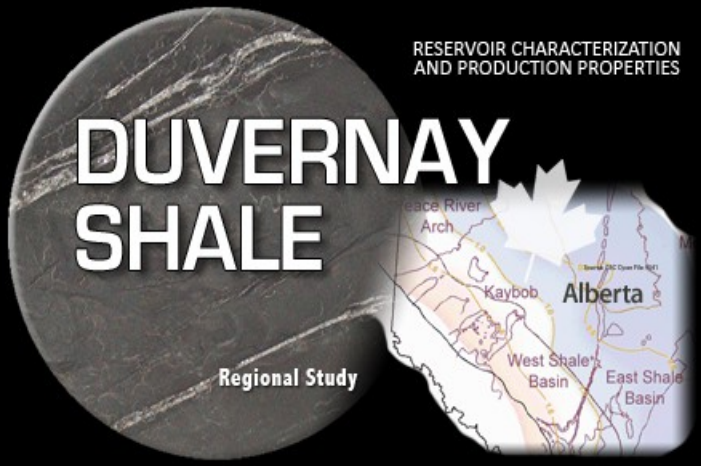


DUVERNAY FORMATION – WHAT HAVE WE LEARNED SO FAR?

OUTLINE

1. Introduction
2. Reservoir Properties
3. Where next?

REGIONAL DEPOSITIONAL SETTING

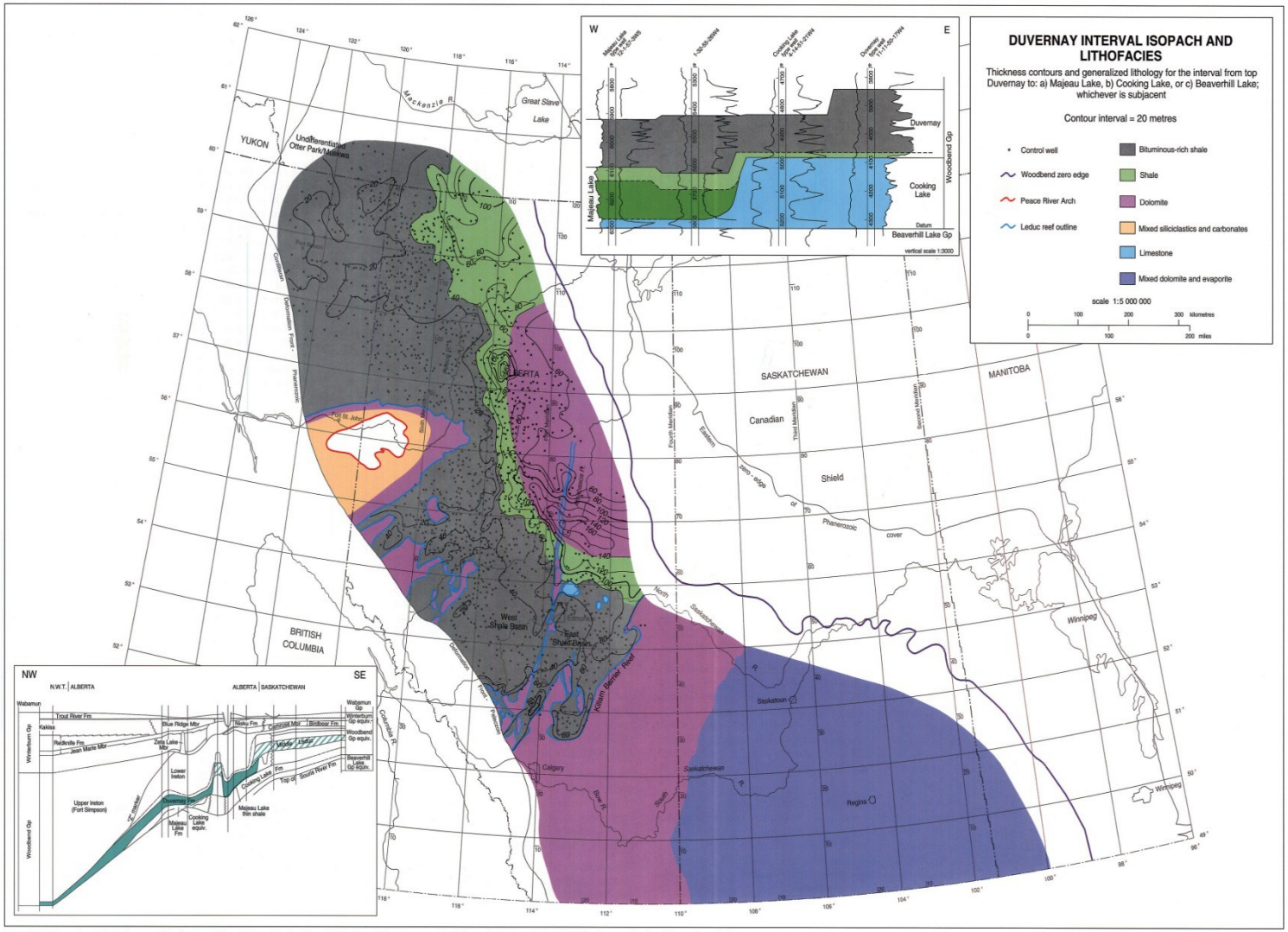
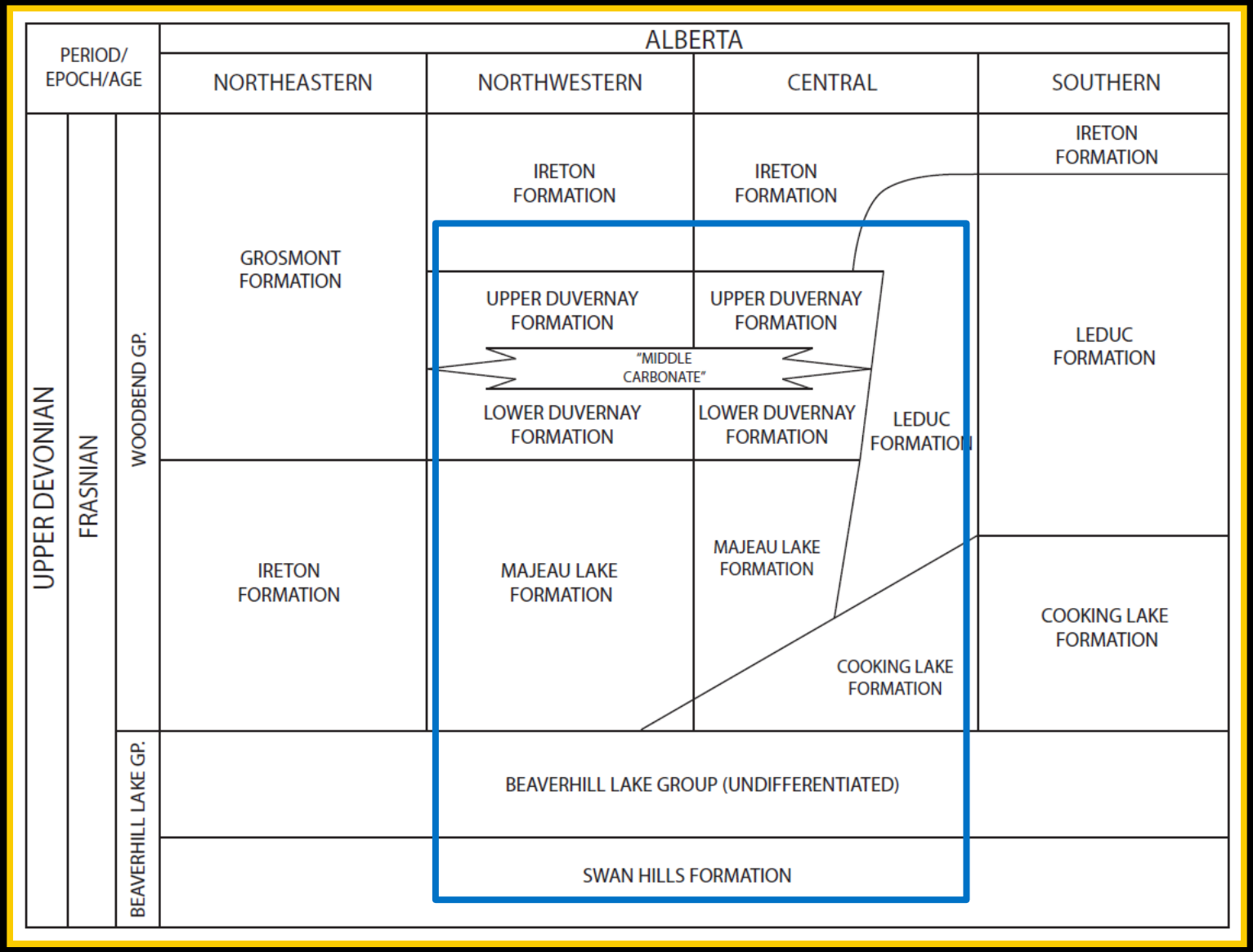


Figure 12.17 Isopach and lithofacies map of the Duvernay interval. The solid colour interval in the lower left inset cross section is isopached. The equivalent Middle Leduc stage (hachured) is not isopached.

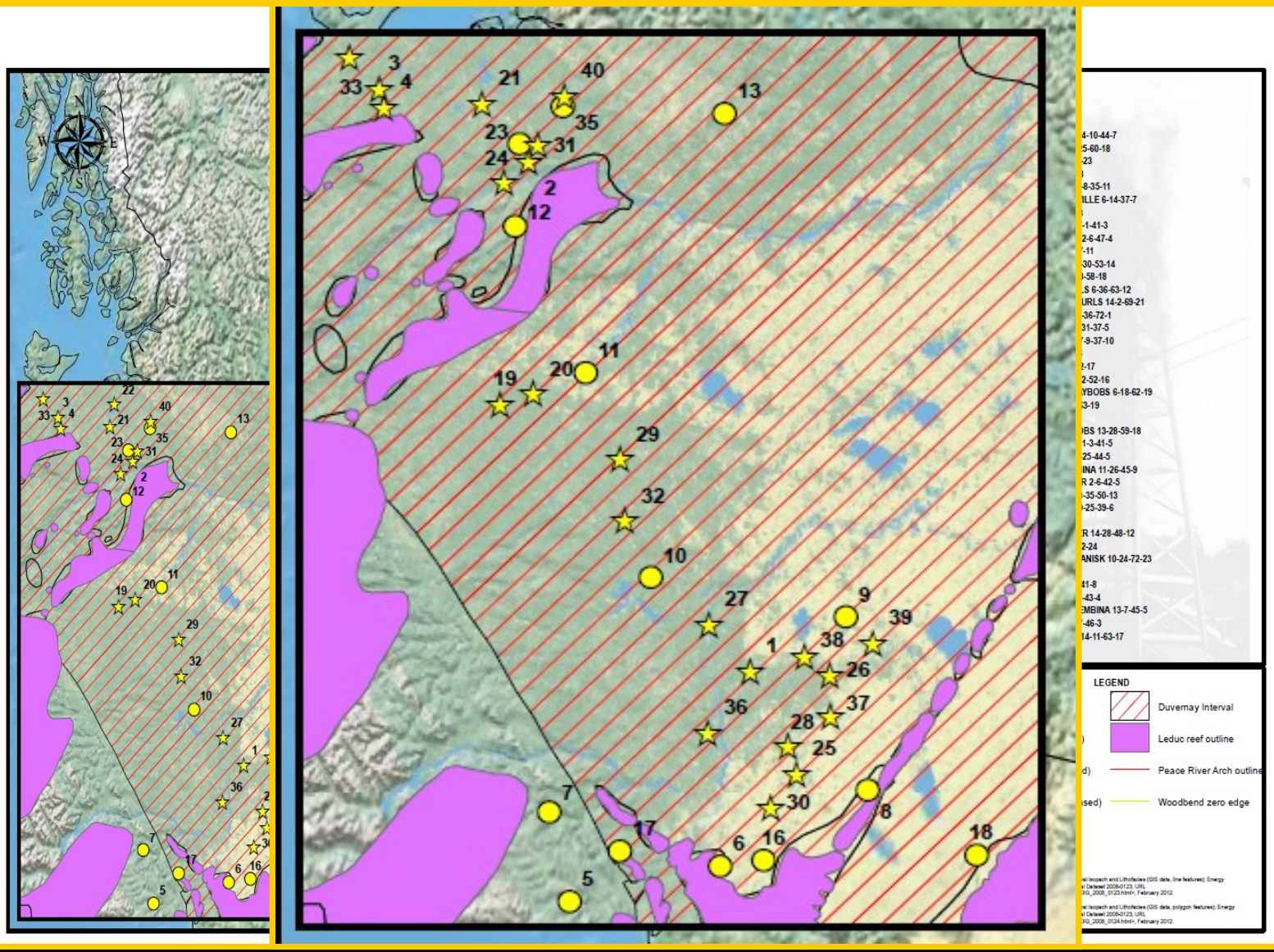
Modified from Geological Atlas of the Western Canada Sedimentary Basin

UPPER DEVONIAN STRATIGRAPHY



Modified from Geological Atlas of the Western Canada Sedimentary Basin

DUVERNAY JIP - LOCATION MAP



DUVERNAY JIP – DATABASE

Analyses completed or in-progress as of March 26, 2015

1431	Core Description (m)
604	Thin Section & Whole Thin Section
65	Scanning Electron Microscopy (FIB-SEM)
545	X-Ray Diffraction (XRD)
528	Basic Rock Properties (481 GRI, 41 CMS, 6 Nanopermeameter)
545	Total Organic Carbon/Rock Eval Pyrolysis (TOC/RE)
115	Vitrinite Reflectance (% Ro)
18	Oil Fingerprinting
26	Mercury Injection & Pore Size Distribution
172	Desorbed Gas Content
72	Desorbed Gas Composition
63	Adsorption Isotherm (Methane)
16	Mud Gas Isotopes
7	Chloride Determination
64	Geomechanics (45 Single-Stage, 19 Multi-Stage Mohr-Coulomb)
58	Capillary Suction Time (CST) & Roller Oven (RO) Fluid Sensitivity Analysis
29	Unpropped Fracture Conductivity

DUVERNAY CORE

RESERVOIR GEOLOGY

- **Shale basin – fine grained sediments, mostly variations on a silty mudstone**

- **Variations of this rock type and the mineralogy are largely controlled by proximity to the reef complexes.**

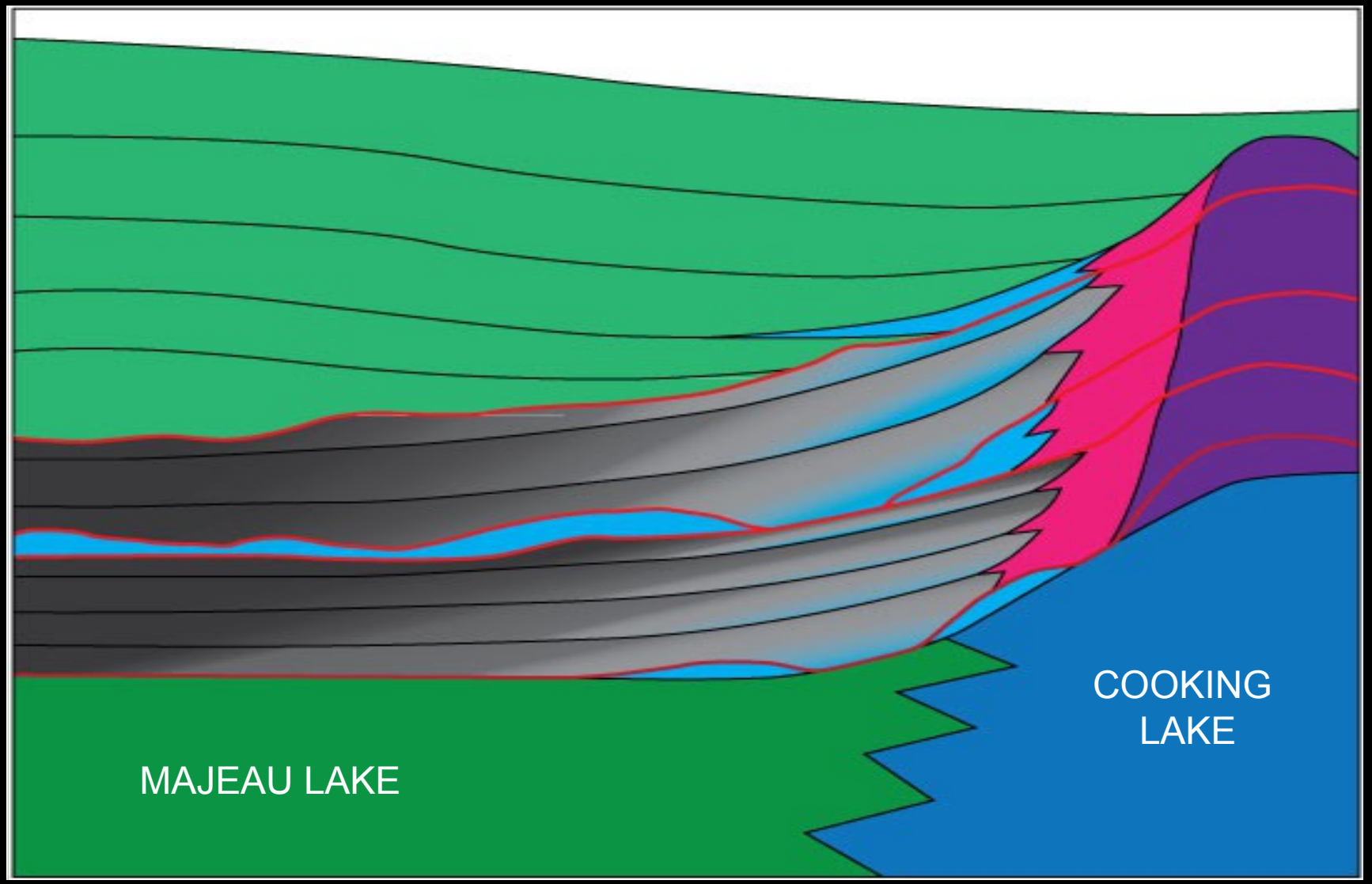
*PROXIMAL TO REEF COMPLEX	*DISTAL TO REEF COMPLEX
Increase in carbonates	Little or no carbonates
More internal stratification (well laminated)	Mostly massive to faintly laminated
Increase in skeletal material	Very minor skeletal material
Moderate to intense bioturbation	Minor to no bioturbation evident
Decrease in organic content	Organic-rich

*Distal and proximal are used here as relative terms.

DEPOSITIONAL ENVIRONMENTS

Formation	Depositional Environment	Rock Types	Carbonate Content	Bioturbation Intensity	Oxic/Dysoxic/ Anoxic	TOC
Ireton	Distal Deep Basin	Siliceous calcareous shales, carbonate mudstone, minor calcareous silty shales	Moderate to High	Minor to Moderate	Oxic	Very Low
Duvernay	Fore Reef to Proximal Deep Basin	Calcareous and non-calcareous silty mudstones, limestones (wackestones, packstones, minor grainstones), limestone breccias (Floatstone)			Oxic to Dysoxic	
	Proximal to Mid Deep Basin	Abundant calcareous silty mudstones, minor silty mudstones, limestones (wackestones, minor packstones)			Dysoxic to Anoxic	
	Mid to Distal Deep Basin	Calcareous and non-calcareous silty mudstones, very minor limestones (wackestones)			Dysoxic to Anoxic	
	Distal Deep Basin	Abundant silty mudstones, minor calcareous silty mudstones and limestones (wackestones - carbonate mound facies)			Anoxic	
Majeau	Distal Deep	Siliceous calcareous shales	Moderate to	Minor	Oxic	Very

DEPOSITIONAL FRAMEWORK



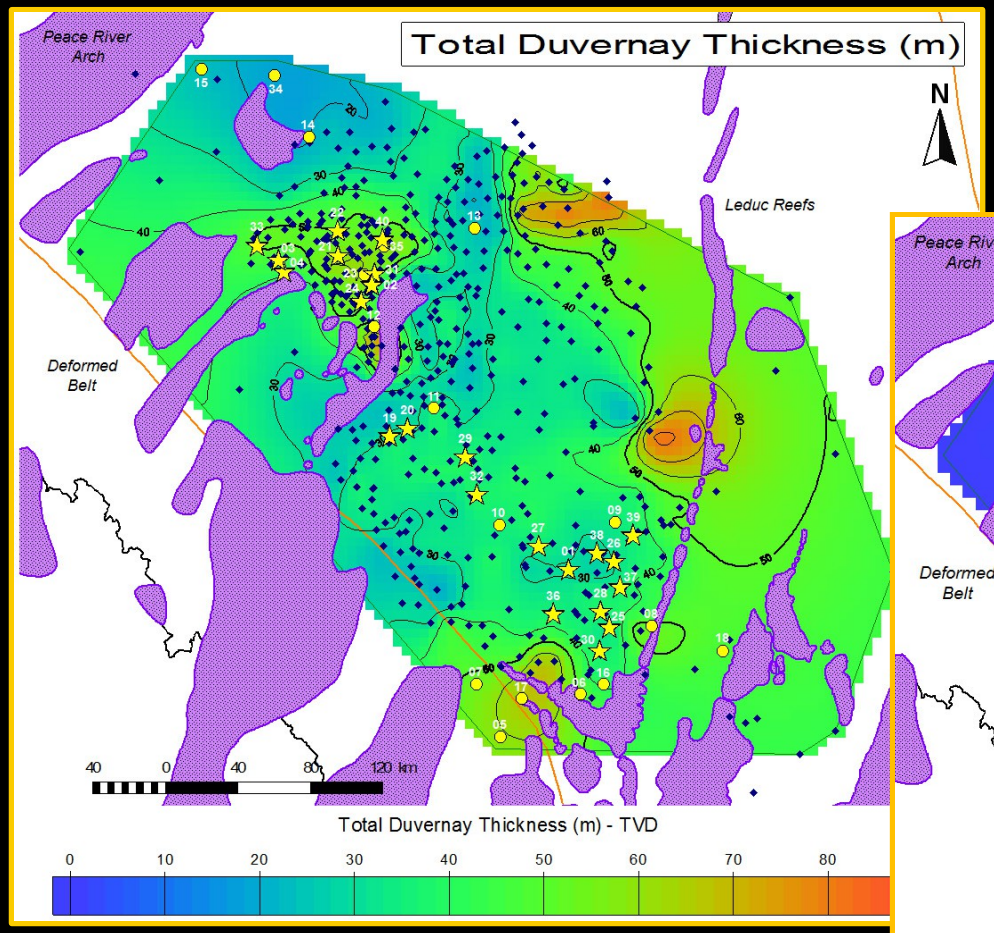
OUTLINE

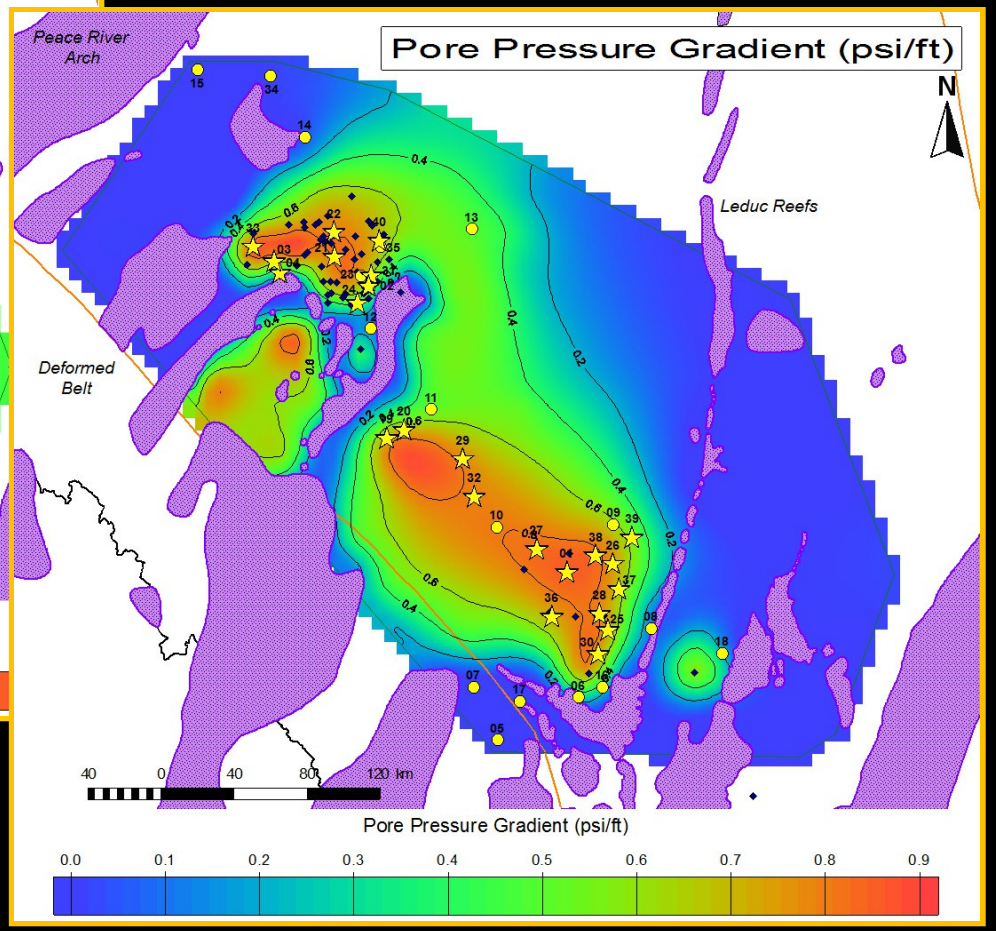
1. Introduction
2. Reservoir Properties
3. Where next?

What Makes a Good Shale Reservoir?

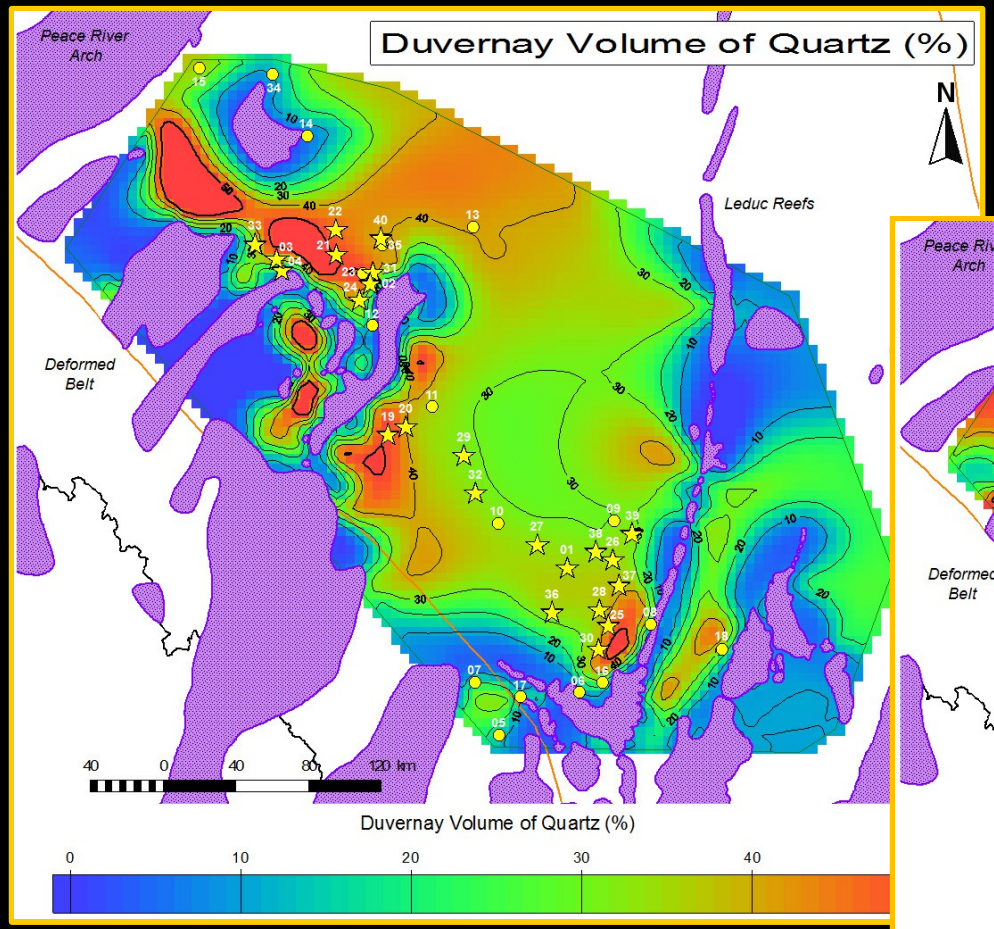
- Key attributes for successful shale plays:
  - Reservoir Thickness
  - Pressure Gradient
  - Lithology
    - Quartz + Carbonate content
    - Clay types/content – hydrated vs. desiccated, fluid compatibility
  - Porosity (Effective and Hydrocarbon-Filled) and Permeability
  - TOC/Thermal Maturity

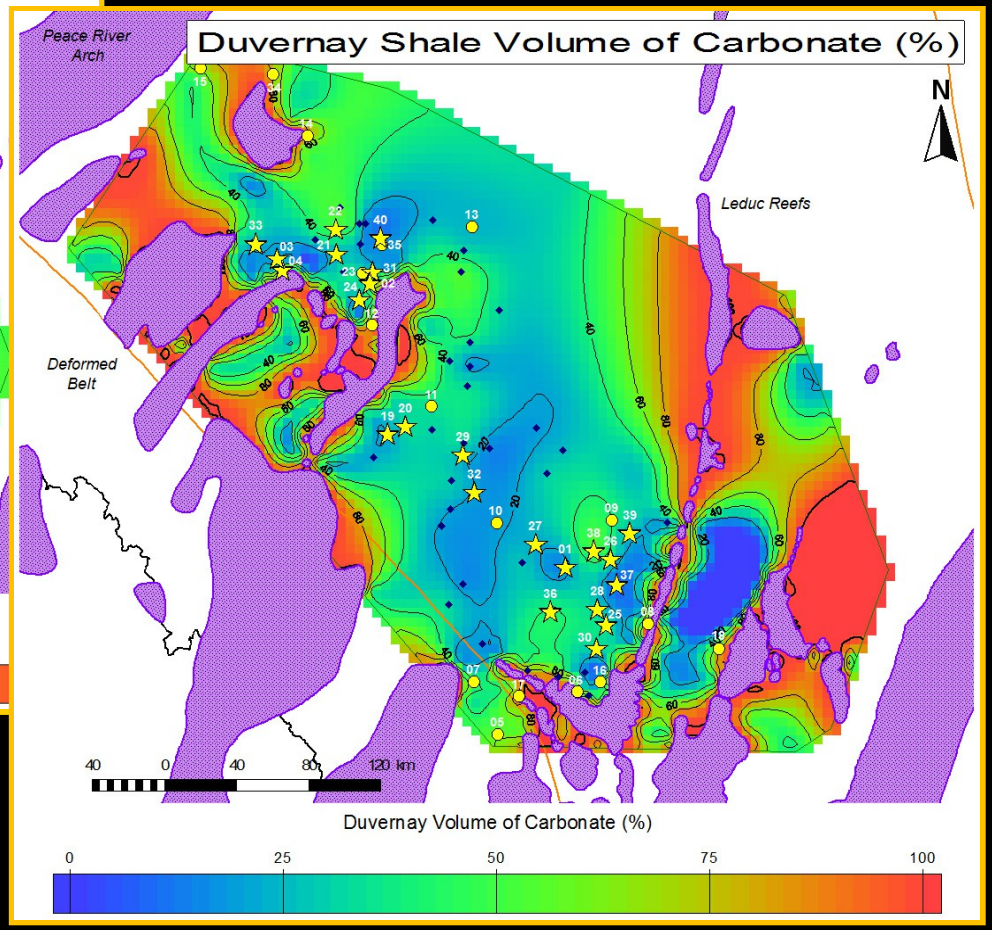
RESERVOIR THICKNESS AND PRESSURE GRADIENTS



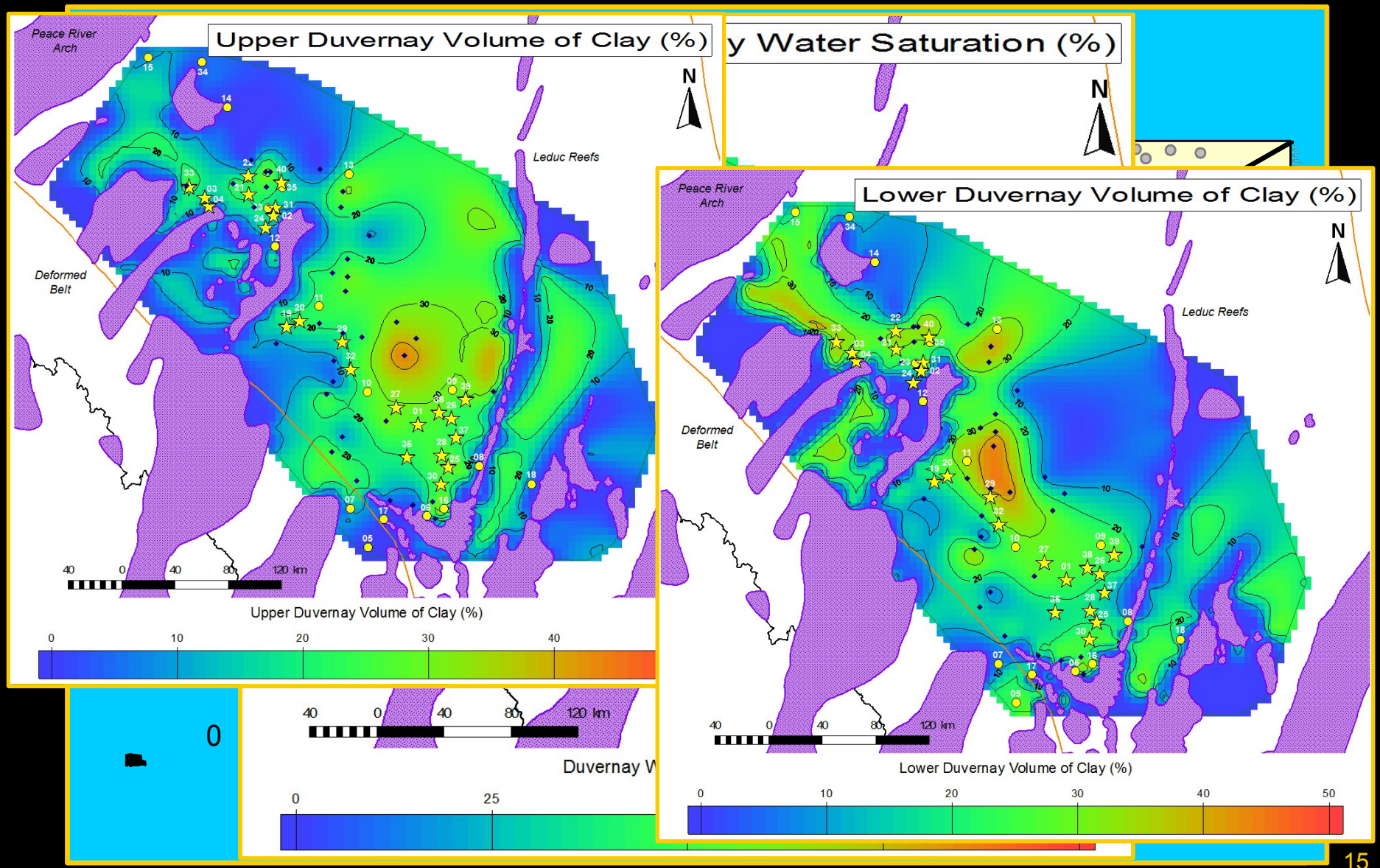


LITHOLOGY: QUARTZ+CARBONATE



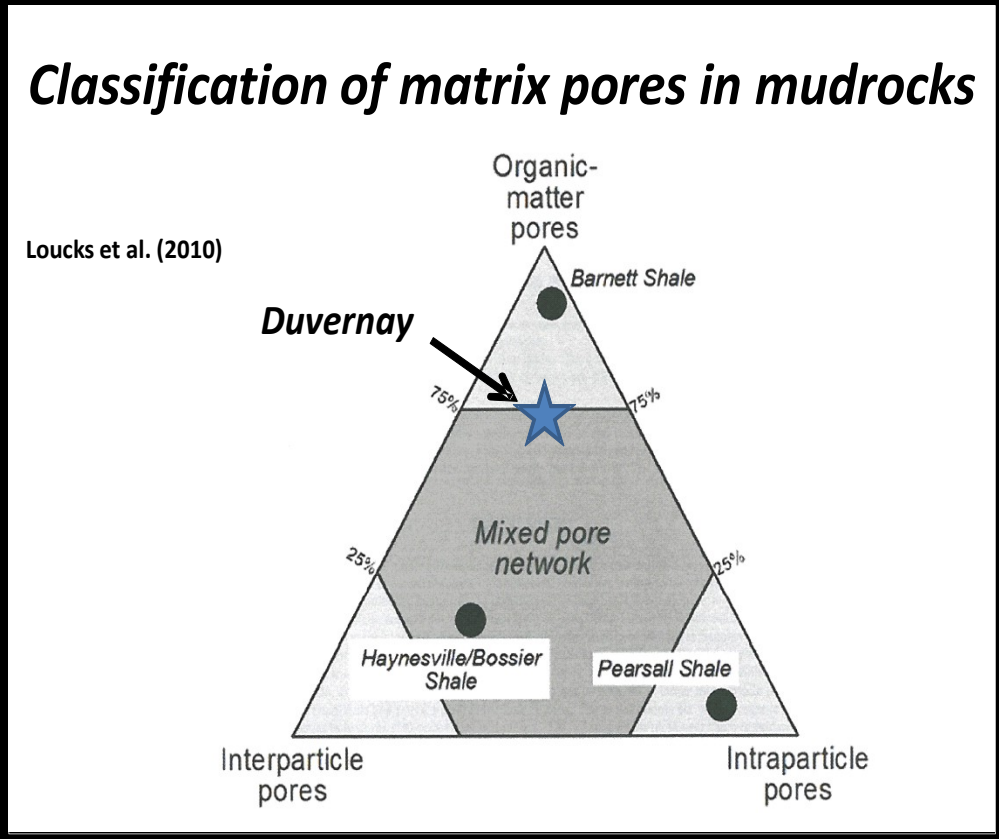


LITHOLOGY: CLAY MINERALOGY AND WATER SATURATION

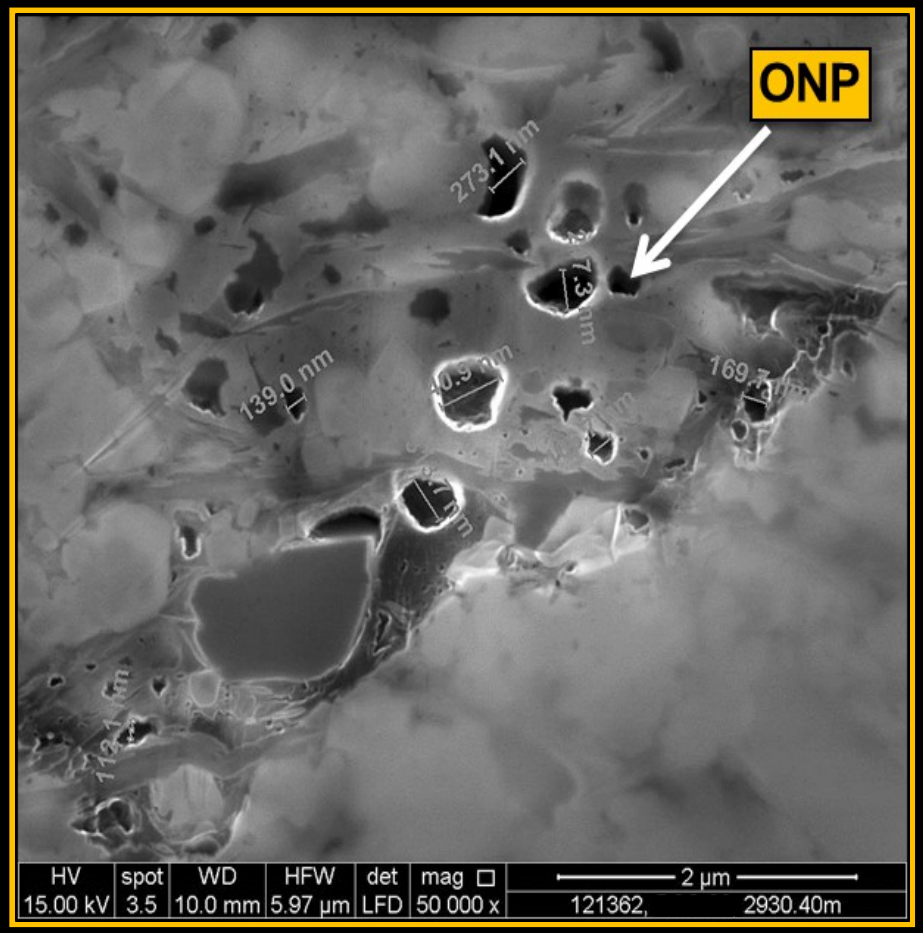


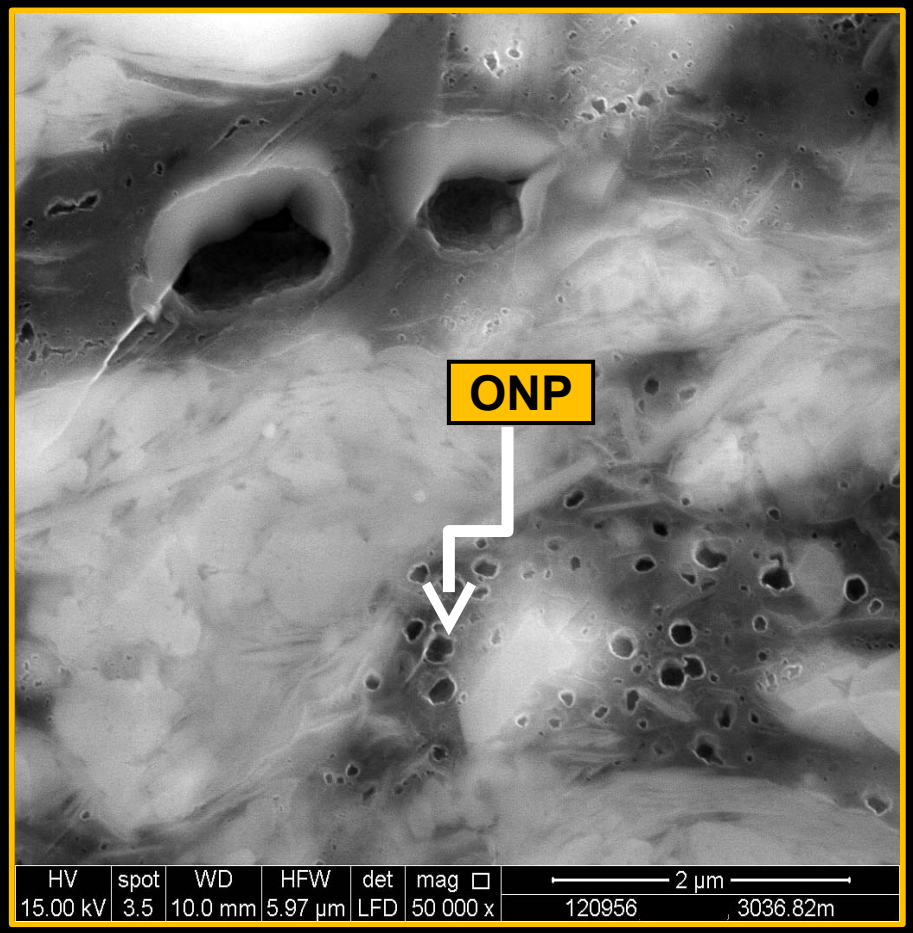
POROSITY AND PERMEABILITY

- **Porosity types include:**
  1. Interparticle micro-porosity between silt grains and clays
  2. Intraparticle micro-porosity within skeletal grains in tighter limestones
  3. Intercrystalline porosity and micro-porosity in limestones and mineralized fractures
  4. Organic nano-porosity in bituminous mud matrix

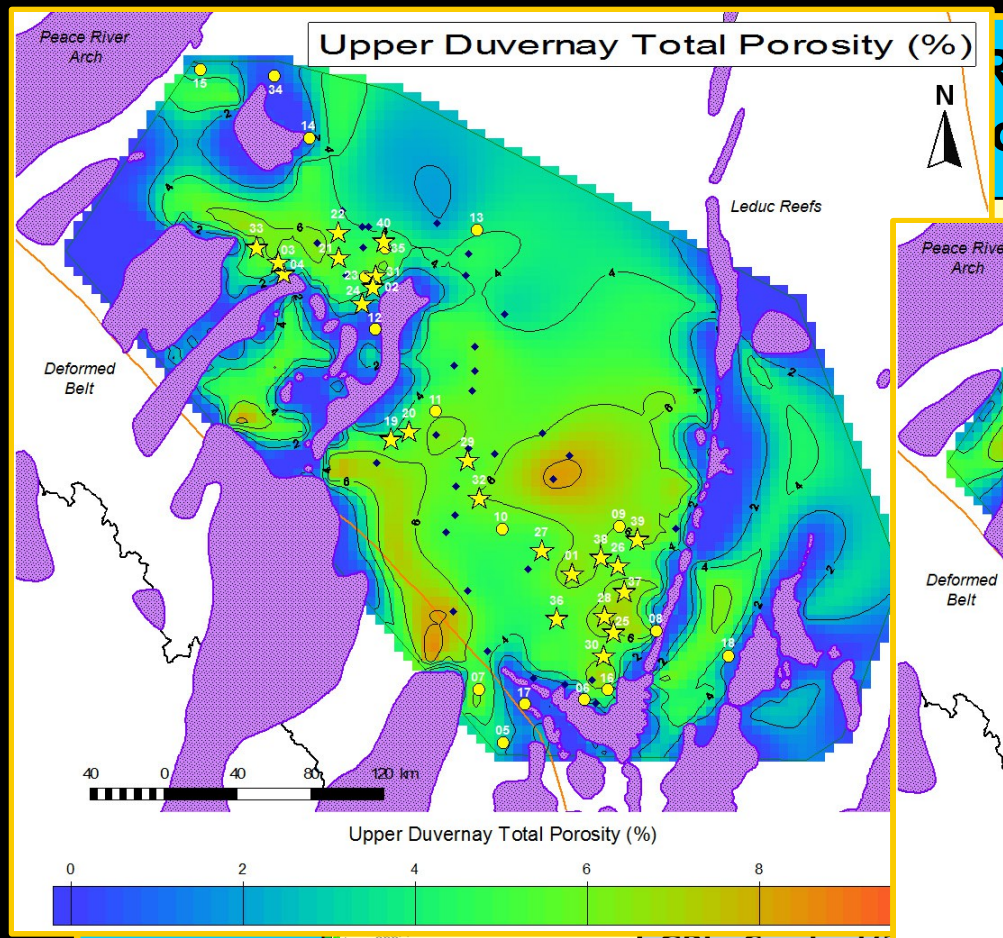


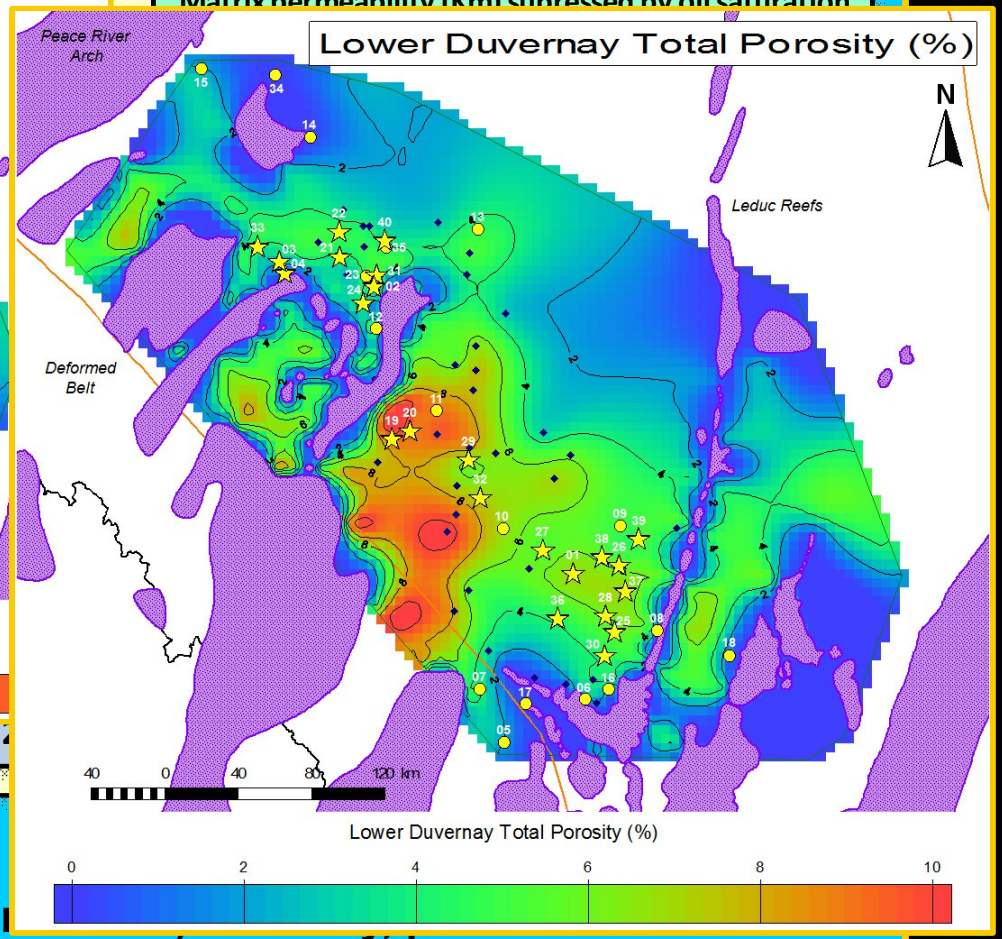
PORE TYPES – ORGANIC NANO-PORES





POROSITY AND PERMEABILITY





ROPERTIES
otal Porosity)

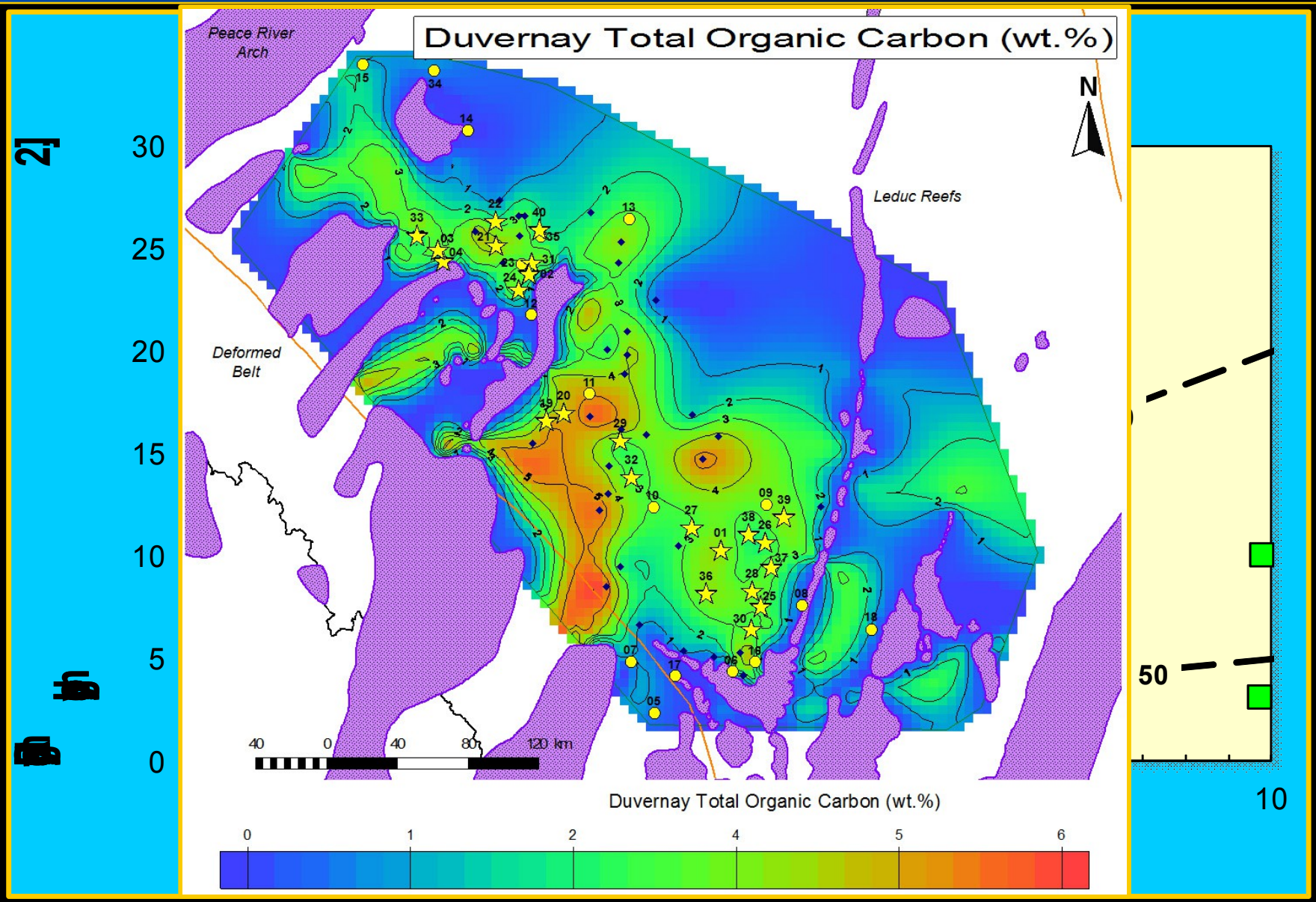
Matrix permeability (Km) supressed by oil saturation

GRI: Crushed (

1E-13
1E-14
0 2 4 6

Total (Interco

ORGANIC RICHNESS AND MATURITY



ORGANIC RICHNESS AND MATURITY

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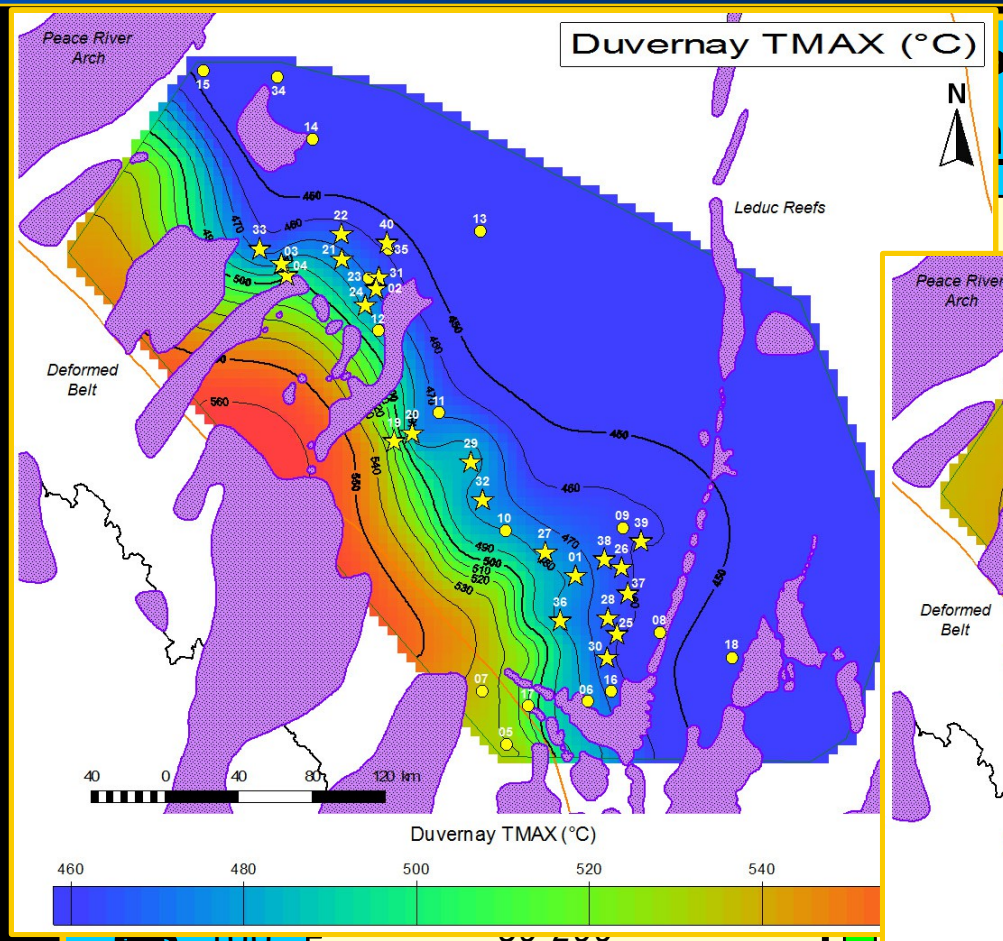
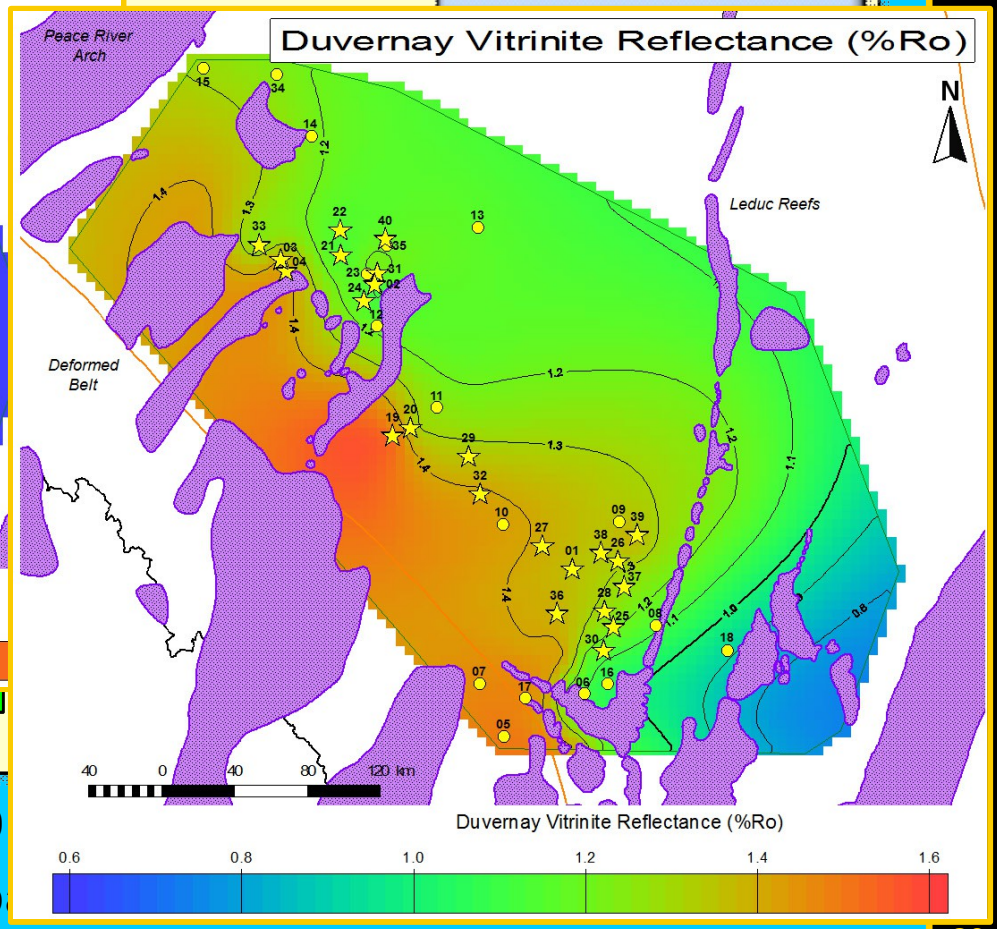
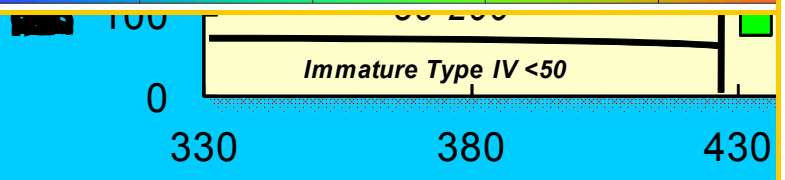
RESERVOIR OPTIMIZATION



ROPERTIES
nature) and Maturity)

Tmax used when the following conditions are met:



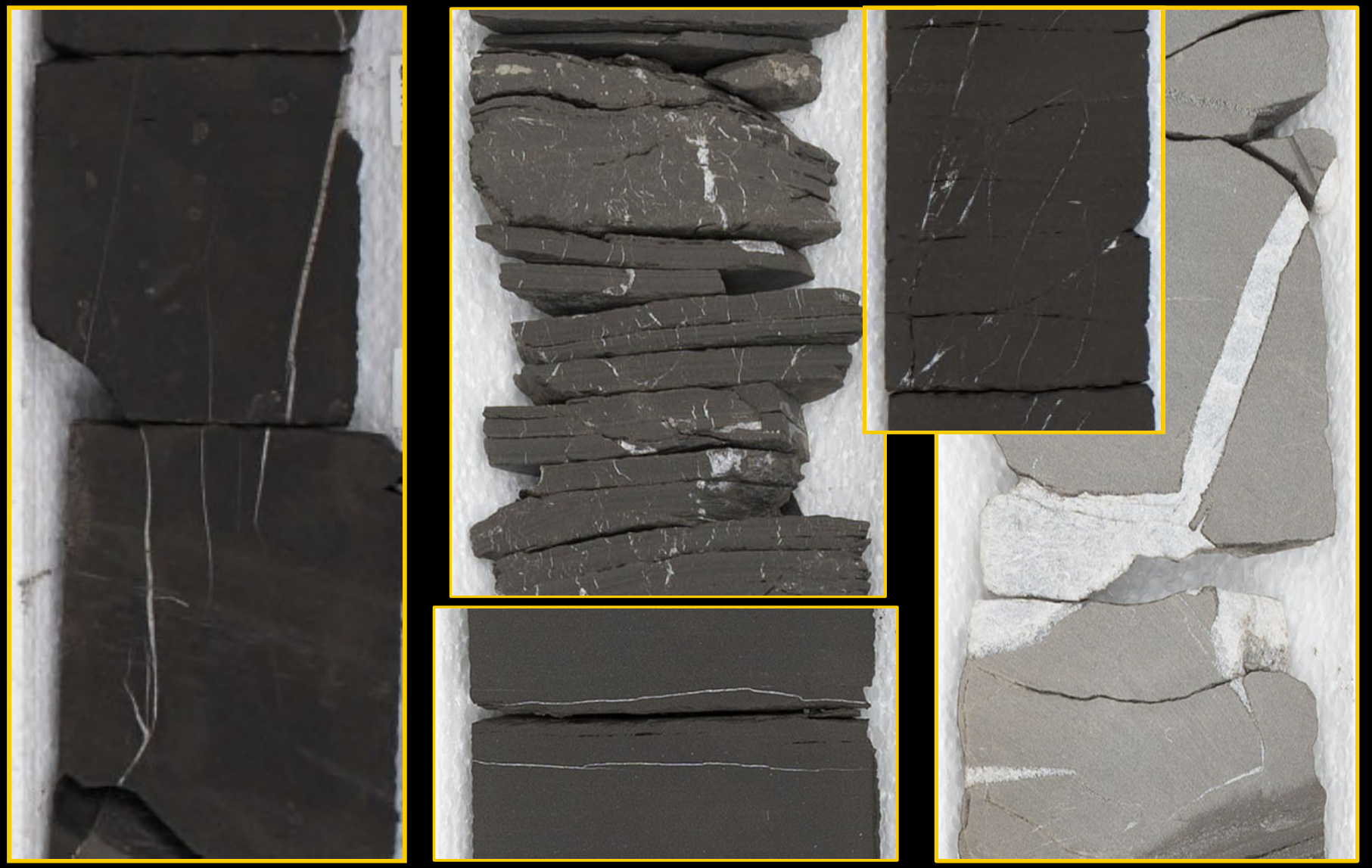


Maturity [b

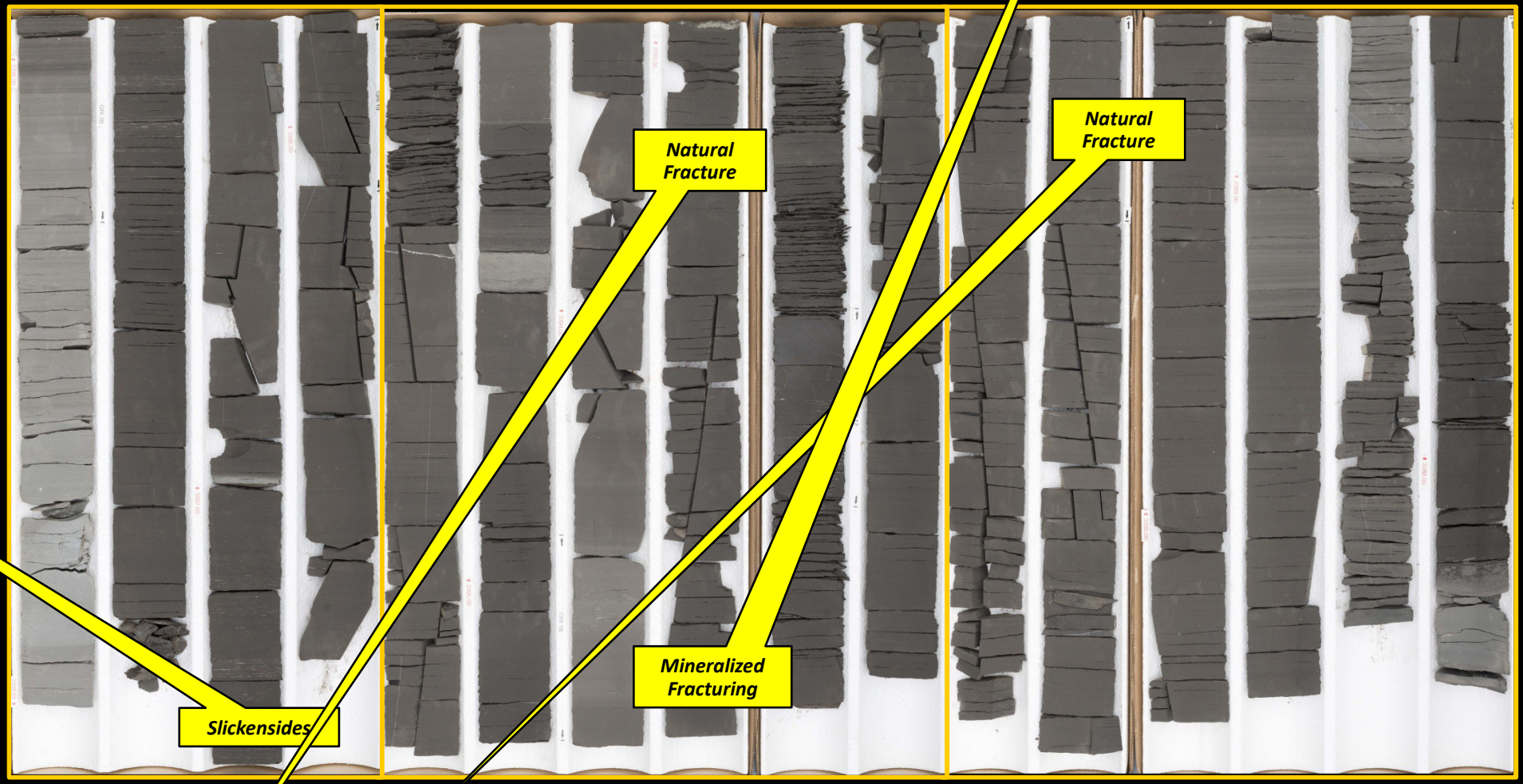
OUTLINE

1. Introduction
2. Reservoir Properties
3. Where next?

FRACTURES: Mineralized Fractures



FRACTURES: Natural Fracture System



OIL WINDOW AND EAST SHALE BASIN

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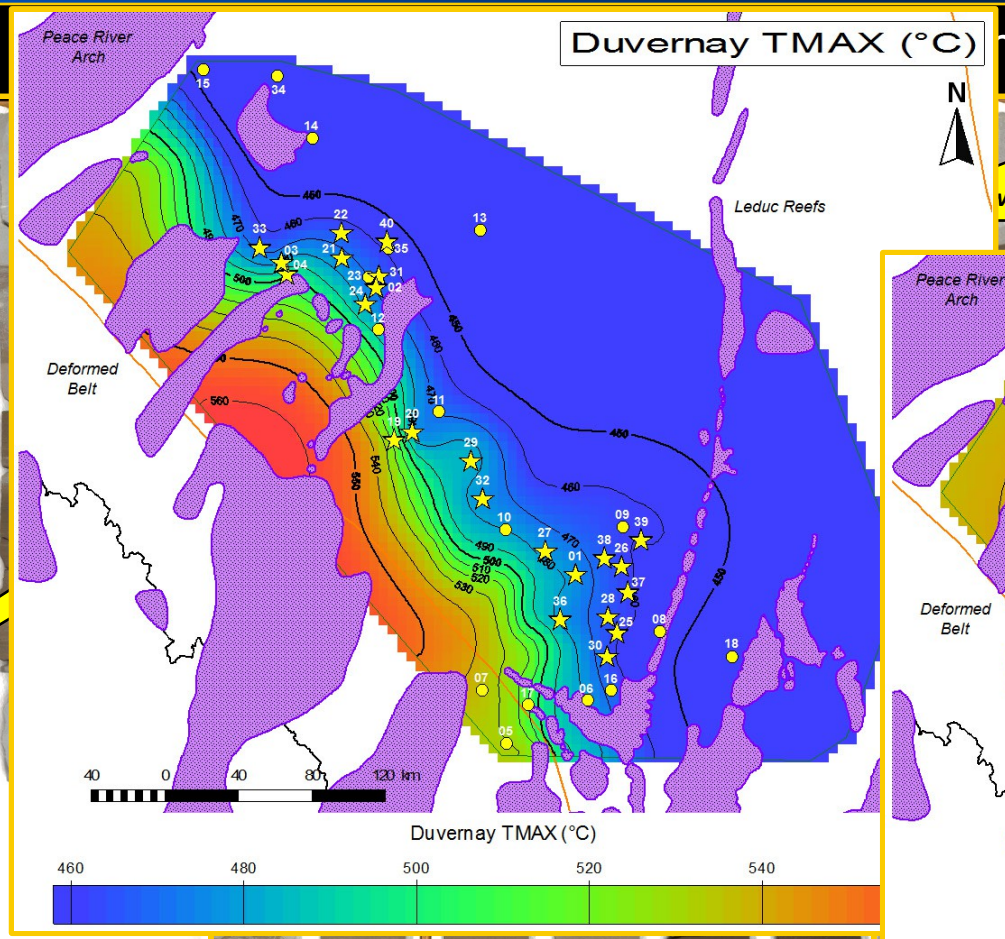
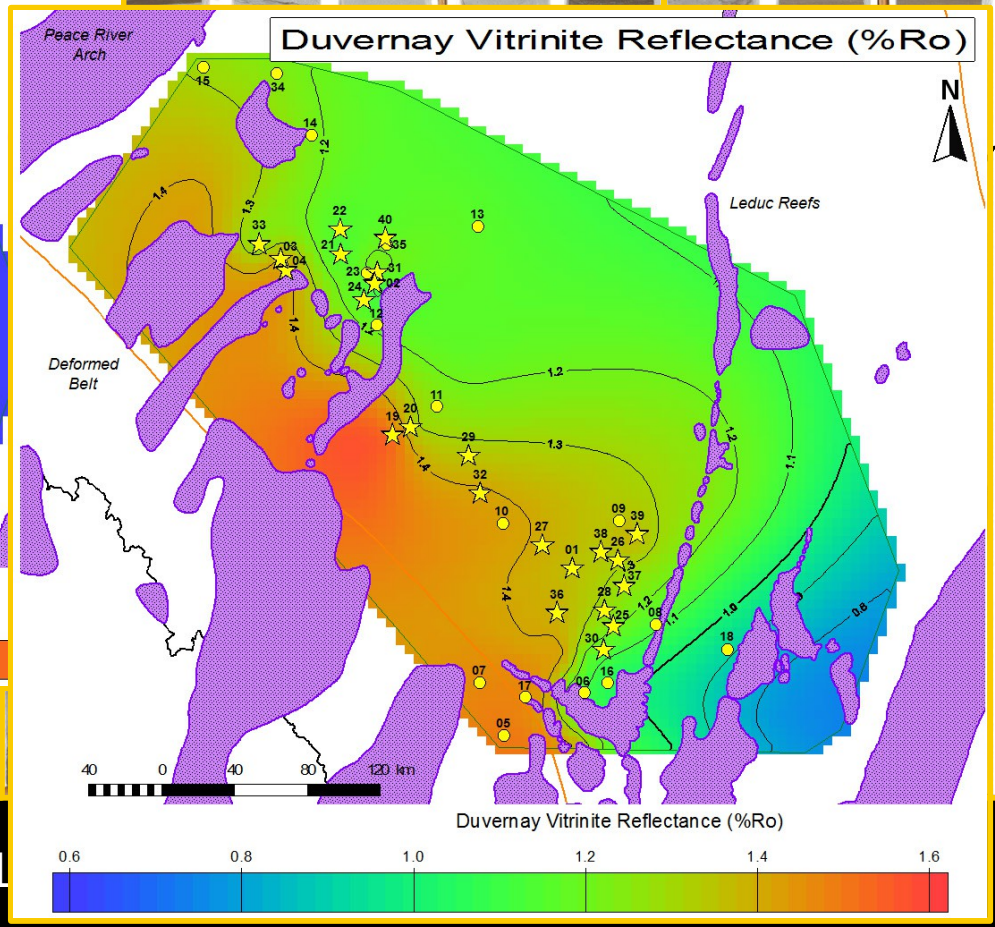
max: 443 - OIL

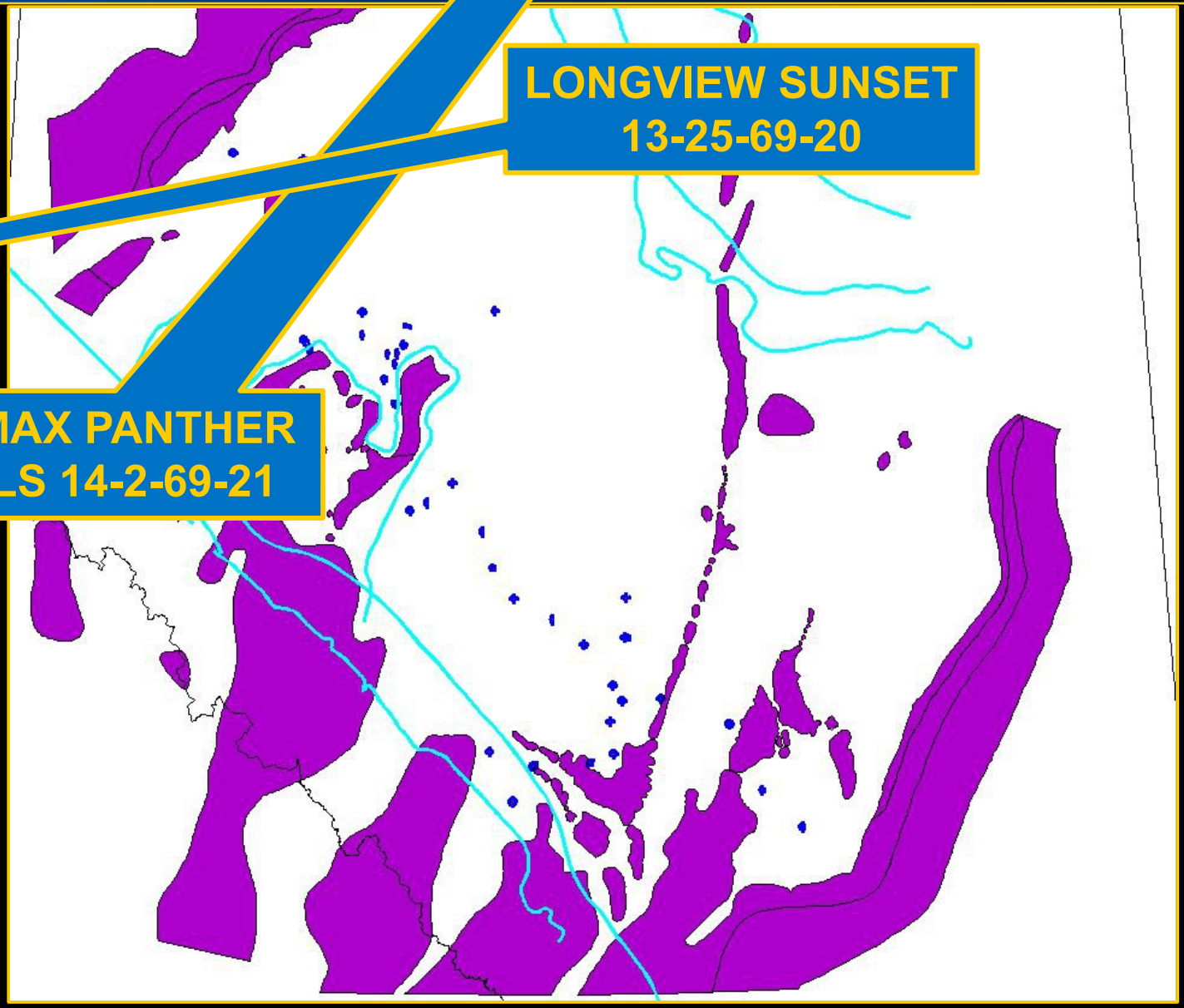
vt.%





EAST SHAL

NORTH OF KAYBOB
DUVERNAY + M[illegible]JEAU LAKE



NORTH OF KAYBOB
DUVERNAY + MAJEAU LAKE

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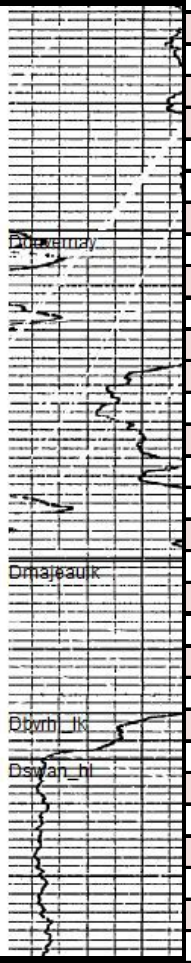
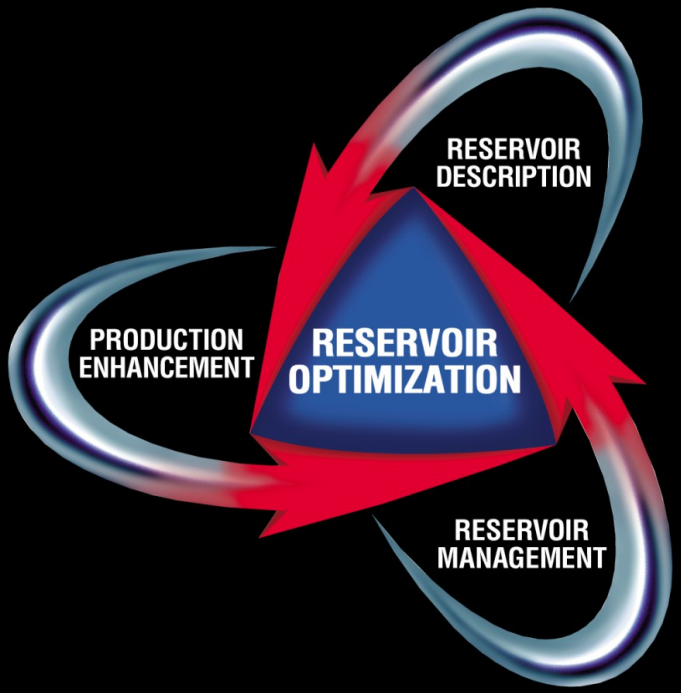
RESERVOIR OPTIMIZATION

GR



Sample I.D.	Sample Type	Formation	Zone #	Measured Core top (m)	Total Organic %	Zone Average %	Tmax °C	Zone Avg Tmax °C	Effective Ø (%)	Total Ø (%)	Average Effective Zone Ø (%)	Average Total Zone Ø
B104	canister	Duvernay	1	2713.00	3.02	2.53	447	445			3.17	5.49
AB104	plug		1	2713.30	3.49		441		3.38	6.66		
B106	canister		1	2715.00	2.92		444					
AB106	plug		1	2715.30	2.81		442		2.33	4.24		
AB109	plug		1	2717.00	2.69		443		3.69	6.97		
B109	canister		1	2717.10	2.61		446					
B113	canister		1	2719.00	2.99		446					
AB113	plug		1	2719.33	3.23		447		3.47	5.78		
B115	canister		1	2721.00	2.36		448					
AB115	plug		1	2721.34	1.59		441		0.93	2.21		
B116	canister		2	2723.00	0.87		447					
AB116	plug		2	2723.35	1.53		444		2.99	4.39		
AB117	plug		2	2725.00	0.54		449		3.49	4.88		
B117	canister		2	2725.19	1.19		448					
AB129	plug		2	2727.00	0.90		443		4.96	7.24		
B129	canister		2	2727.19	1.61		447					
B130	canister		2	2729.00	4.01		448					
AB130	plug		2	2729.30	3.68		446		2.24	5.58		
B131	canister		2	2730.97	4.07		449					
AB131	plug		2	2731.27	4.41		446		4.20	6.94		
B132	canister	Majeau LK	3	2732.97	1.14	2.32	446	445			3.51	6.89
AB132	plug		3	2733.27	1.07		439		5.33	8.39		
B133	canister		3	2734.97	1.65		449					
AB133	plug		3	2735.27	1.66		445		2.86	6.14		
B134	canister		3	2736.97	1.94		450					
AB134	plug		3	2737.32	1.64		446		3.03	7.42		
B137	canister		3	2738.97	2.42		447					
AB137	plug		3	2739.27	2.64		441		2.90	7.31		
B138	canister		3	2741.00	2.78		448					
AB138	plug		3	2741.30	3.42		439		1.97	4.97		
B140	canister		3	2743.00	3.73		446					
AB140	plug		3	2743.30	3.73		445		4.94	7.14		

N



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Integrated Reservoir Solutions Division