New Interpretations of the Evolution of the West Siberian Basin, Russia: Implications for Exploration*

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Search and Discovery Article #10161 (2008)
Posted December 15, 2008

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Abstract

Russia's West Siberian basin is the largest petroleum basin in the world. With proven reserves of 450+ BBOE, it will remain a strategic energy resource for the next millennium. New regional maps shed new light on the basin's evolution and petroleum system.

Late Paleozoic collision of the East Siberian plate with the European craton resulted in development of the Ural Mountains on the western margin. East of the Urals, assemblage of large blocks of accreted Paleozoic terrains created topographic relief locally exceeding 2 kilometers. Early Triassic sub-basins formed during post collision sag. These terrains and Triassic basins not only fundamentally controlled patterns of Jurassic deposition, but exerted a profound influence on geothermal gradients and source rock maturation.

Early Jurassic transgressions deposited source rock and reservoirs in large estuaries. Episodic fill ended when the Upper Jurassic Bazhenov source rock finally buried most of the terrains. Neocomian regressions deposited multiple shoreline, deltaic, and deep water sandstones over the Bazhenov, forming the most important reservoirs.

Major strike-slip faults split the basin into several tectonic elements and control the location of many of the most prolific hydrocarbon accumulations. Regional mid-Tertiary uplift removed up to 2.5 kilometers of sediment, resulting in expansion of gas caps and flushing of earlier oil accumulations, particularly in the Yamal autonomous region. Oil rims around the edges of gas accumulations are common, as are residual saturations in numerous reservoirs.

While most large structures have been drilled, deeper overpressured horizons and stratigraphic traps will provide abundant new hydrocarbon resources well into this next century.

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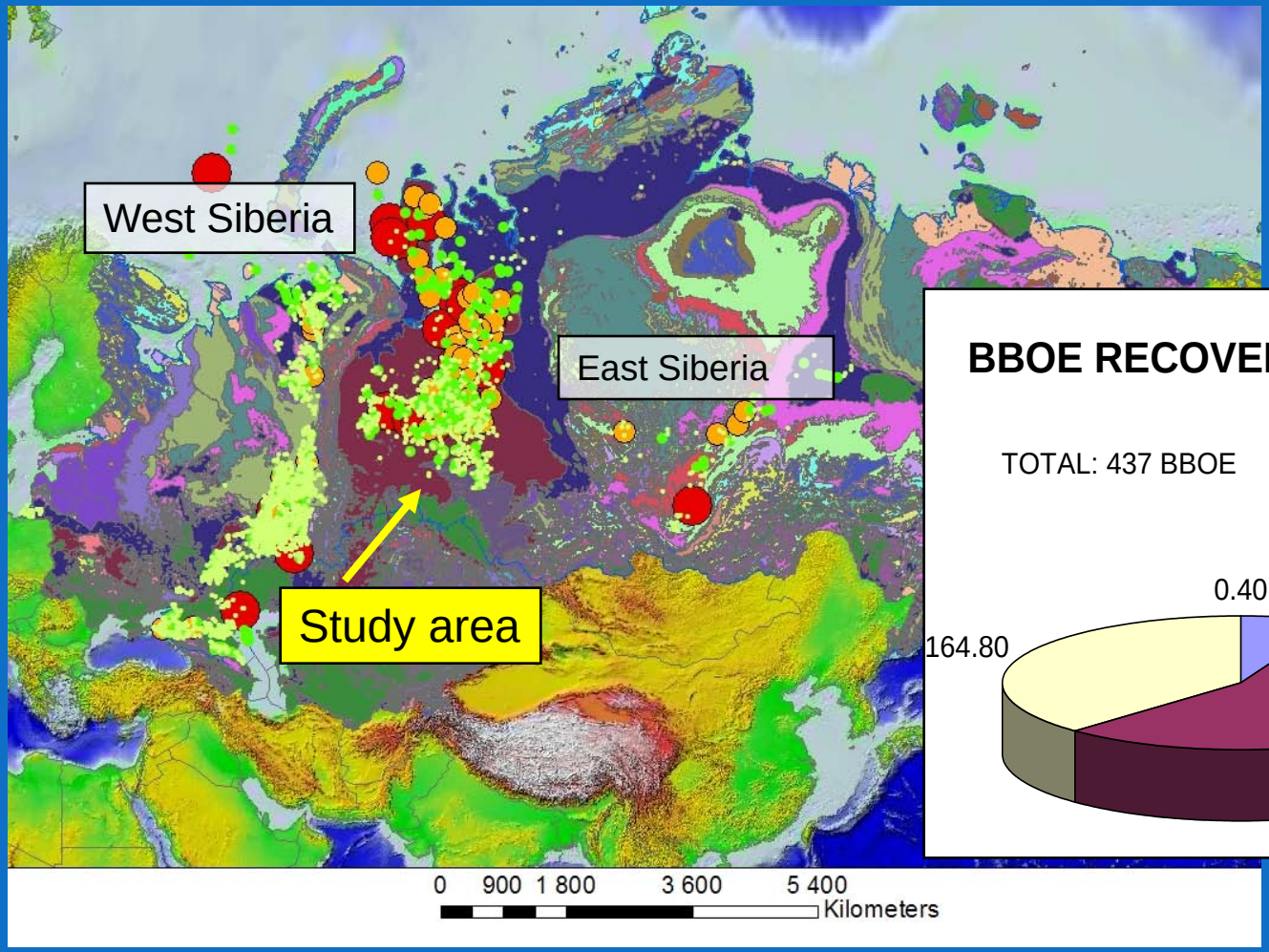
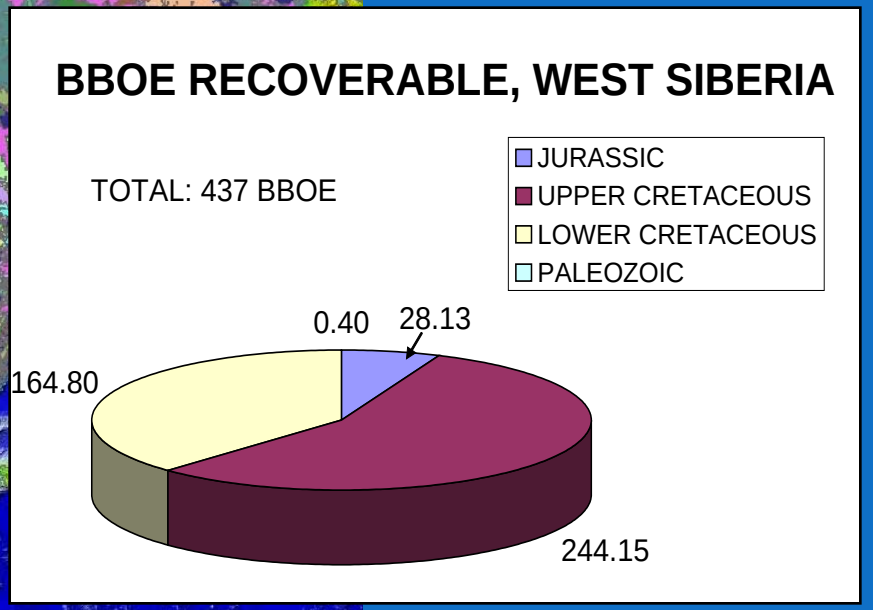
Geoseis Co., Tyumen[1]

BP[2]

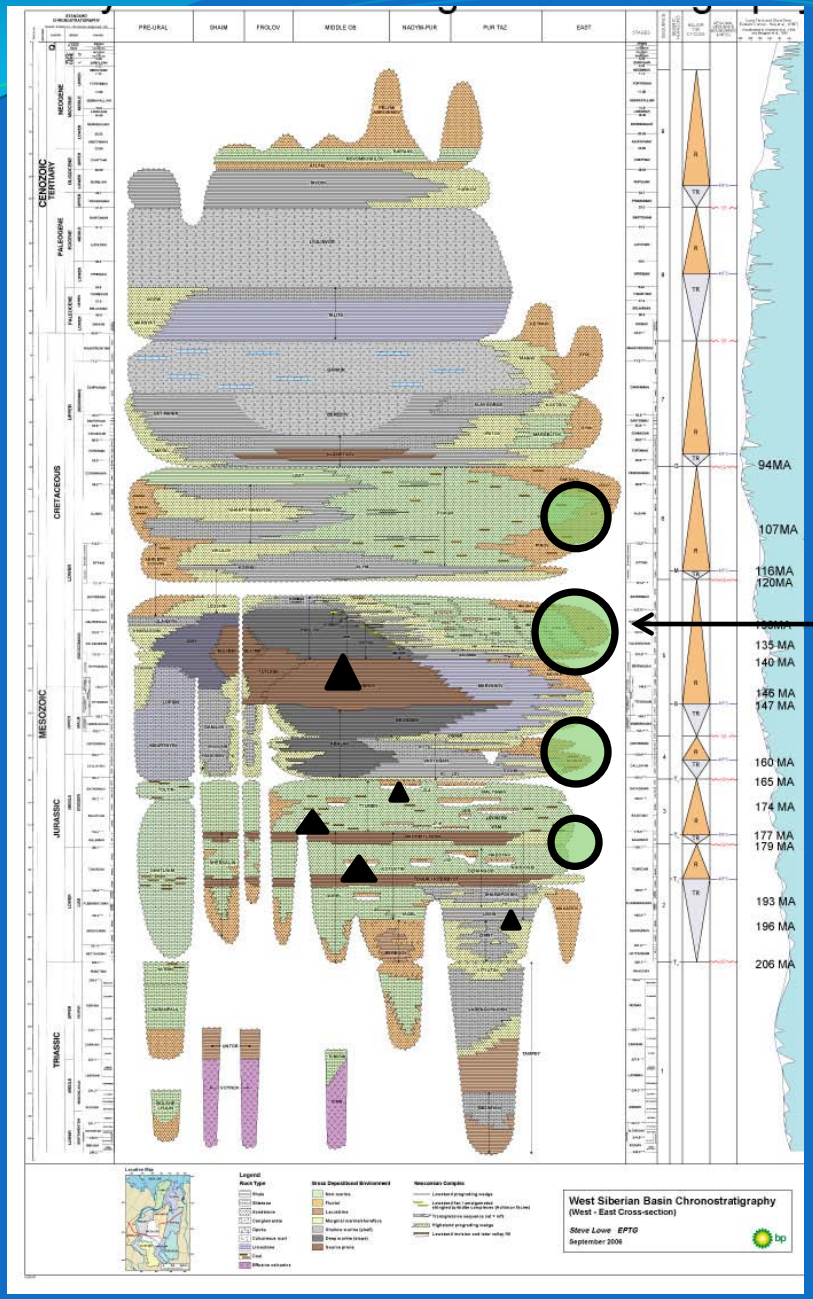
TNK-BP[3]

West Siberian Basin: World's Largest Basin





West East



Chronostratigraphy

Major Source Rocks

Major Reservoirs

Bazhenov

Neocomian deltas and turbidites

Tyumen Coals

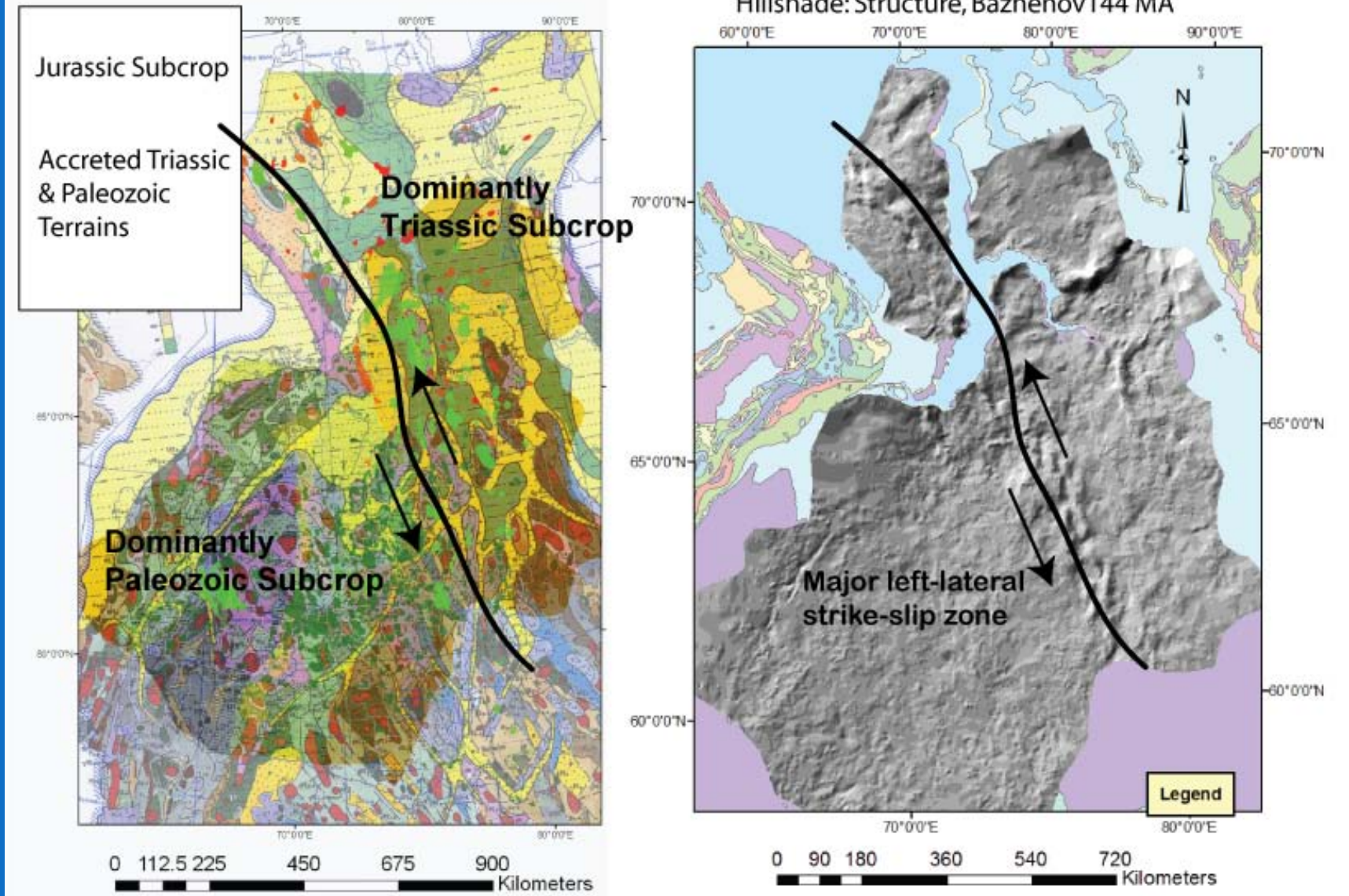
Radom + Togur

Upper Jurassic deltas and estuaries

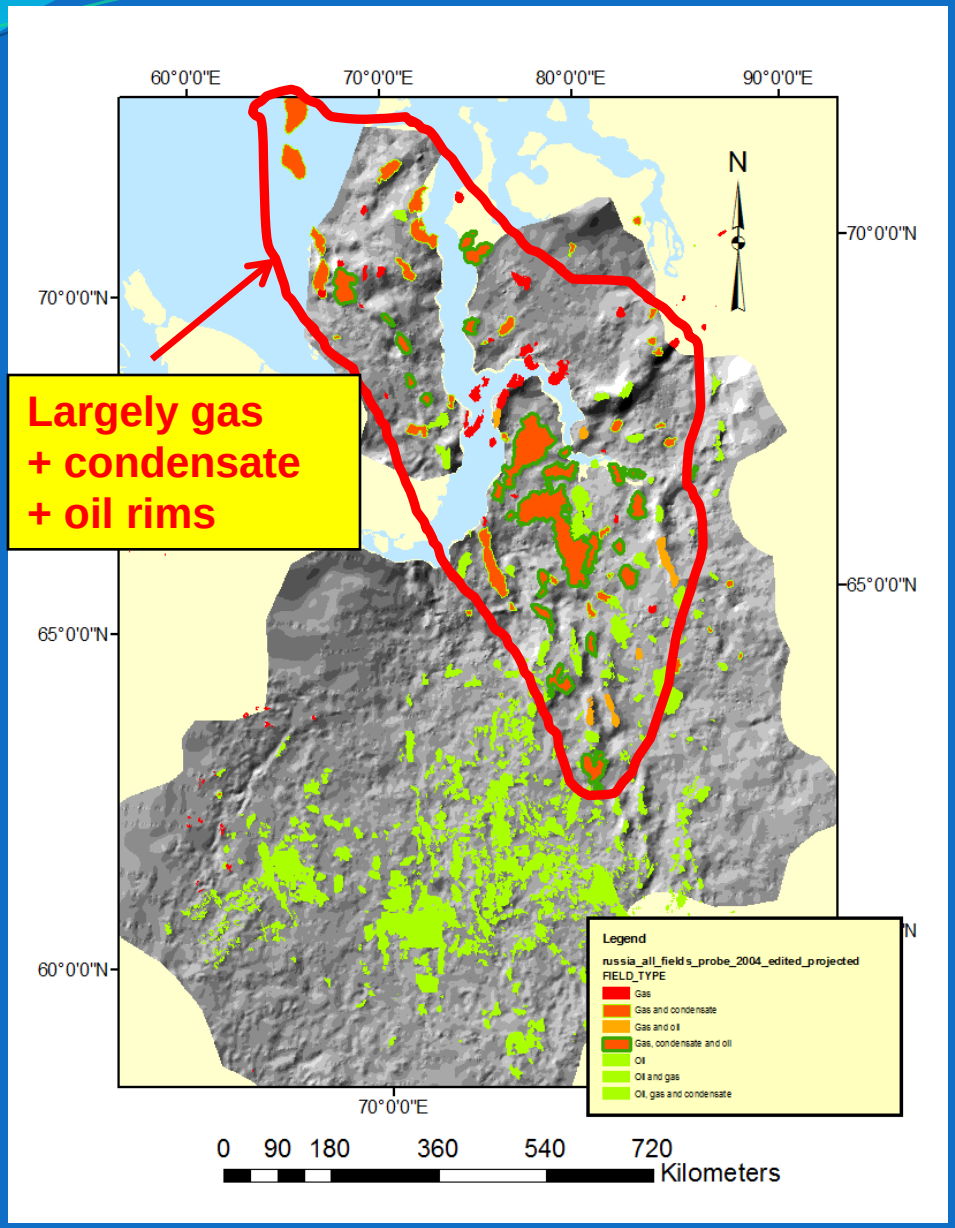
Triassic

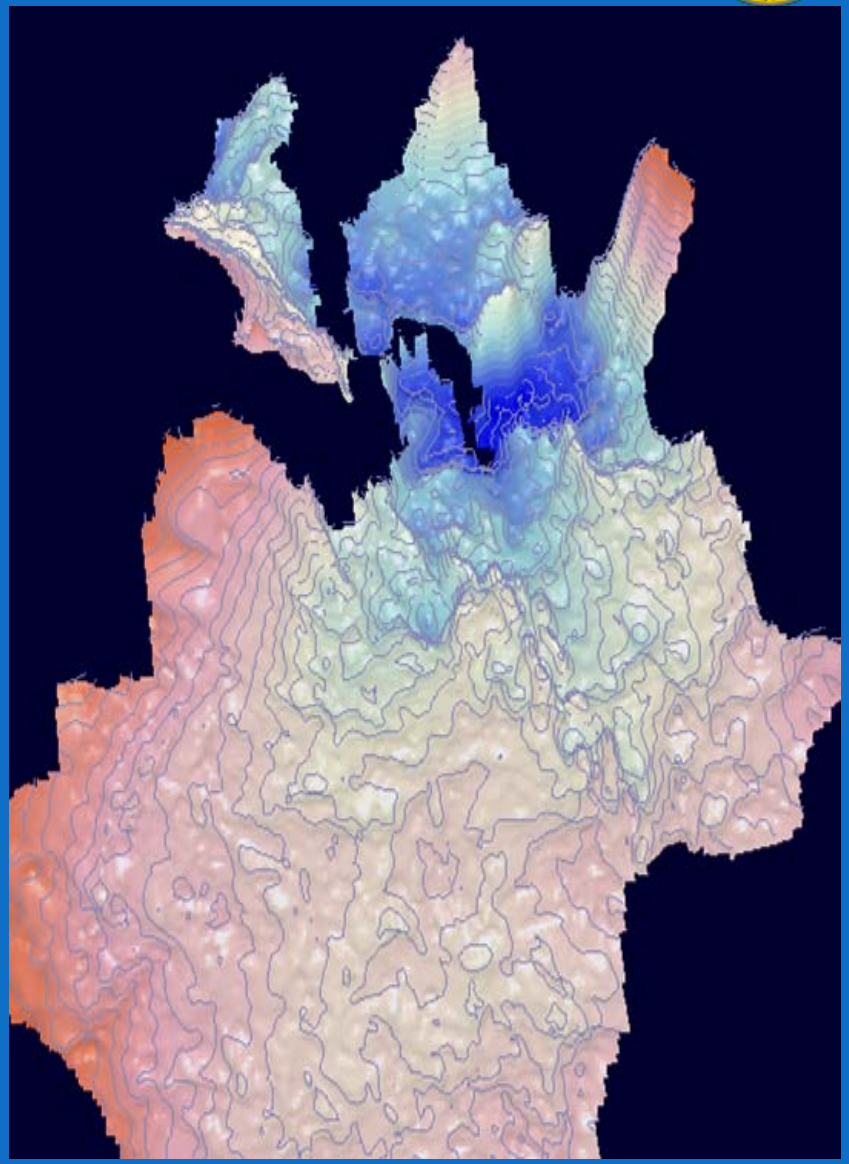
Middle and Lower Jurassic estuaries

Location of major left-lateral fault system and pre-Jurassic subcrop

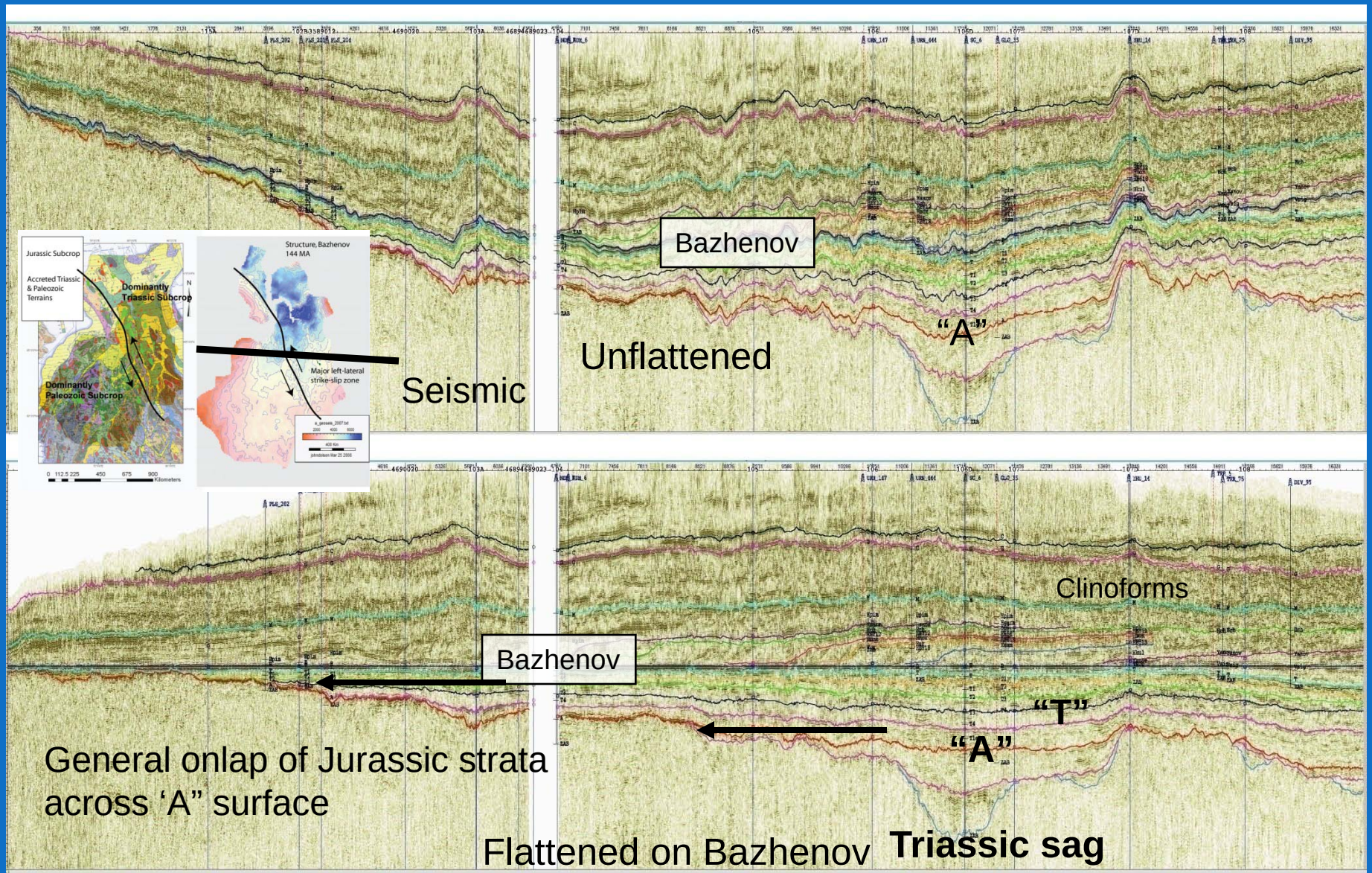


Location of fields and 3D view of Bazhenov Structure

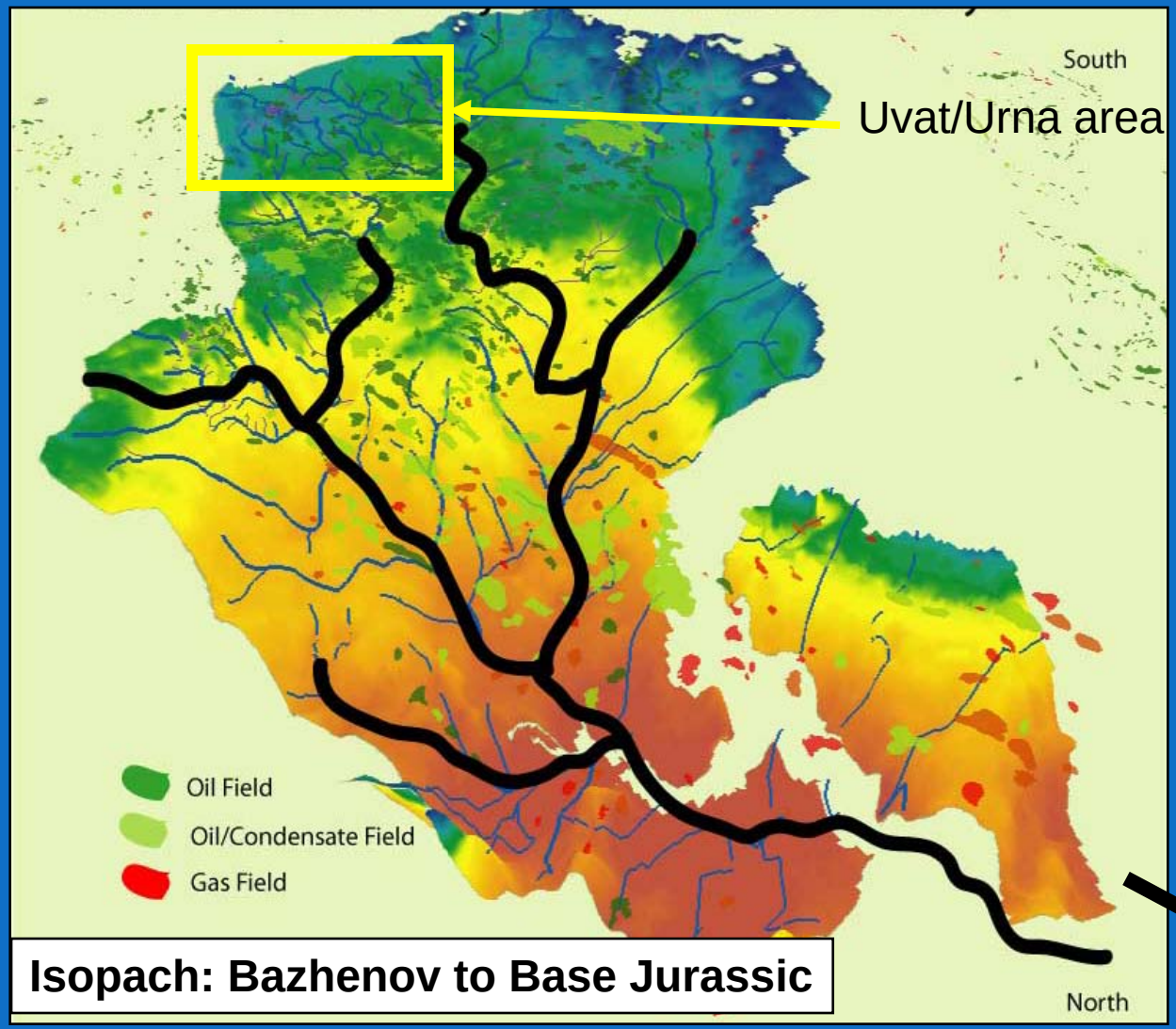




West to East Seismic Line



Regional Jurassic paleotopgraphic context



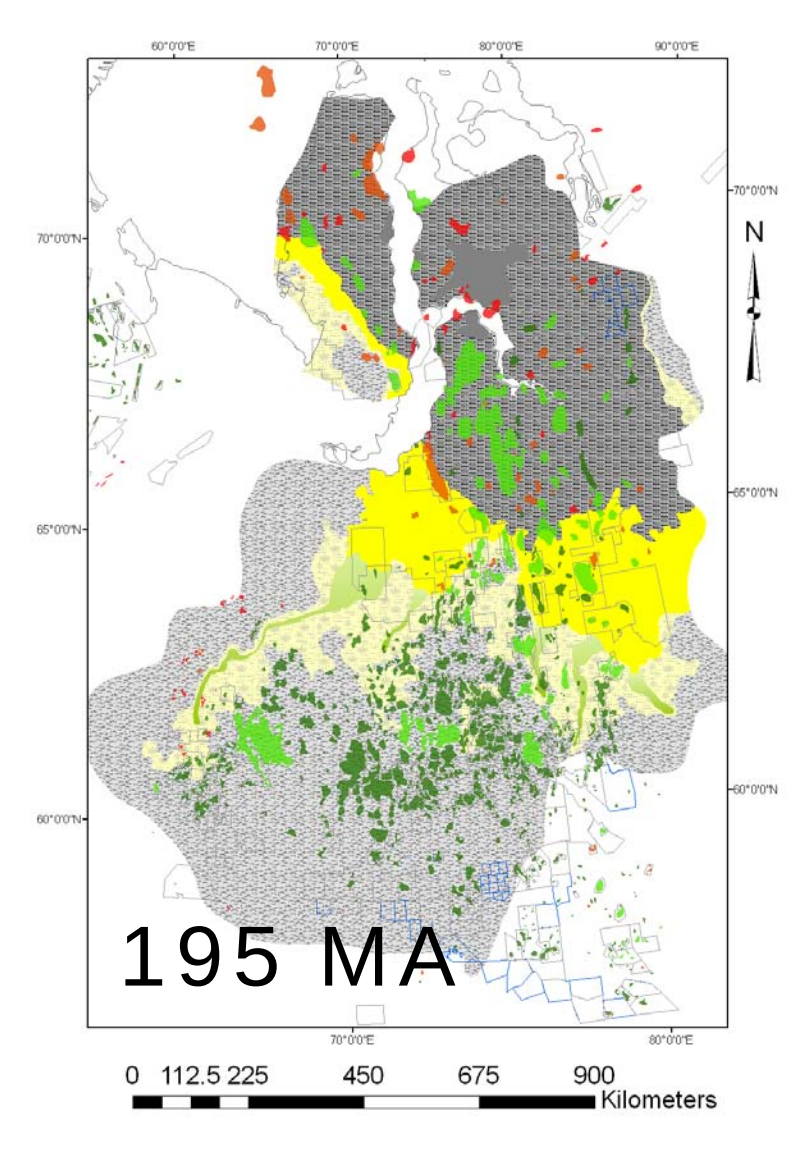
Isopach: Bazhenov to Base Jurassic

Up to 1.5 Km paleotopgraphic Relief

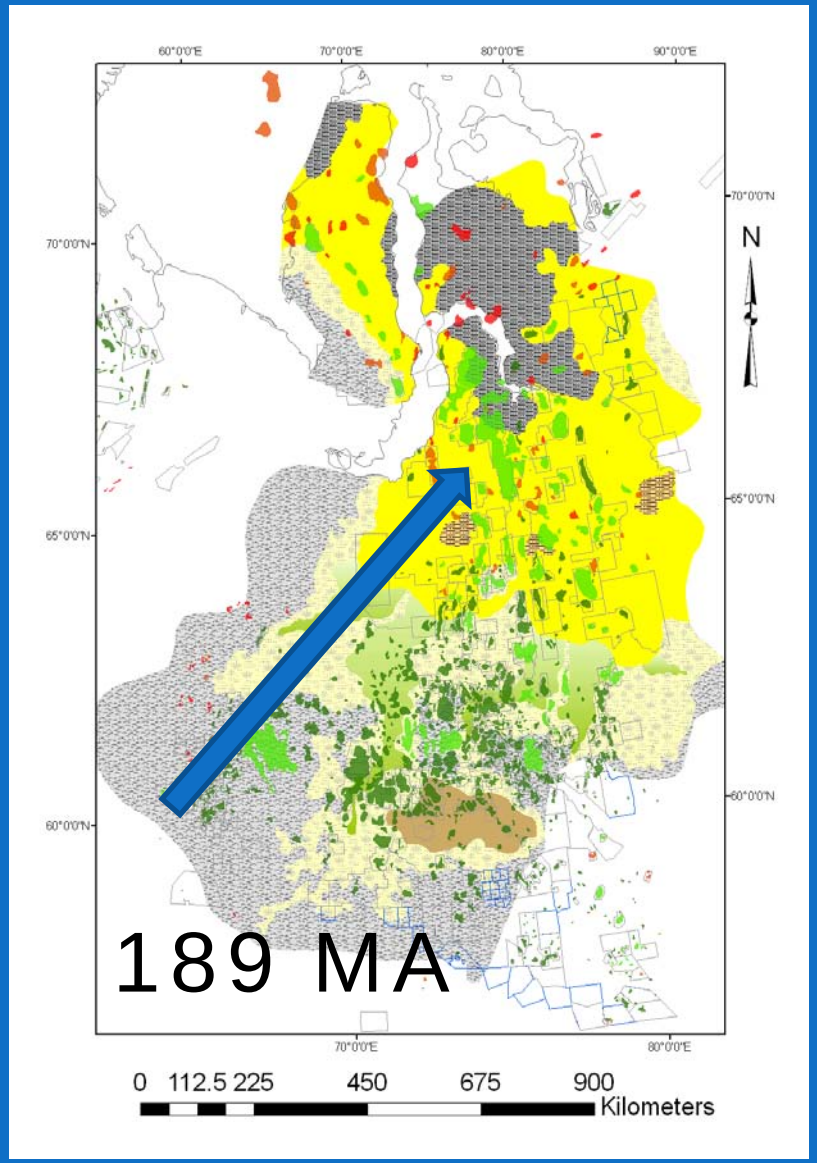
Multiple sequences

NORTH

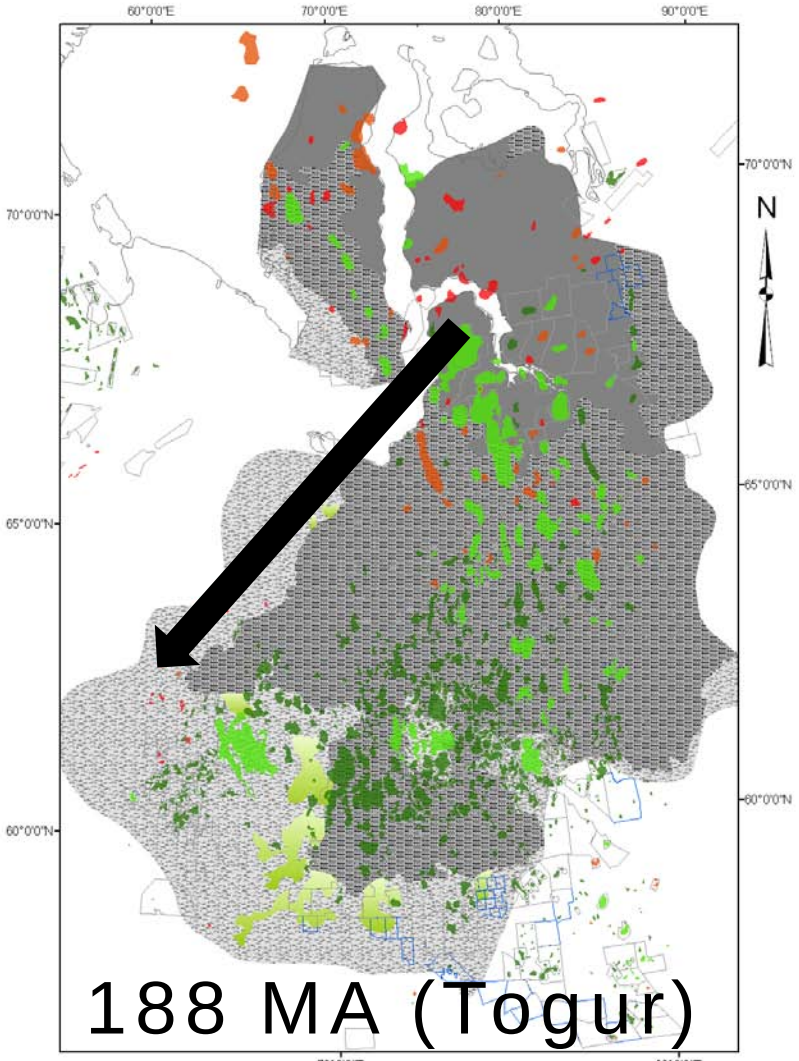
‘J12” Event



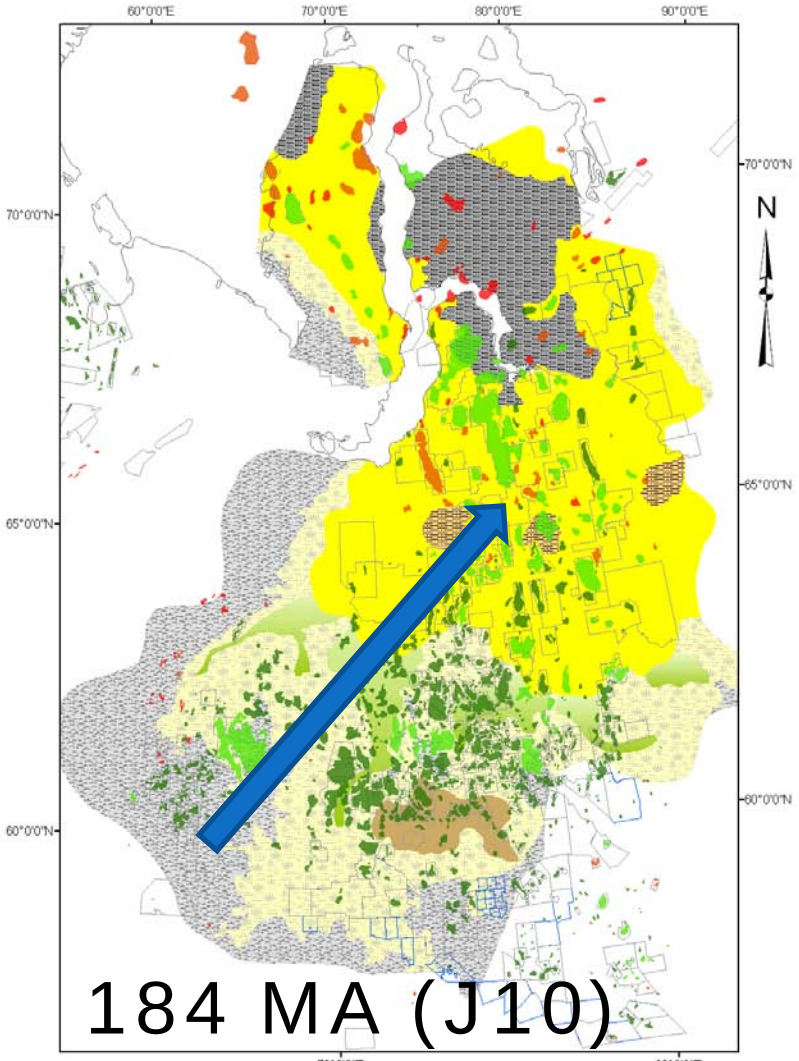
‘J11” Regression with multiple incisions



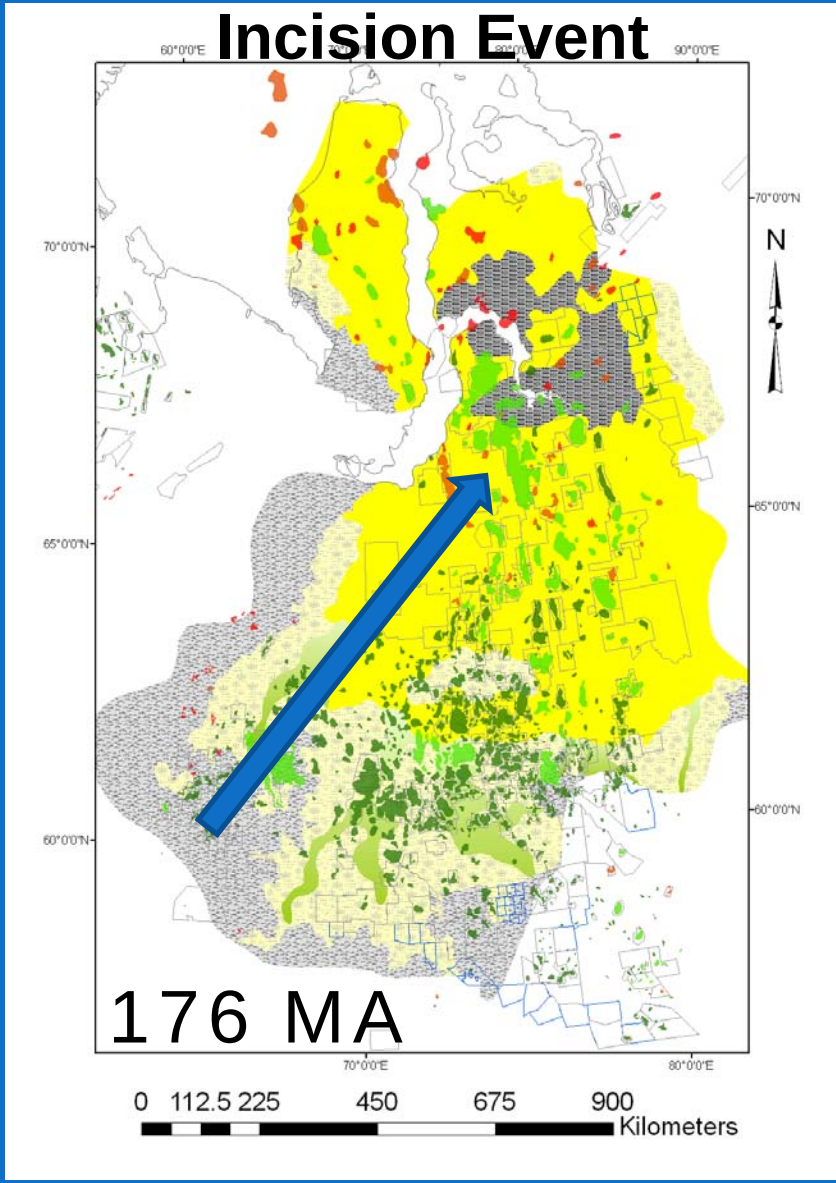
Major Transgression: Source + Seal

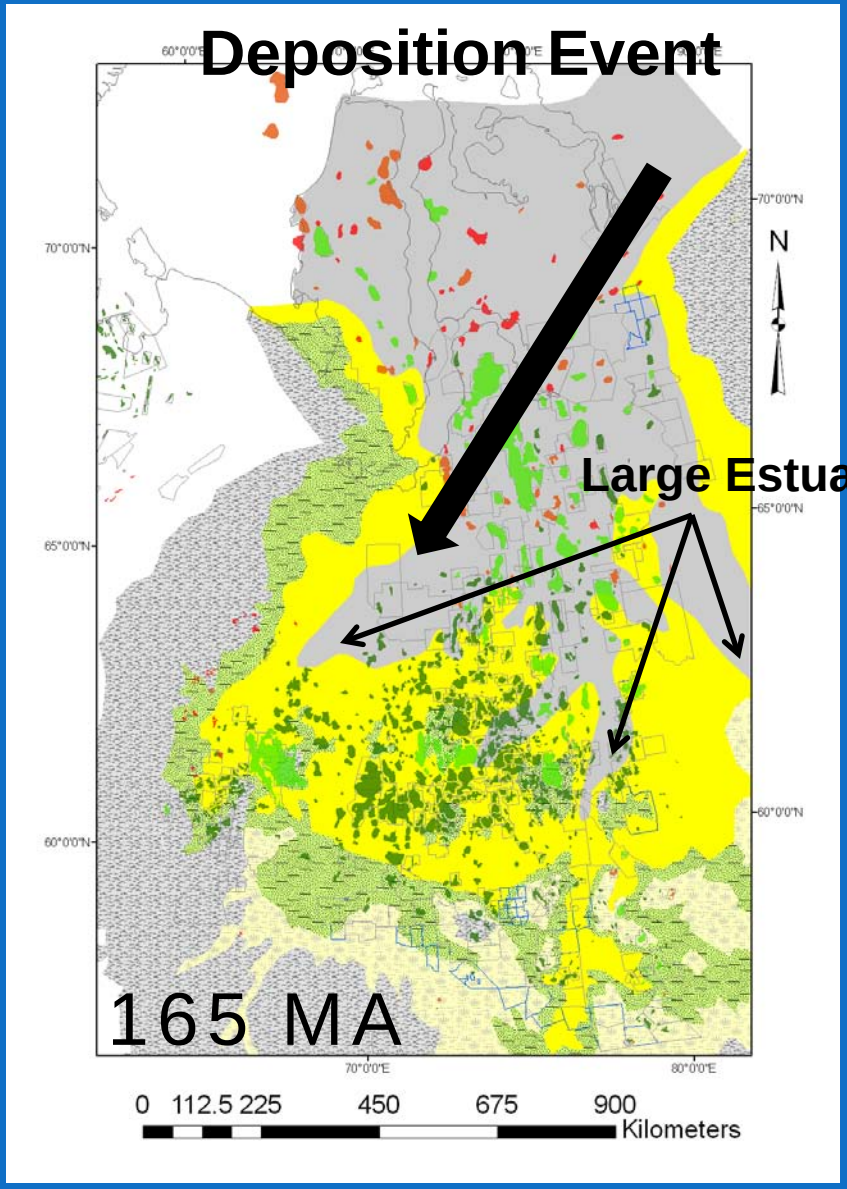


Major Regression with Multiple Incisions

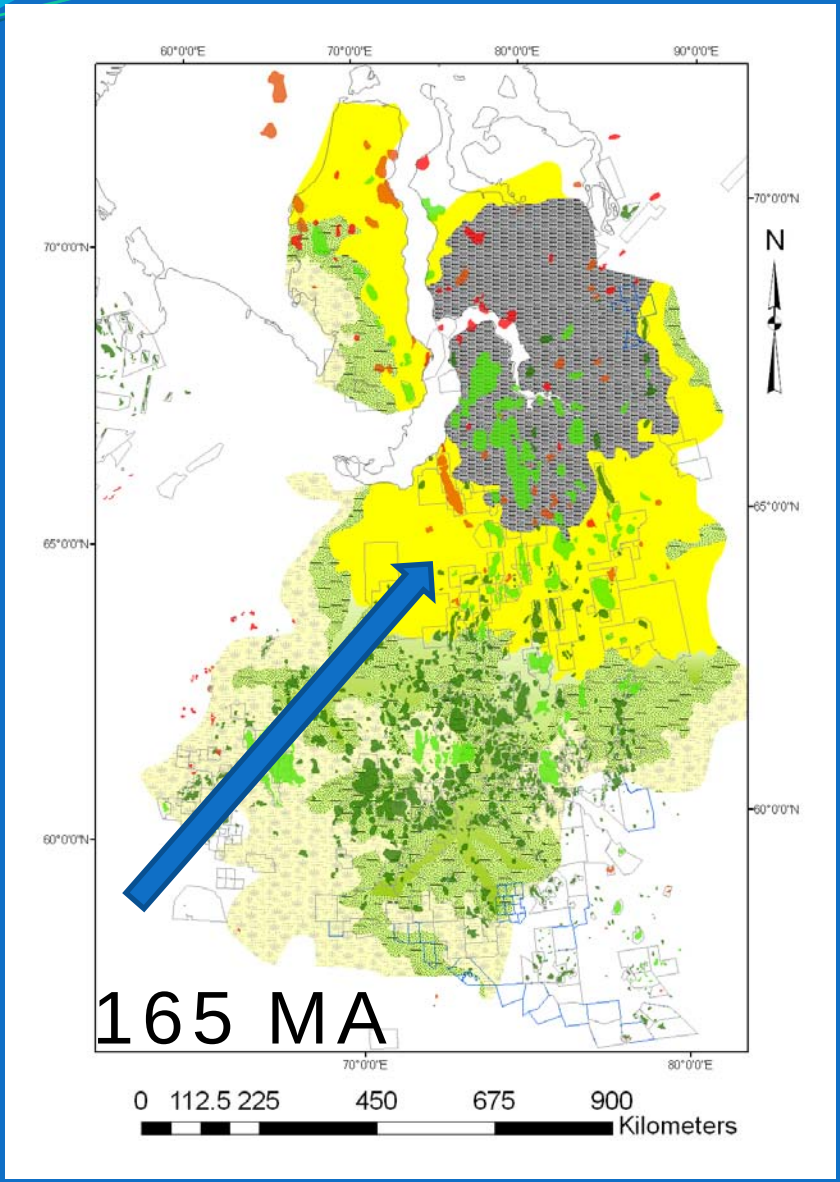


Middle Jurassic Events

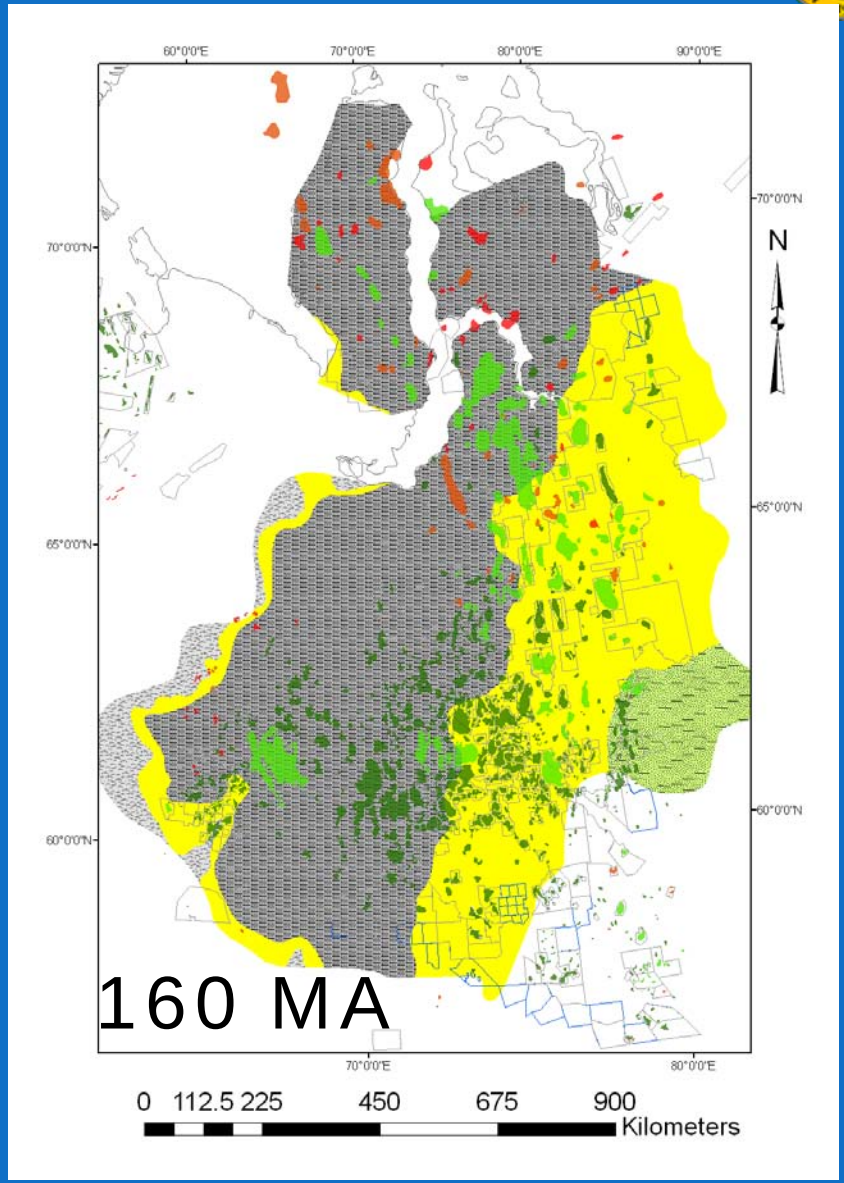




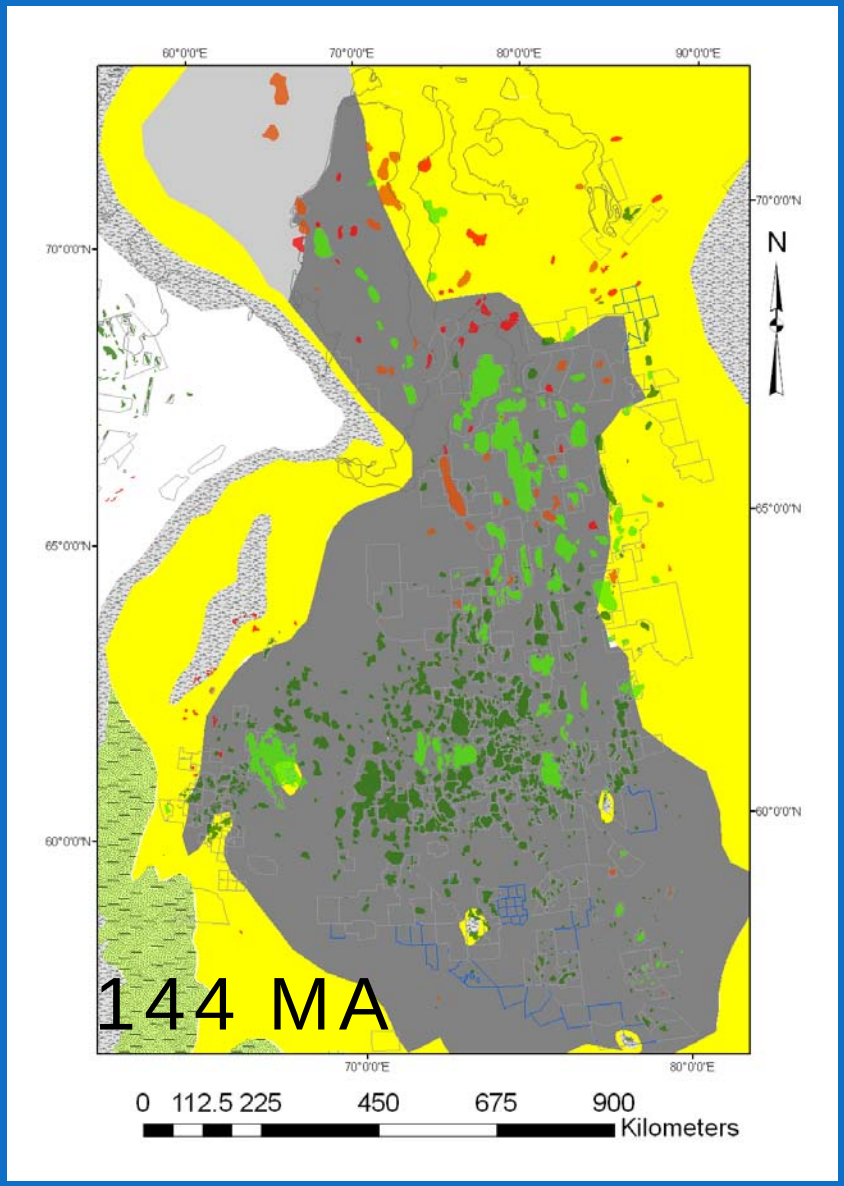
Major Unconformity and Erosion Event): “J2/J4”



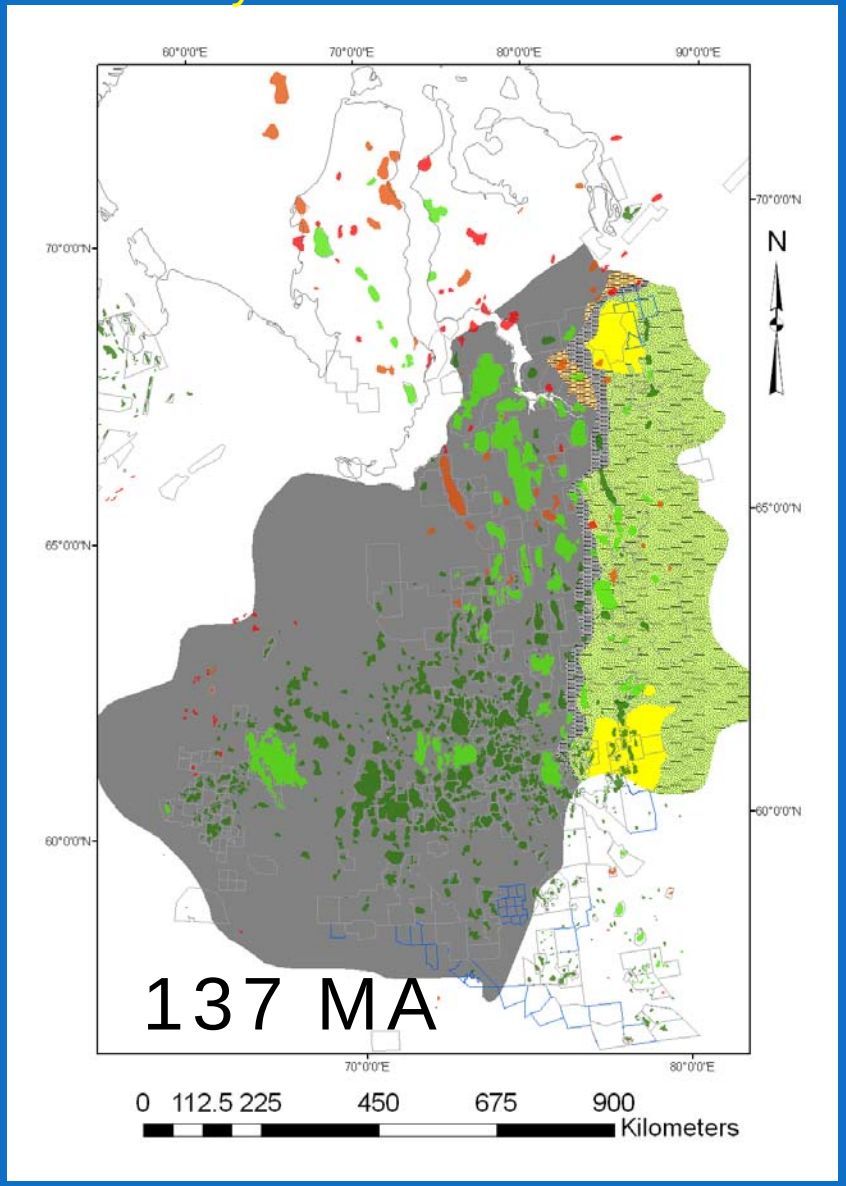
“J1” Callovian Transgresion



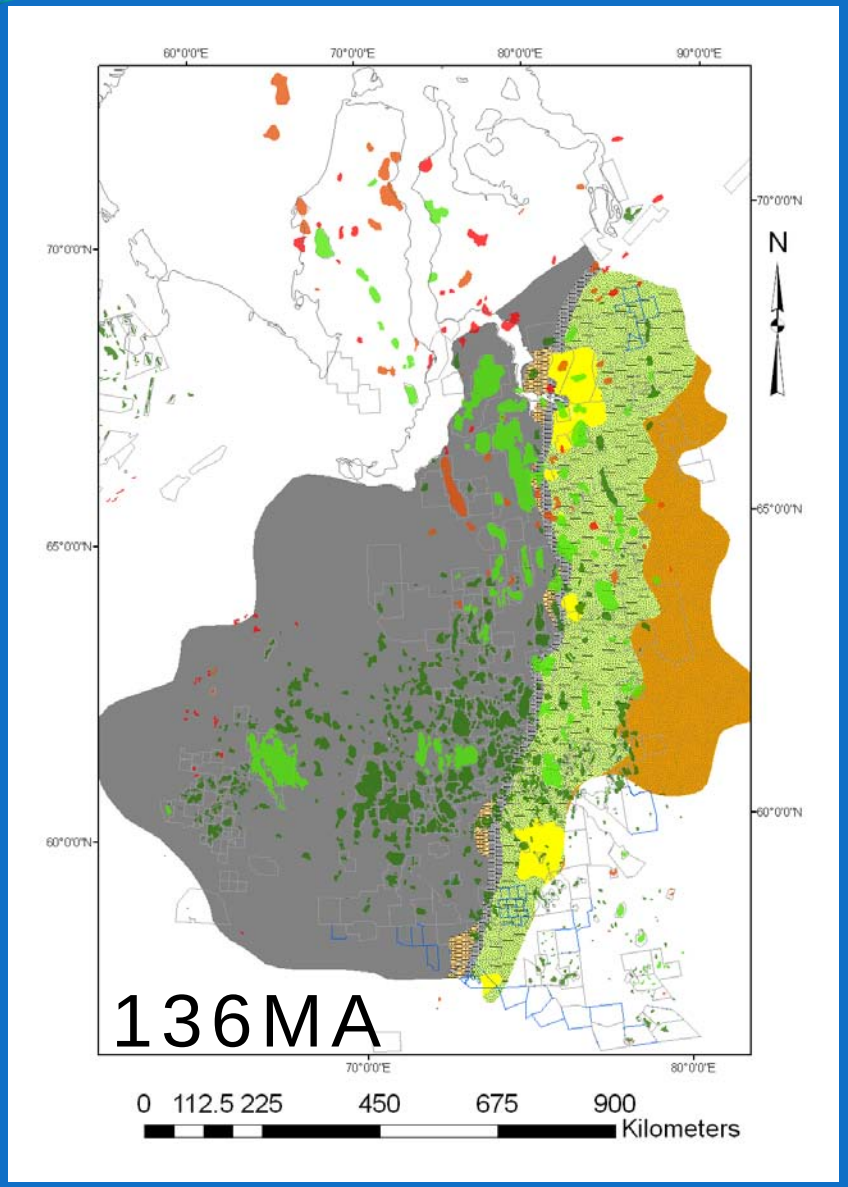
Bazhenov Source Rock

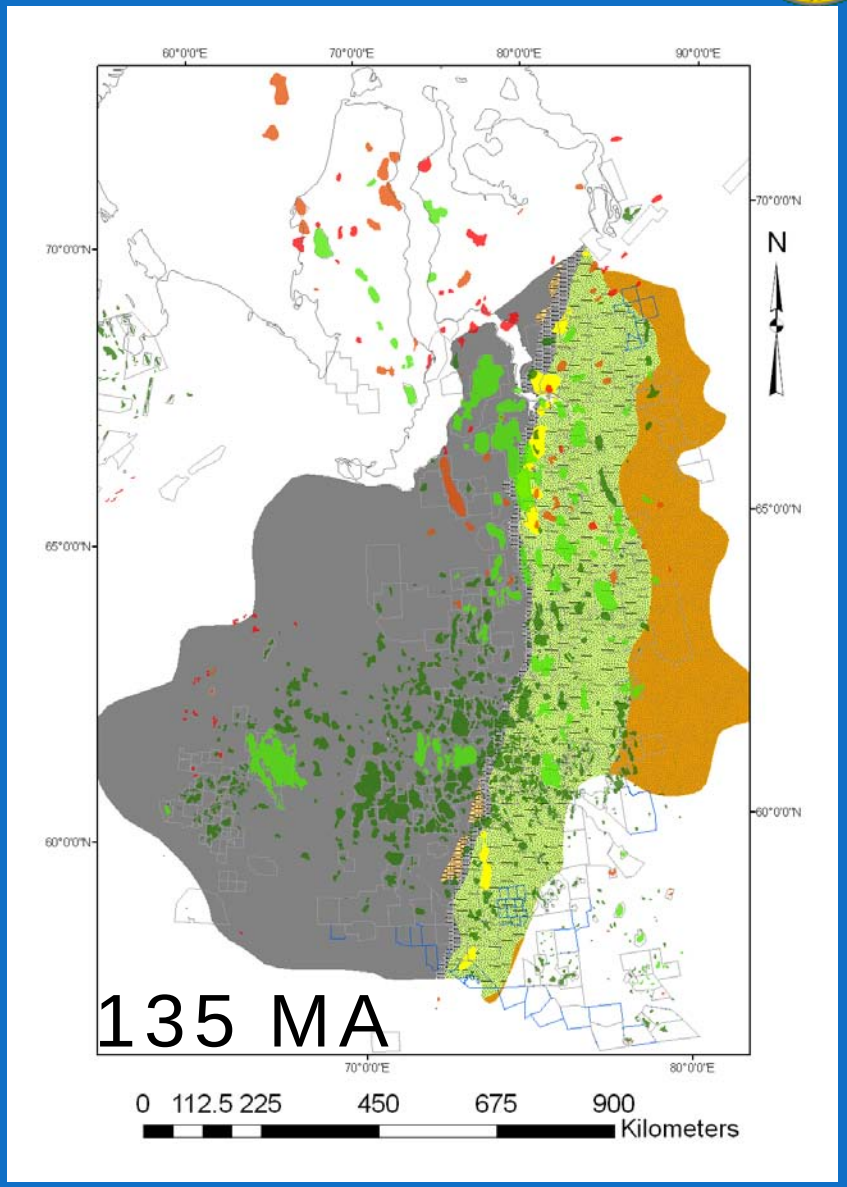


Early Neocomian Deltas

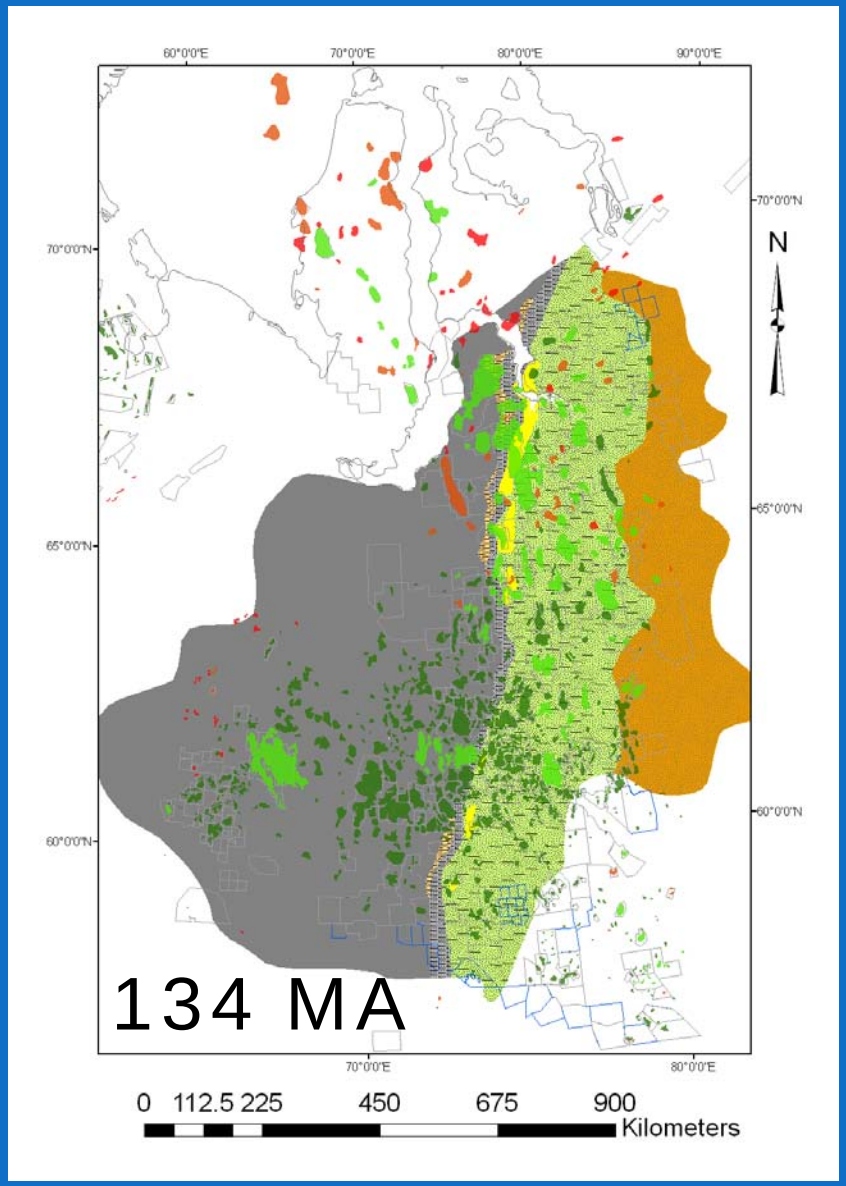


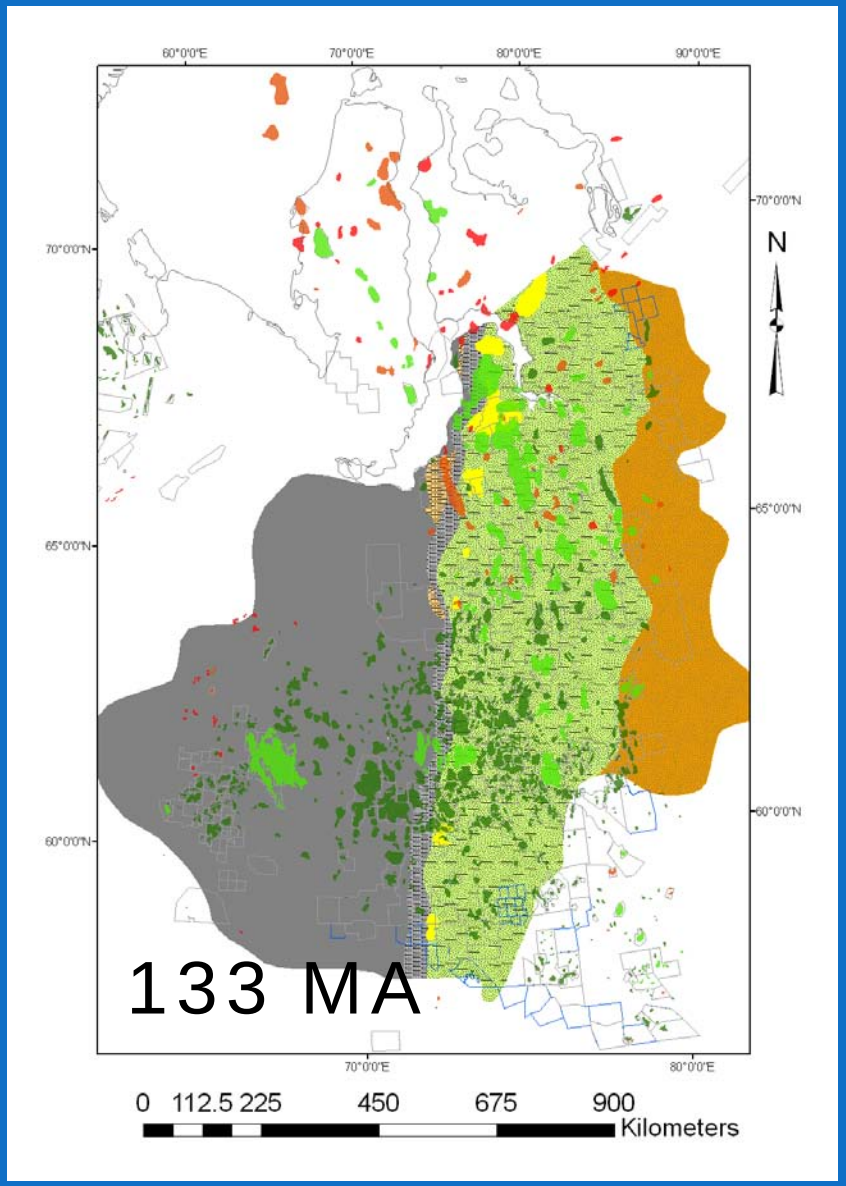
Neocomian Regressions



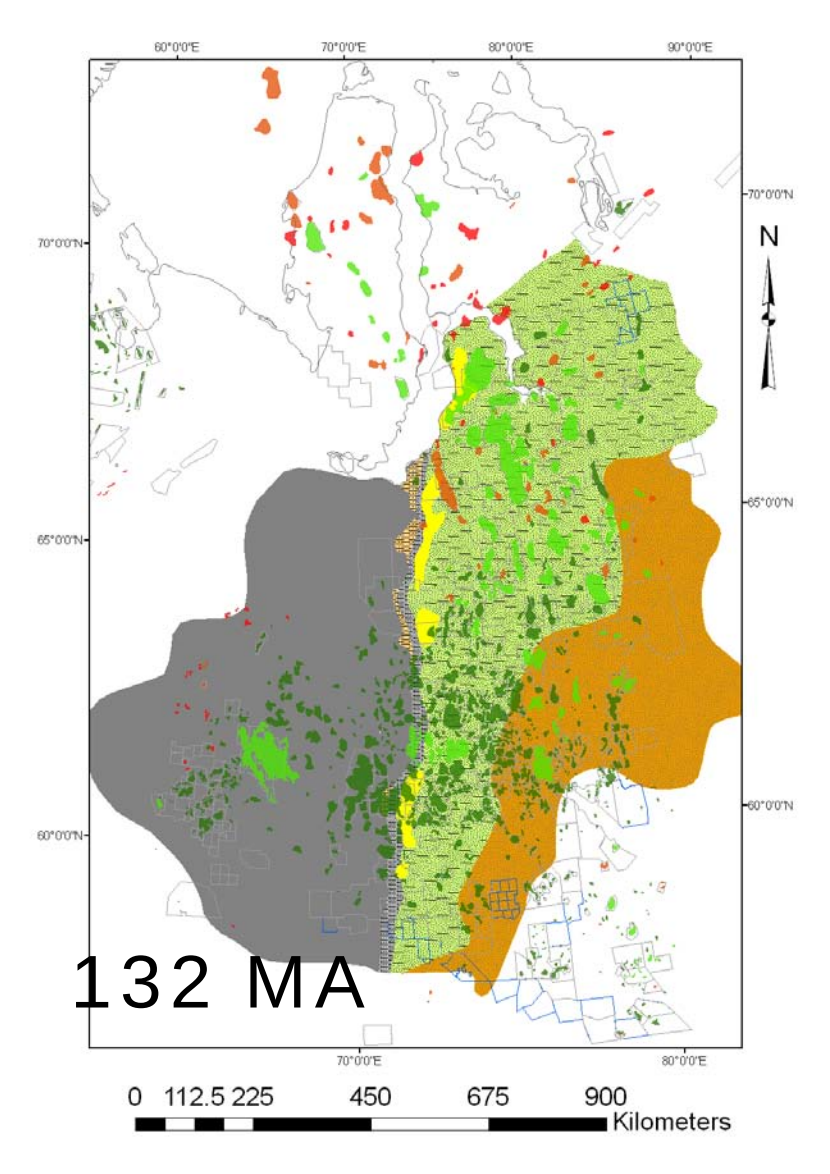


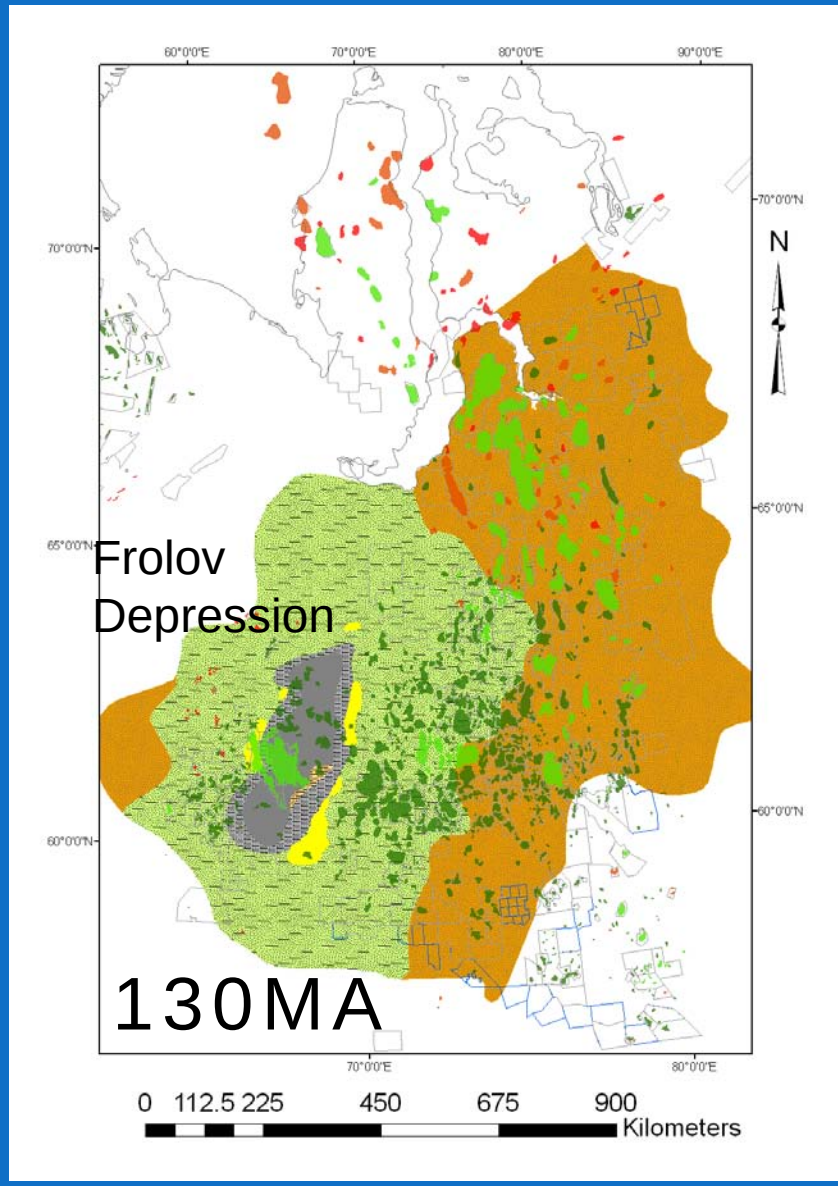
Neocomian Regressions



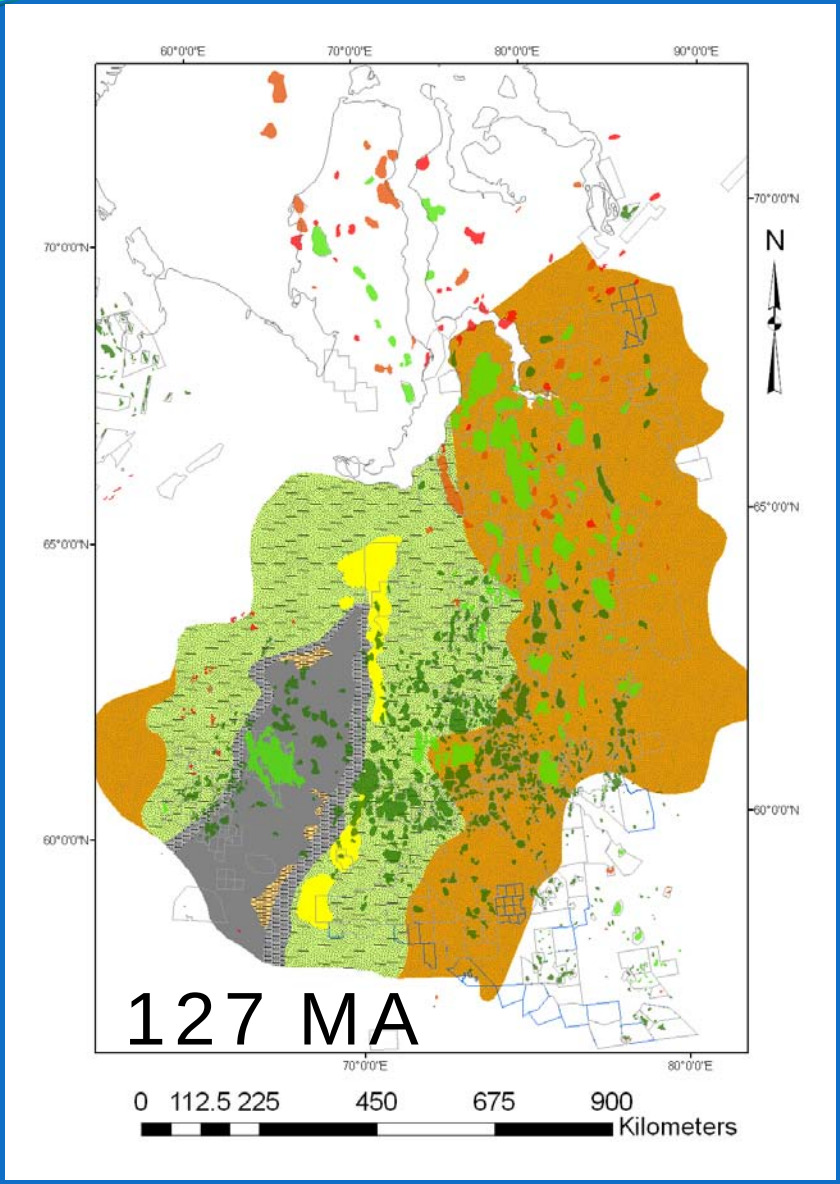


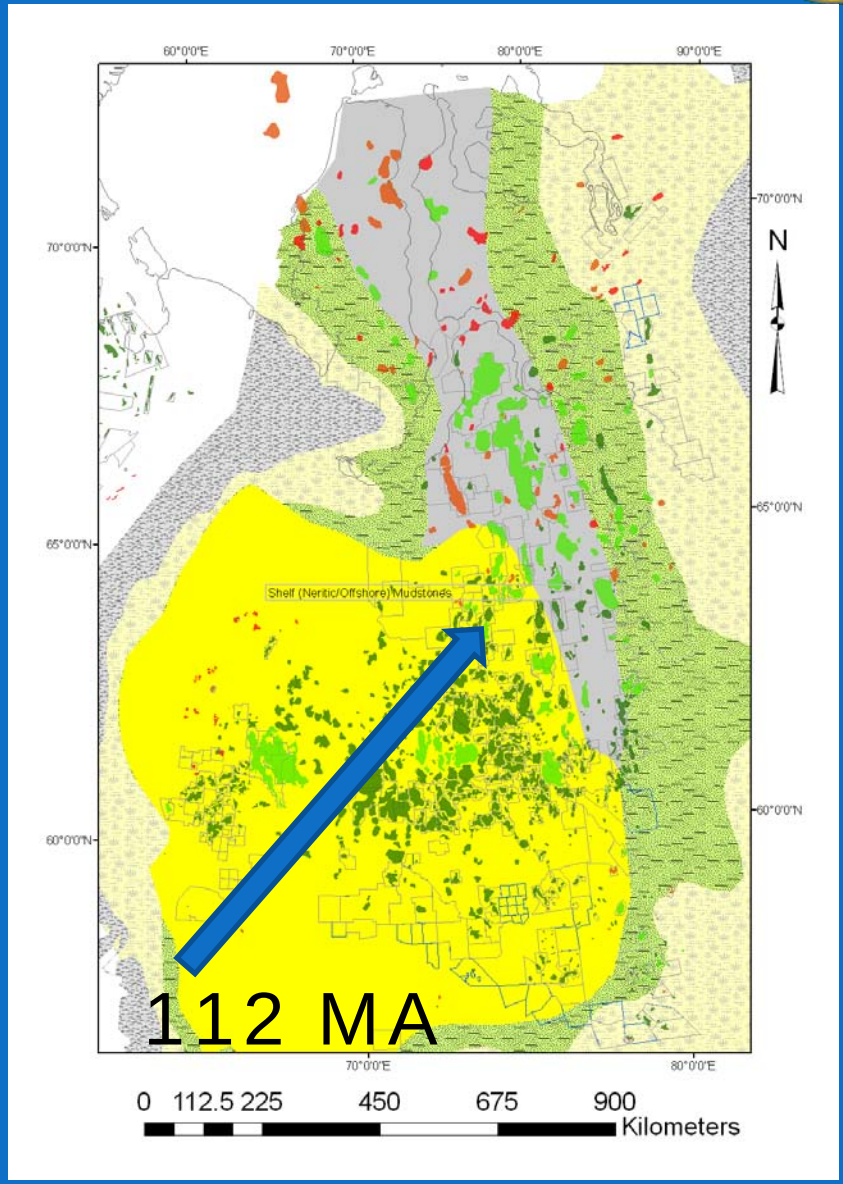
Neocomian Regressions



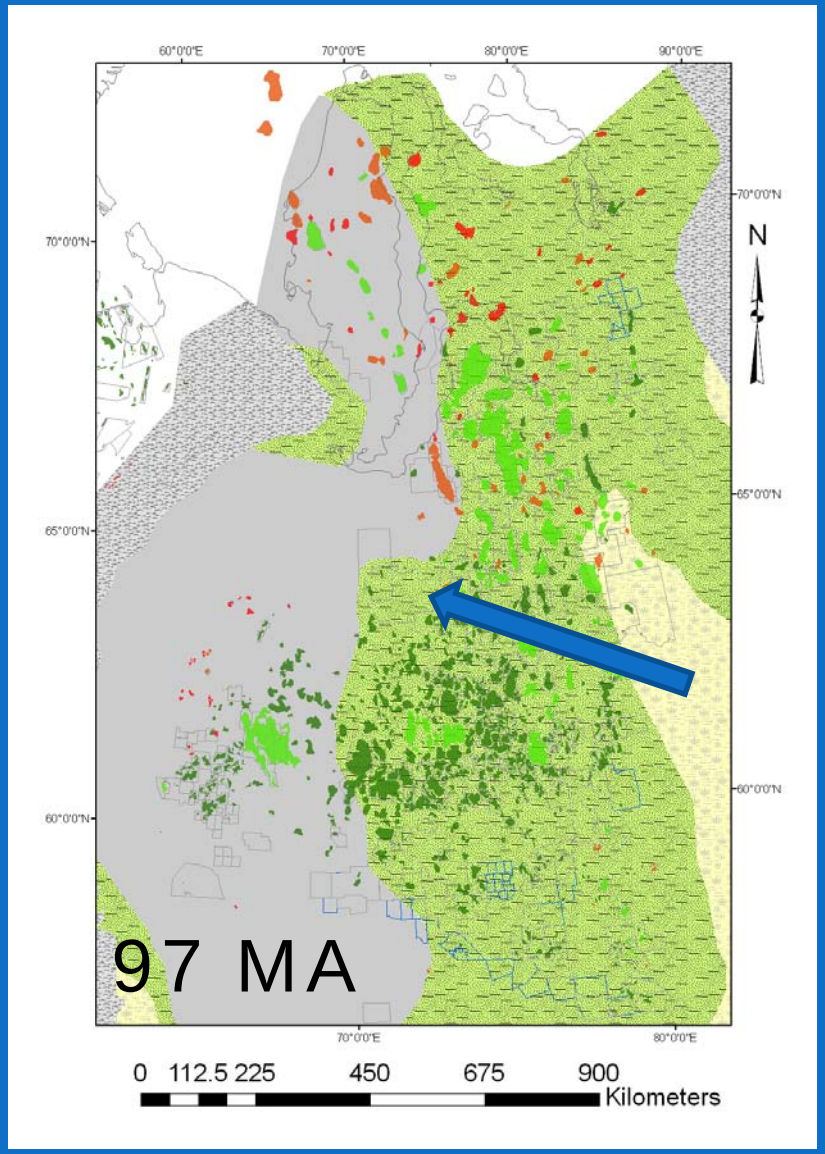


Aptian regression with incision

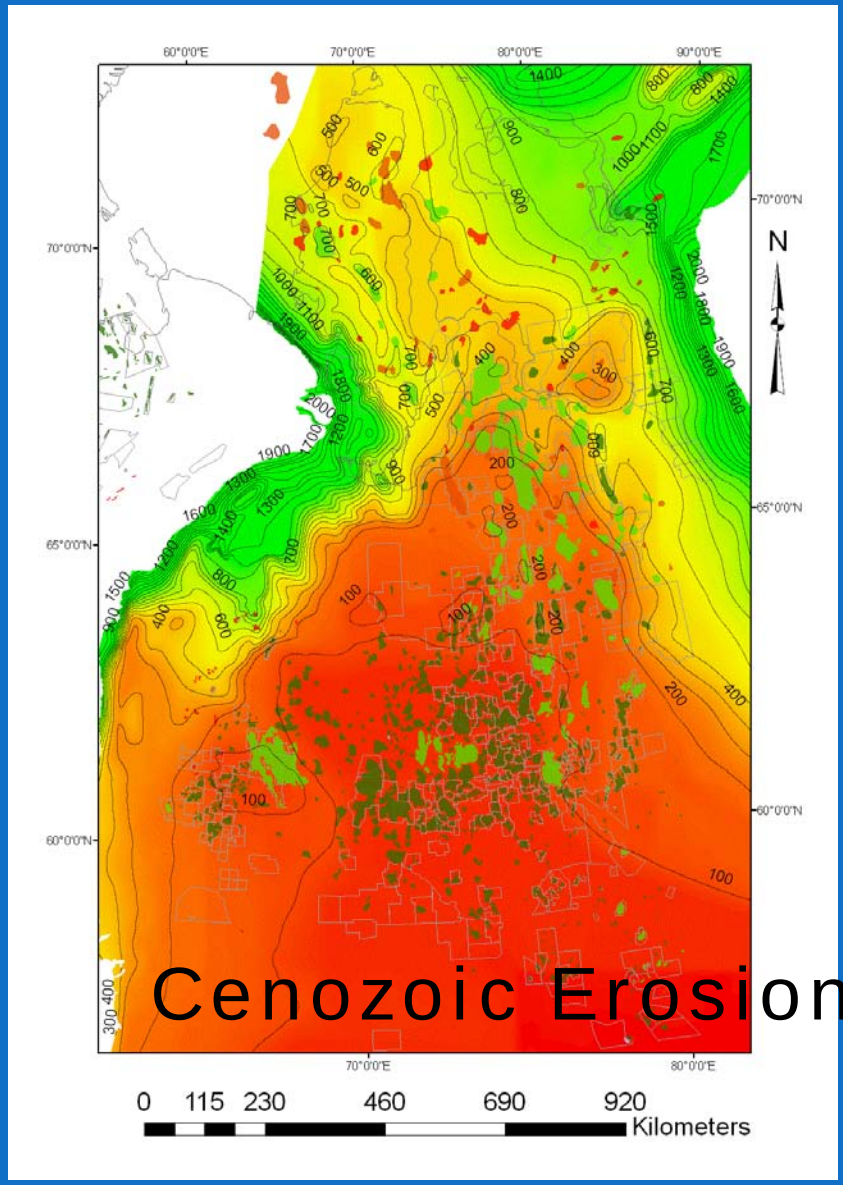


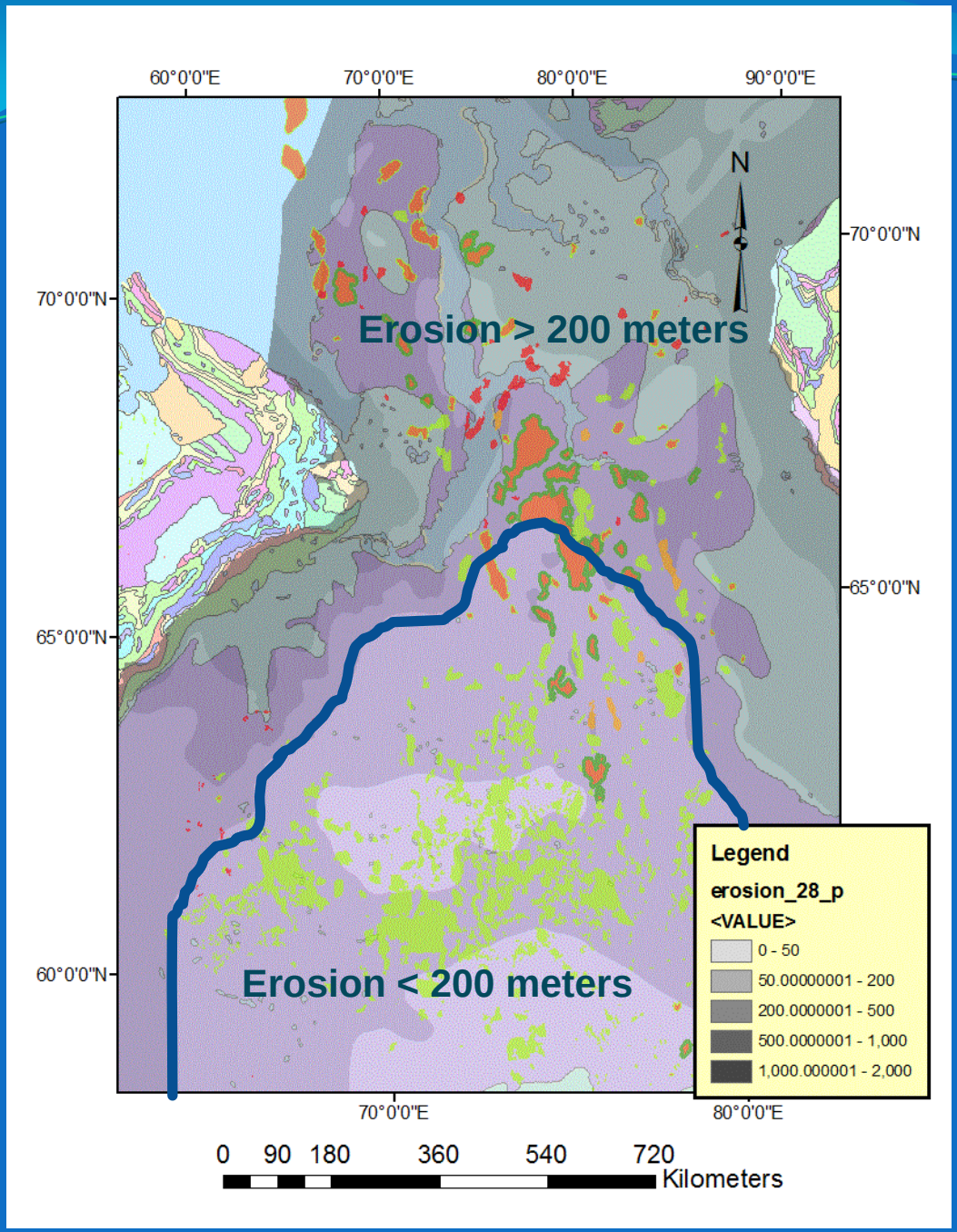


Cenomanian Deposition



> 2500 meters locally



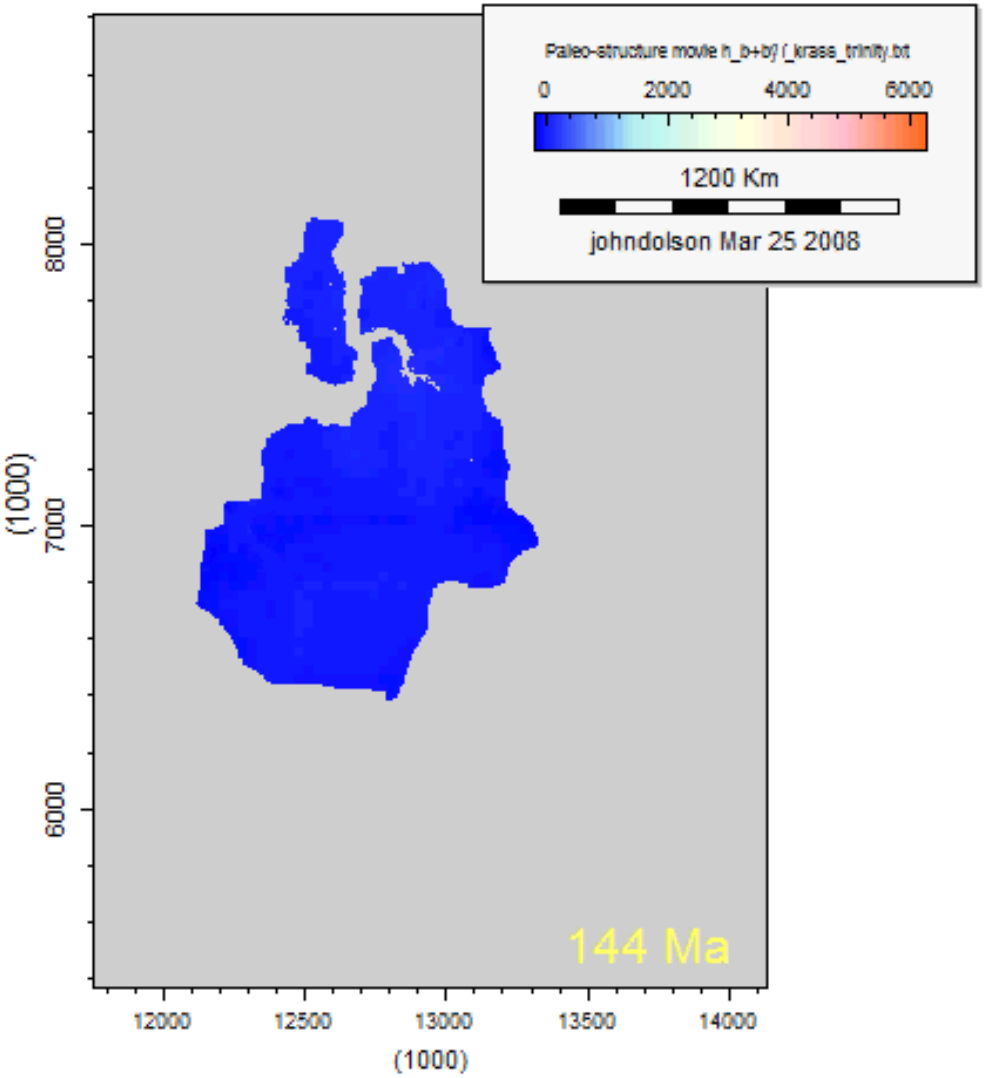


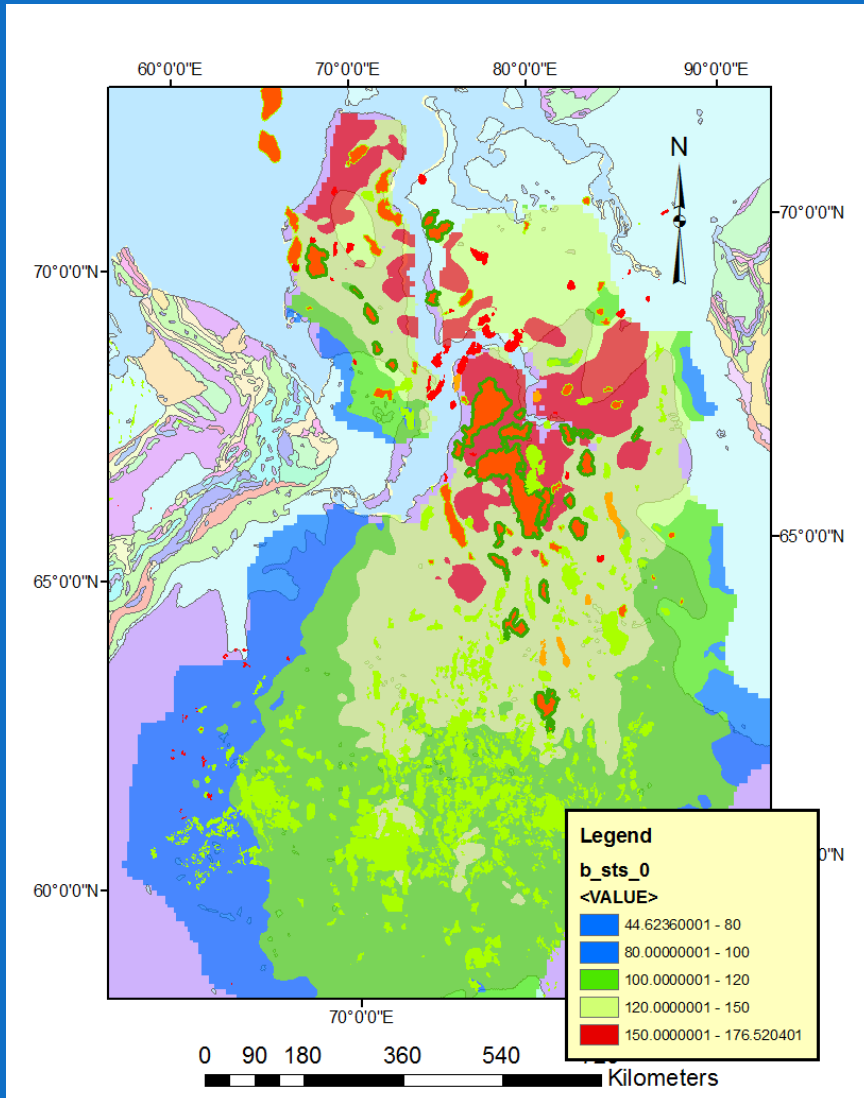
Erosion map and field type

Gas fields with condensate and oil rims generally lie north of the 200 meter erosion line

- Gas + Condensate with oil rim
- Dominantly gas
- Dominantly oil

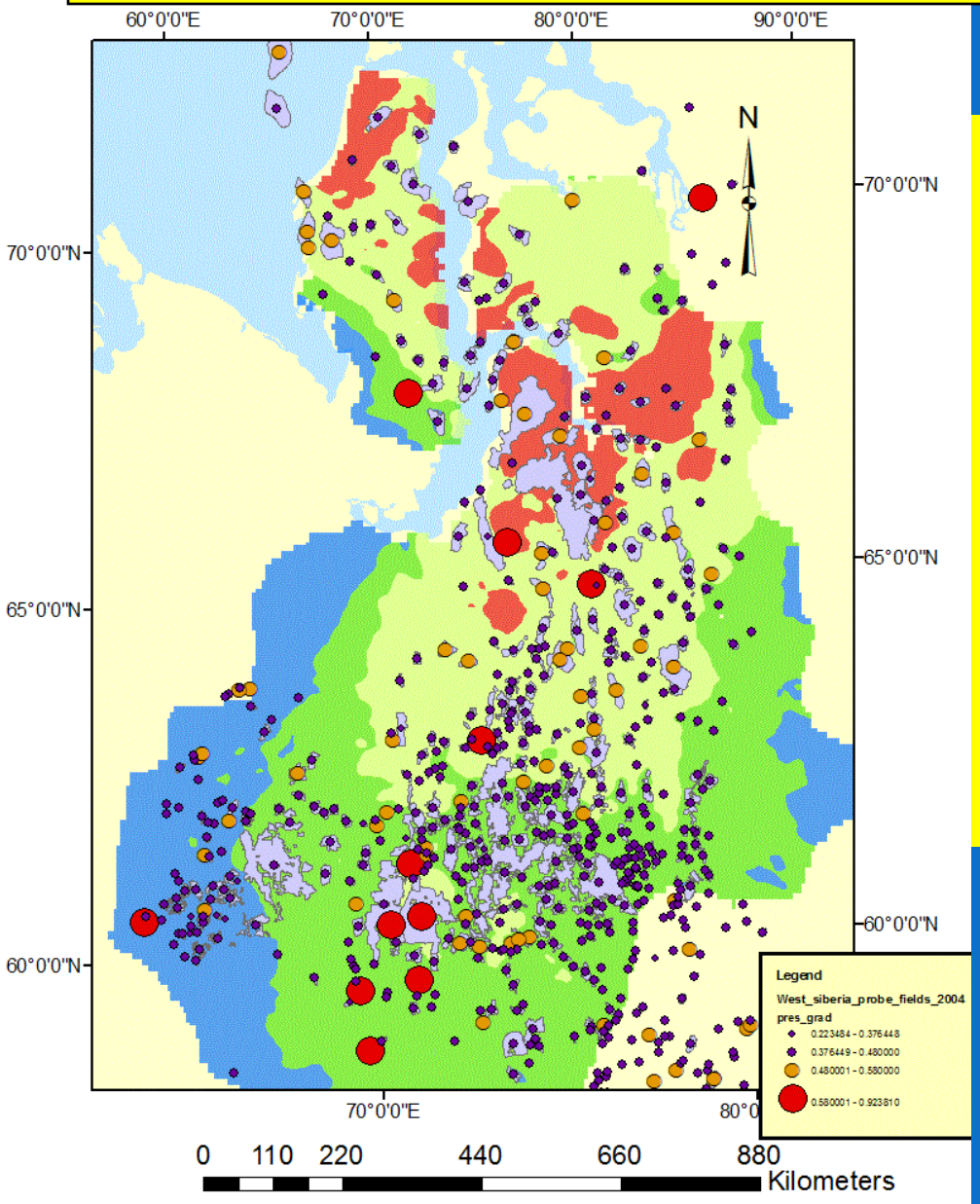
Burial History + Uplift, Gas Expansion: Dominantly gas in north with numerous oil rims from gas expansion



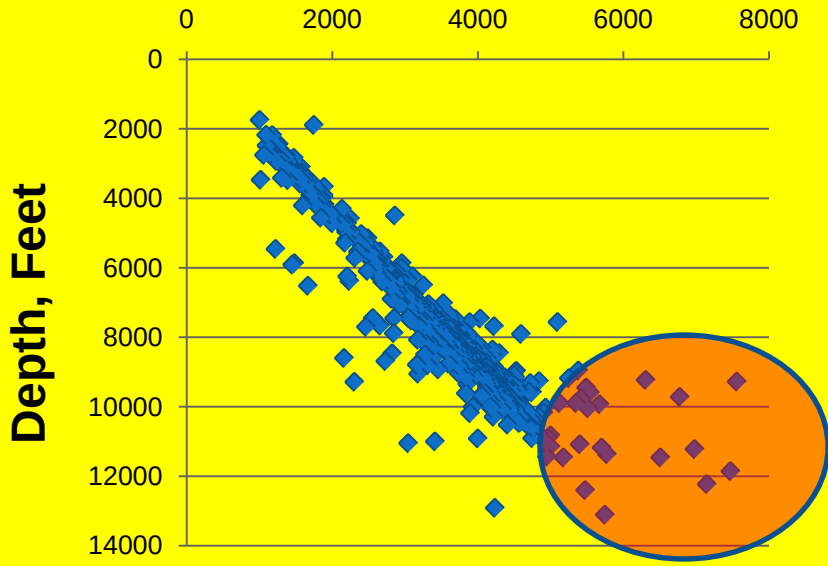


Thermal Stress Map
+ Fields

Most Over-pressured Trends Not Explored



DEPTH VS. PRESSURE

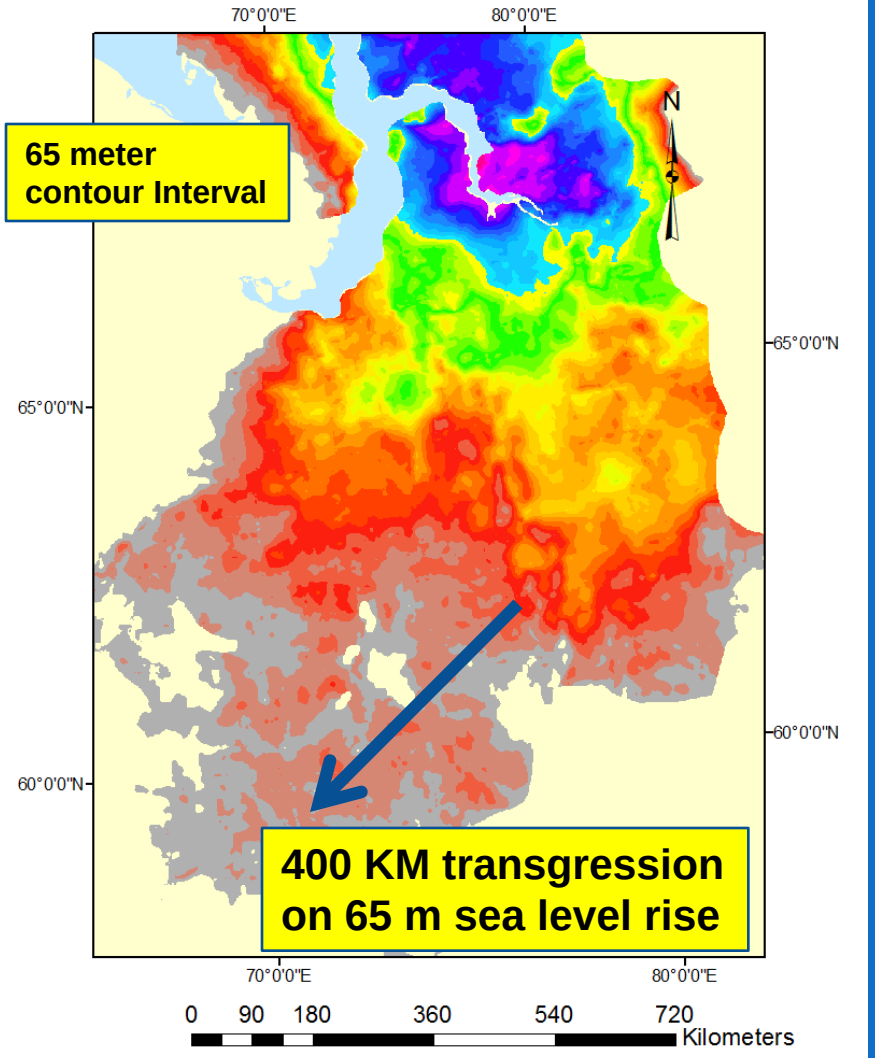


IMPLICATIONS FOR EXPLORATION

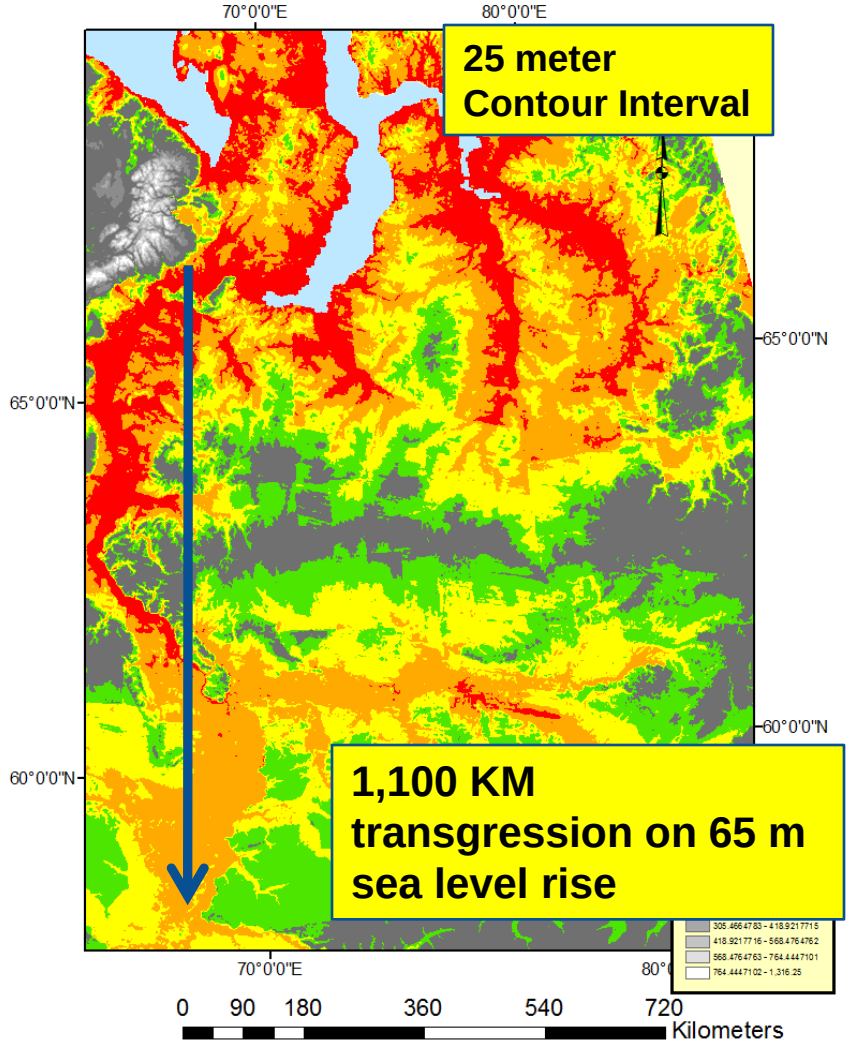
- NUMEROUS UNCONFORMITIES
  VALLEY FILLS COMMON
- TRADITIONAL ‘LAYER CAKE’ CORRELATIONS DON’T WORK
- STRATIGRAPHIC TRAP POTENTIAL IS HIGH:
  Multiple seals, reservoirs
  Short columns can cover wide areas due to low structural dip
- Abundant oil rims and re-migrated oil mixed with gas in Yamal/northern part of basin

Relationship of low topographic relief, sea level fluctuation and multiple high frequency incisions

Lower Jurassic Isopach



Current topography analog



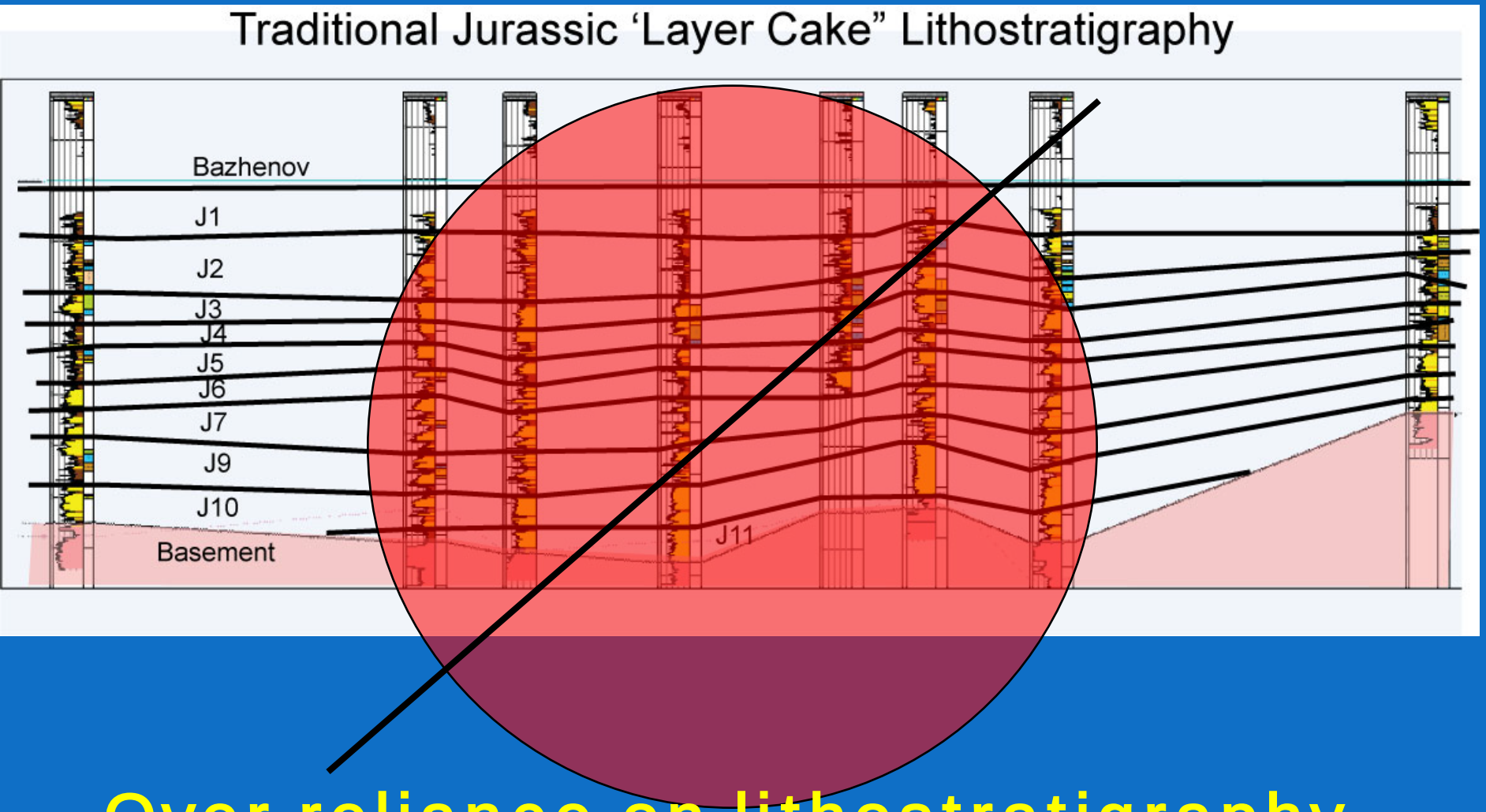
Some examples of re-thinking the traditional

Jurassic

+

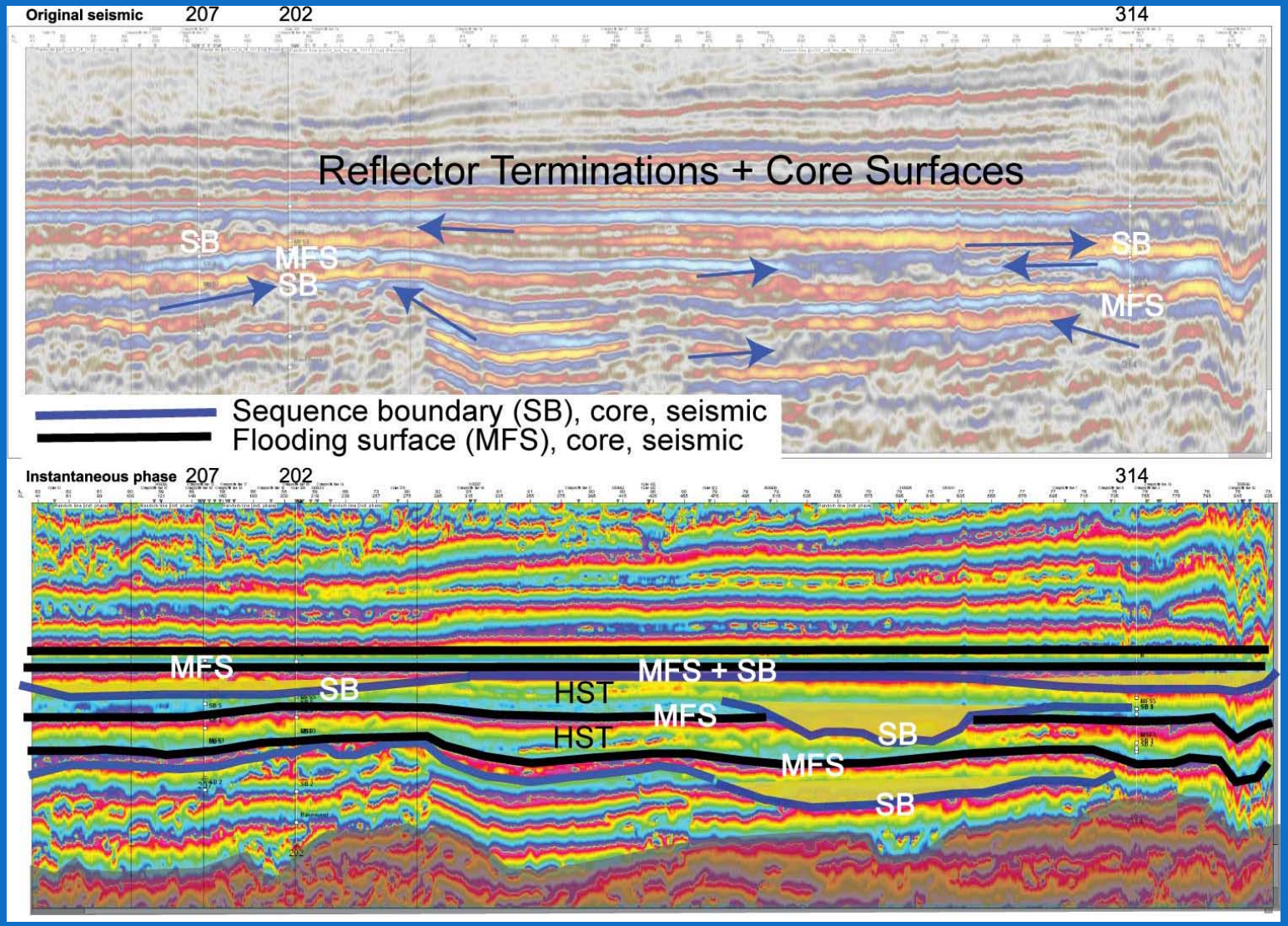
Neocomian

Re-thinking the traditional ‘layer-cake Jurassic nomenclature



Over-reliance on lithostratigraphy and simple one transgression models

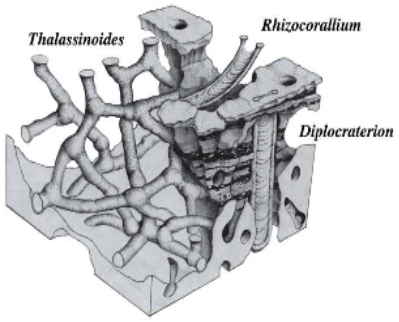
Start from scratch: Jurassic Seismic Surfaces and Sequences

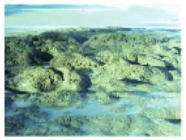


Jurassic Core Surfaces + Facies Confirm Multiple Unconformities

Glossifungites Ichnofacies

Semi-cohesive Substrates





Detail of modern *Glossifungites* Ichnofacies, St. Catherine's Island, Georgia.

Upper surface of exhumed mud.

1. Vertical, cylindrical, tear- or U-shaped dwelling burrows.
2. Protrusive spreiten burrows resulting from animal growth
3. Suspension feeders or animals that leave the burrow to feed.
4. Low diversity but individual structures may be abundant.
5. Burrow walls may display scratch marks.

Stage Development of *Glossifungites* Ichnofacies

burial ➤ erosional exhumation ➤ colonization ➤ deposition and passive infill

Location: UT-115
Depth: 2477.97m

Location: UT-104
Depth: 2825.00m

Location: UT-104
Depth: 2707.57m

Selected Examples of the Glossifunites Ichnofacies from UT and URNA Cores

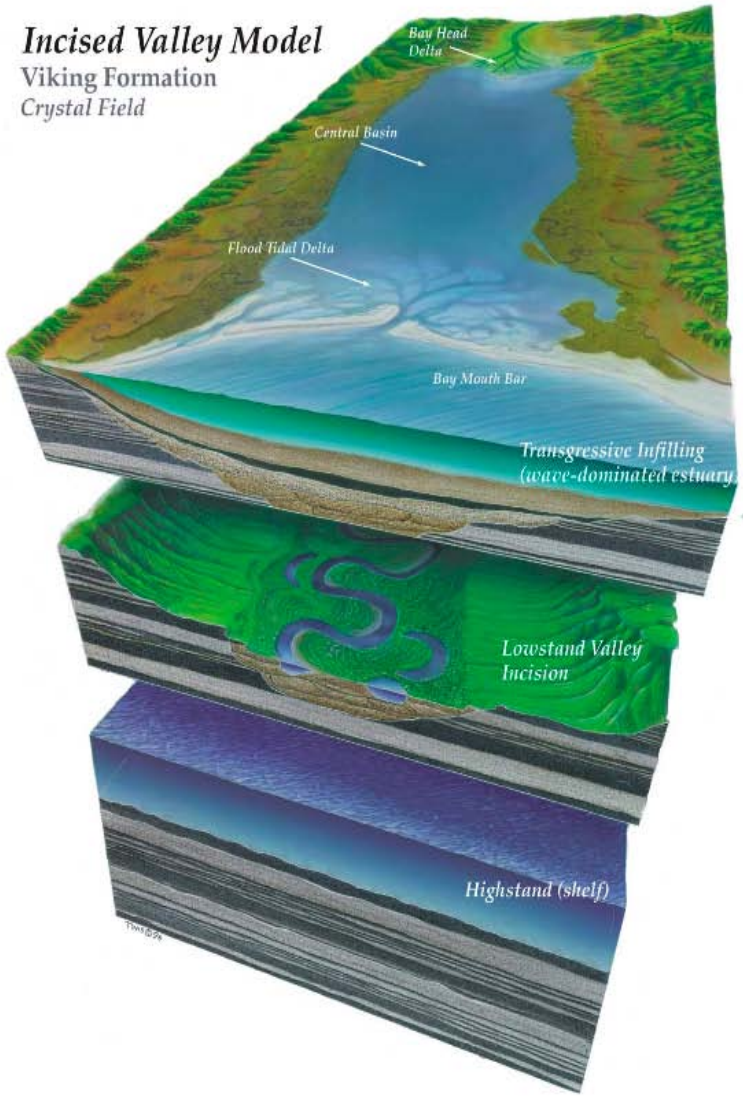
Location: UT-116
Depth: 2502.74m

Location: VA-1
Depth: 2447.82m

Location: UR-34
Depth: 2452.56m

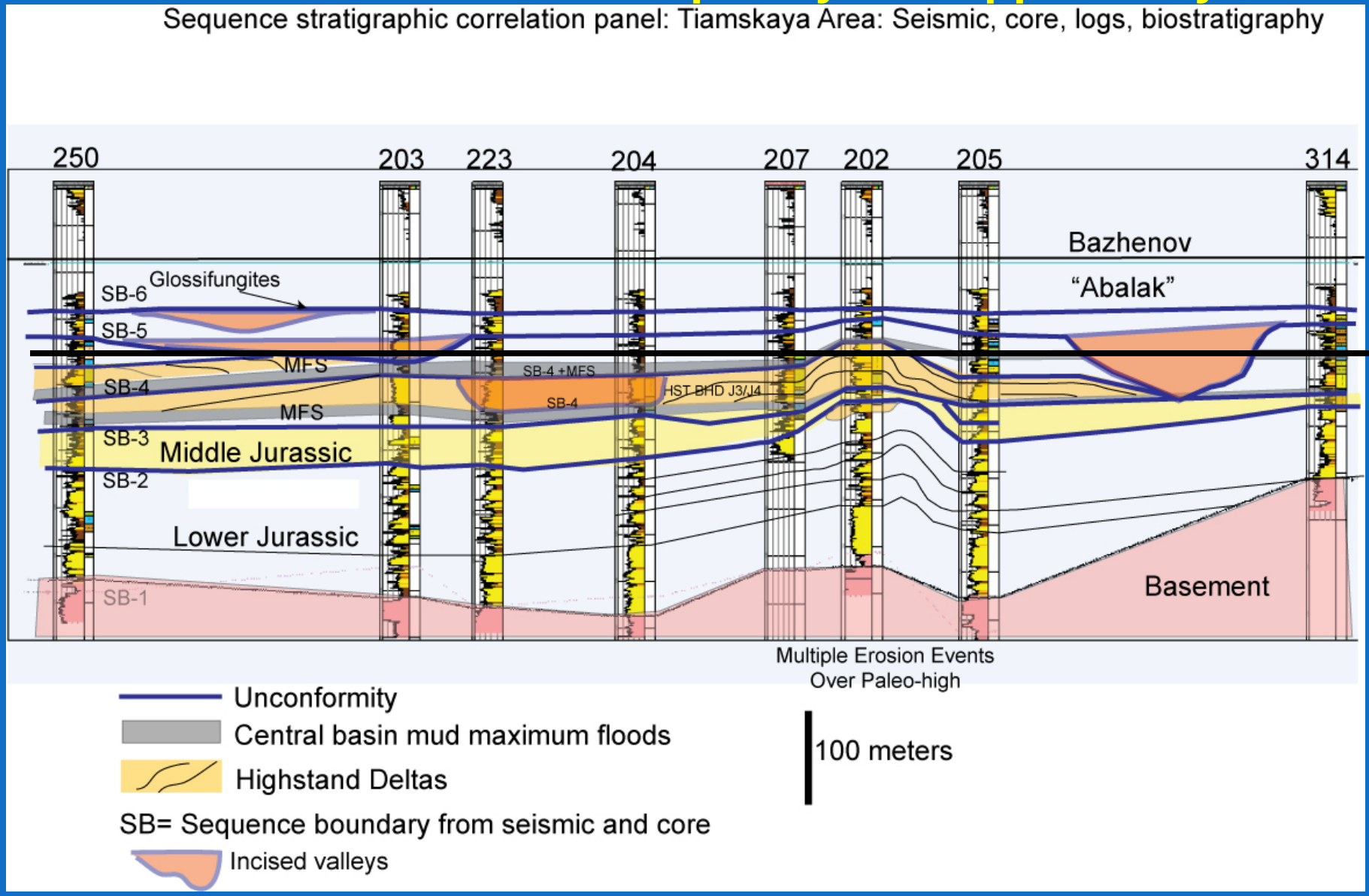
Jurassic cores reveal abundant estuarine Incised valley deposits

Bay Head Delta - Incised Valley Model

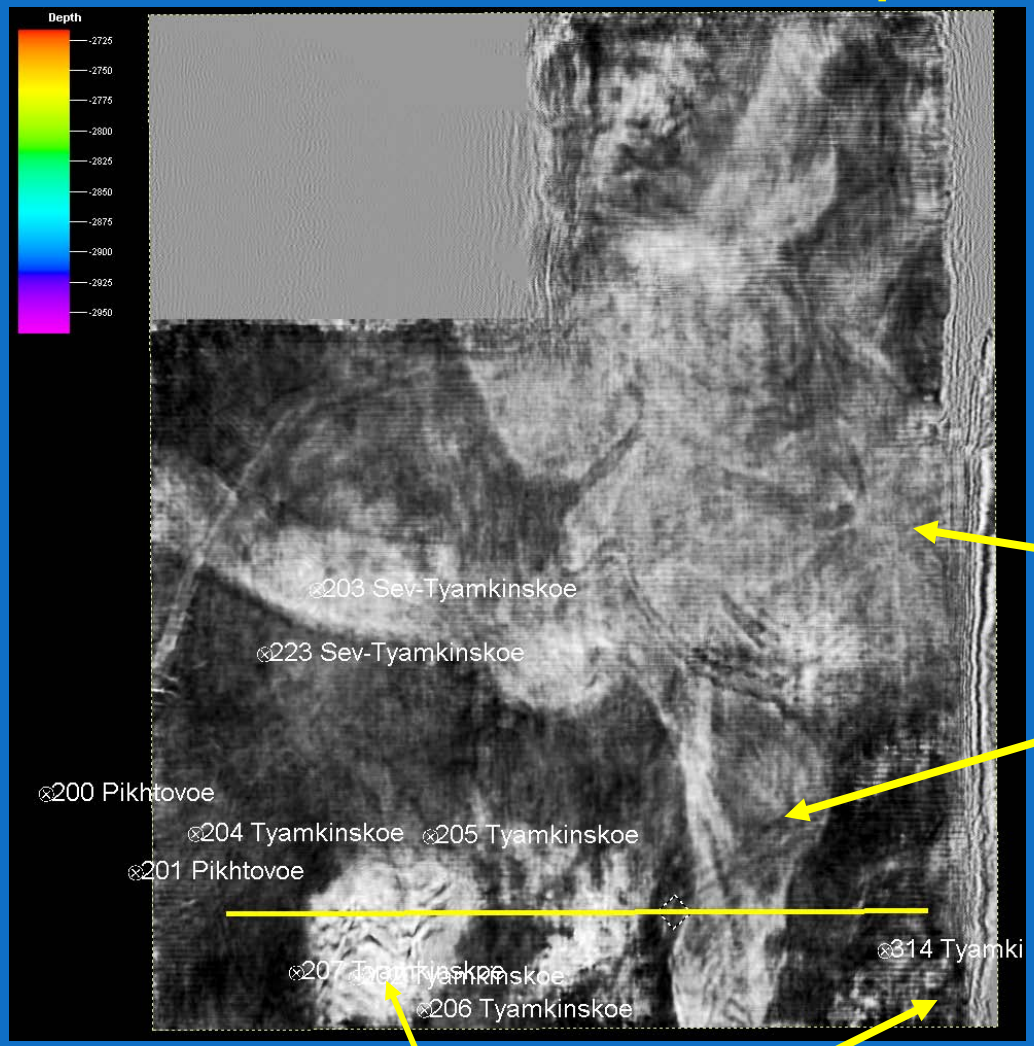


Fine-grained phyto-detrital deposts associated with the fine-grained delta fron deposits of the Bay Head Delta, the sandstones are also characterized by cryptic bioturbation

Integrated log, seismic and core correlations reveal complexity and opportunity



3D seismic is changing how we visualize these traps



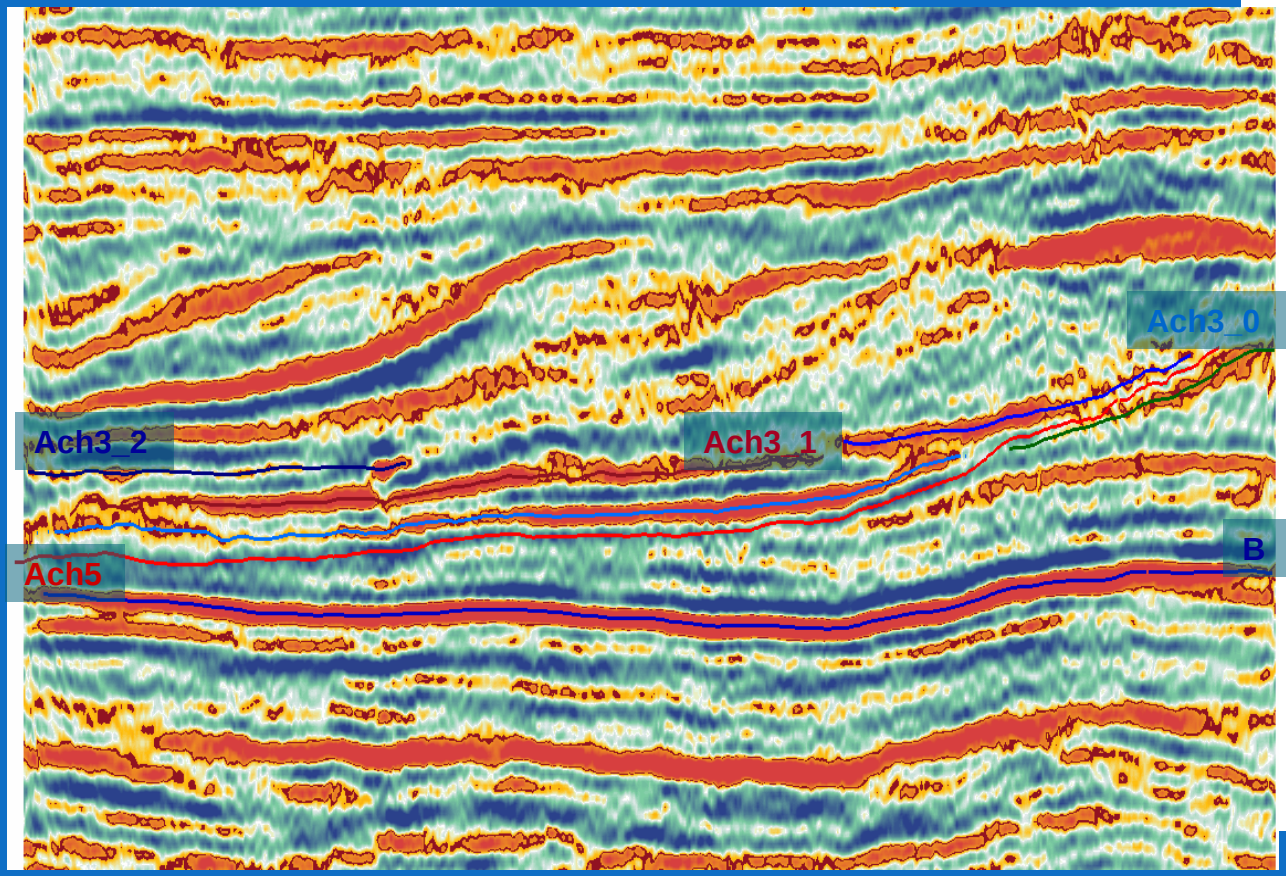
Estuarine Bayhead Deltas

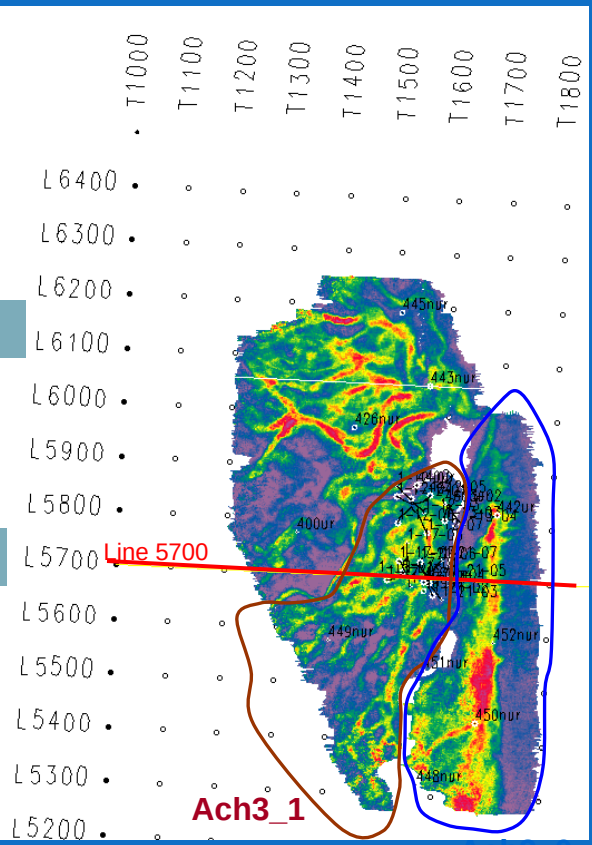
Major Estuary Valley Network

Paleo-structure High

Neocomian 3D expression of Shelf-slope-basin in Achimov Facies

Horizon Ach3
Average trough amplitude
Time window +-5ms

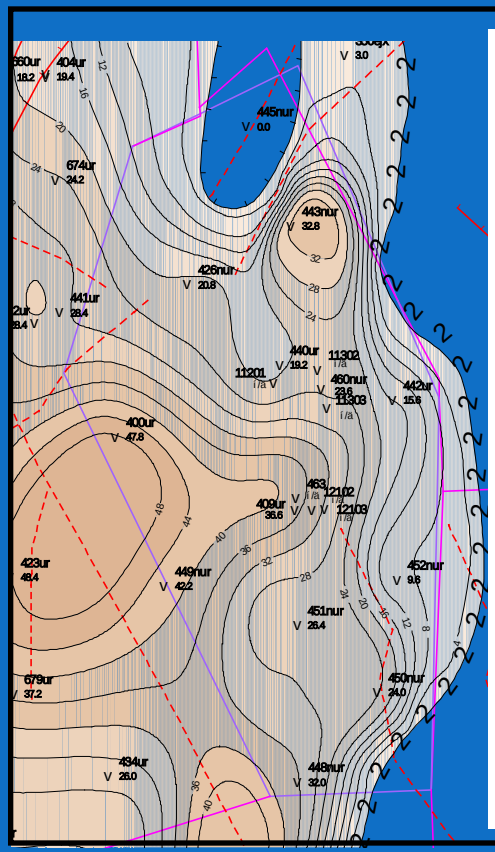


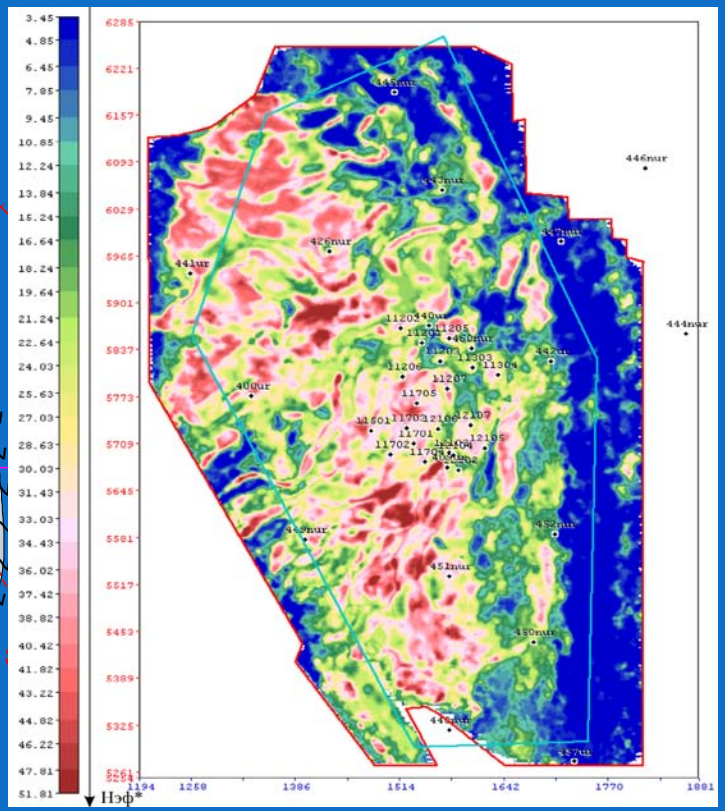


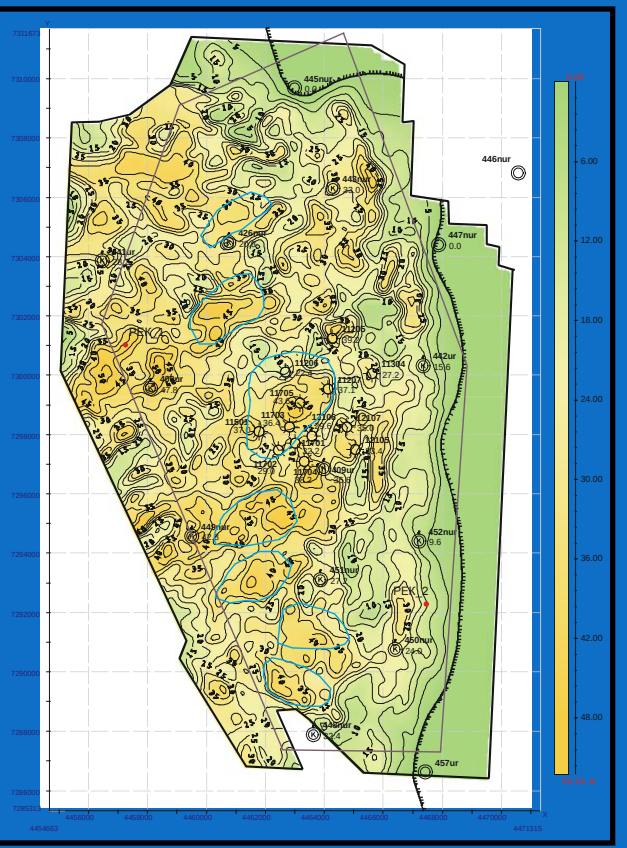
Evolving knowledge of deep water deposits from 3D seismic

2D Model of Turbidte Fan Effective Thickness

3D Attribute to 3D reservoir model

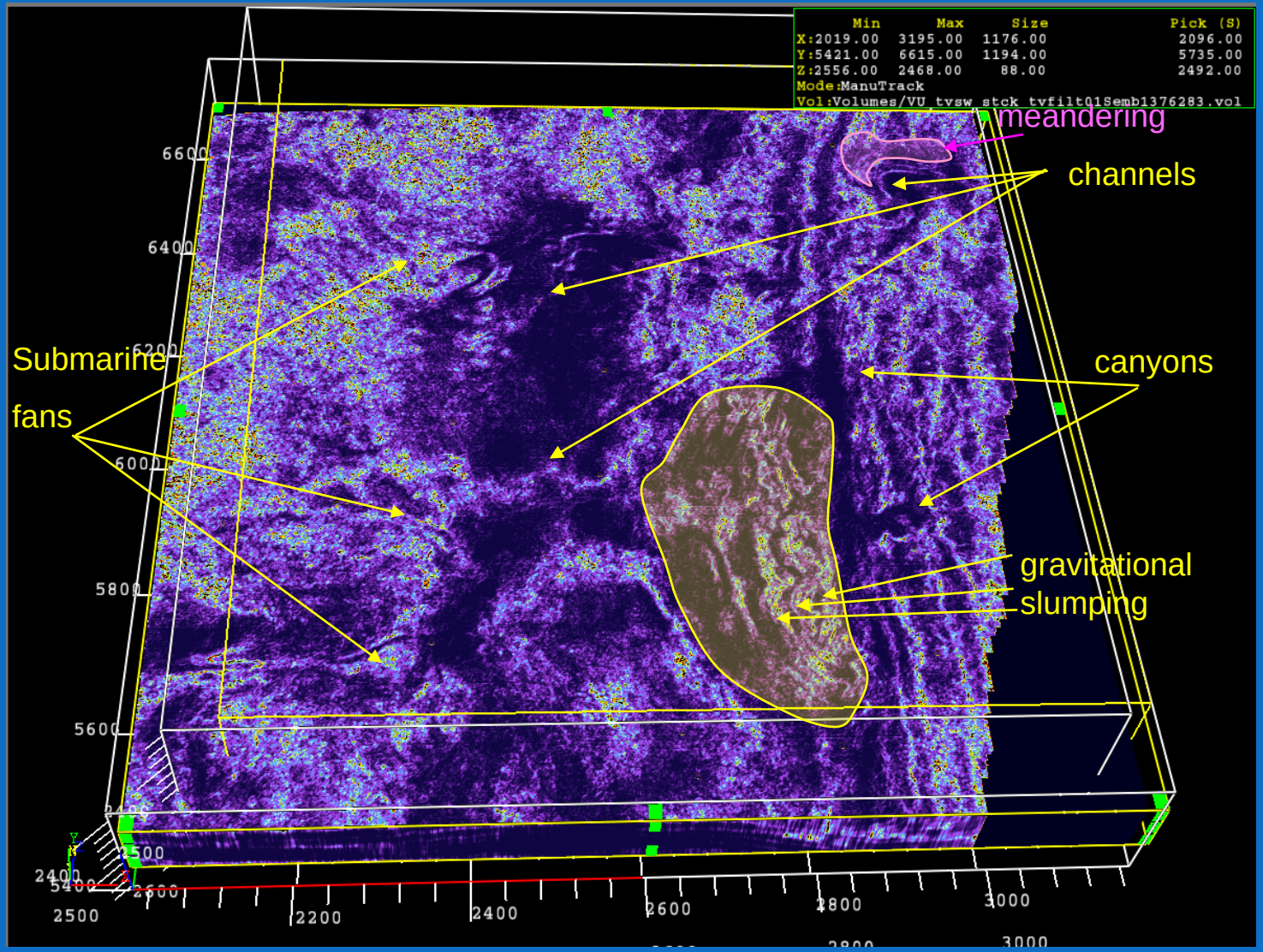






2006 **2007** **2008**

Vostochno-Urengoyskaiya area
Results of spectral decompositions



Layer Ach5_2-3

There is lot of oil left to find:

- In the north—where did the flushed oil go?
- What is left in deep overpressured trends?
- The big structures have been drilled

The key to the future success will be:

- New 3D Seismic
- Integrated Studies
- Modern applications of sequence stratigraphy and reservoir modeling

Acknowledgements

- Special thanks to TNK-BP management Chris Einchcomb and Richard Herbert

- Also outstanding technical contributions form our Russian, TNK-BP and BP expatriates and external consultants

  James Illife, Petroleum Systems, BP

  George Pemberton, Univ. of Alberta

  Keith Shanley, Consultant, Denver

  Sergei Hafizov (now Gasprom)

  Katya Volfovich and Irina Guskova, TNK-BP

  Vera Bratkova's team in TNNC for leading the way on seismic integration with core

- Staff at the Geoseis company, in Tyumen

  "simply the best and most aggressive group of geoscientists I have met in Russia—JD"