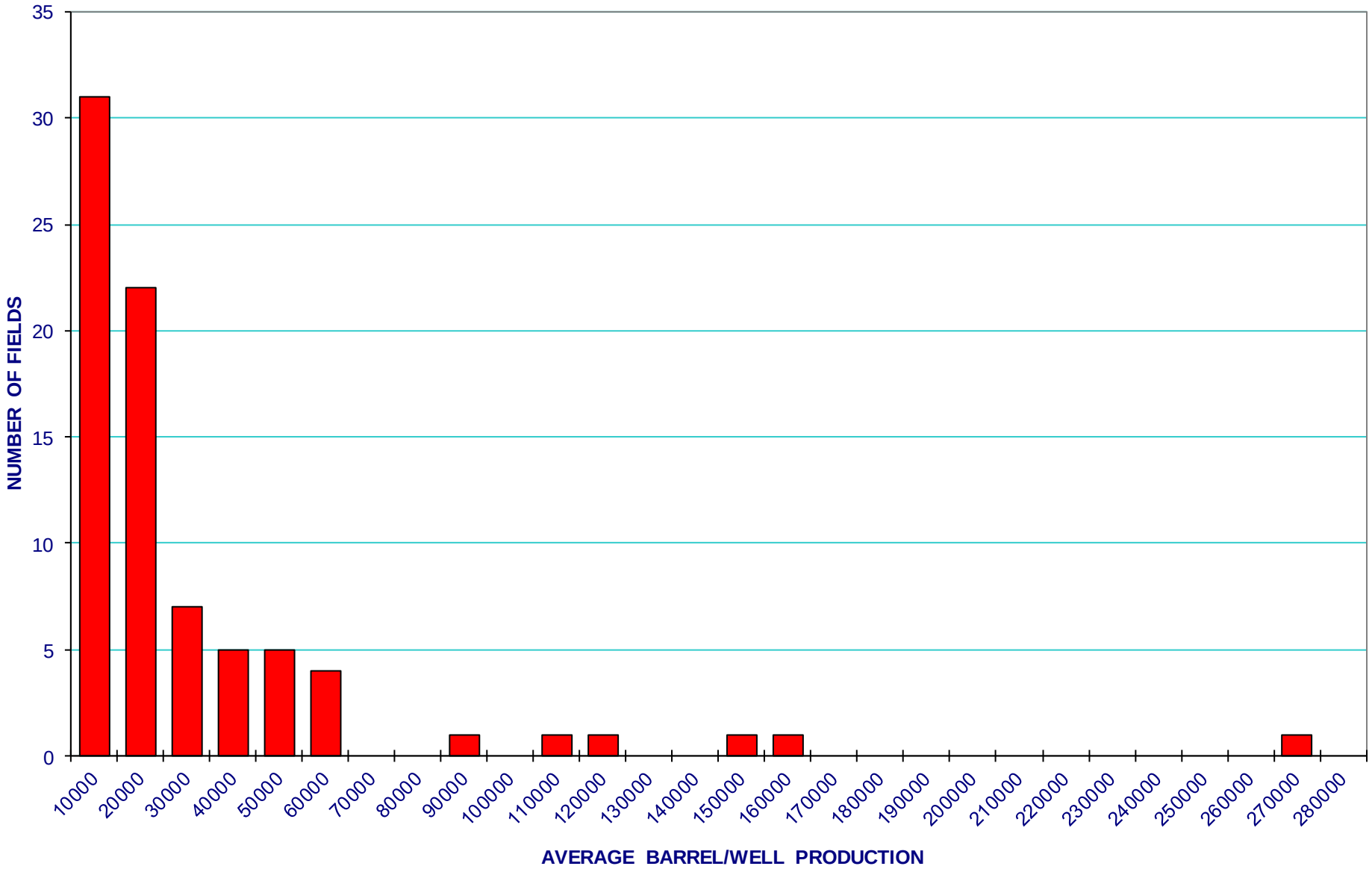
FIELD SIZE DISTRIBUTION - TRAVERSE LIME RESERVOIRS, MICHIGAN (100000 BARREL MINIMUM)



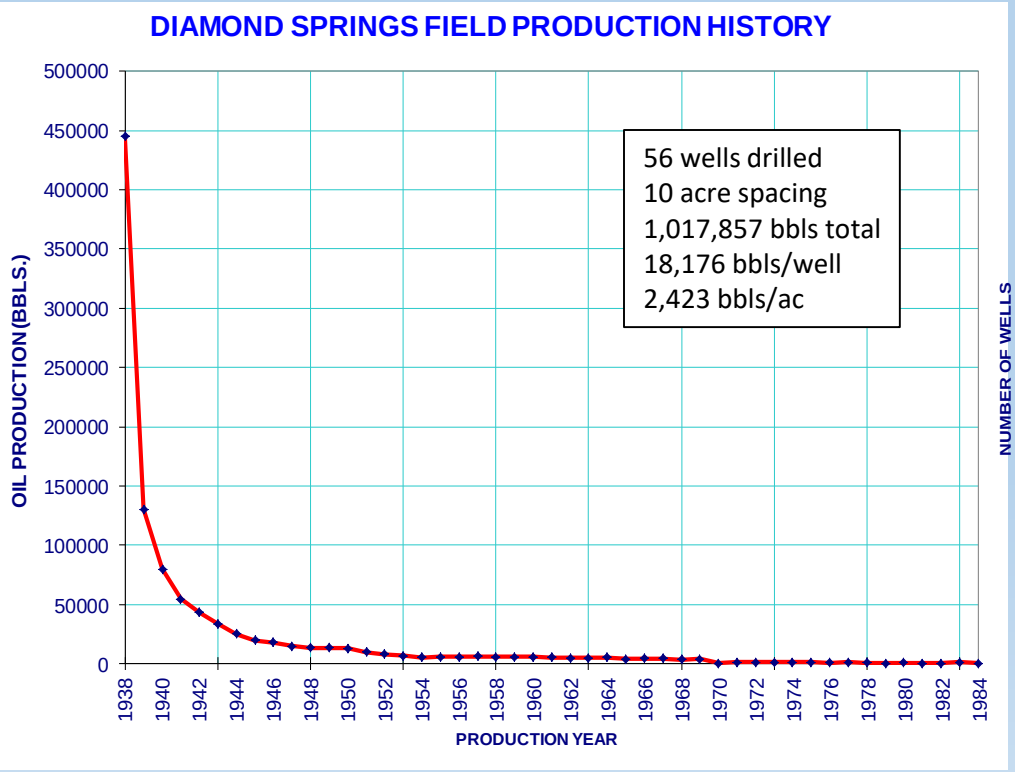
FIELD SIZE AND YEAR OF DISCOVERY - TRAVERSE LIME FIELDS, MICHIGAN (100000 BARREL MINIMUM)

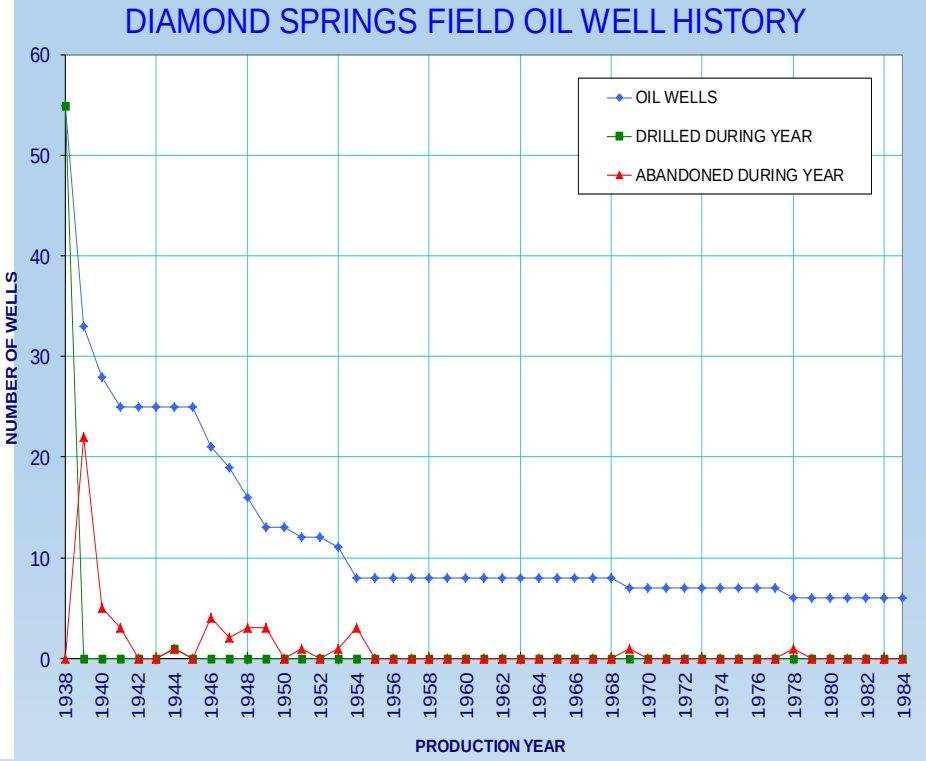


AVERAGE PRODUCTION IN BARRELS/WELL FOR TRAVERSE LIME FIELDS (MINIMUM FIELD SIZE 10000 BBLS/WELL)

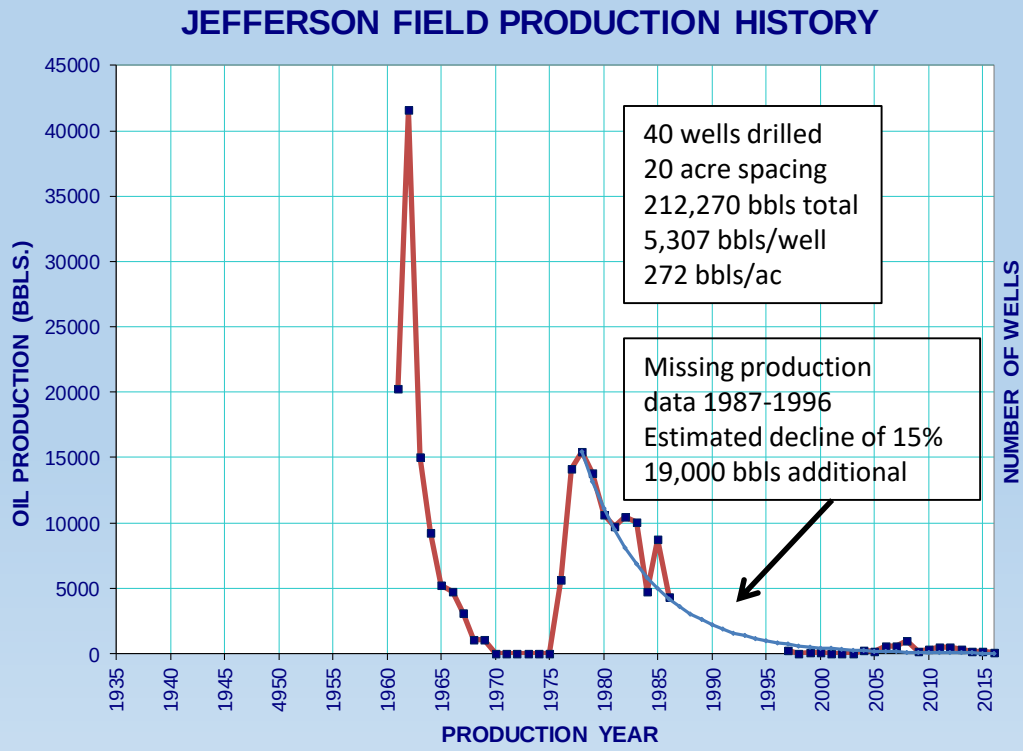


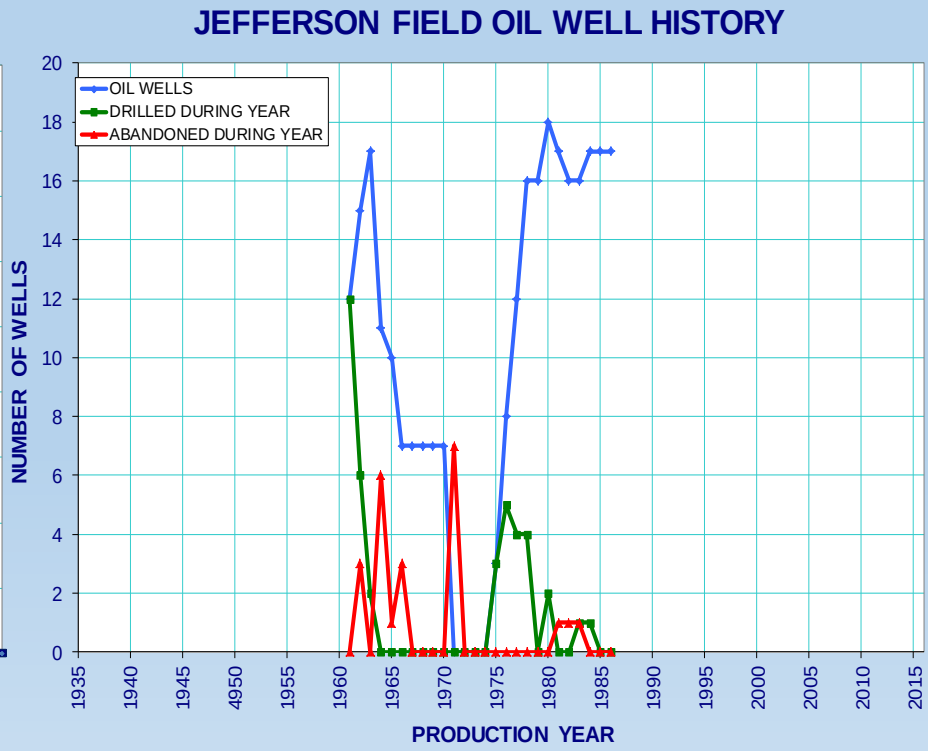
Diamond Springs Field



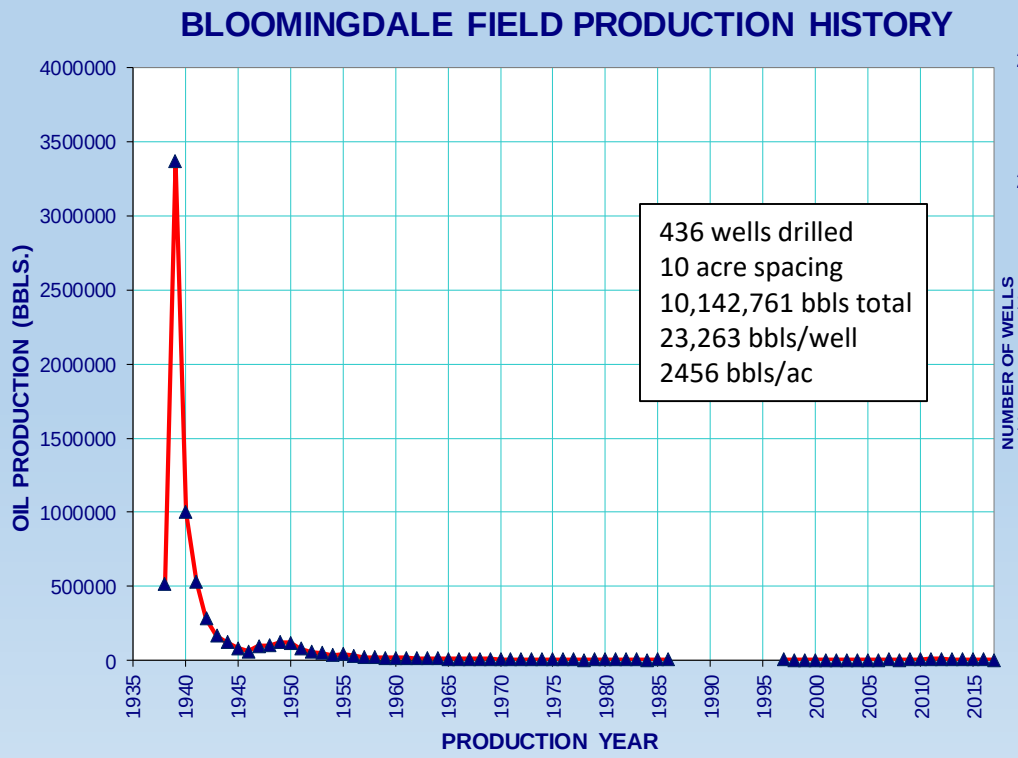


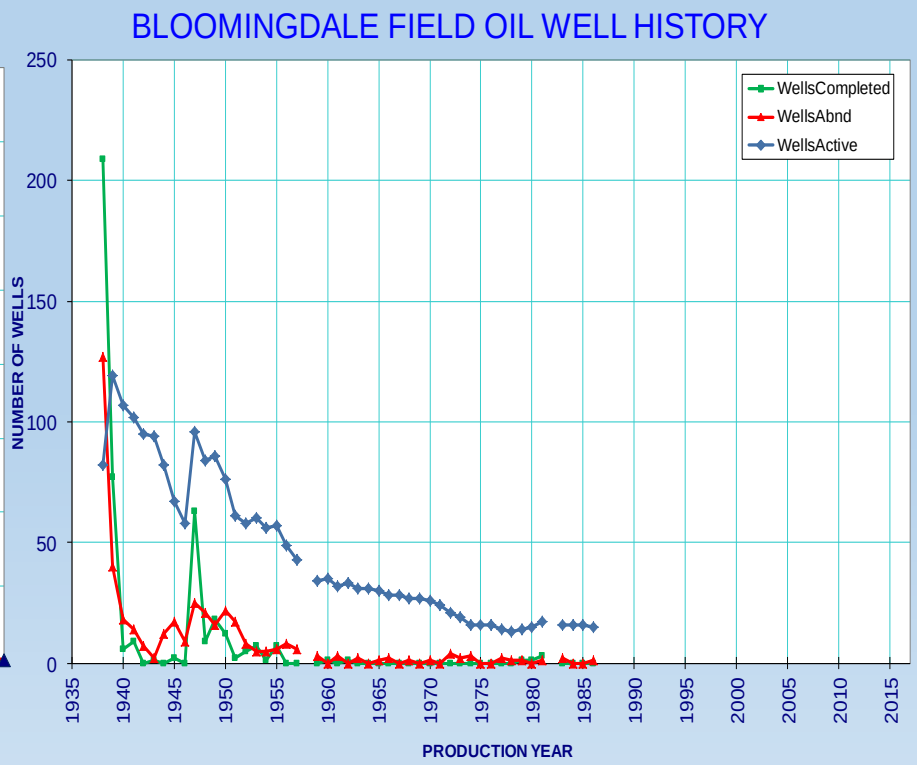
Jefferson Field





Bloomingdale Field





Key Points

- Primary fabrics – generally muddy or early cemented – poor reservoir quality
- Reservoirs – spatially located beneath contact with Squaw Bay Fm.
- Dolomitized skeletal-rich and bioturbated facies – intercrystalline and vuggy porosity – good to great reservoir quality
- Squaw Bay – seal
- Source rocks? – down gradient Antrim (Swezey, 2015)

Stromatoporoid Rudstone
Sunset Park, Petoskey, MI

Picture courtesy of Linda Harrison