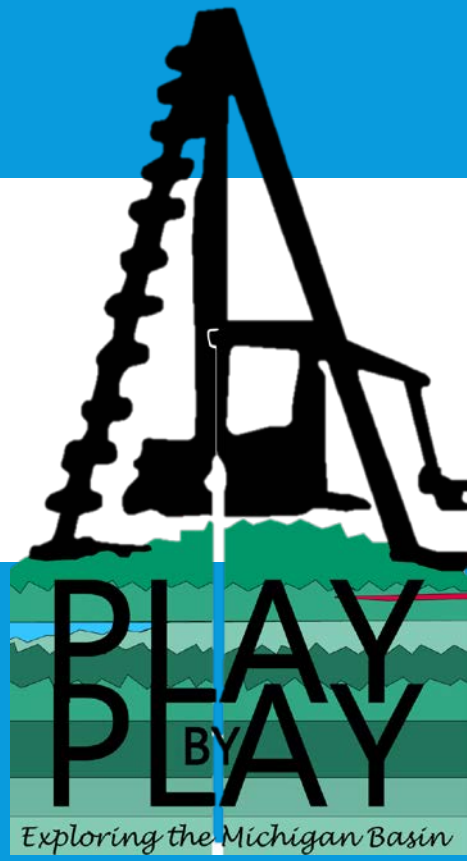
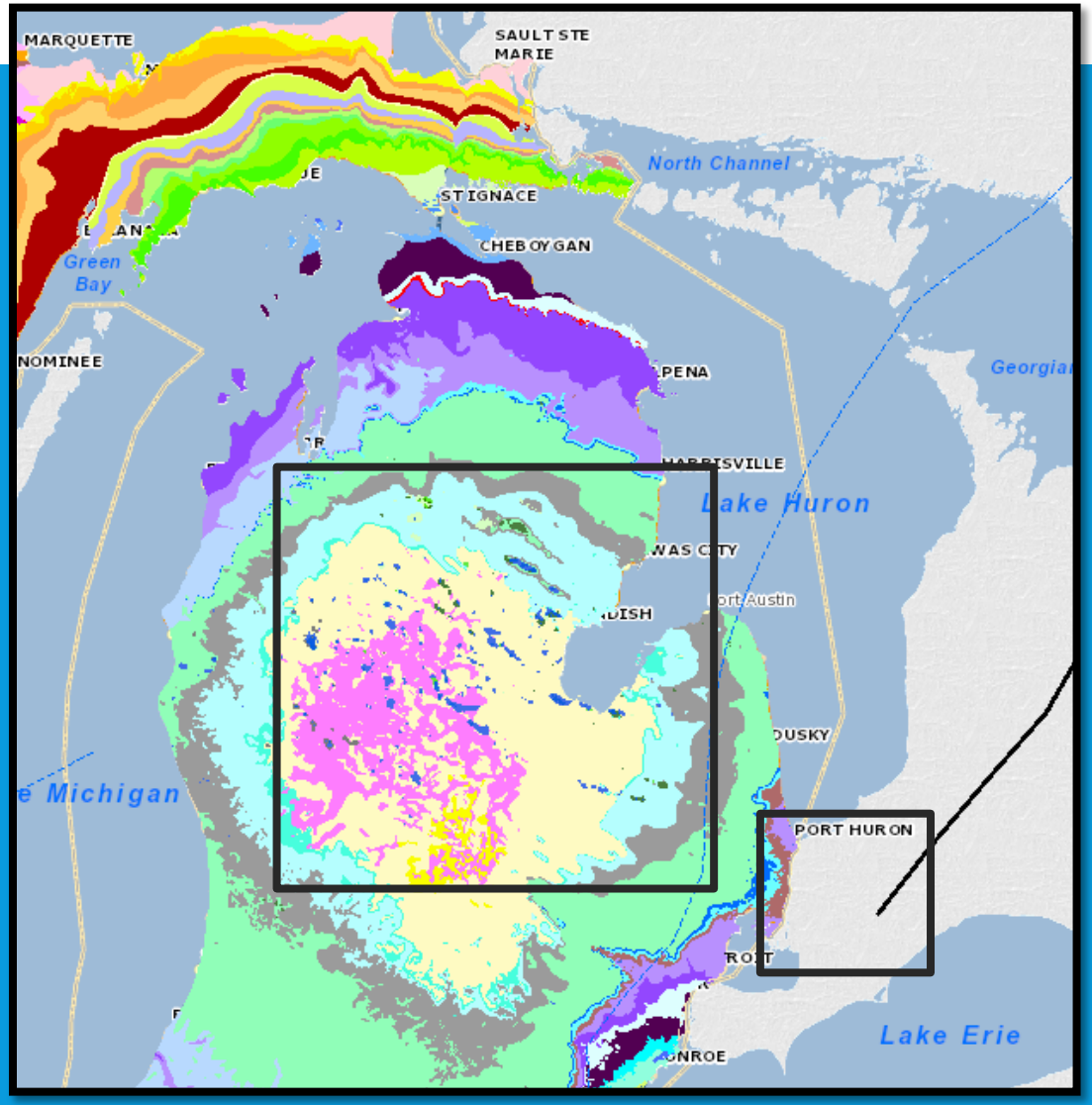
MIDDLE DEVONIAN PLAY
MICHIGAN BASIN OF ONTARIO

Duncan Hamilton



Middle Devonian Pools of the Michigan Basin



- 375+ Million Barrels Michigan
- 45+ million Barrels Ontario

Outline of Presentation

- History of the Play
- Significant Devonian Pools
- General Play Parameters
- Field Example Rodney Pool
- Use of Modern Technology
- Future Potential

History of the Play

Oil Springs Field, Lambton County – the site of the first commercial oil well in North America

- First commercial oil discovery at Oil Springs 1858
- 73% of oil discovered prior to 1900
- Last major discovery in 1949
- Initial flow rates as high as 7,500 bbls/d
- Produced 45+ million barrels to date
- Some of the original pools still producing
- Pools found mainly from oil seeps, tar beds
- Limited and sporadic drilling in recent times

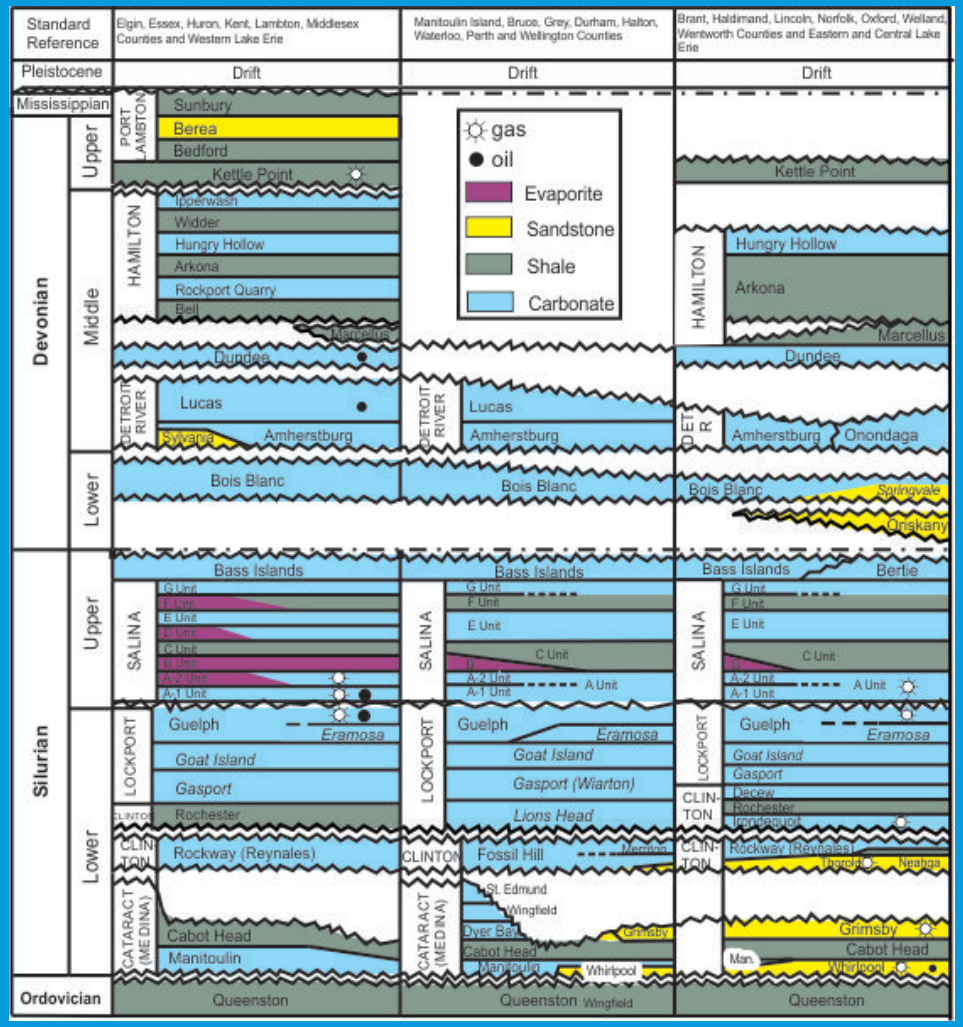
Significant Devonian Pools of Ontario

POOL NAME	DISCOVERY YEAR	CUMMULATIVE PRODUCTION (barrels)	ACTIVE
Oil Springs	1858	10,437,000	Yes
Petrolia	1862	18,798,000	Yes
Bothwell-Thamesville	1862	3,354,000	Yes
Wallacetown	1898	253,000	No
Glencoe	1917	1,139,000	No
Watford-Kerwood	1938	132,000	No
Rodney	1949	10,845,000	Yes

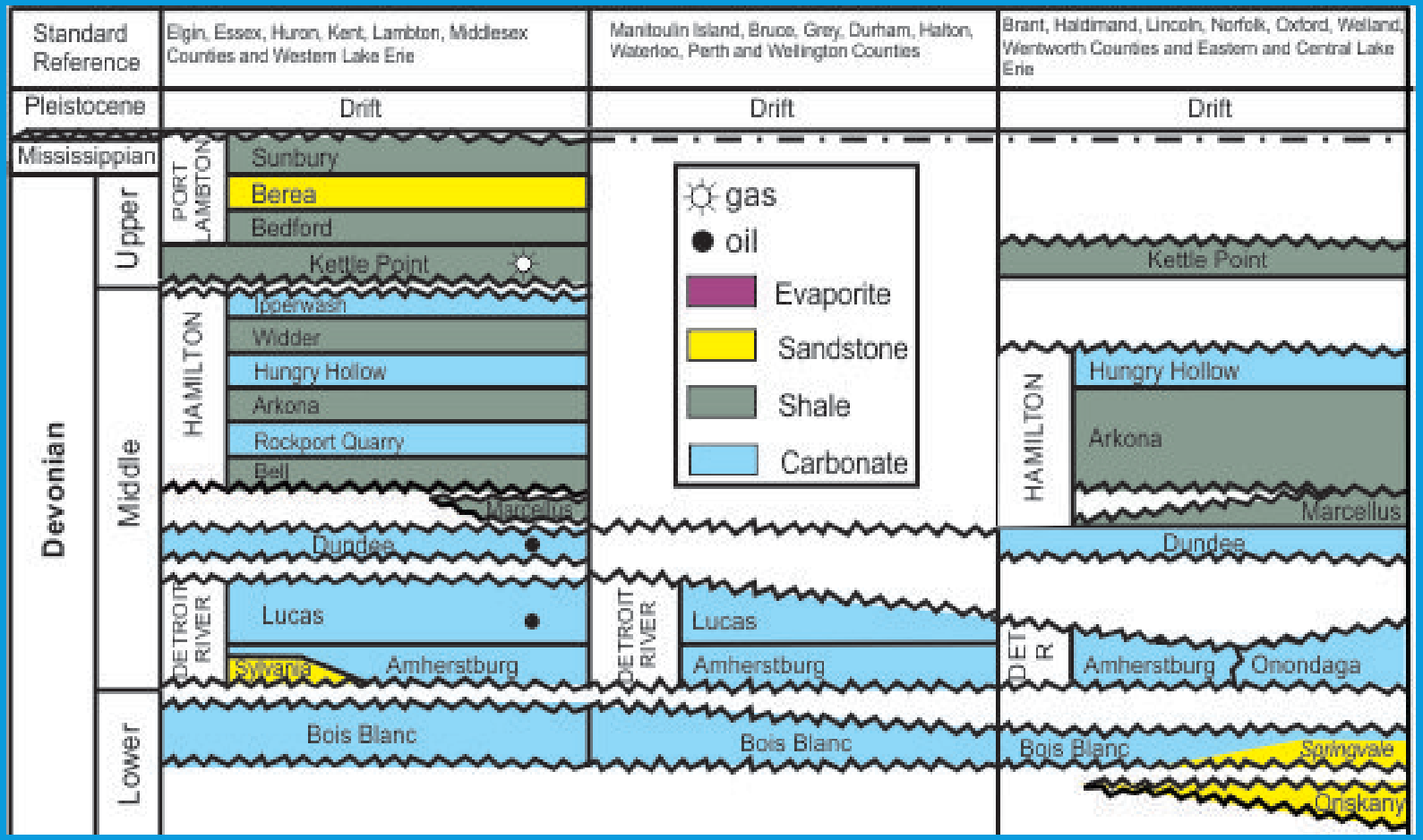
General Play Parameters

- Stratigraphy
- Devonian Play Fairway
- Location of Pools
- Dundee Structure
- Structural Trap Formation Concept
- Summary of Play Parameters

Stratigraphic Column



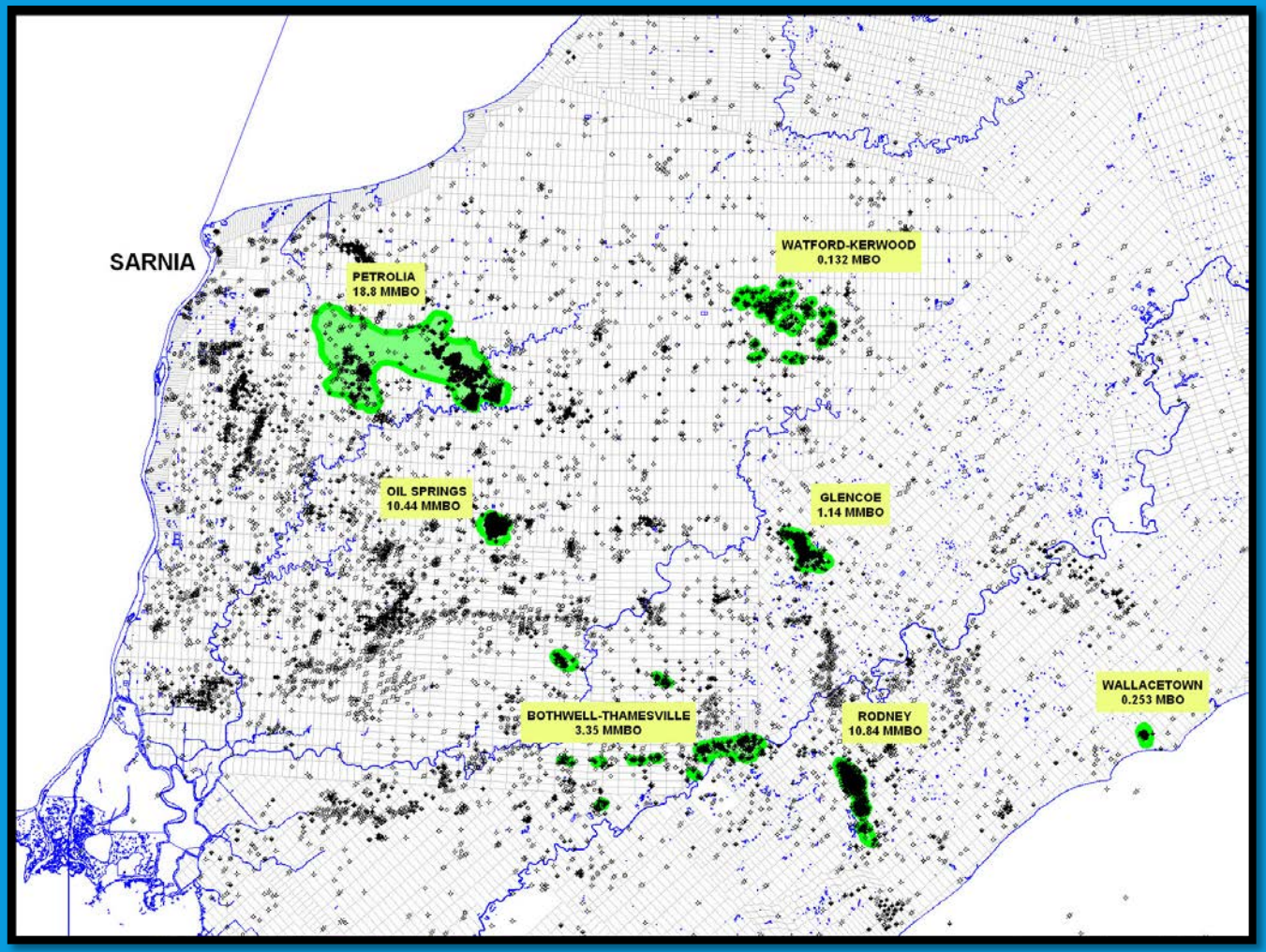
Middle Devonian Play Stratigraphy



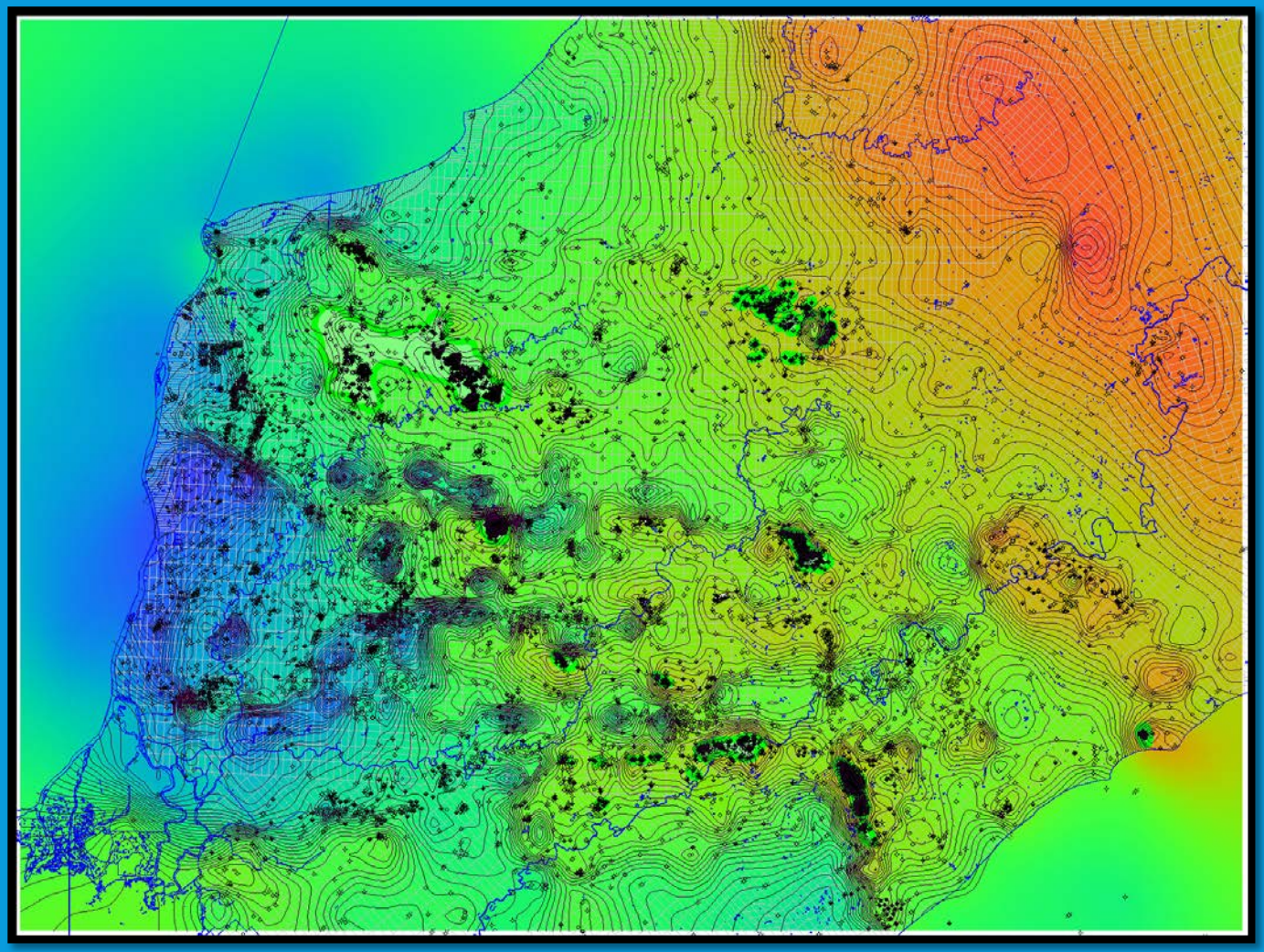
Middle Devonian Pool Fairway

Devonian Pool Fairway (Lazorek, M., and Carter, T.R., 2008)

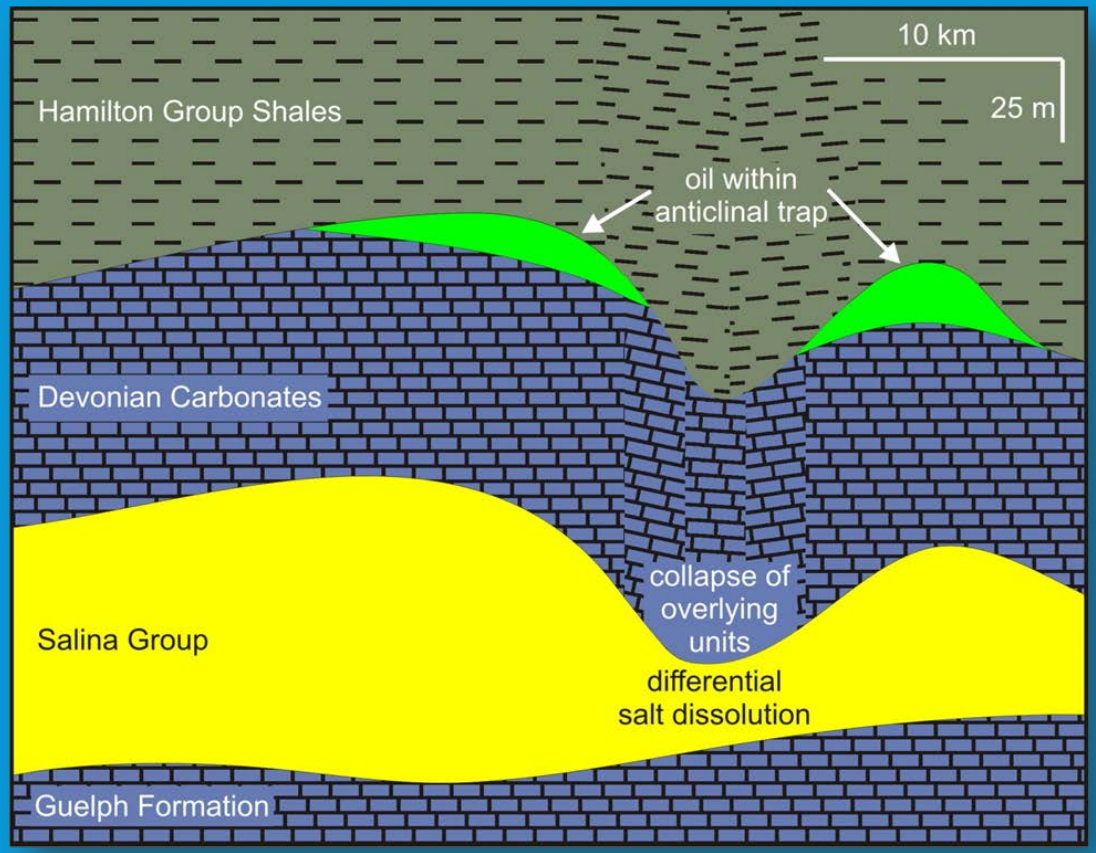
Devonian Pool Location Map



Dundee Structure Map



Salt-Dissolution Generated Structural Traps



Conceptual model of Devonian structural traps formed by differential salt dissolution in the Salina Group (Lazorek, M., and Carter, T.R., 2008).

Summary of Play Parameters

Key Reservoirs:

Dundee Formation :	**Siliclastic-rich dolomite (Rodney)** **(from 100% sand to 100% dolomite)**
Lucas Formation:	**Sucrosic Dolomite (Oil Springs, Petrolia)** **Sandstone (Glencoe)**
Other Production/Shows:	**Dundee fractured limestones** **Hamilton fractured shale**
Porosity:	**8 to 30%**
Permeability:	**5 to 2,500 mD**
Trapping Seal:	**Hamilton shale, tight Dundee limestone**

Summary of Play Parameters

Trapping Mechanism:	**Salt-Solution generated structural highs**
Depth of Reservoirs:	**350 to 450 feet**
Thickness of Overburden:	**50 to 300 feet**
Exploration Methods:	**Oil Seeps, tar beds, structural testing**
Drilling and Casing:	**Mainly cable tool and minor rotary Open-hole and cased-through and perforated**
Completion:	**Acidization and some frac'ing**

Rodney Field Example

General Field Data

Date of Discovery:	**1949**
Exploration Methods:	**Structural Testing**
Type of Trap:	**Structural (Salt-generated)**
Reservoir Lithology:	**Siliclastic-rich dolomite**
Producing Area:	**1600 acres**
Number of Producing Wells:	**200 Producers, 100 Injectors**
Drilling and Casing:	**Open-hole and cased-through and perforated**
Completion:	**Acidization and some frac'ing**

Rodney Field Example

Reservoir Data

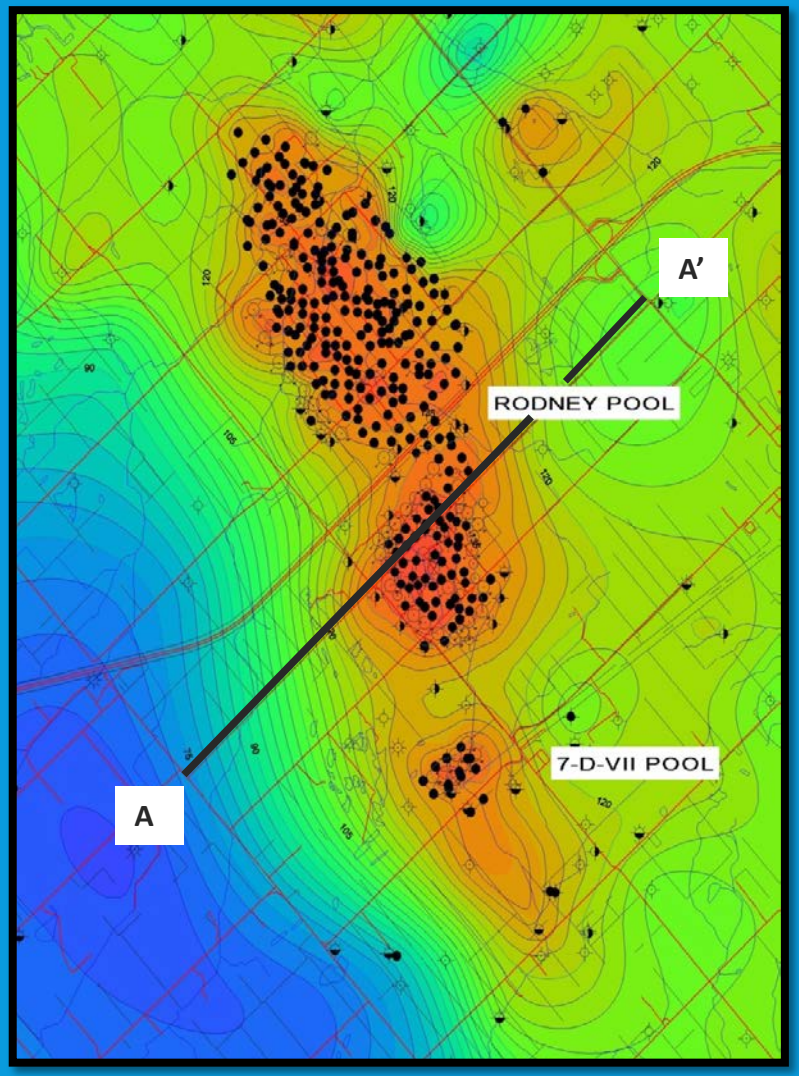
Producing Formation:	**Dundee “Columbus” Zone**
Depth to Reservoir:	**360 to 430 feet**
Deepest Zone Tested:	**Cambrian**
Pay Thickness:	**15 to 24 feet (4 to 6 meters)**
Pay Lithology	**Siliciclastic-rich Dolomite**
Pore Types:	**Intercrystalline, vuggy, fracture and intergranular**
Porosity:	**10 to 30%**
Permeability:	**5 to 2,500 mD**
Oil Character:	**38 API (sour)**
Water Saturation:	**Variable 10 to 30%**

Rodney Field Example

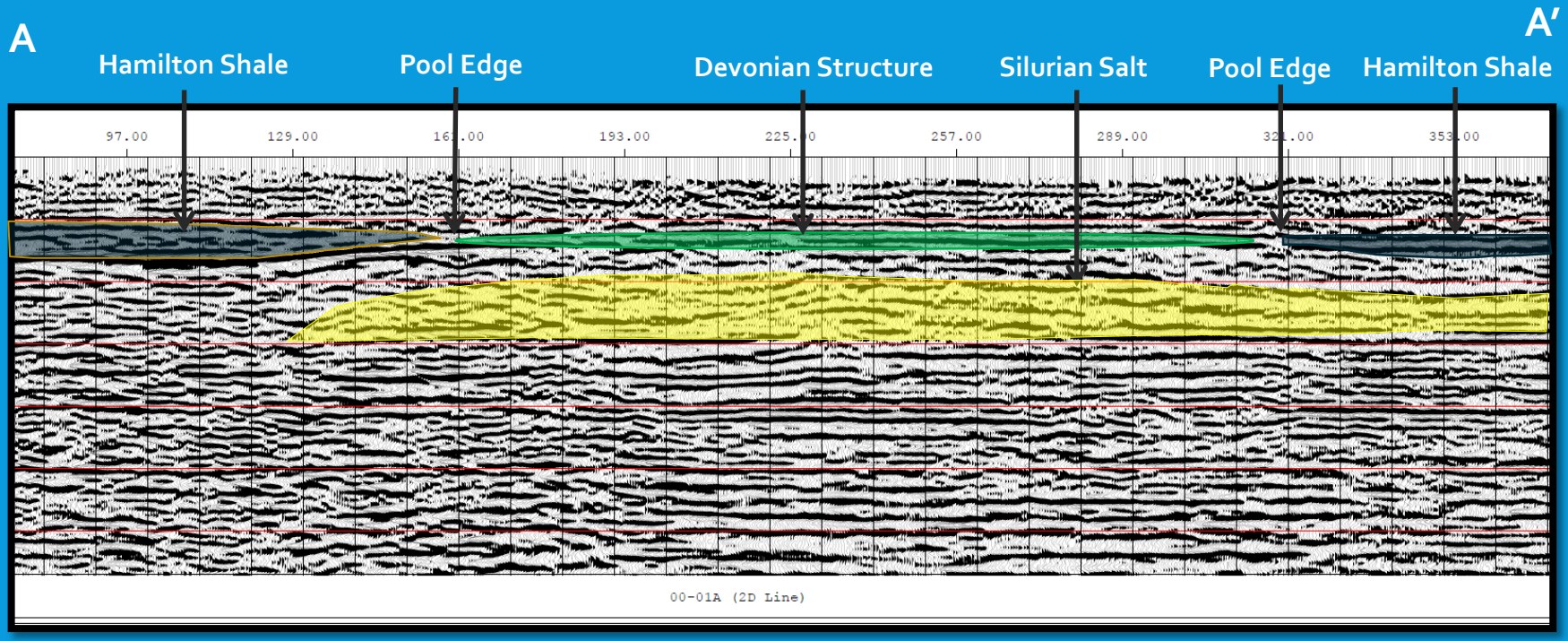
Other Reservoir Data

Original Reservoir Pressure:	175 psig (1,206 kPa)
Drive Mechanism:	Solution Gas
Original OOIP:	18 million barrels
Production to Date:	10.845 million barrels
Initial Production/Well:	2 to 118 BOPD
Peak Daily Production:	1,200 BOPD
Current Daily Production:	60 BOPD
Secondary Recovery:	Water-flood on 5-spot, line and peripheral pattern
Cores:	10
Wireline Logs:	Basic Gr/N to Nil.

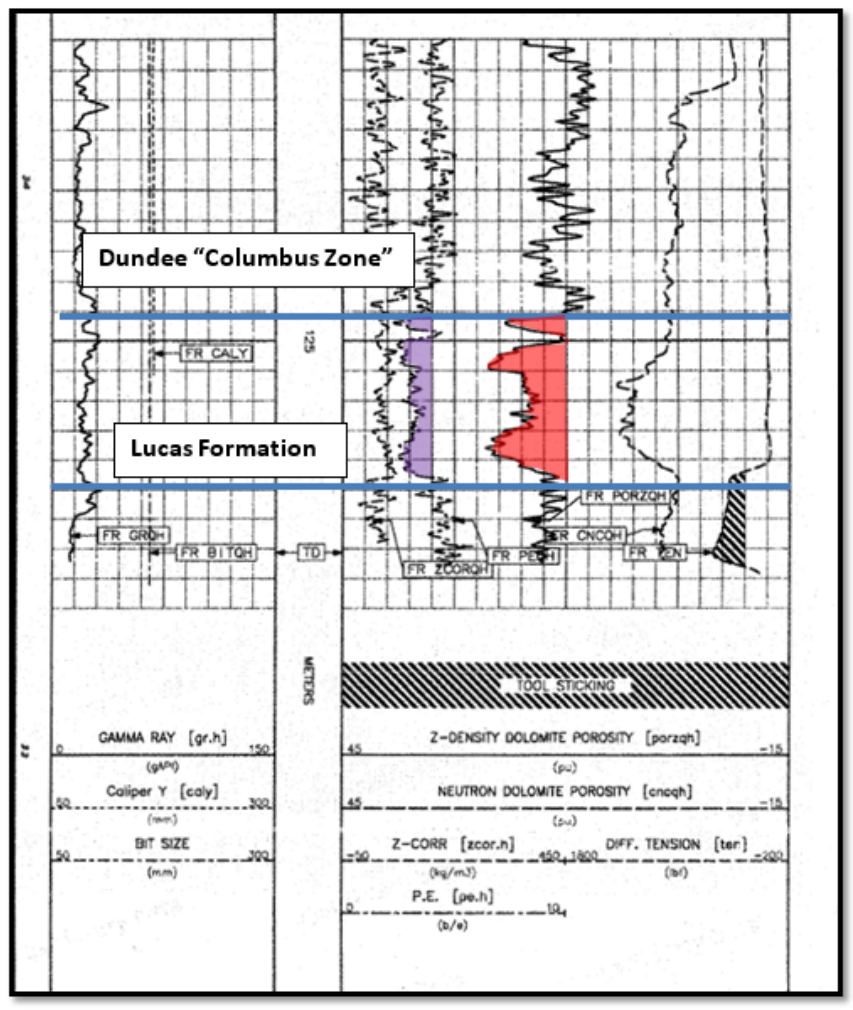
Dundee Structure Map Rodney Pools



Rodney Pool 2D Seismic Template Line



Rodney Field Type Log



- 12 to 24% porosity
- Quartz-sand-rich intervals
- Dolomitized crinoidal grainstone to packsone
- 20 foot (6 m) pay section

Use of Modern Technology

Exploration Tools

- Computer mapping of key geological tops and isopachs
- High-resolution gravity and magnetics
- Potential mapping of structures with 2D (3D) seismic

Waterflooding

- Successful water-flood results in the Rodney field
- 5-spot flood pattern very effective
- To date recovered approximately 60% of OOIP

Use of Modern Technology

Horizontal Drilling

- To date marginal success based on 3 wells
- Challenge to make the turn within 100 to 150 feet bedrock
- Relatively thin pay zone and heterogeneous reservoir
- Vertical permeability variable
- Due to shallow depth, lack of significant reservoir drive
- Limited stimulation options due to proximity of overlying fresh water aquifer and underlying Lucas water zones

Future Potential

- Remaining potential for smaller pools in 1 to 5 million barrels
- Areas within the Devonian fairway with relatively sparse drilling
- Potential to image structures with high-resolution gravity due to density contrasts of preserved sections of Salina salts.
- Use of magnetics data (OGS dataset) to map potential faults
- Use of old-fashioned conventional geological mapping
- Use of 2D seismic to confirm structure and drill locations
- Attractive economics with relatively low cost to drill a vertical test well $75,000 to $80,000

Future Potential Exploration Areas