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 108 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!

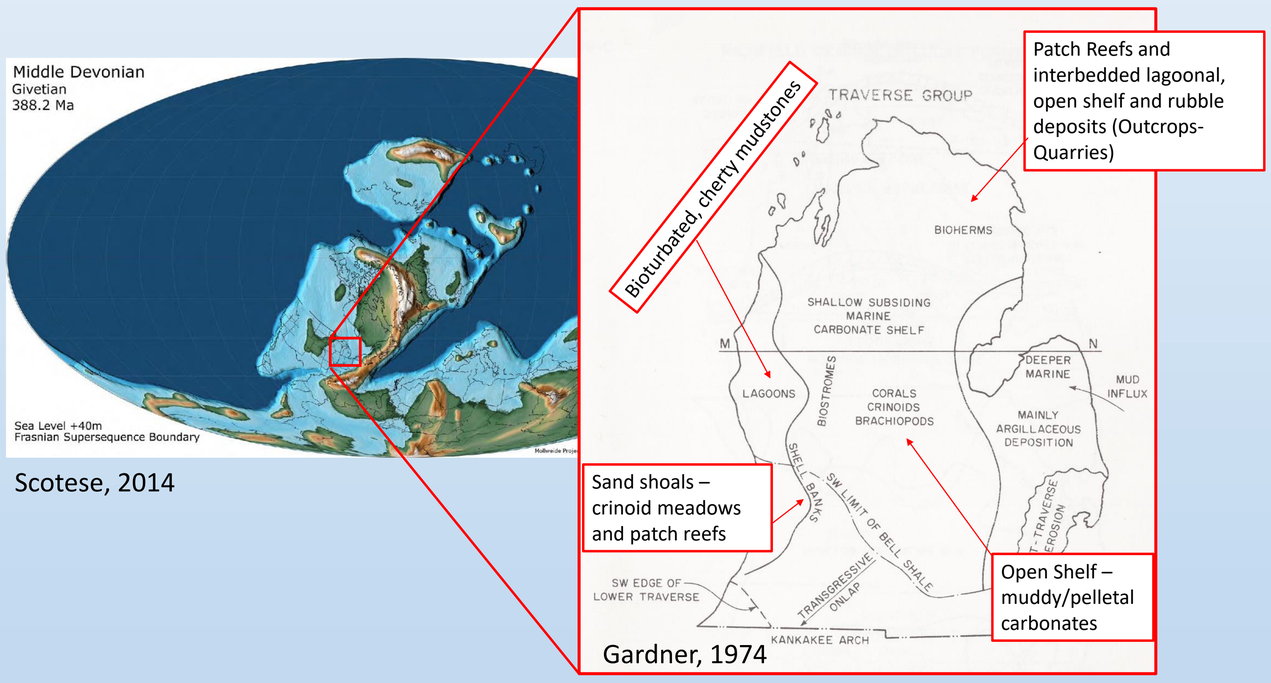


Figure 1: The Michigan Basin was located in the Tropics during the Middle Devonian. During this interval, the Michigan Basin was a shallow marine intracratonic basin. The Traverse Group consists of lagoonal and open shelf carbonates in the Lower Peninsula of Michigan.

NW MI:

Antrim Shale

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

Rogers City Formation

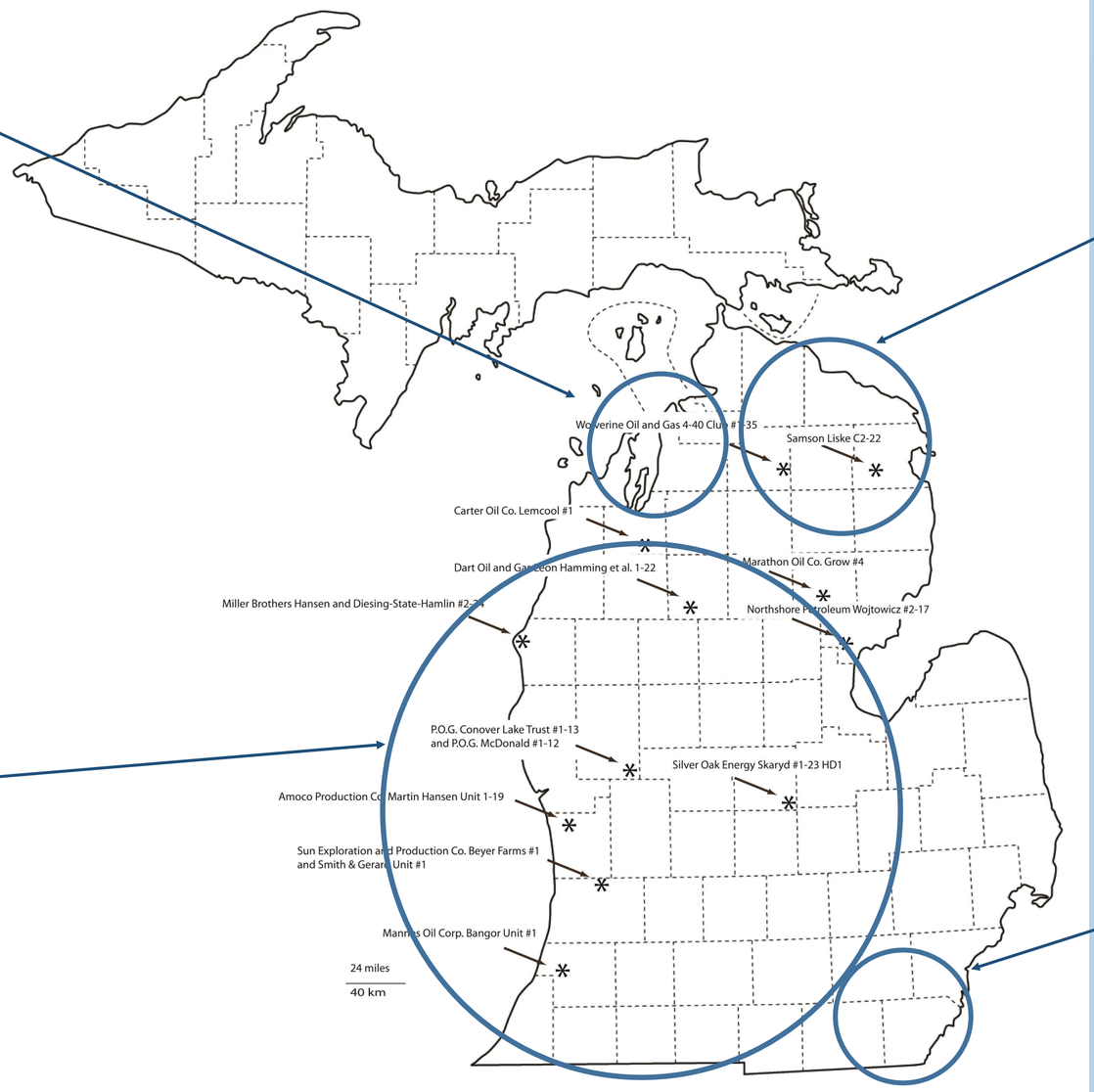
Subsurface:

Antrim Shale

Squaw Bay Formation

Traverse Group
- Traverse Limestone
- Bell Shale

Rogers City Formation



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

SE Mi:

Antrim Shale

Traverse Group
- Ten Mile Creek Dolomite
- Silica Formation

Dundee Limestone

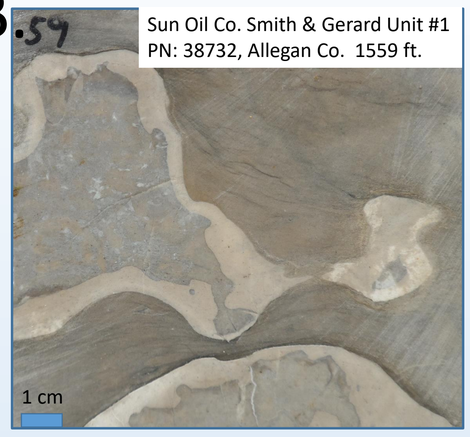
Figure 2: Stratigraphic Nomenclature for the Traverse Group in the Lower Peninsual (compiled from Catacosinos et al., 2001, Ehlers and Kesling, 1970, Kesling et al., 1974, and Kesling and Chilman, 1975). The Traverse Group is the shallow subcrop and outcrop in the northeastern, northwestern and southeastern corners of the Lower Peninsula. The difficulty of correlating the Traverse Group through the basin has led to the proliferation of terms. In the subsurface, the drillers have simplified the nomenclature to a lower shale (Bell Shale) and an upper mixed carbonate-shale interval (Traverse Limestone). Note that the Squaw Bay Formation in older publications is referred to as the Traverse Formation.

The locations marked with asterisks on the map are wells used in this study to identify and describe facies in the upper Traverse Limestone. The marked wells have core in the upper 10 to 40 ft (3 to 12 m) and in many cases the contact with the overlying Squaw Bay Formation.

A.

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

B.



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

Lagoonal Facies

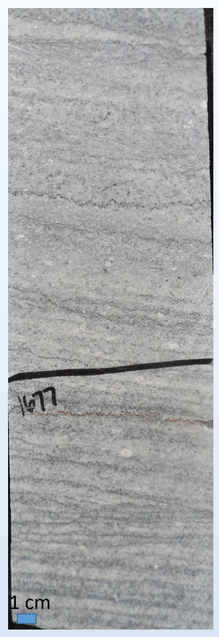
- Muddy or pelletal – lime mudstones and wackestones
- Dispersed skeletal material – dominantly brachiopods ± tabulate corals, crinoids, rugose corals, trilobites, gastropods, stromatoporoids
- Large, irregular burrows? Filled with chert cement

C.

D.

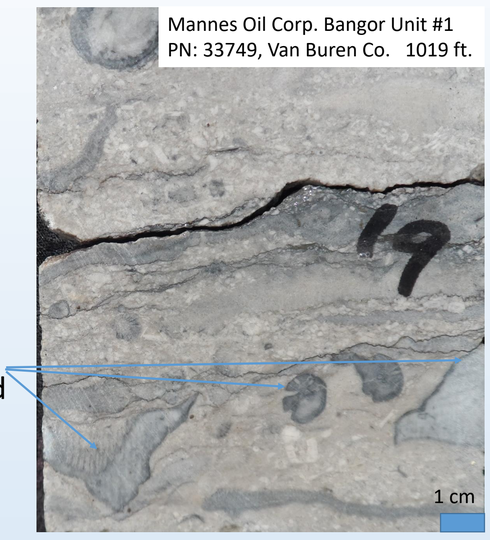
E.

Figure 4: Lagoonal Carbonates in the Traverse Group. A. Tabulate coral rubble floating in lime mud. B. Chert nodules after burrows? C.-E. lagoonal carbonates in the Gravel Point formation, Fisherman's Island State Park, Charlevoix, MI.



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

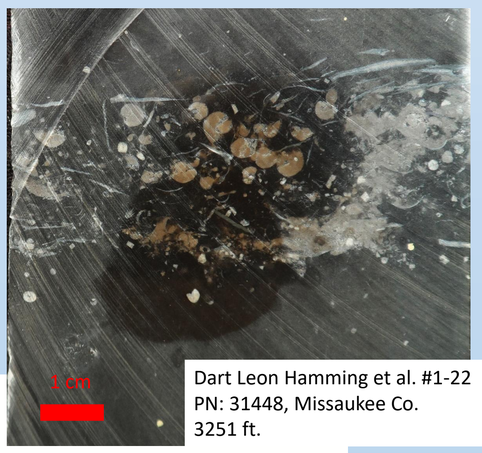
Influx from local reefs? – rugose and tabulate corals



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

Figure 5: Sand shoals in the Traverse Group consist of cross-bedded skeletal sands – mostly crinoidal hash. Local coral (rugose and tabulate) and stromatoporoid debris. Facies exhibits fining upward cycles and abundant stylolitization (digitate stylolites).

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



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

Figure 6: Open Shelf Carbonates consist of muddy, nodular wackestones with skeletal-rich storm beds.

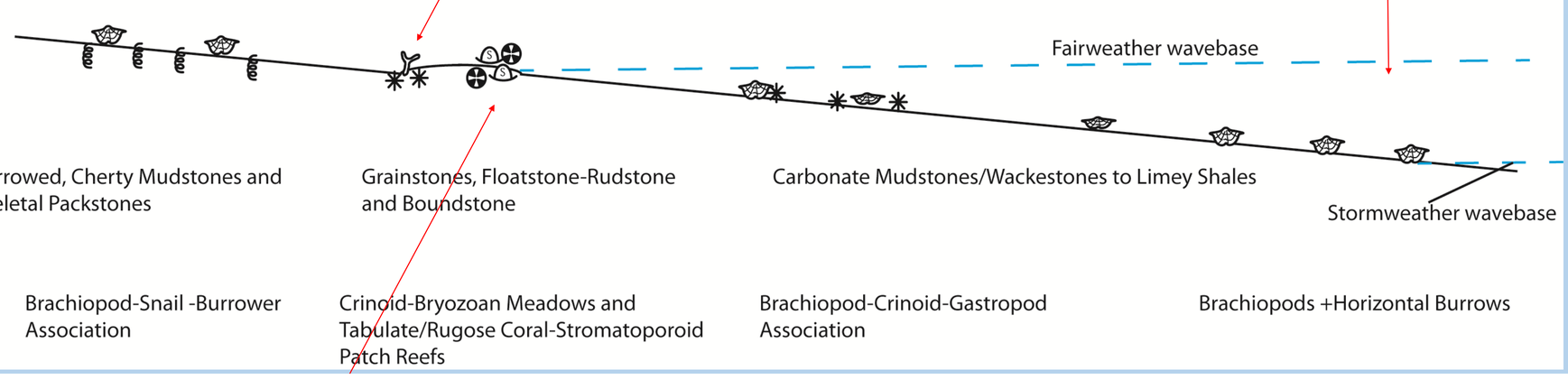
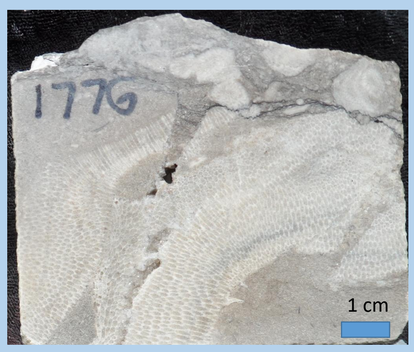


Figure 3: Model Bathymetric Profile for the Traverse Group carbonates in the Michigan Basin based on the facies observed in core. The Traverse Group in Michigan was deposited in subtidal depths across the entirety of the Lower Peninsula . In the uppermost Traverse Group (upper 10-40 ft (3-12 m)), there are two geographic trends:

1. An increase in interpreted water depth to the East – Water depths deepen from lagoonal deposits in the west (near fairweather wave base) to Open Shelf deposits in the south and west (near storm wave base).
2. An increase in clay content to the East – sourced from clastic input into the basin from the adjacent Appalachian system (Wylie and Huntoon, 2003).

A.



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

B.

C.

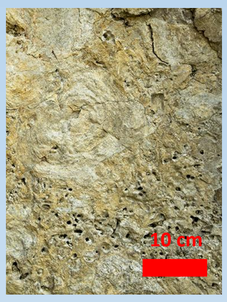
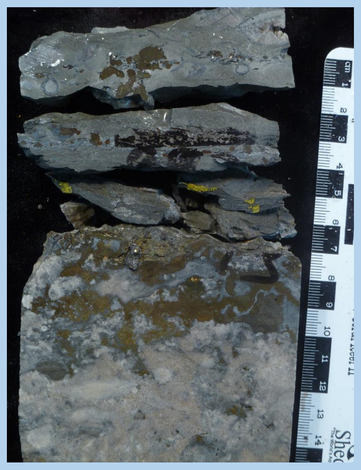


Figure 7: Patch Reef and Reef-associated facies in the Traverse Group are characterized by an incredibly diverse fauna of corals and stromatoporoids with associated reef-dwellers. A. Two core intervals with reef rubble floating in a mudstone matrix. B. Small patch reef in the Genshaw Formation in Quarry wall at the LaFarge Quarry, Alpena Michigan. Reef is outlined in red dashed line. C. Stromatoporoid rudstone, Sunset Park, Petoskey, MI (Photograph courtesy of Mrs. Linda Harrison).



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

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

Figure 8: Photographs of the contact between the Traverse Limestone and the overlying Squaw Bay Formation. Photographs courtesy of Mr. Kyle Cox.

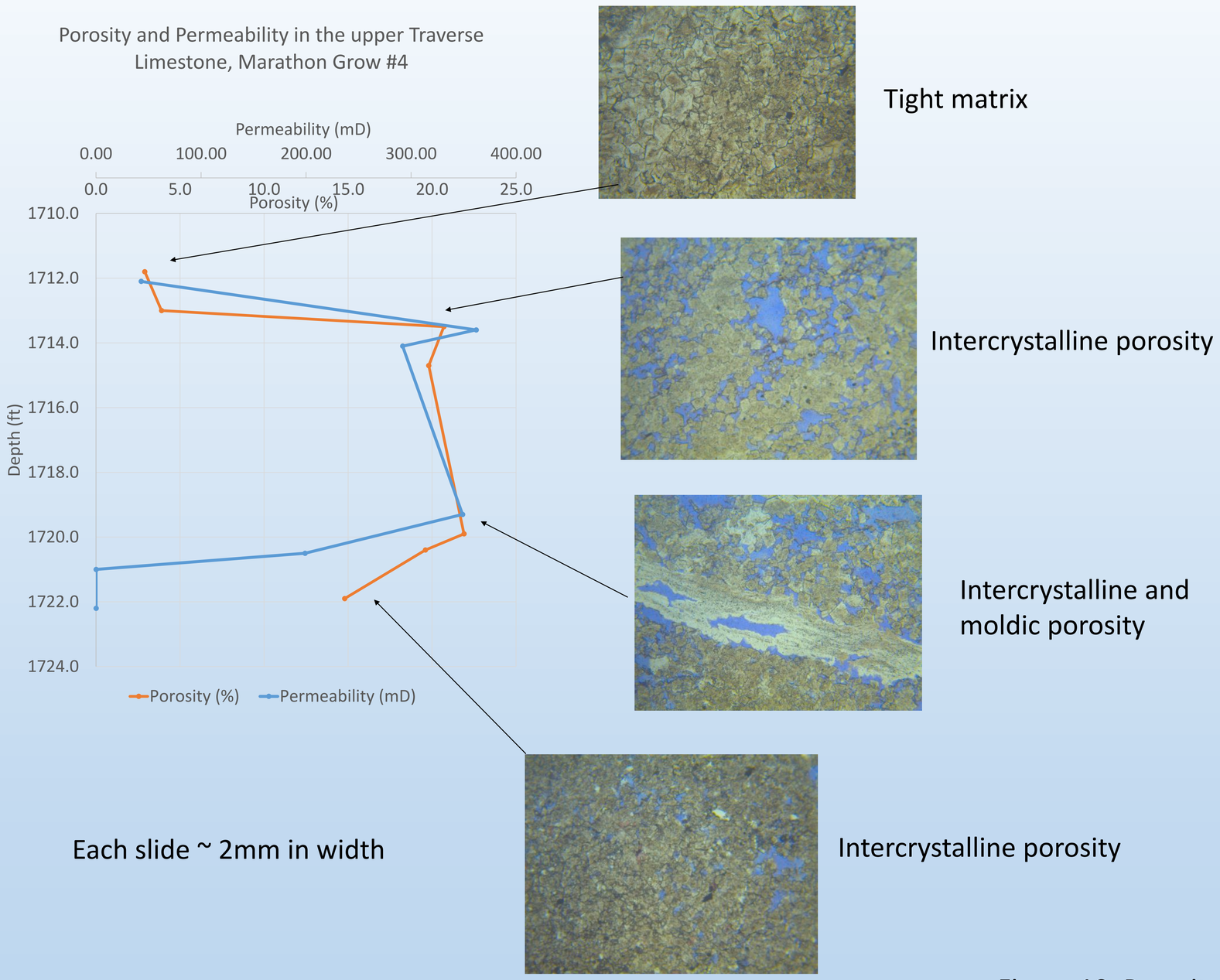


Figure 9: Porosity and Permeability trends in the Marathon Grow #4 (Westbranch Field, Ogemaw Co., PN: 28399). The most porous interval is two feet below the contact with the Squaw Bay Formation. Porosity includes both intercrystalline and moldic porosity.

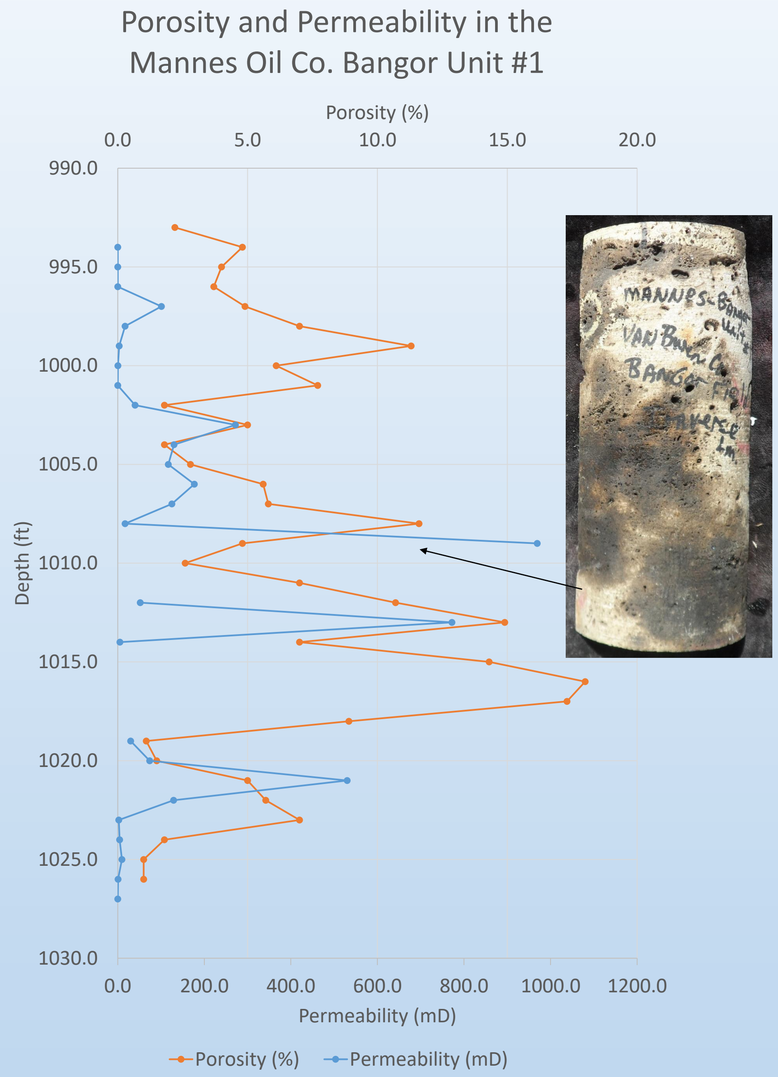


Figure 10: Porosity and Permeability trends in the Mannes Oil Co. Bangor Unit #1 (Van Buren County, PN: 33749). The Traverse Limestone is again both porous and permeable near the contact with the Squaw Bay Formation (at 993'). Core photograph exhibits oil staining from a sample at 1008'.

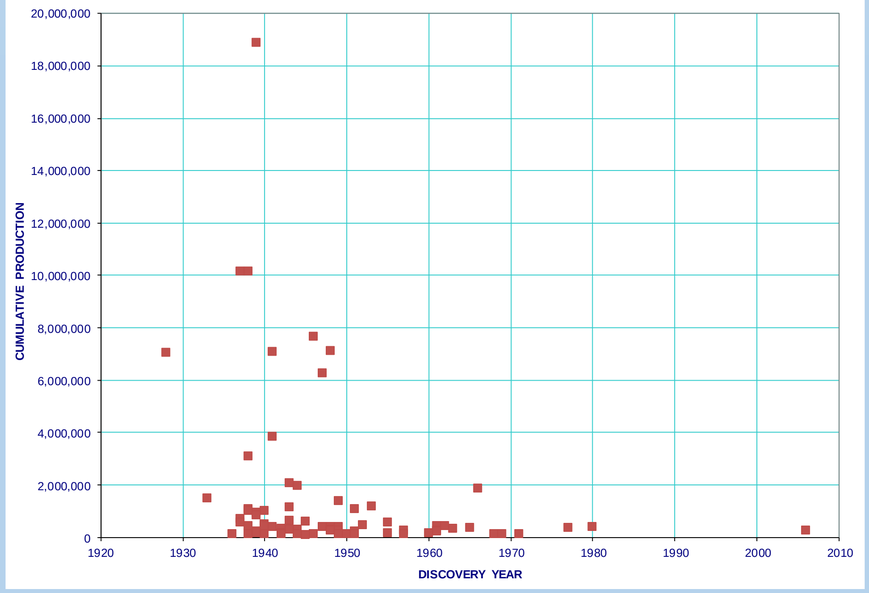


Figure 11: Traverse Limestone fields are old – most were discovered prior to revolutions in geophysical mapping of reservoirs (both seismic and wireline log data) and stratigraphy (facies models and sequence stratigraphy). The early discovery of these fields was from extensive drilling and structural mapping – which identified many of the larger Traverse fields.

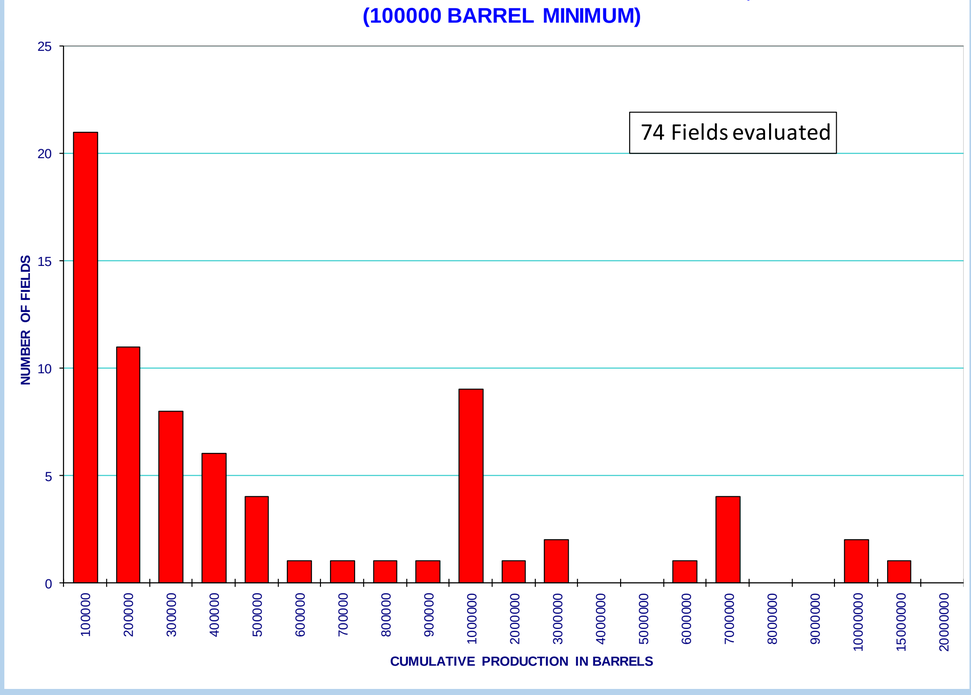


Figure 12: Traverse Fields show a skewed distribution with a significant number of fields producing less than 500,000 barrels of Oil and fewer fields producing more than 6,000,000 barrels. Large fields dominate the cumulative production from the Traverse Group in Michigan.

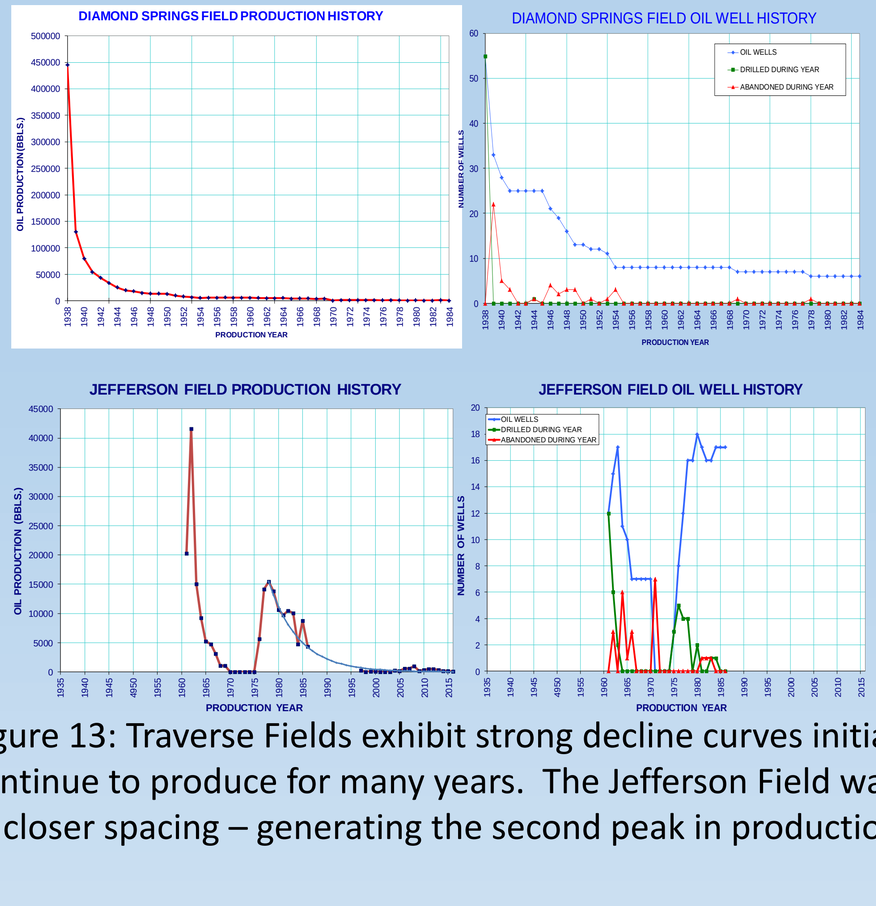


Figure 13: Traverse Fields exhibit strong decline curves initially, but continue to produce for many years. The Jefferson Field was re-drilled at closer spacing – generating the second peak in production.

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)

Note references available upon request.