

Geological, Geochemical and Geophysical Characteristics of the Devonian Oil Shales in Central Mackenzie Valley, NWT, Canada*

Michael E. Enachescu¹, Paul R. Price², John R. Hogg², Fred Kierulf², Murray F. J. Cooper², and A. C. Springer²

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¹MGM Energy Corp., Calgary, Alberta, Canada (Michael.Enachescu@mgmenergy.com)

²MGM Energy Corp., Calgary, Alberta, Canada

Abstract

A significant land posting and bidding event has occurred in Canada's north near the Arctic Circle. During the 2011-2012 period over 1 million hectares (2.5 million acres) were licensed in a region within the Northwest Territories of Canada called the Central Mackenzie Valley (CMV). A combined 624 Million dollars (CDN) were pledged as work commitments for unconventional oil shale exploration.

Within the CMV a well-developed and extensive Paleozoic basin had seen significant exploration for conventional oil and gas resources. While exploring this basin two highly prospective Mid to Upper Devonian organic rich shales were delineated at depths of 100 to over 2400 m. One of these shales has been identified by rock geochemistry as the source rock for the giant conventional Norman Wells Oil field (greater than 300MMBbls recoverable).

These shales, the Canol Formation and Bluefish Member, have excellent total porosity (8% to more than 16%), high total organic carbon (6% and greater), very low clay content, high silica content and low bound water, all of which makes them excellent candidates for oil shale development using horizontal wells and multi-staged fracture technology. The main target on the MGM's operated exploration licenses is the Canol Shale with its thickness up to 130 m. This paper will discuss the geological, geochemical, and geophysical characteristics of the two shale sections and present some preliminary results from a 2012 vertical well drilling, coring and testing program.

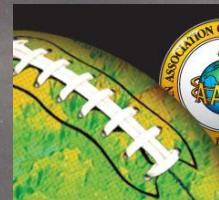
Selected Website

Blakey, R.C., 2011, Colorado Plateau Geosystems, Inc. Website accessed December 12, 2013. <http://www2.nau.edu/rcb7/>

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MGM Energy Corp

Pittsburgh, Pa, 22 May 2012



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WITH SEPM (SOCIETY FOR SEDIMENTARY GEOLOGY)

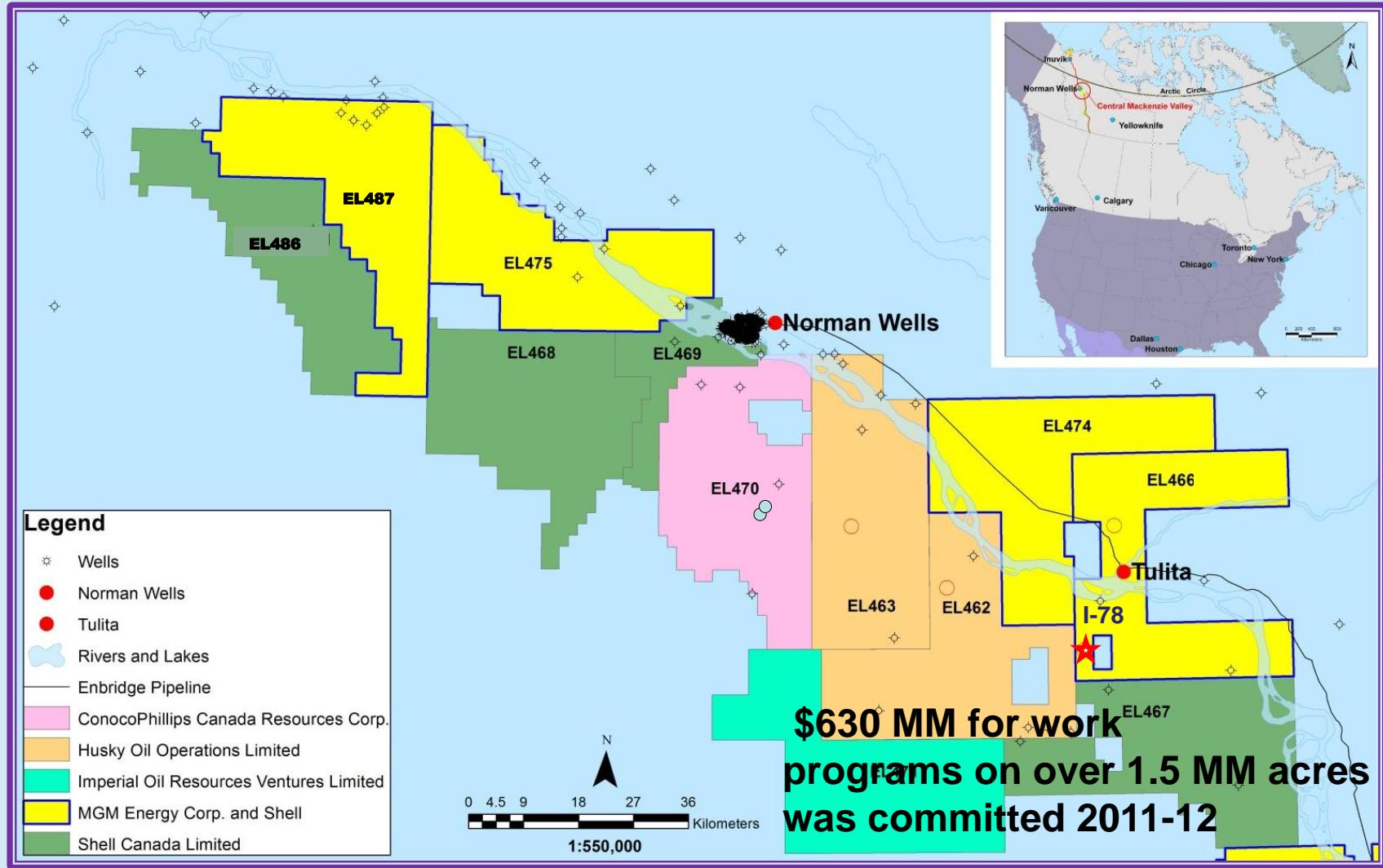
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- **Regional Geological Setting**
- **Organic Geochemistry and Petrography**
- **Seismic Characteristics of Devonian Shales**
- **Regional Canol Profile and Map**
- **East MacKay I-78**
- **Conclusions**



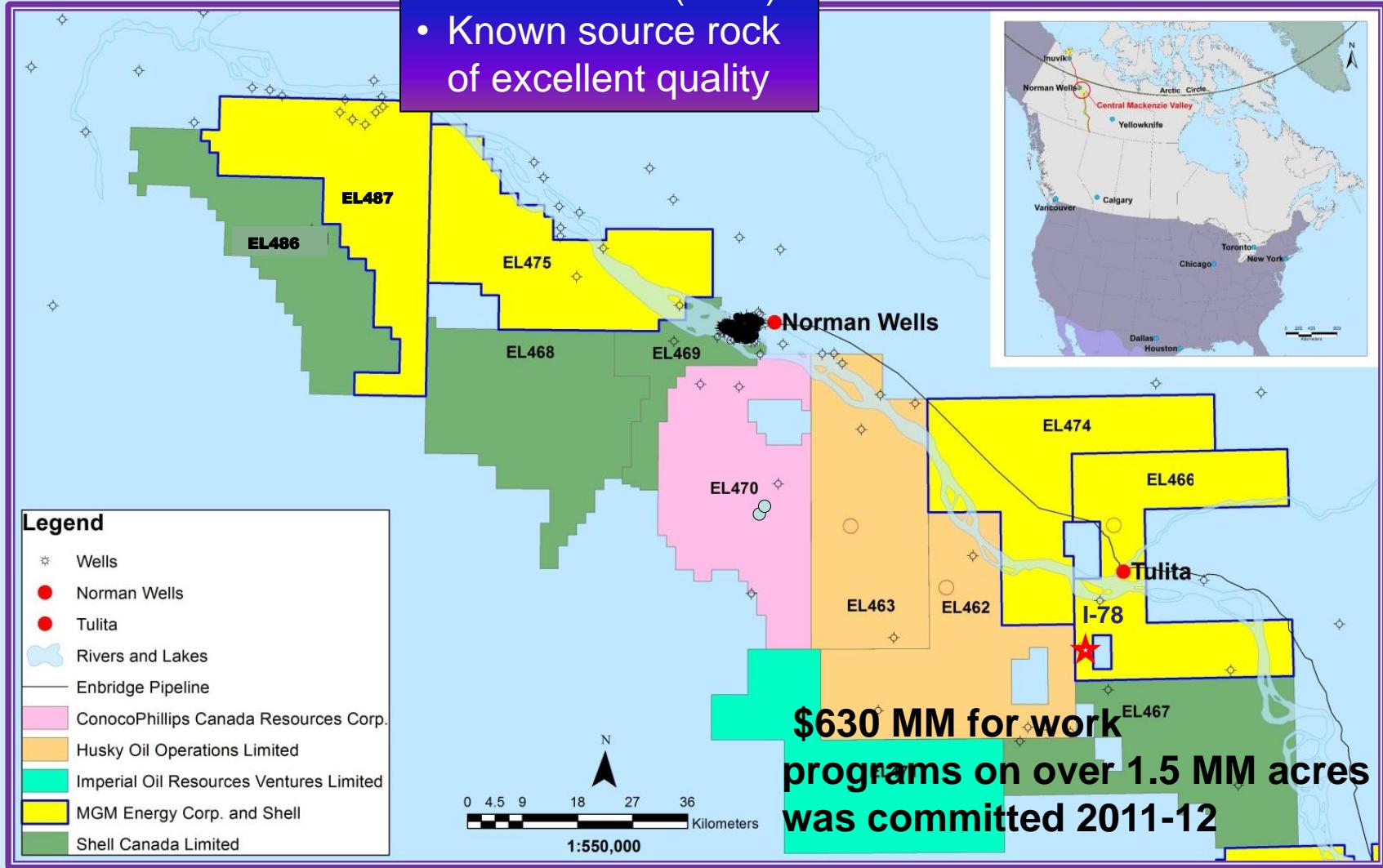
Introduction





- 270 MMbbls produced from a Recoverable Resources of over 300 MMbbls (NEB)
- Known source rock of excellent quality

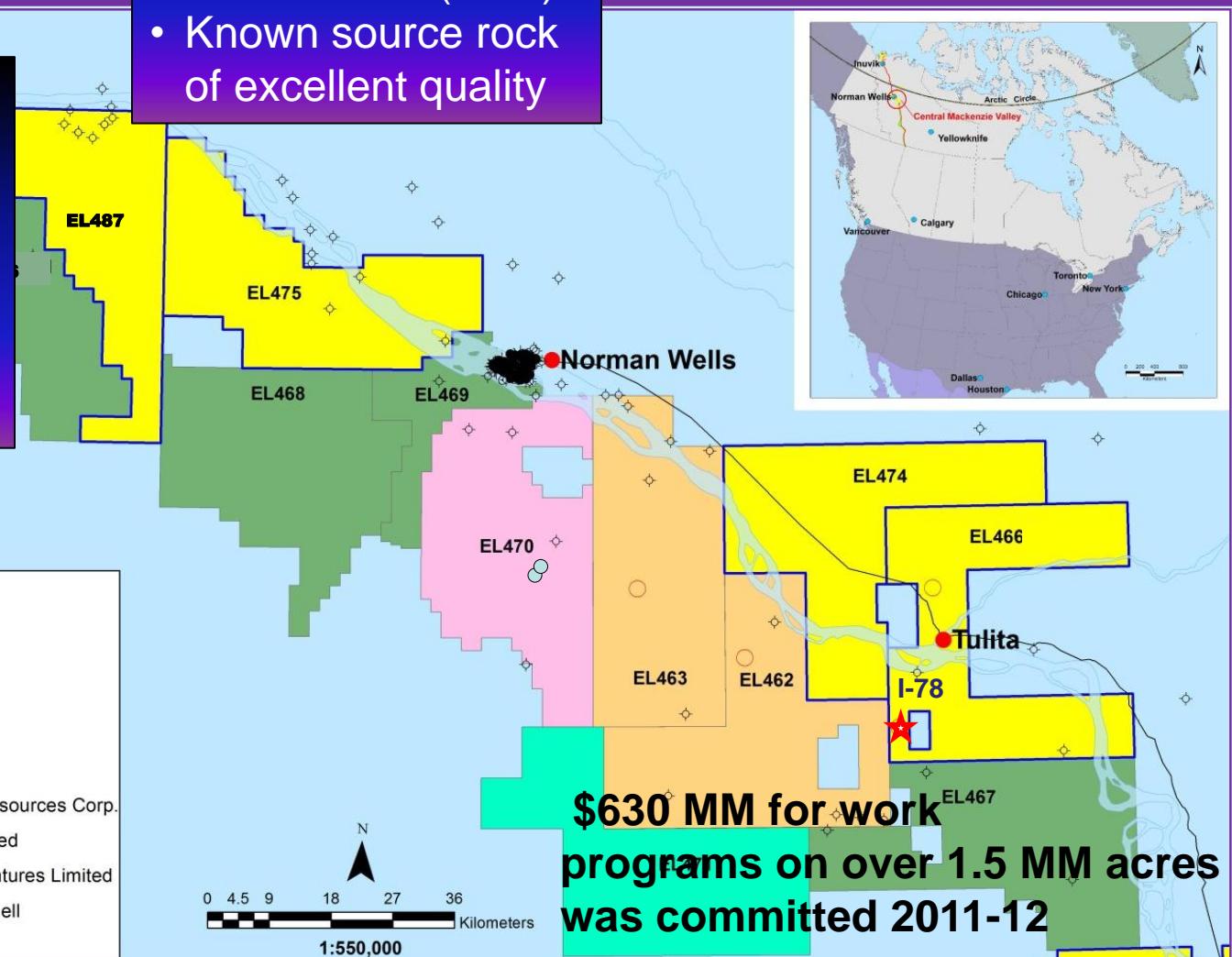
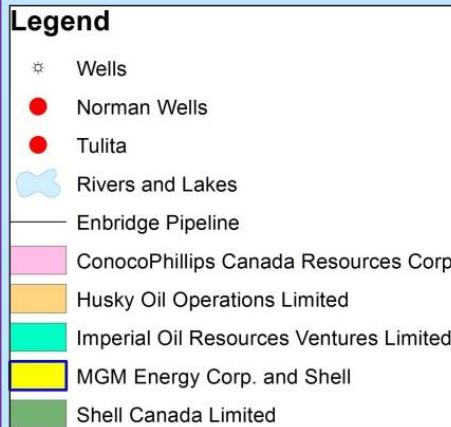
Introduction





- 270 MMbbls produced from a Recoverable Resources of over 300 MMbbls (NEB)
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A 39,400 bopd pipeline, operated by Enbridge from Norman Wells to Zama (870 Km) is running at about 20 % capacity



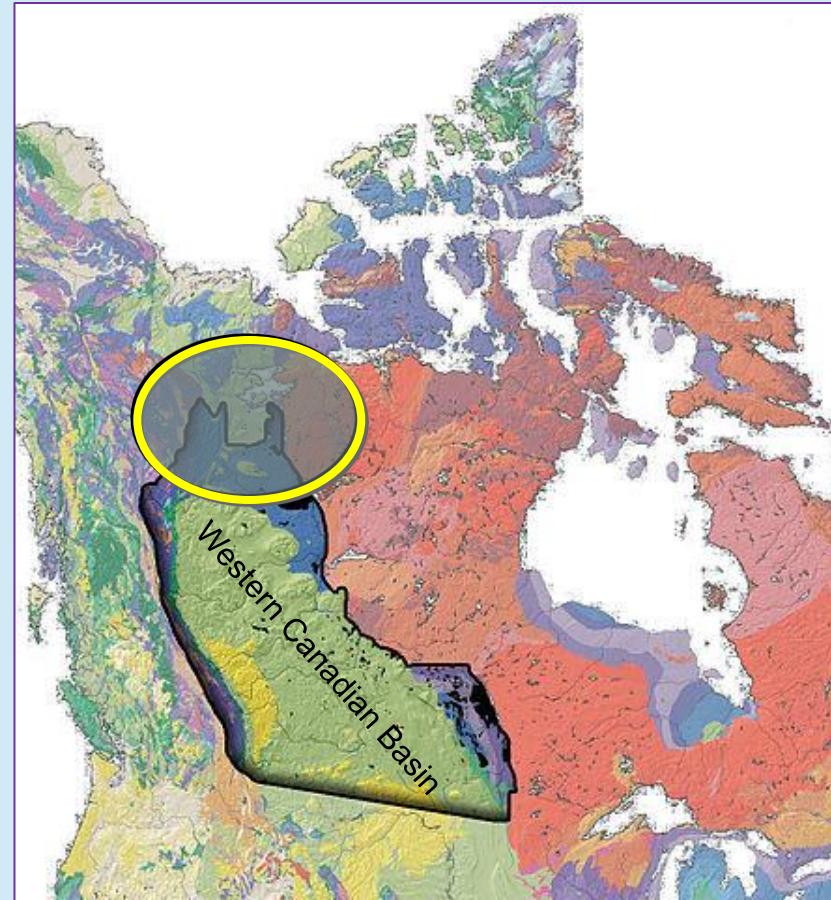
Introduction

Up to Now, Only Winter Operation Feasible!

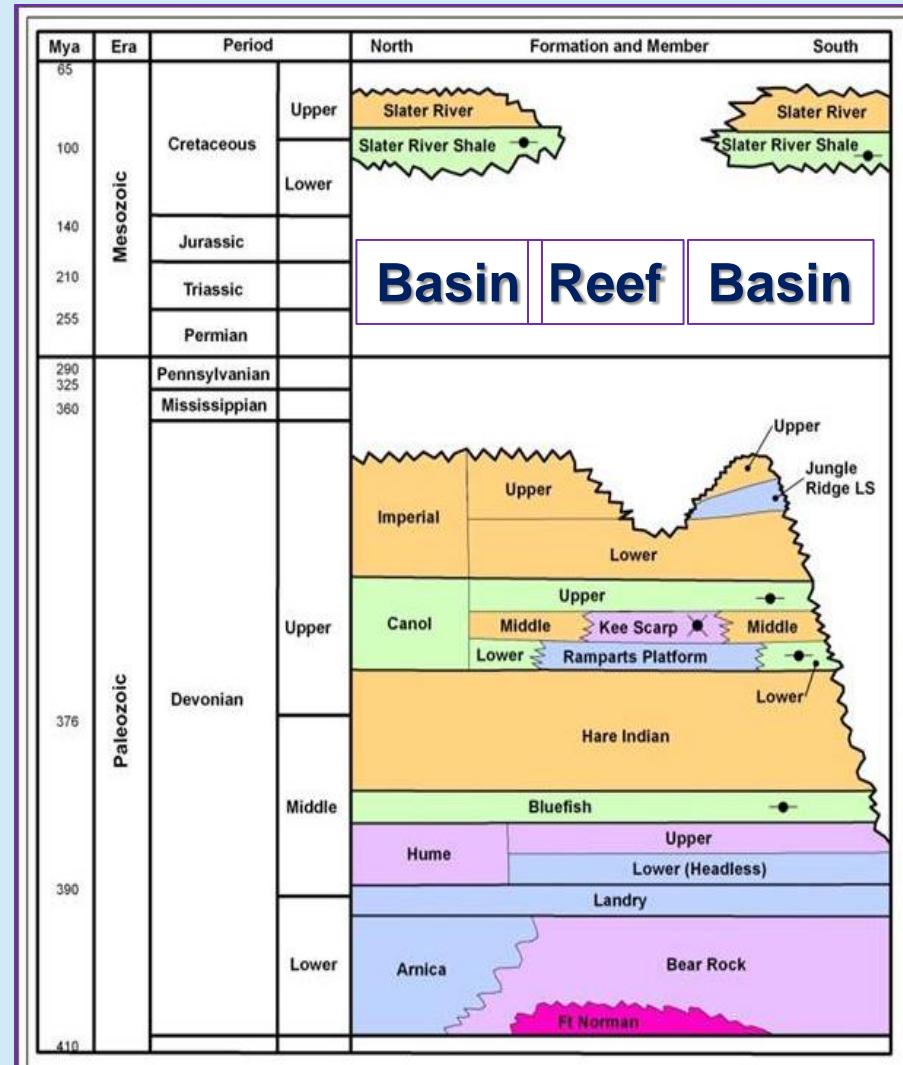
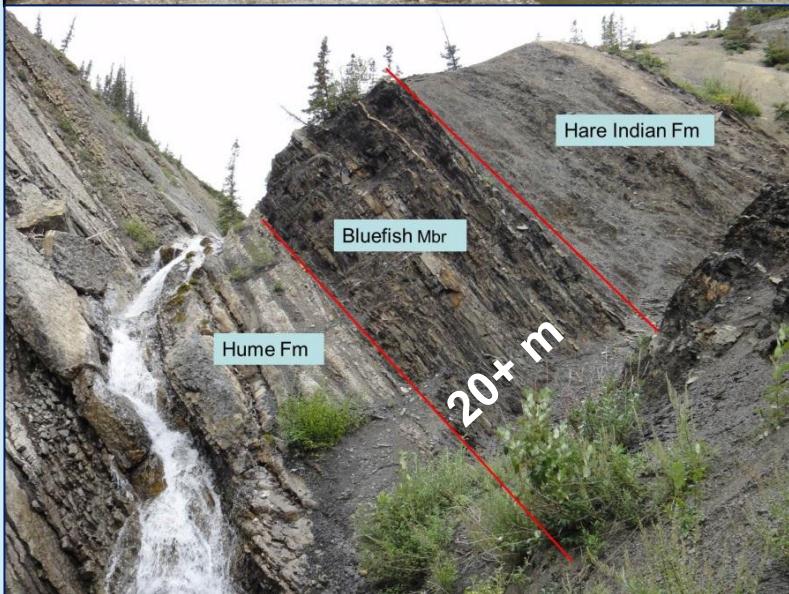


Central Mackenzie Valley Regional Geological Setting

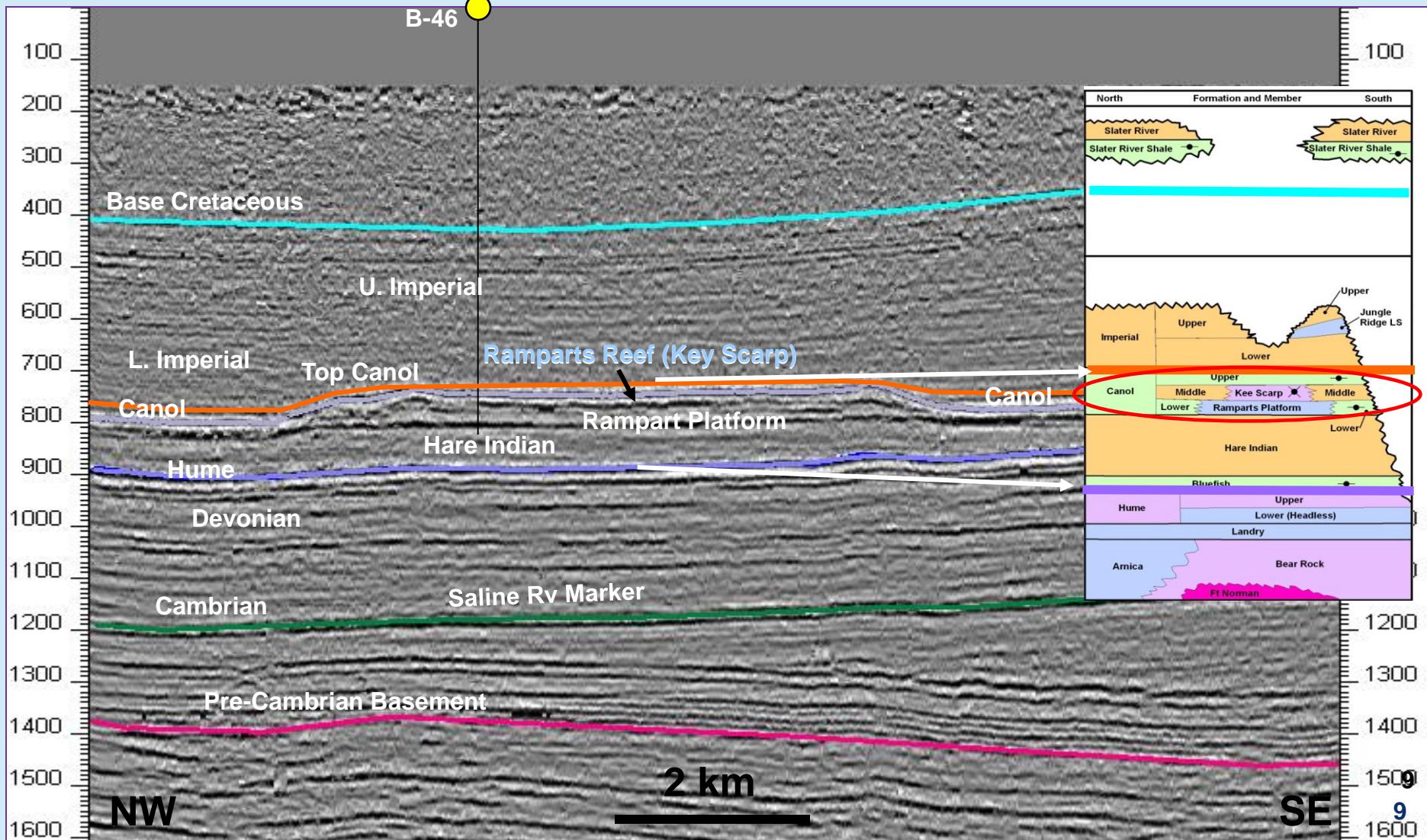
- Northern extension of the WCSB
- Paleozoic continental margin basin
 - Platformal/Reefal carbonates
 - Evaporites
 - Clastics
- Unconformably overlain by a Cretaceous foreland basin
 - Clastics and Coals
- Evolution includes repeated episodes of extension, trans-tension and compression
 - Platformal in the east through simple monoclines to a fold and overthrust belt in the west



Reef and Basinal Stratigraphy

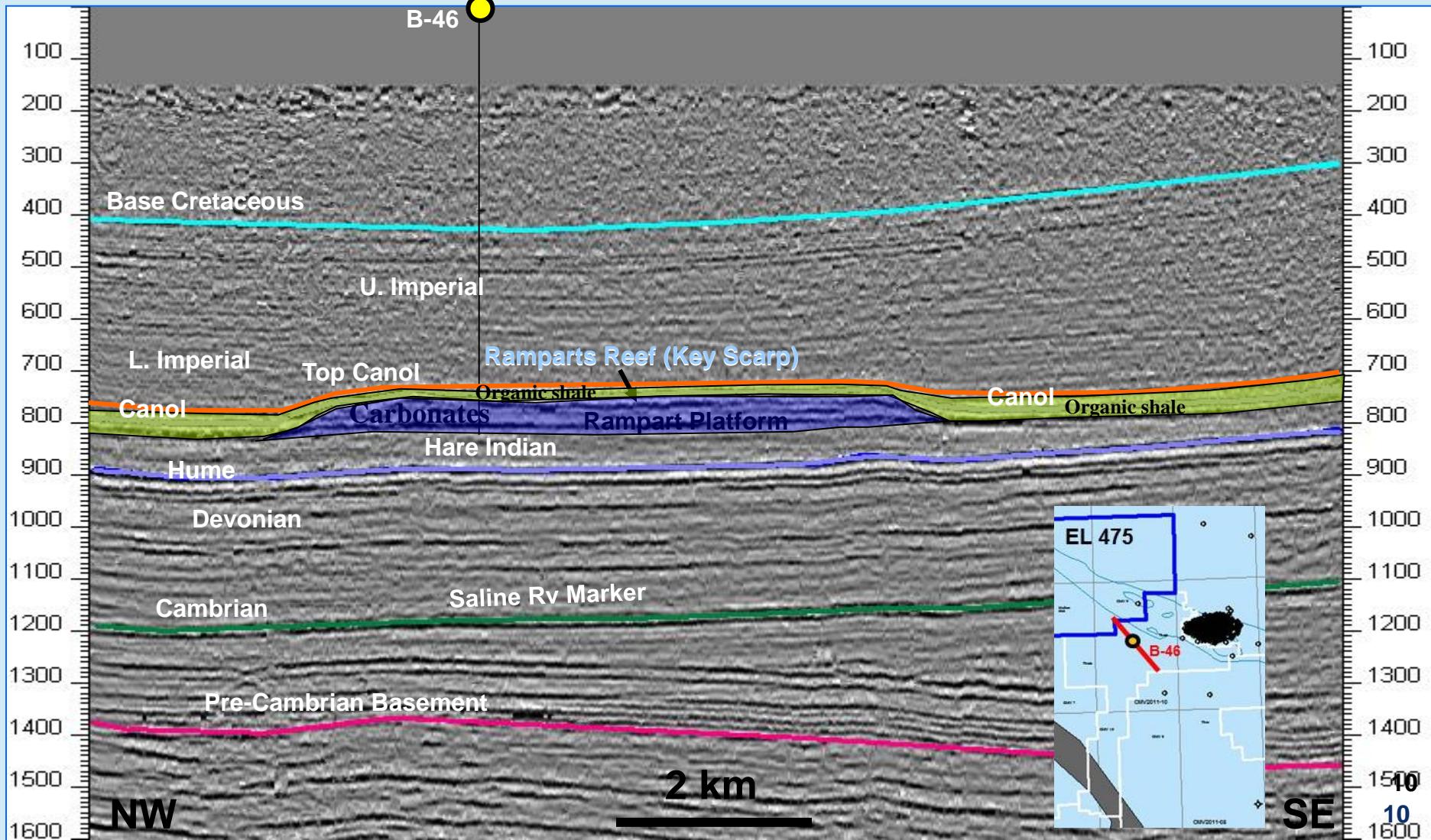


Regional Geology, Ramparts Reef and Shale Basin



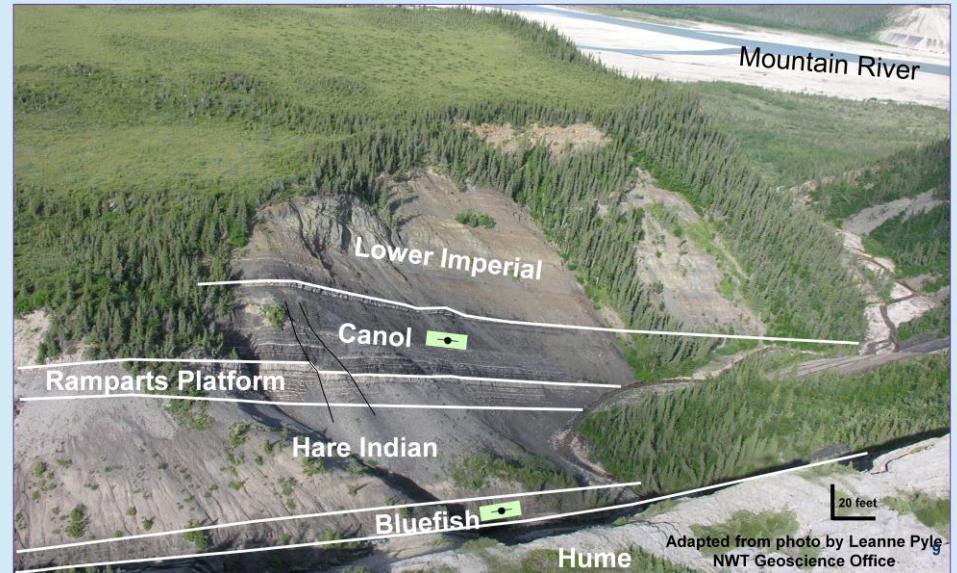


Regional Geology, Ramparts Reef and Shale Basin





Middle to Late Devonian Geology of the Central Mackenzie Valley



Presenter's notes: **Stratigraphy from bottom up:**

Hume – last of a long succession of platformal carbonates and local evaporitic basins that began in the lower Devonian; composed of limestone/dolomite; may locally be a potential conventional reservoir, locally porous, locally vuggy, massive, nodular, fossiliferous, argillaceous; locally reefal and/or dolomitized

Bluefish - represents a marine transgression of the previous stable platform; – first of 2 such drowning events; composed of a bituminous highly organic black shale; occasional thin limestone interbeds potential source rock

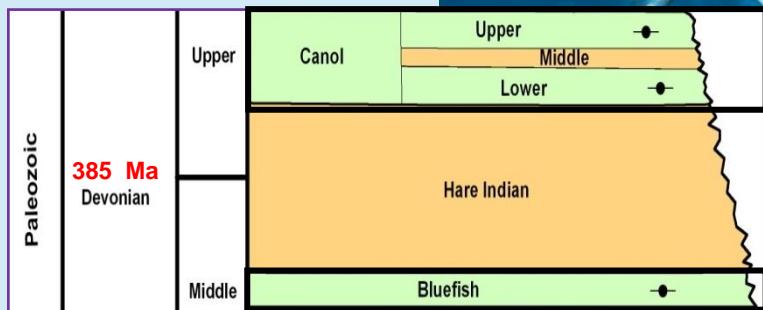
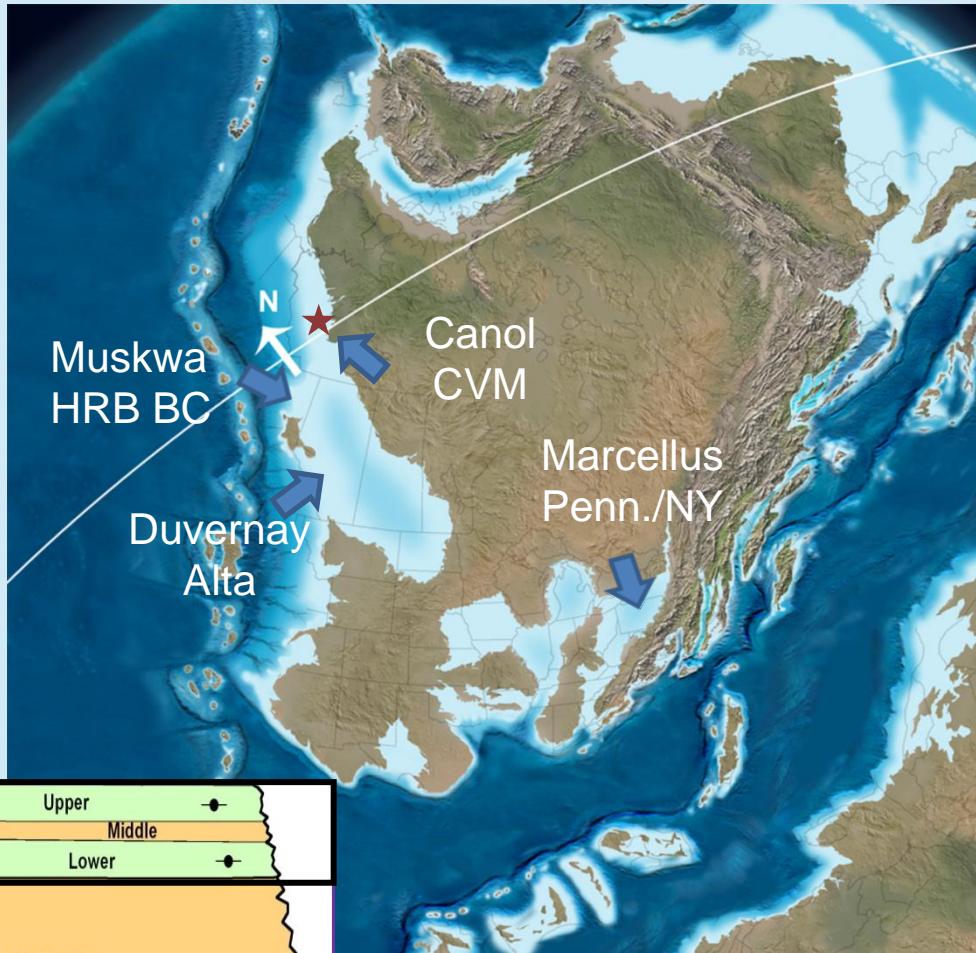
Hare Indian – Shale generally thin-bedded, calcareous, micaceous with minor thin limestones; generally low TOC and tight

Ramparts Platform – not present everywhere;

Canol – Shale - Second major flooding event; Dark grey to black, organic rich, bituminous, yellow and rusty-brown weathering, siliceous, thin-bedded, fissile and predominantly non-calcareous shales; may locally contain paper thin black chert beds; may contain ironstone nodules at discrete stratigraphic intervals; in outcrop may have bright yellow sulphide and white mineral coatings at scattered intervals.

Lower Imperial – Predominantly marine shale with occasional interbedded marine siltstones and sandstones; major sandstone (Canyon SS) locally developed - tight fine to medium-grained sandstones and sandy shales

Paleogeographic Setting Middle Devonian Time (385 Ma)

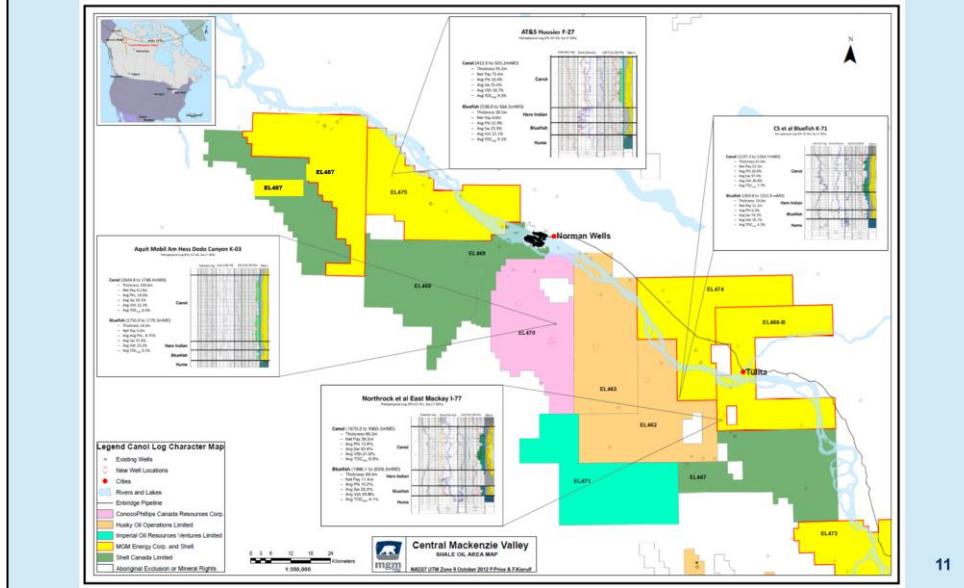


Adapted from figure on Colorado Plateau Geosystems, Inc. website after Blakey, R.C.
March 2011



CMV Land and Key Well Logs

mrm



Presenter's notes: Now take you on a bit of a geological field trip

We will look at 4 key wells in basin (from south to north) and Travel ~124kms from south to the north

- 1) Start at I-77 (on EL 466) then go to
- 2) K-71 (on EL 474).... 15 kms from I-77 then go to
- 3) K-03 (on EL 470).... 58 kms from I-77 (43 kms from K-71) and finally go to
- 4) F-27 (on EL 475).... 124 kms from I-77 (67 kms from K-03)

I Want to show how:

- a) correlatable lower Imperial to Hume section is
- b) How consistent along strike the thicknesses and other parameters are within the Canol and Bluefish

Northrock et al East Mackay I-77

Petrophysical Log (Φ_T GT 6%, Sw LT 50%)

Induction log

Sonic/DN-PE

GR/TOC/SP/Phi

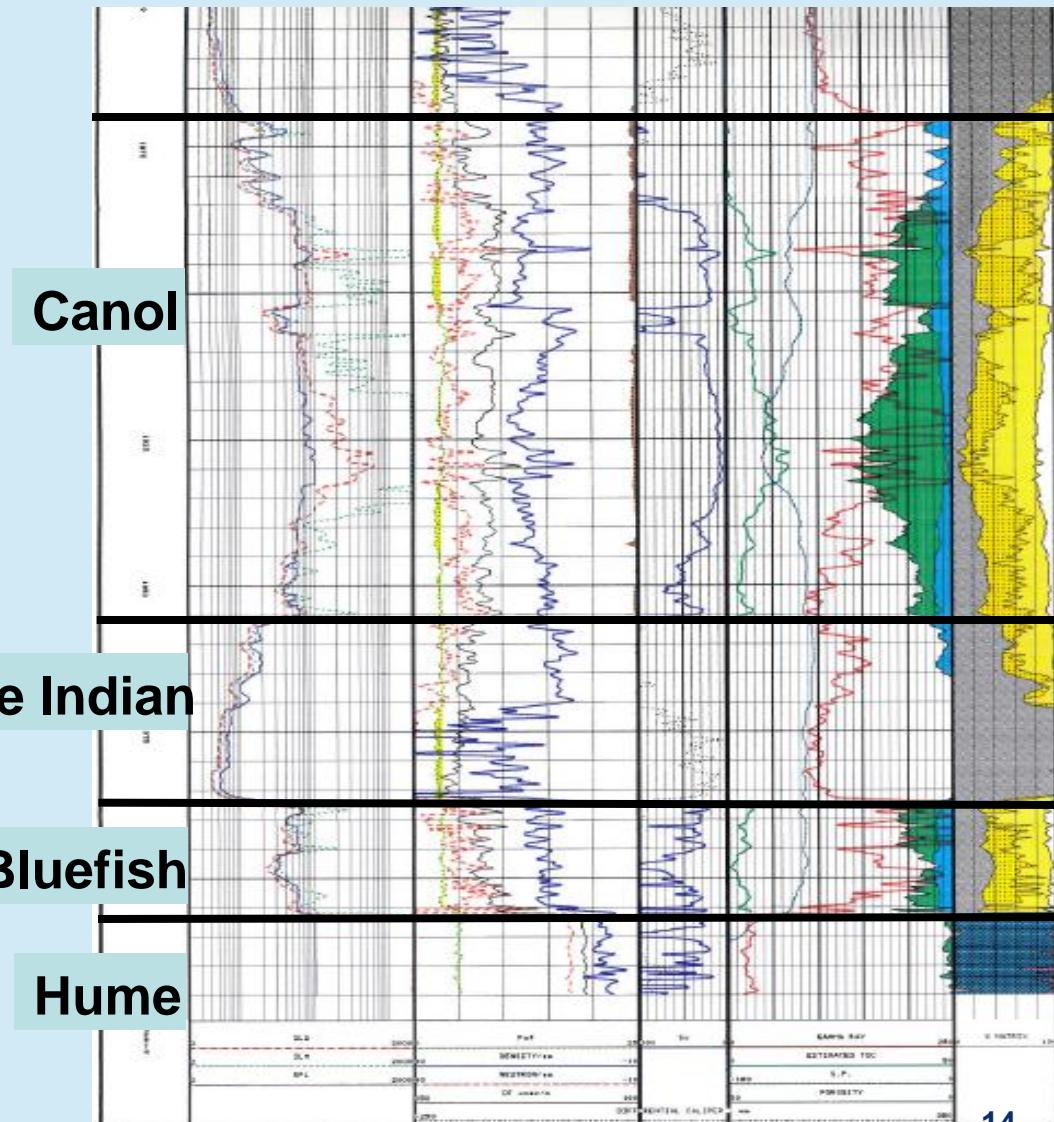
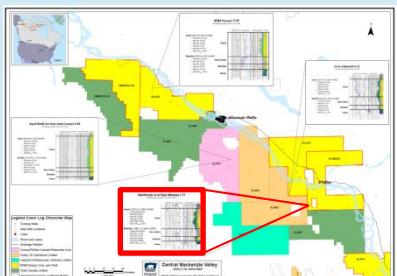
Matrix

Canol (1870.2 to 1965.5mMD)

- Thickness 95.3m
- Net Pay 59.3m
- Avg Φ_T 13.9%
- Avg Sw 20.9%
- Avg VSh 21.9%
- Avg TOC_{calc} 6.9%

Bluefish (1986.1 to 2006.5mMD)

- Thickness 20.4m
- Net Pay 11.4m
- Avg Avg Φ_T 10.2%
- Avg Sw 35.3%
- Avg Vsh 29.8%
- Avg TOC_{calc} 4.1%





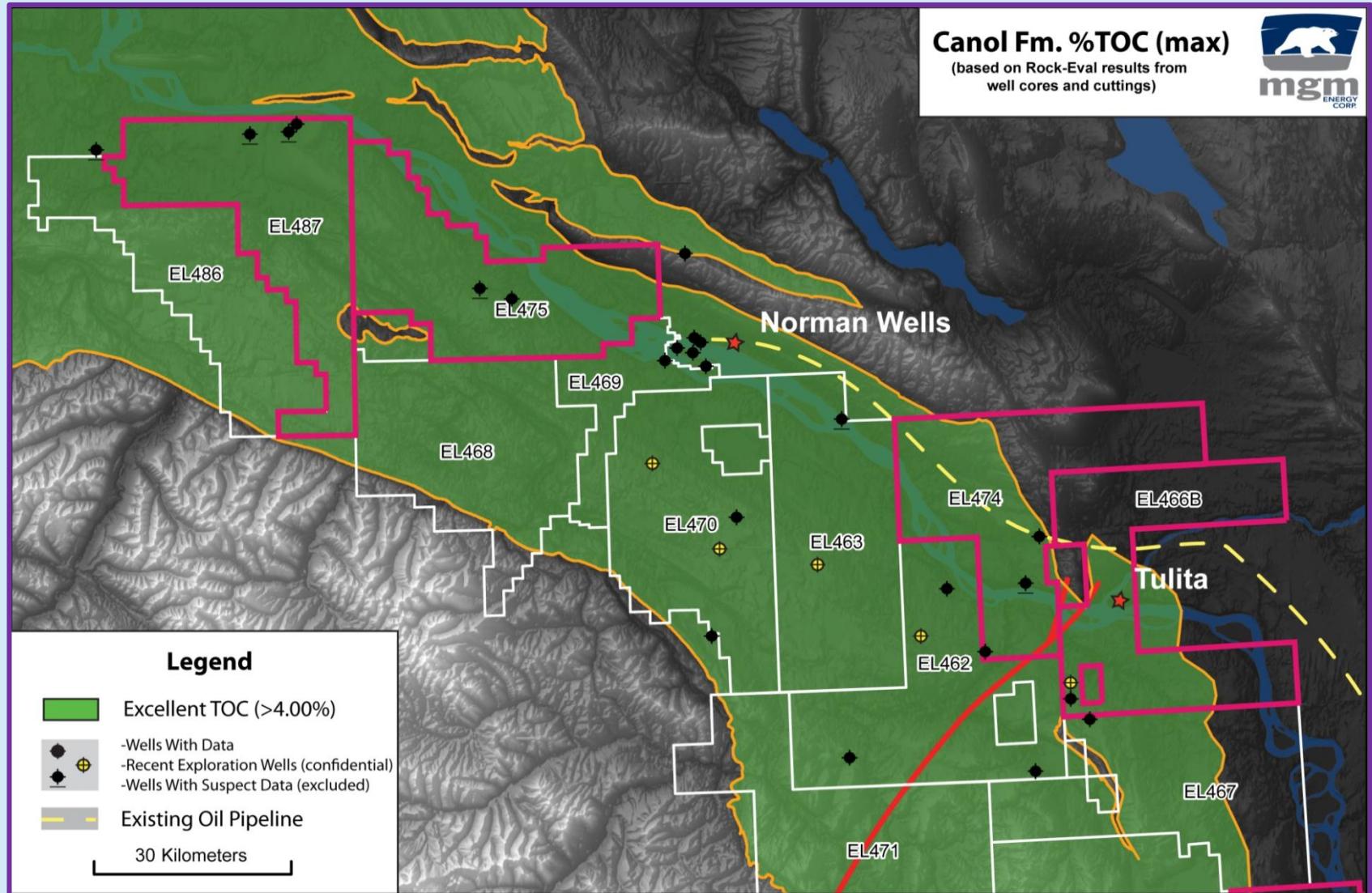
Petrophysical Summary

| Parameter | Canol | Bluefish |
|--------------------|--|---------------------|
| Depth (m) | Subcrop to 2000 | Subcrop to 2200 |
| Thickness (m) | 0 to 180 Avg Basinal 70 Avg on Reef 20 | 0 to 25 |
| Vsh (%) | 15 to 29 Avg 20 | 14 to 35 Avg 25 |
| Net Pay (m) | 50 to 100 Avg Basinal 75 | 0.5 to 18 Avg 12 |
| Total Porosity (%) | 8 to 18% Avg 12 | 8 to 17 Avg 11 |
| Sw (%) | 15 to 25 | 15 to 25 |
| TOC (%) | 6 to 24 Avg 8 | 4 to 10 Avg 6 |

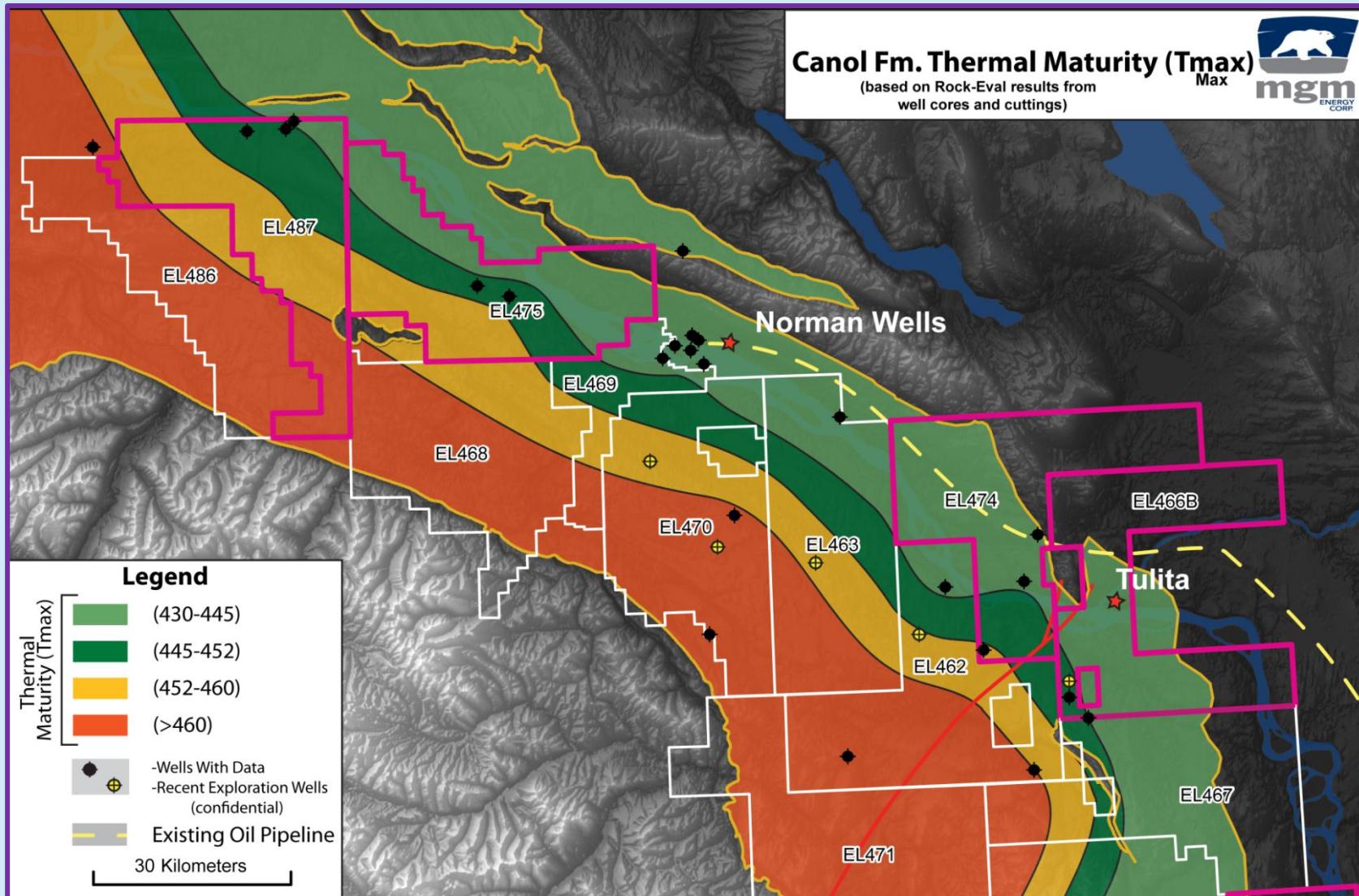
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Presenter's notes: Examined 18 wells in basin ... here is the summary of the data

Organic Geochemistry



Organic Geochemistry



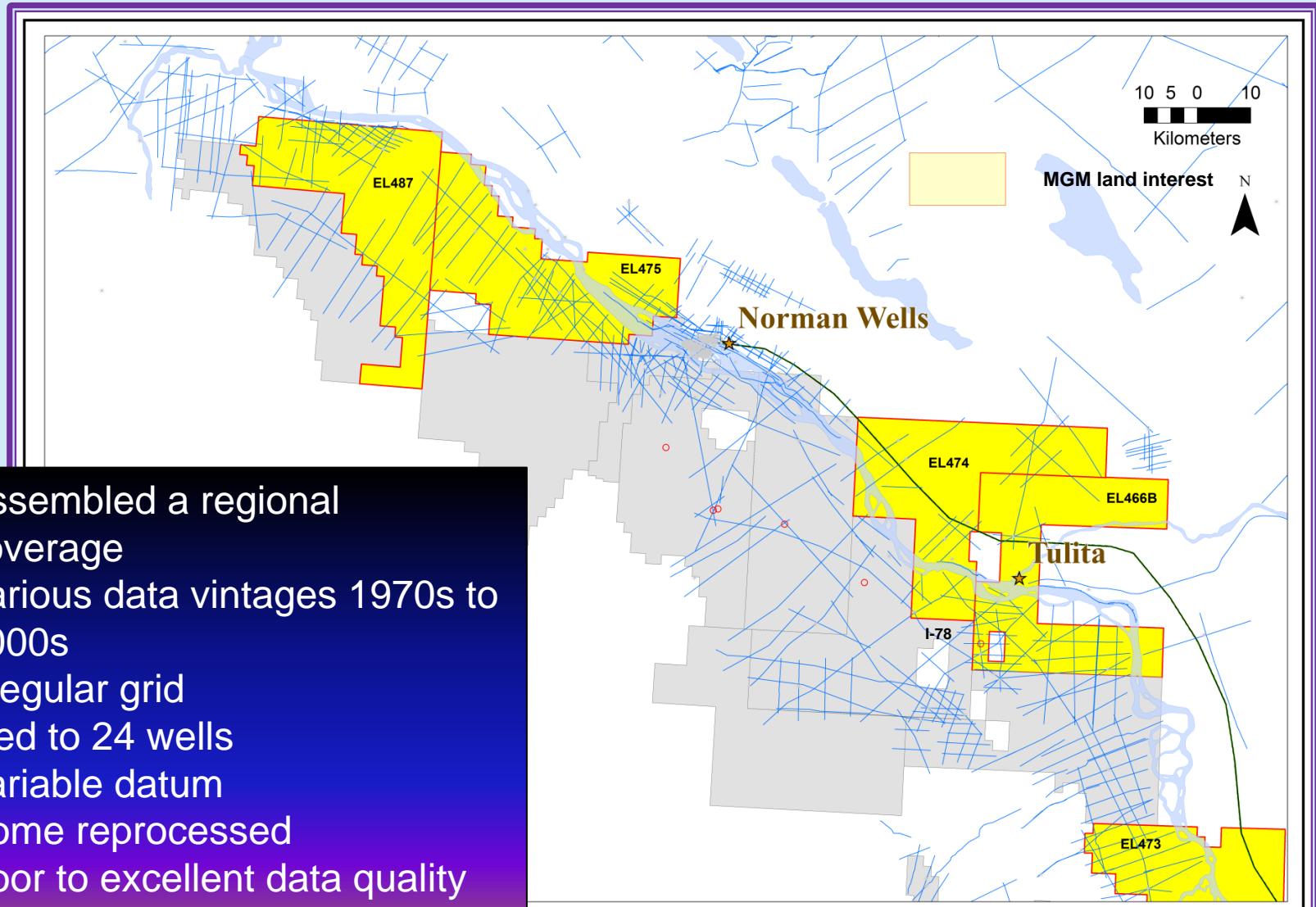
Geochemistry Summary

Canol and Bluefish Shale parameters compare favourably with proven shale resource plays:

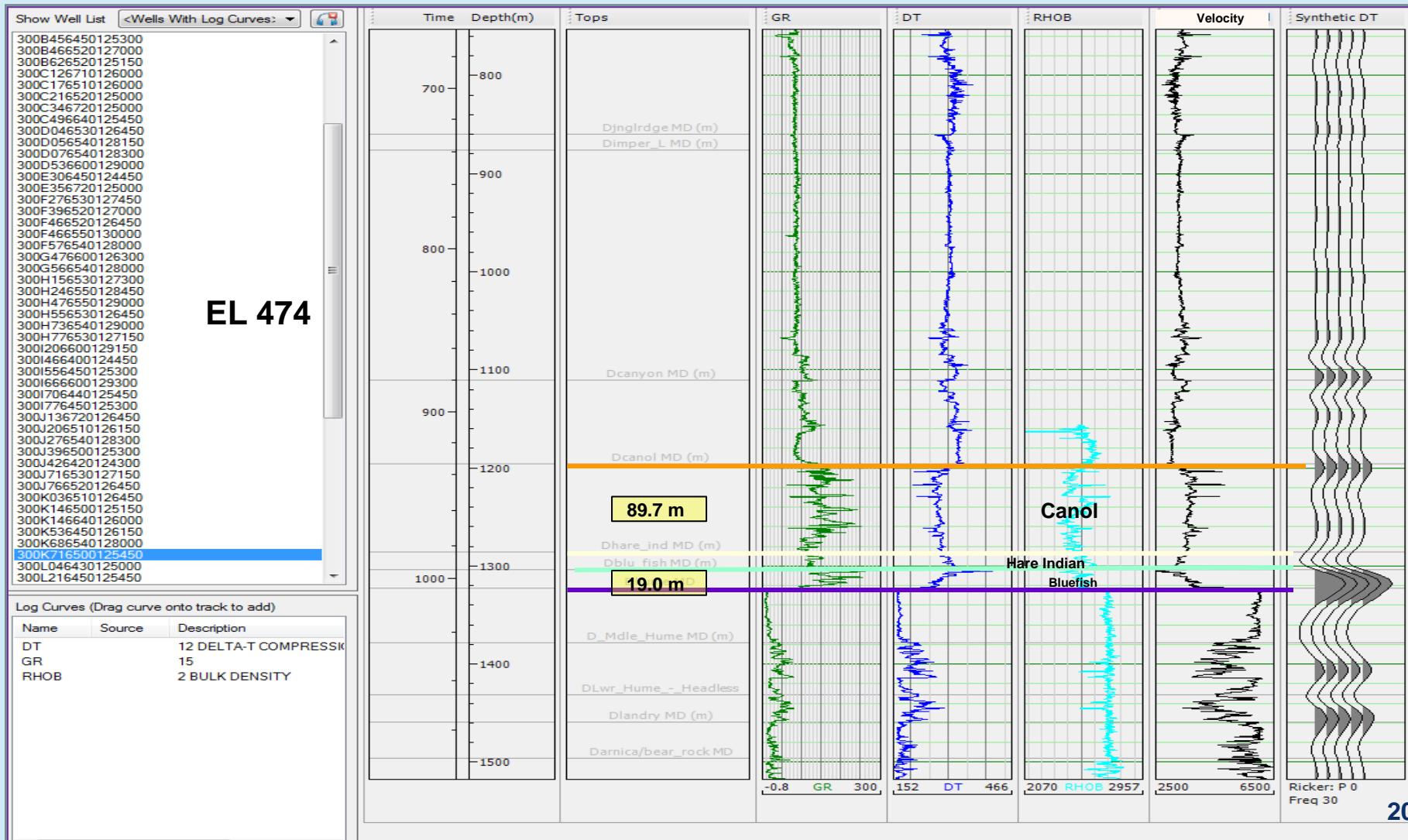
- **Organic Richness:** High TOC, excellent shale oil potential – Canol (3 to 27% in CMV; avg 6 to 8%)
- **Kerogen Type:** Liquid prone
- **Maturity:** Liquid window over most of the blocks



Seismic Coverage

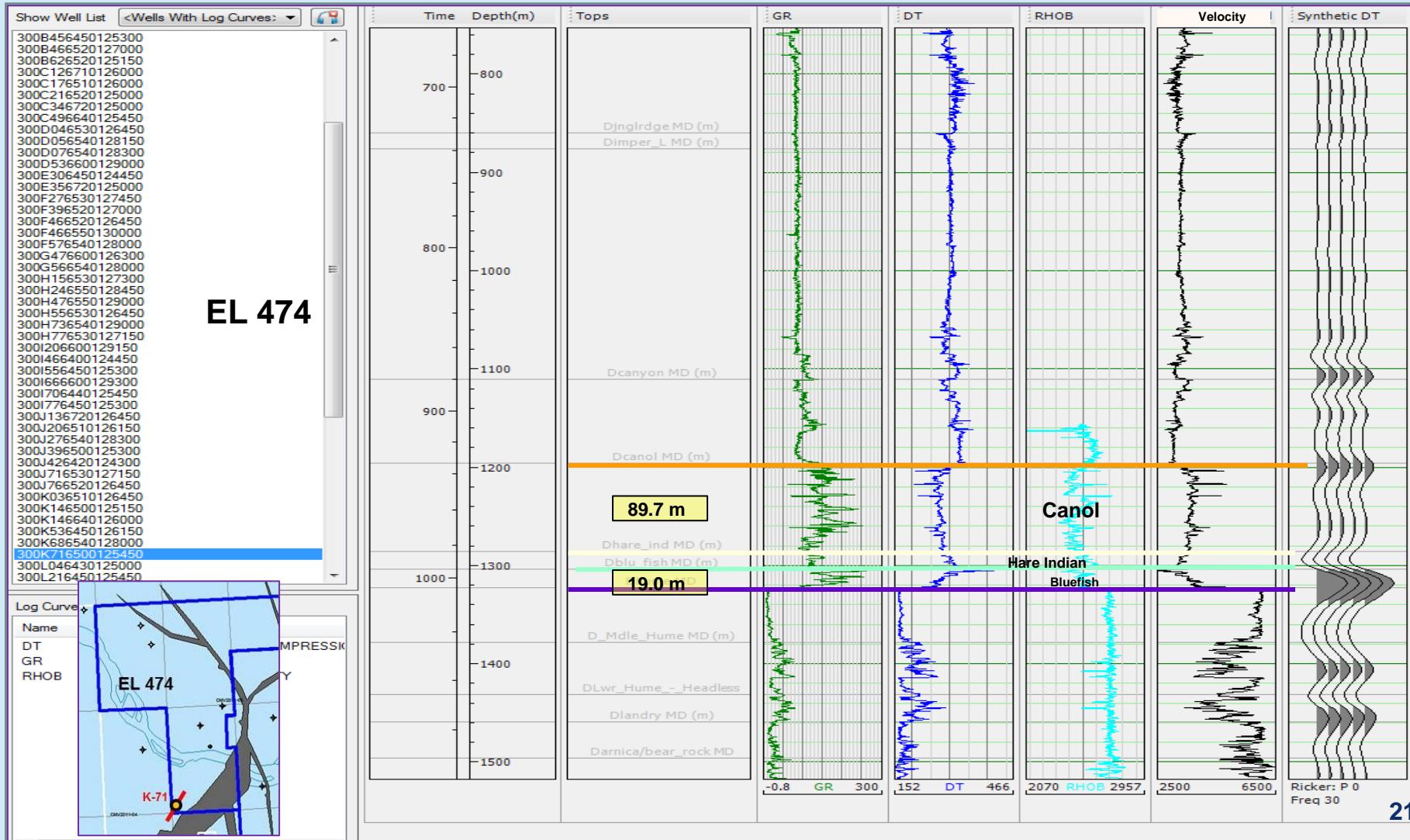


K-71 Synthetic Seismogram

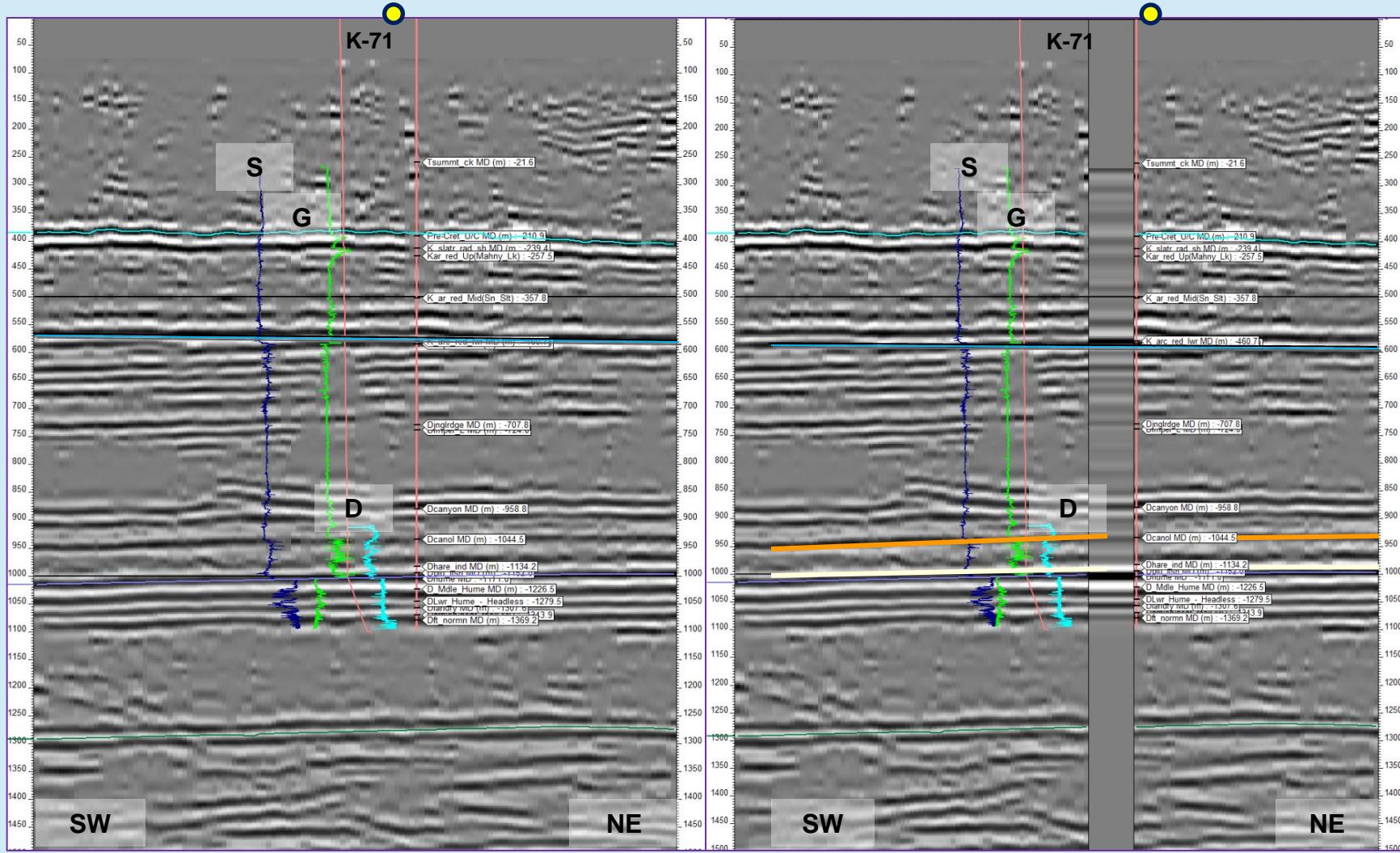




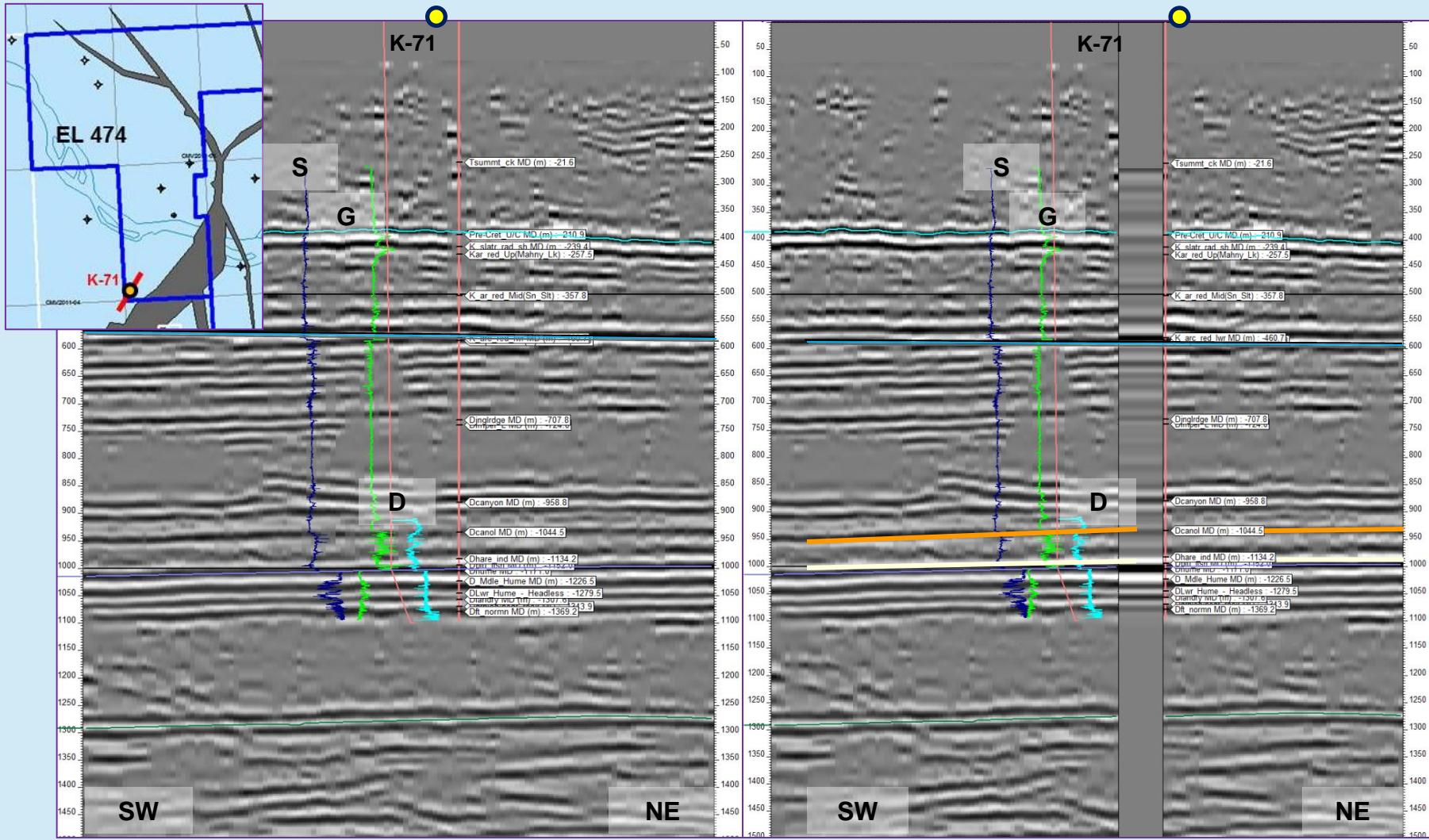
K-71 Synthetic Seismogram



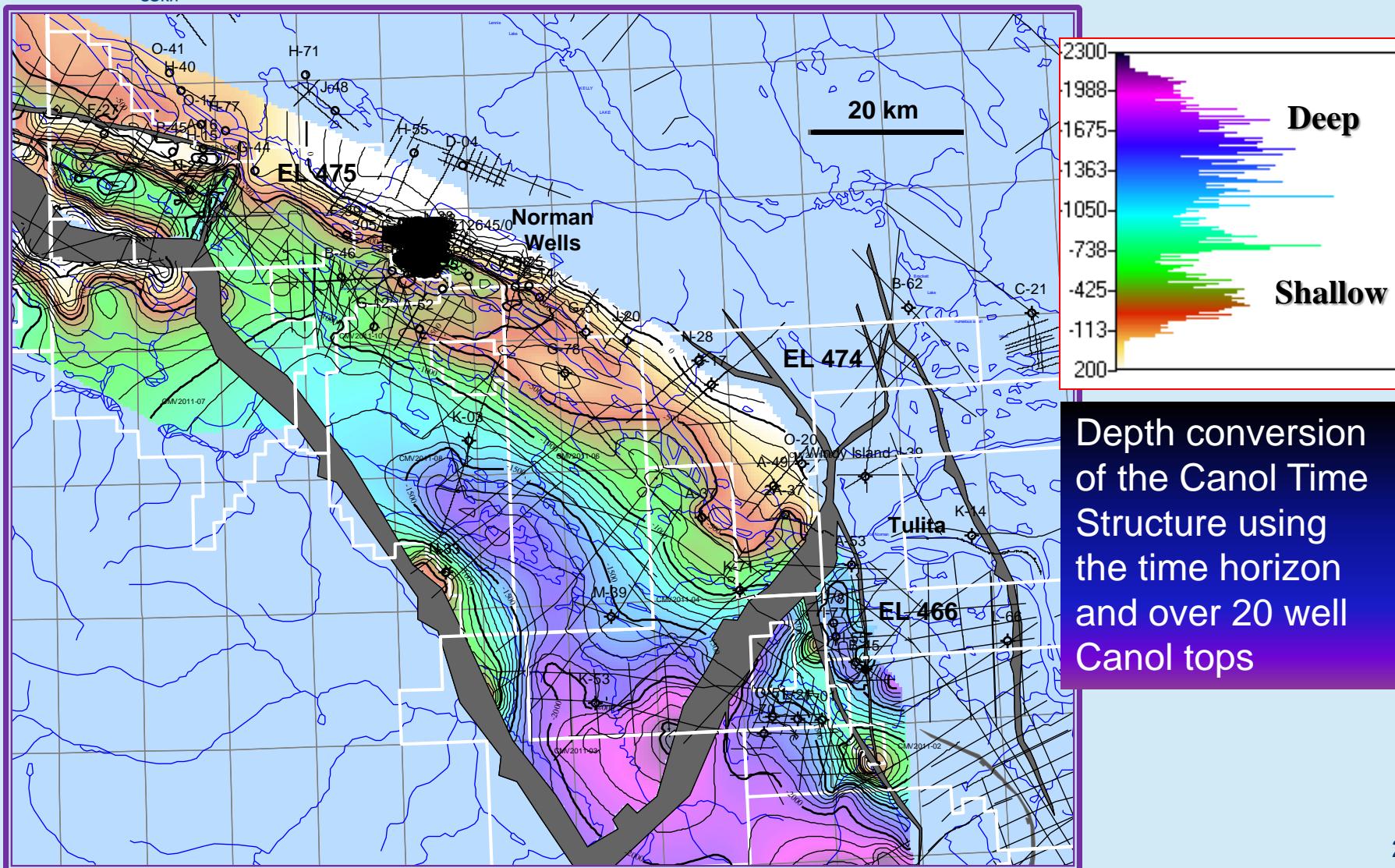
Seismic Section Through K-71



Seismic Section Through K-71



Canol Depth Map



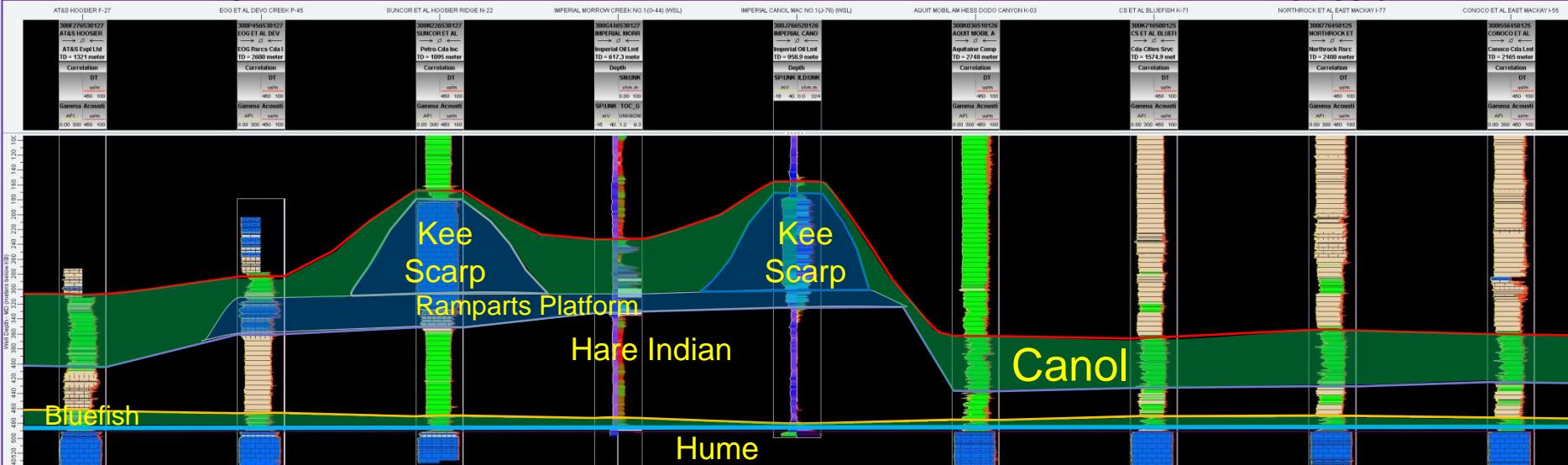


NW-SE Devonian Cross-section

Hoosier Ridge
EL 475

Norman Wells

East Mackay
ELs 466 & 474



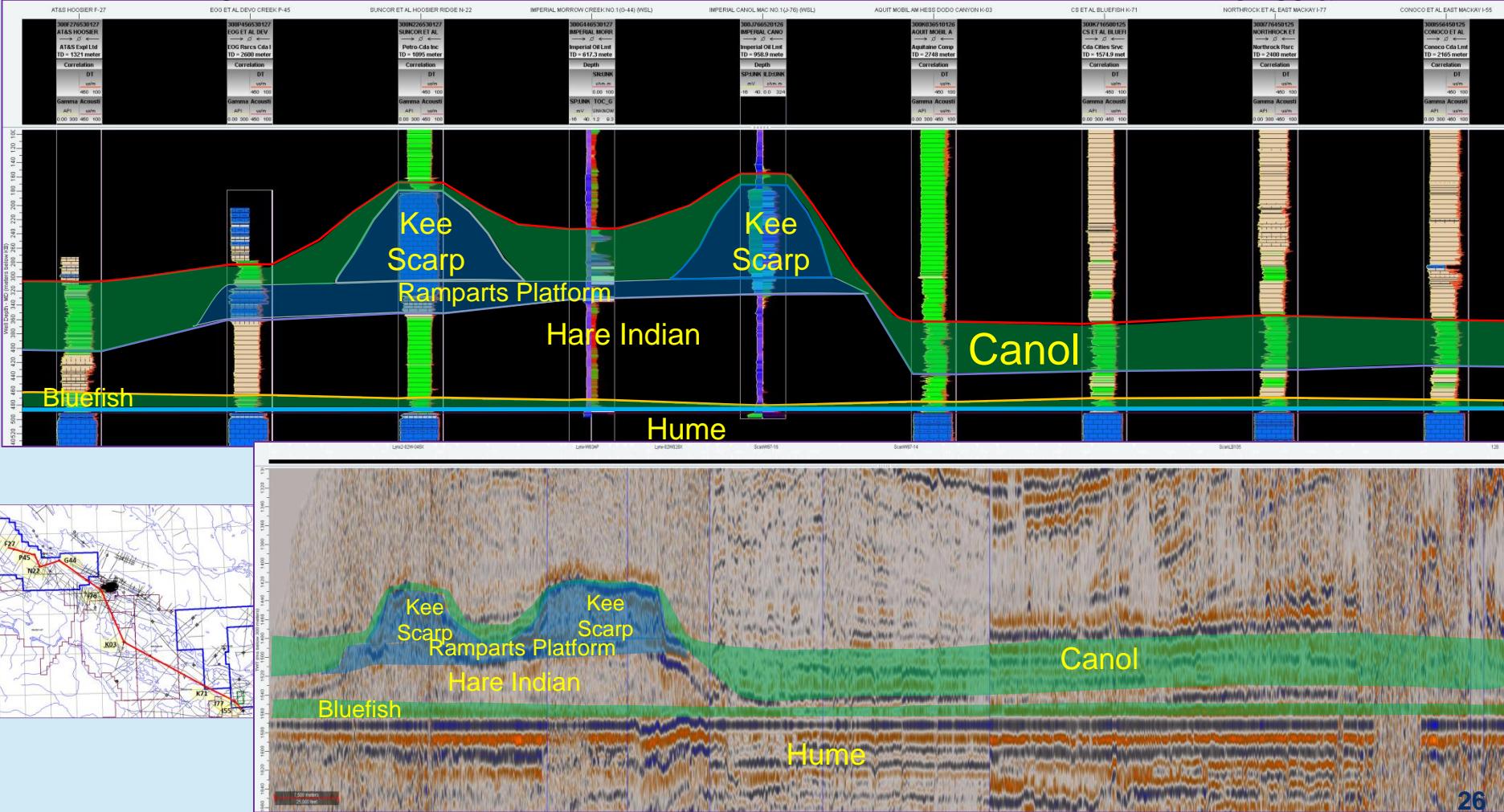


NW-SE Devonian Cross-section

Hoosier Ridge
EL 475

Norman Wells

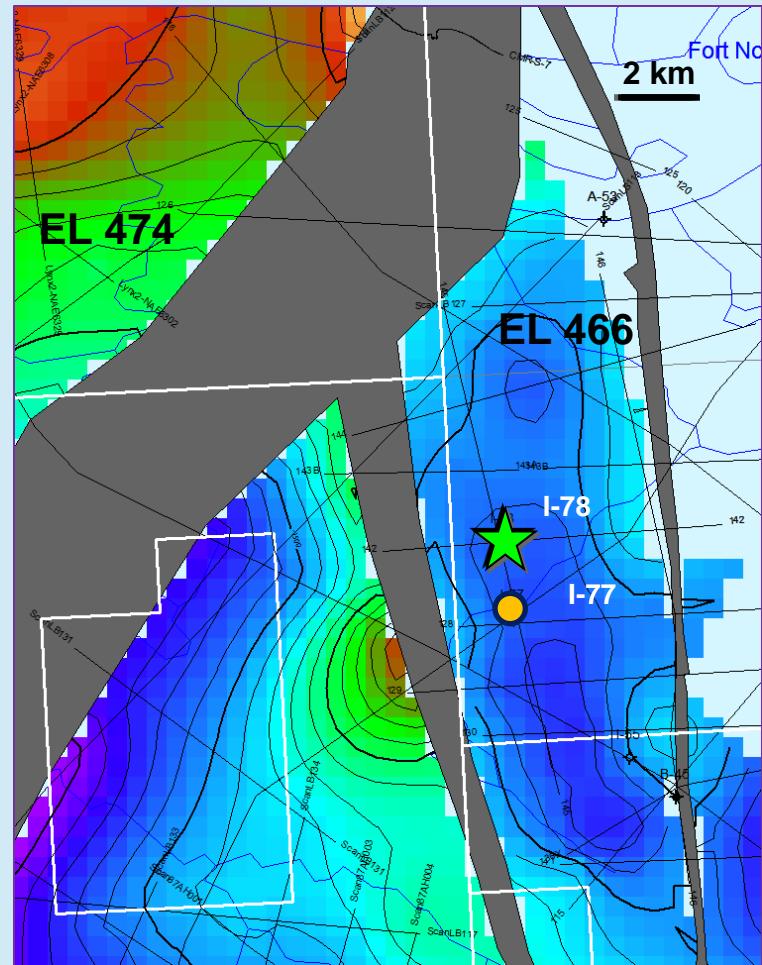
East Mackay
ELs 466 & 474



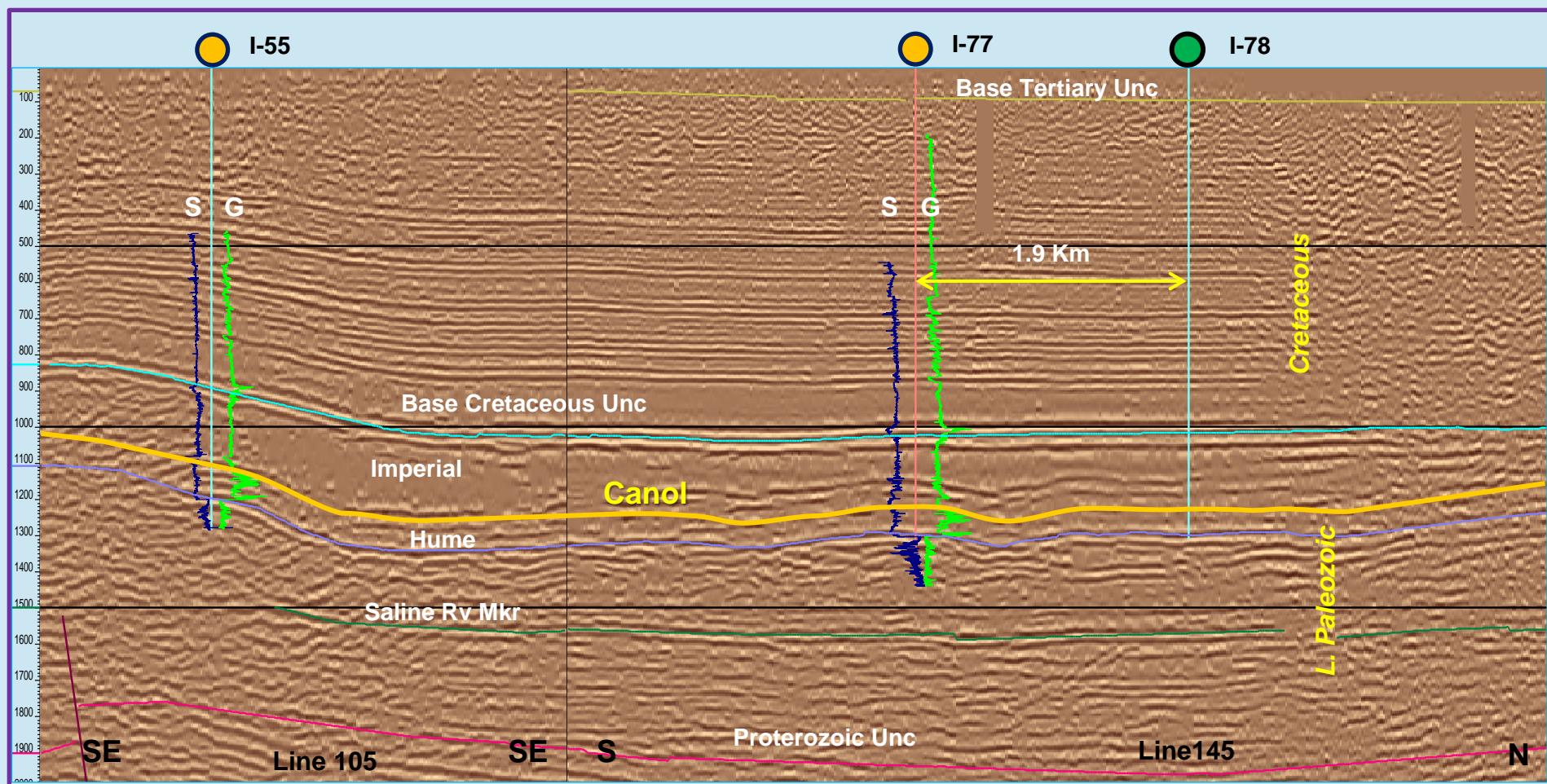
MGM and Shell East MacKay I-78

Why Drill I-78?

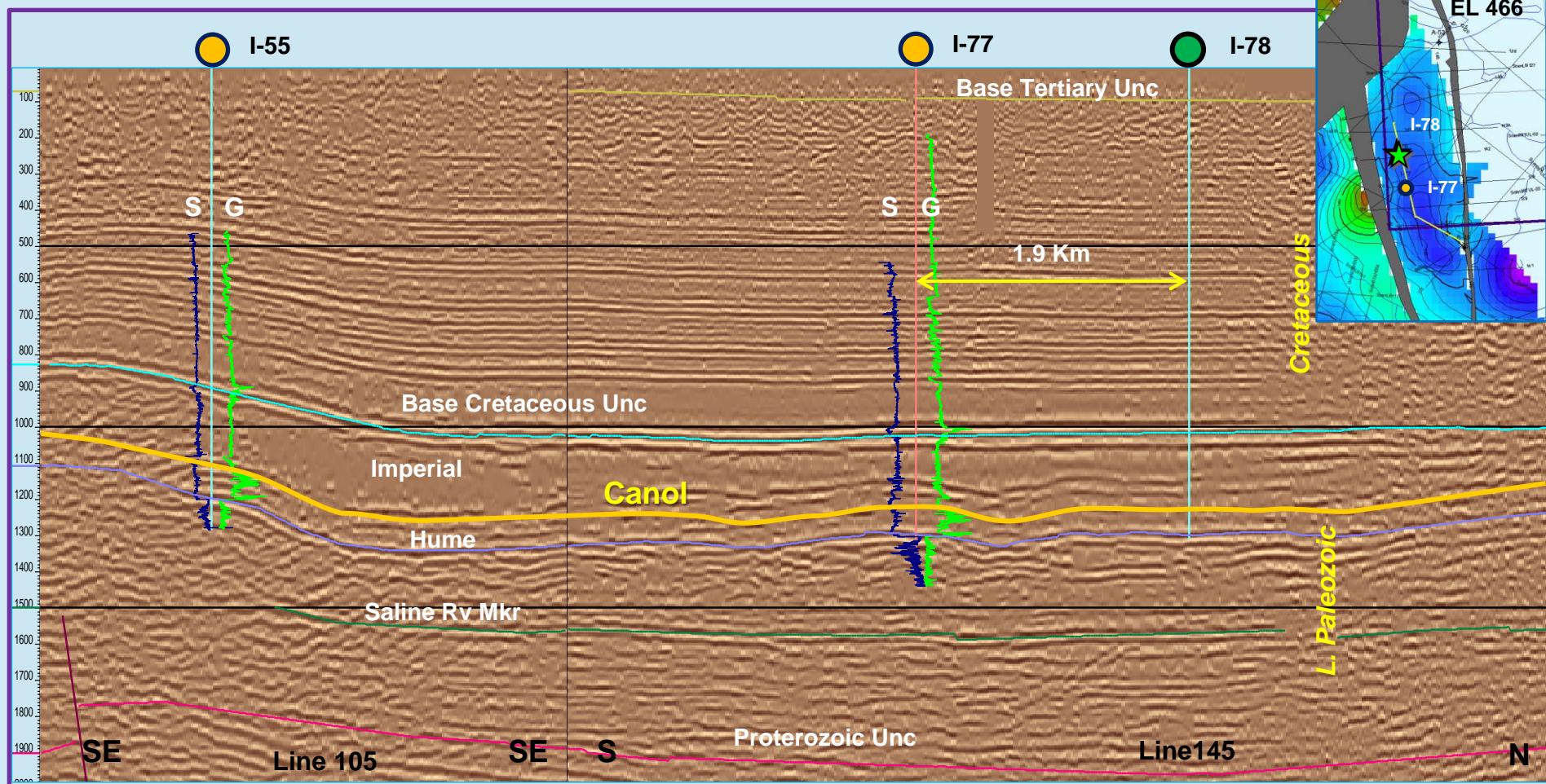
- Located in EL 466
- Vertical Well approved
- Deeper and thick Canol within fault bounded syncline
- Offset East MacKay I-77
- Intersection of seismic lines
- Good seismic data quality
- Coring and logging will allow further research of seismic, geo-mechanical and reservoir properties of Devonian shales

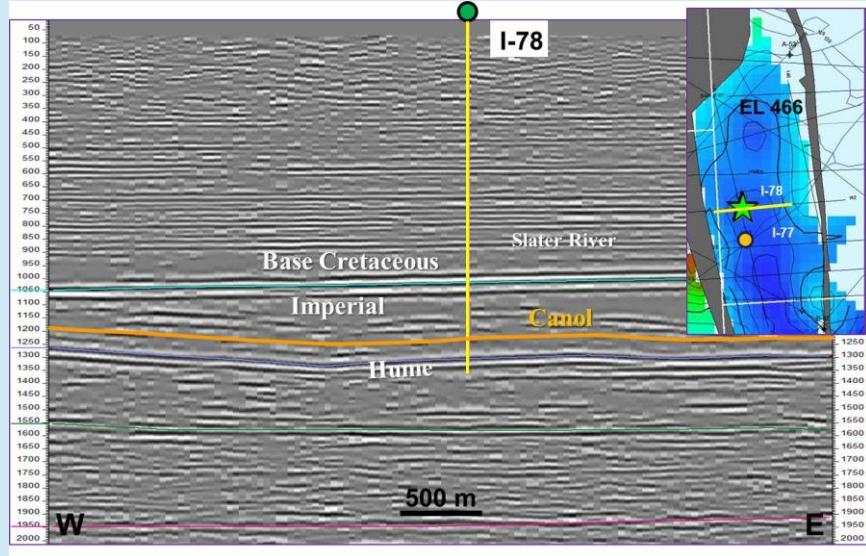


Shale Oil Play in EL 466, CMV



Shale Oil Play in EL 466, CMV





East Mackay I-78

- Drilled to total depth
- Seismically prognosed tops came in \pm 5m
- Cored Canol-Hare Indian-Blue Fish-Hume interval
- Full suite of wire line logs including Dipole Sonic
- Fracture stimulation of Canol and Bluefish using a clear mineral oil
- Confirmed presence of free hydrocarbons
- Shut-in for pressure build-up

Conclusions

- Canol and Bluefish Shales in NWT, Canada are excellent candidates for oil production based on petrophysical and geochemical data
- The prospective Canol shale oil play was seismically mapped in a large area including portions of MGM ELs
- Light oil was produced from the I-78 vertical well
- Canol and Bluefish cored section in I-78 should allow for a better calibration of seismic data and the study of seismic attributes vs shale properties
- A new unconventional oil play will emerge with important consequences for the NWT's and Canada's economy if post-drill analysis of Devonian Shales bring positive results