Salt Evacuation History and Depositional Corridors in the Annapolis and Crimson Region - Do These Wells Really Provide an Accurate Test of Sand Presence in Deepwater?*

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Abstract

Annapolis G-24, drilled in 2002, was the first deepwater well in offshore Nova Scotia to encounter hydrocarbon charged reservoir quality sands. The well encountered 27 m of net gas pay in fine to medium grained turbidite sandstones with good porosity and permeability. Crimson F-81 was drilled two years later, and pursued a similar salt withdrawal related play along the same depositional fairway. The well encountered minor reservoir quality sand, but no significant hydrocarbon bearing zones. This result demonstrates that the depositional systems for transporting reservoir sands from the shelf to the slope are not well understood.

Although the highly complex structural geology makes correlation of seismic markers in the study area challenging, the construction of salt contact maps has helped to improve the understanding of allochthonous salt evolution. This allows us to make educated and geologically plausible correlations through areas of detachment, counter-regional growth, and across salt welds and salt bodies. Combined with time-thickness maps, our results demonstrate that salt tectonics played an important role in controlling the distribution of Jurassic and Cretaceous sediment near these wells. Specifically, salt tectonics created paleo-bathymetric highs and lows on the slope that caused deepwater strata to thin and thicken, respectively.

Jurassic and Cretaceous time-structure maps indicate that paleobathymetric highs were oriented perpendicular to the present-day shelf-edge. The highs influenced the trajectory of sediment gravity flows, with isochron maps indicating that both wells were drilled on stratigraphic thins relative to nearby salt withdrawal depocenters. Stratigraphic thinning appears to be directly linked to paleo-bathymetry, specifically with both wells targeting the thinned flanks of an intra-slope minibasin. The fact that these wells still encountered reservoir quality sand while penetrating stratigraphic thins is promising, and suggests that more sand may be present in

the isochron thicks to the east. Identification of canyons up-slope from these isochron thicks provides a link between the sand-prone Mississauga and Logan Canyon formations on the shelf and intra-slope minibasins located seaward. Recognition of these canyons support the idea that significant quantities of reservoir grade clastics were transported into deepwater, but drilling efforts to date have not yet adequately tested the thickest stratigraphic intervals.

Selected References

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Website

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Salt evacuation history and depositional corridors in the Annapolis & Crimson region – *do these wells really provide an accurate test of sand presence in deepwater?*

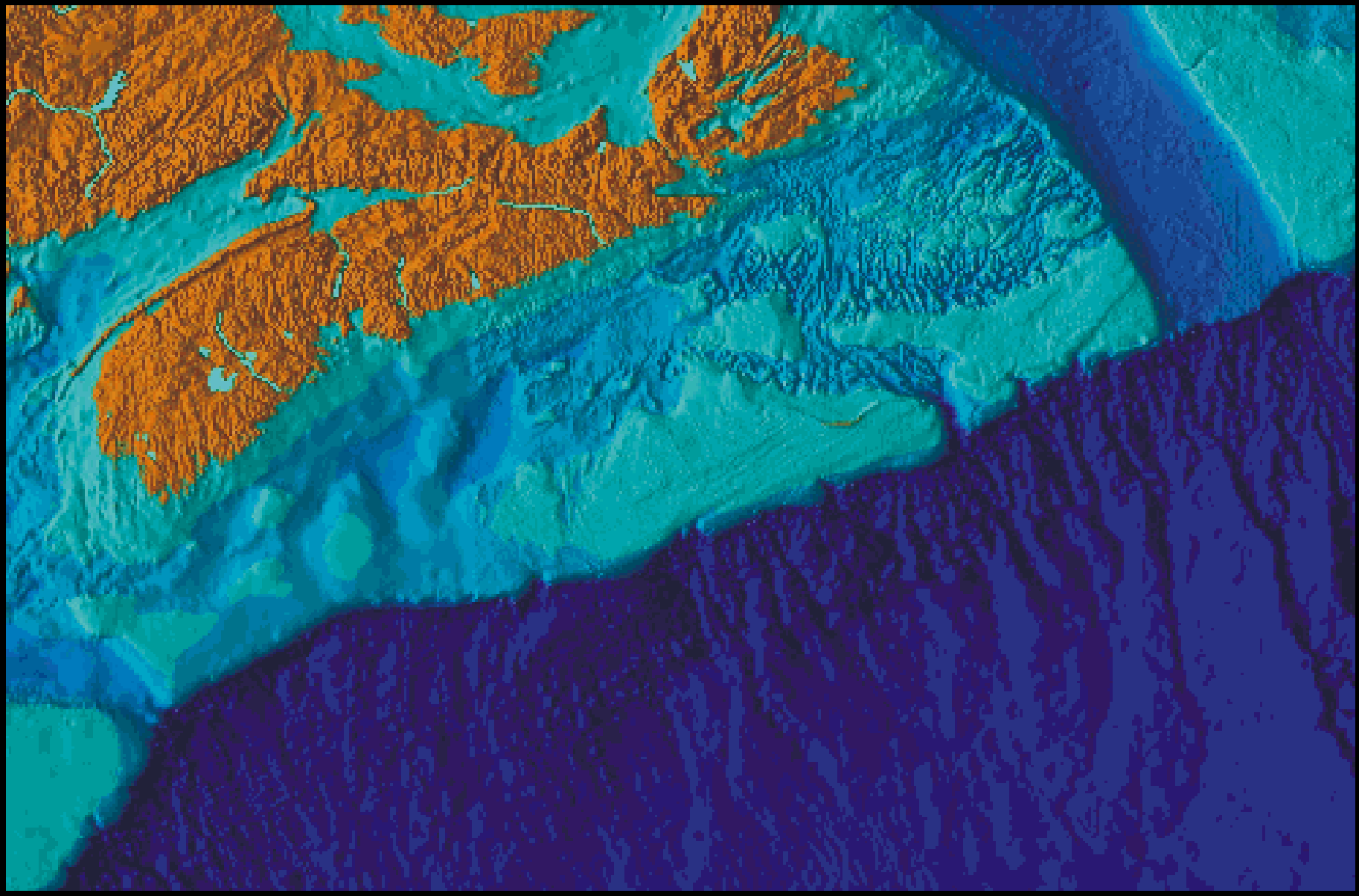
- **Kris Kendell and Mark Deptuck, Canada-Nova Scotia Offshore Petroleum Board**

- 2010 Annual AAPG Convention & Exhibition – New Orleans
- April 14th, 2010

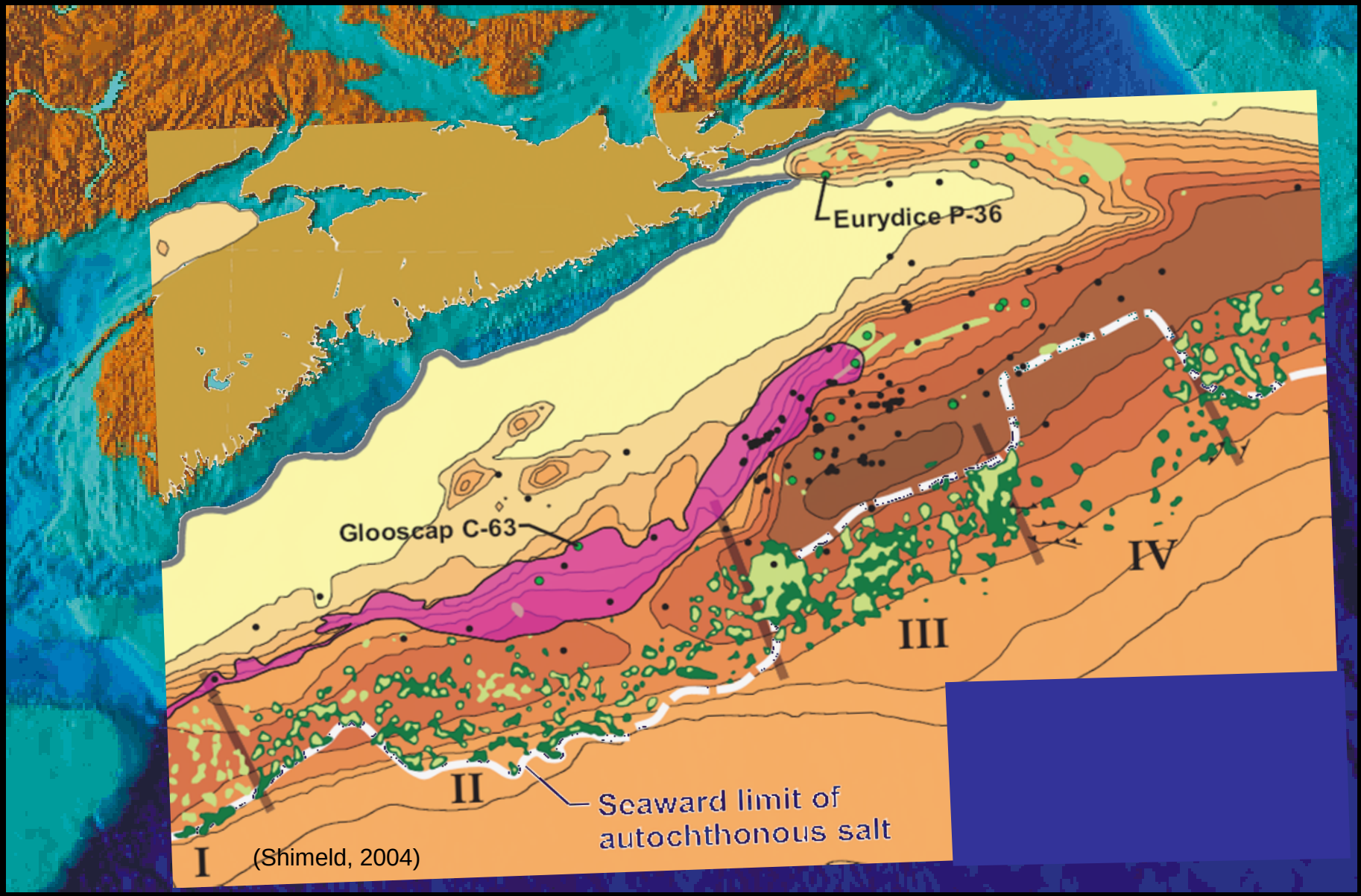
Outline

- Lateral variations of evacuation styles inboard the salt canopy
- Well penetrations and isochron maps within the Annapolis stepped counter-regional system (ASCRS) - interpreted depositional corridors
- Connection between isochron thicks and canyon heads – candidate location for Cretaceous shelf break?

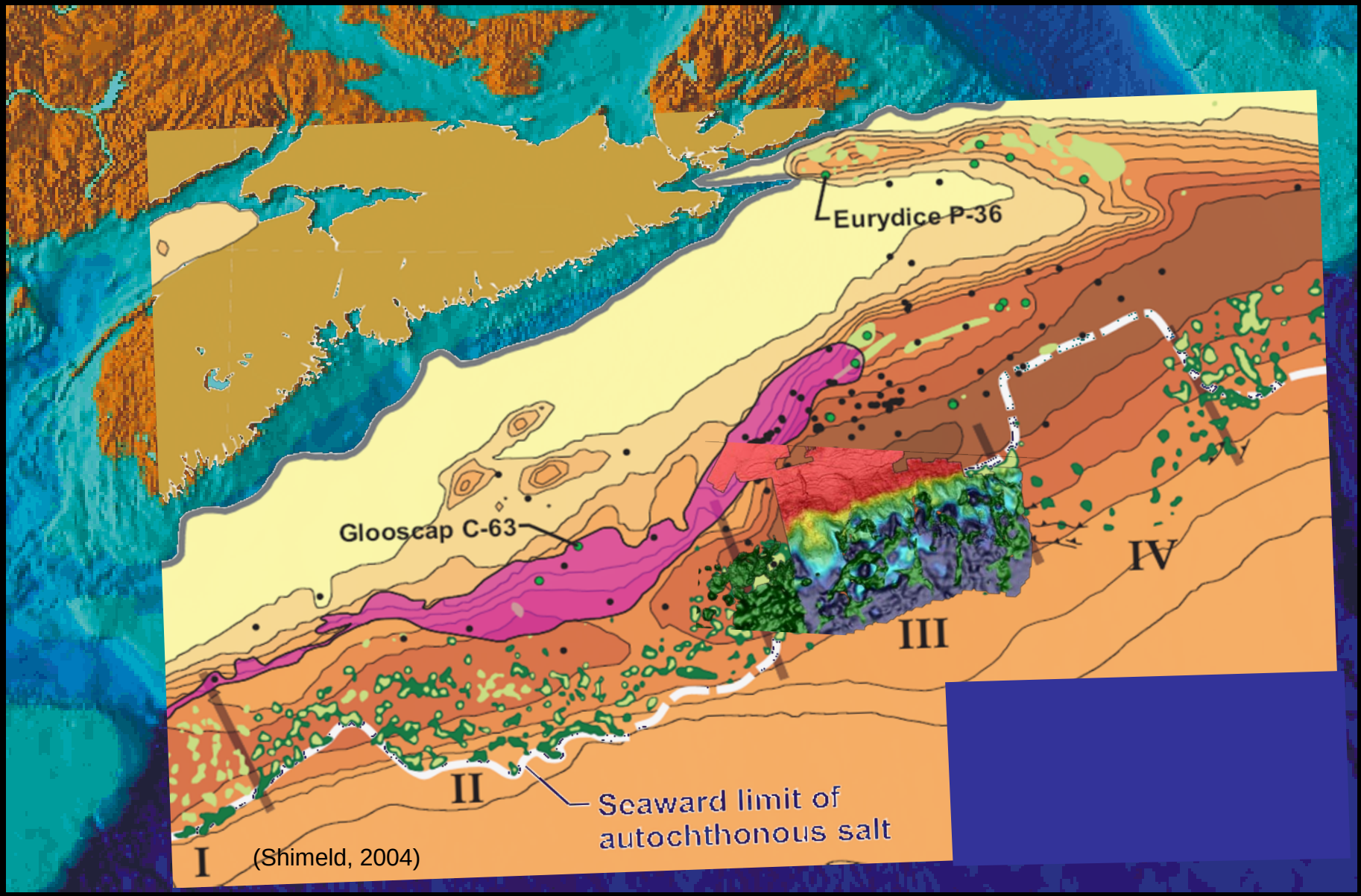
Regional Setting



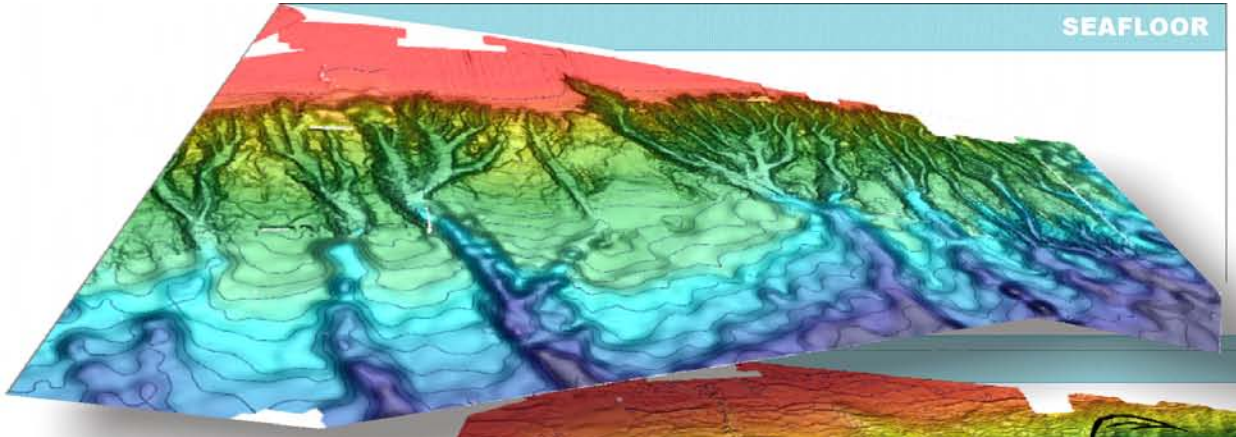
Regional Setting

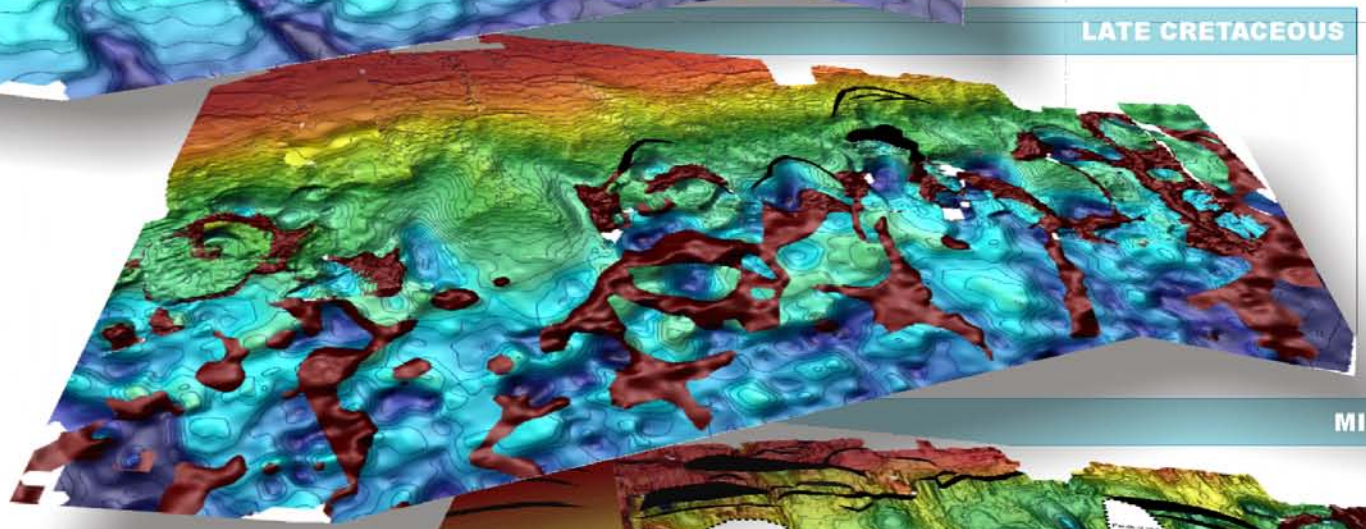


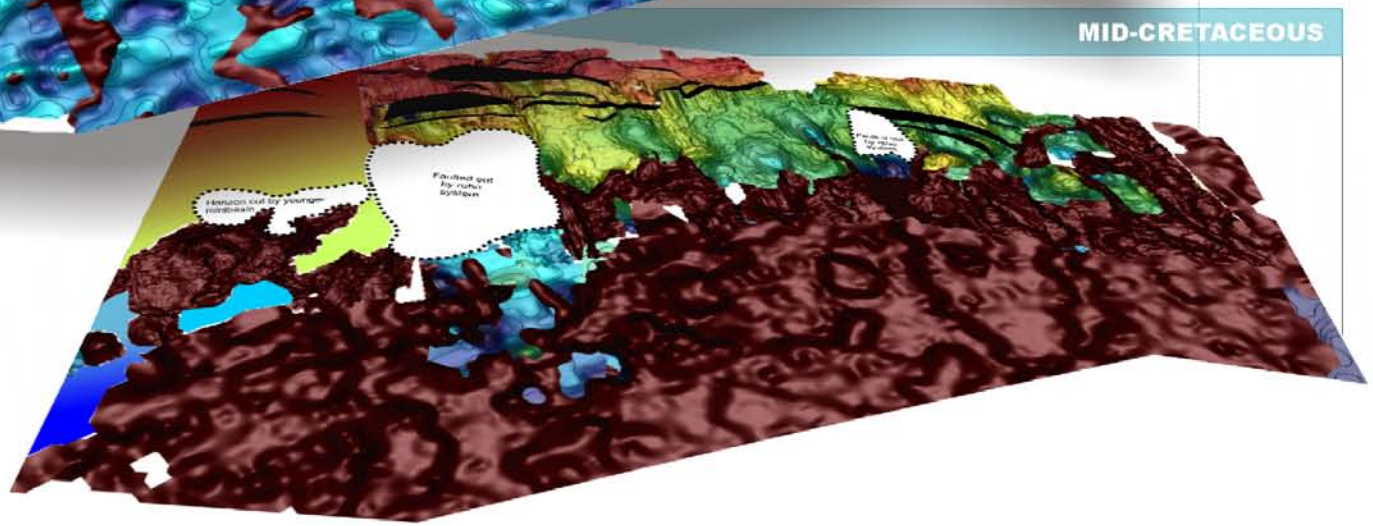
Regional Setting

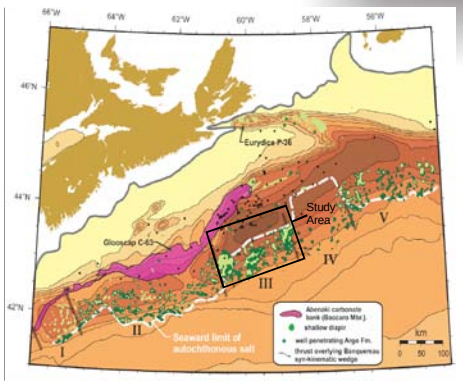


Regional Mapping





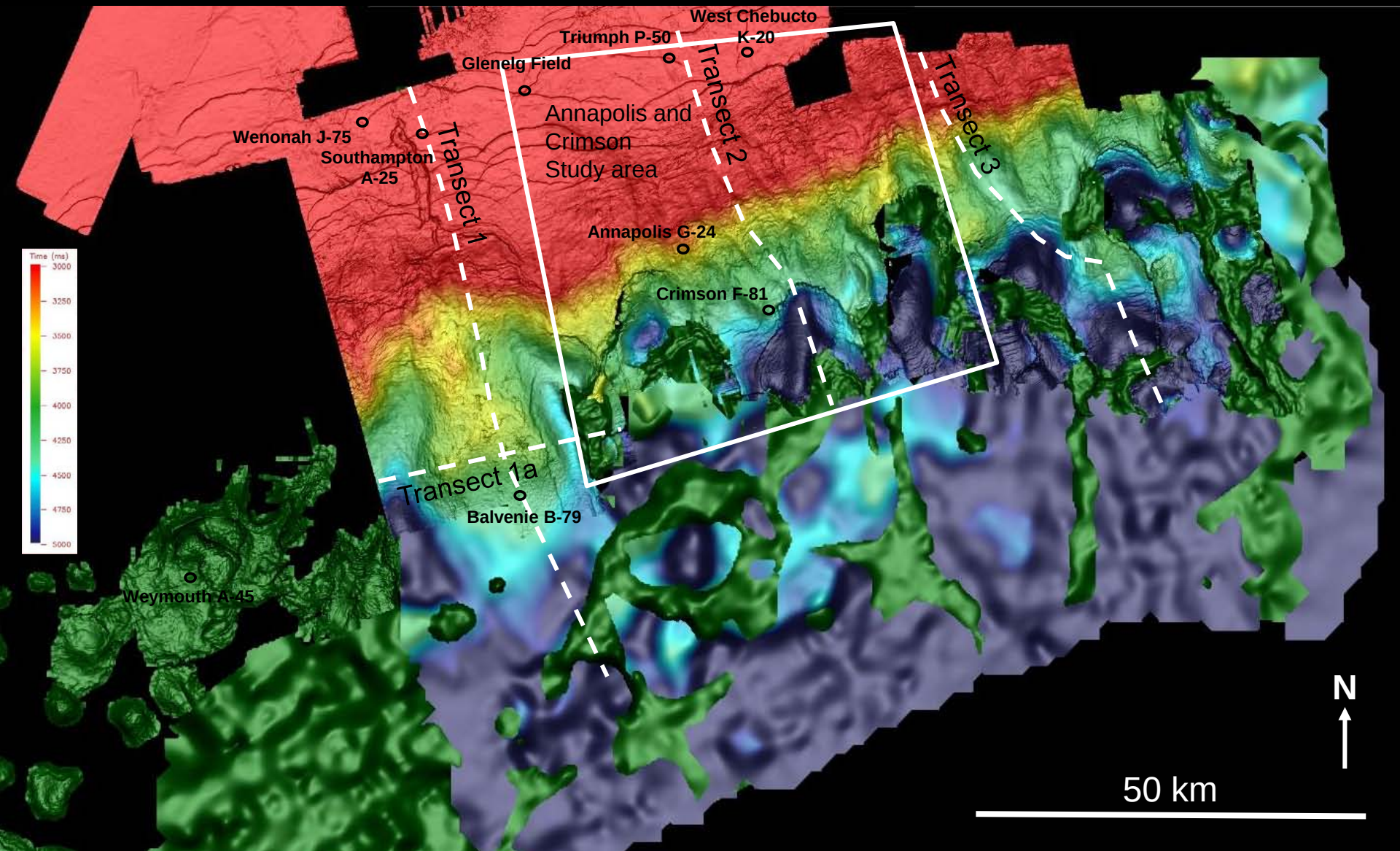




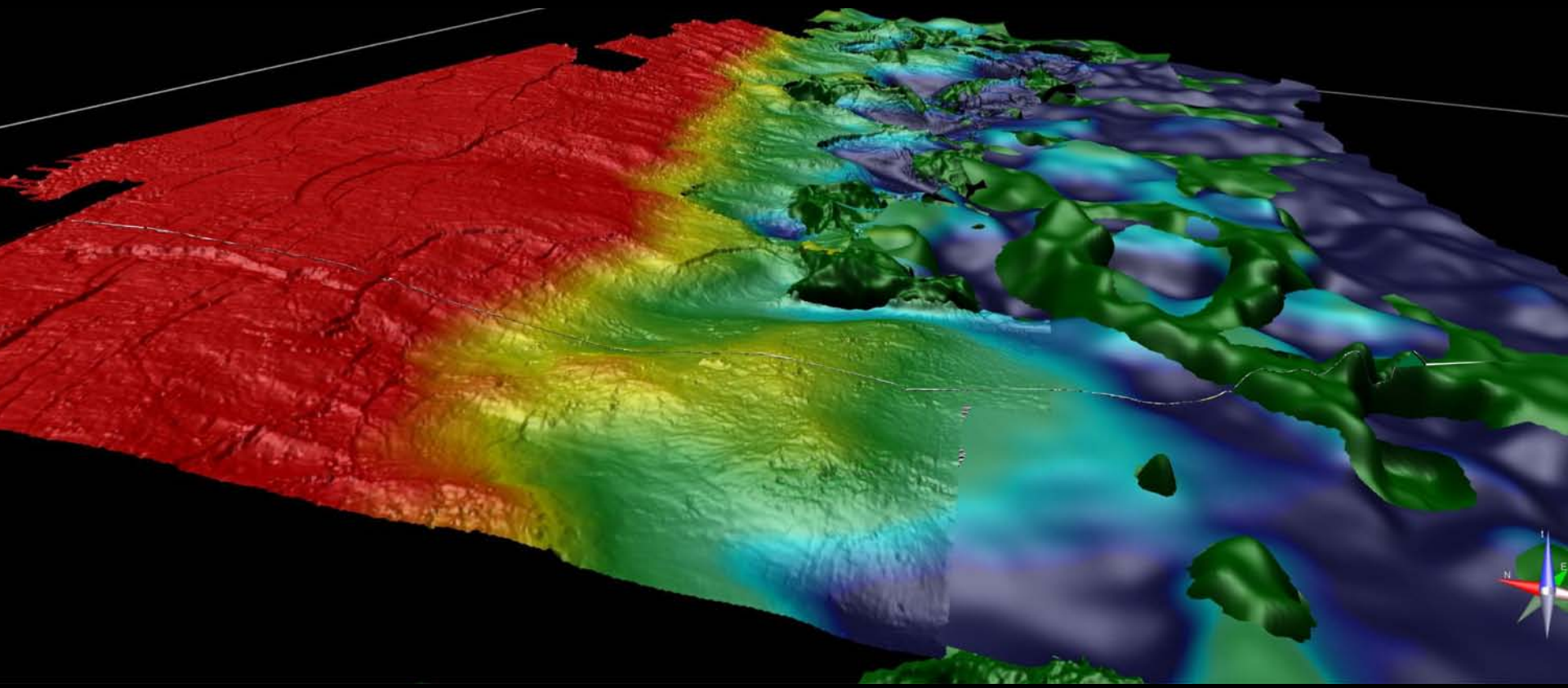
Salt tectonic subprovinces of the Scotian Basin (Shimeld, 2004). Subprovince III, the zone of allochthonous salt canopies is the focus of this study (black box above).

Gridded area is approx. 11 500km^2

Late Cretaceous Structure Map with Salt (green)



Transect 1 – Balvenie Roho System



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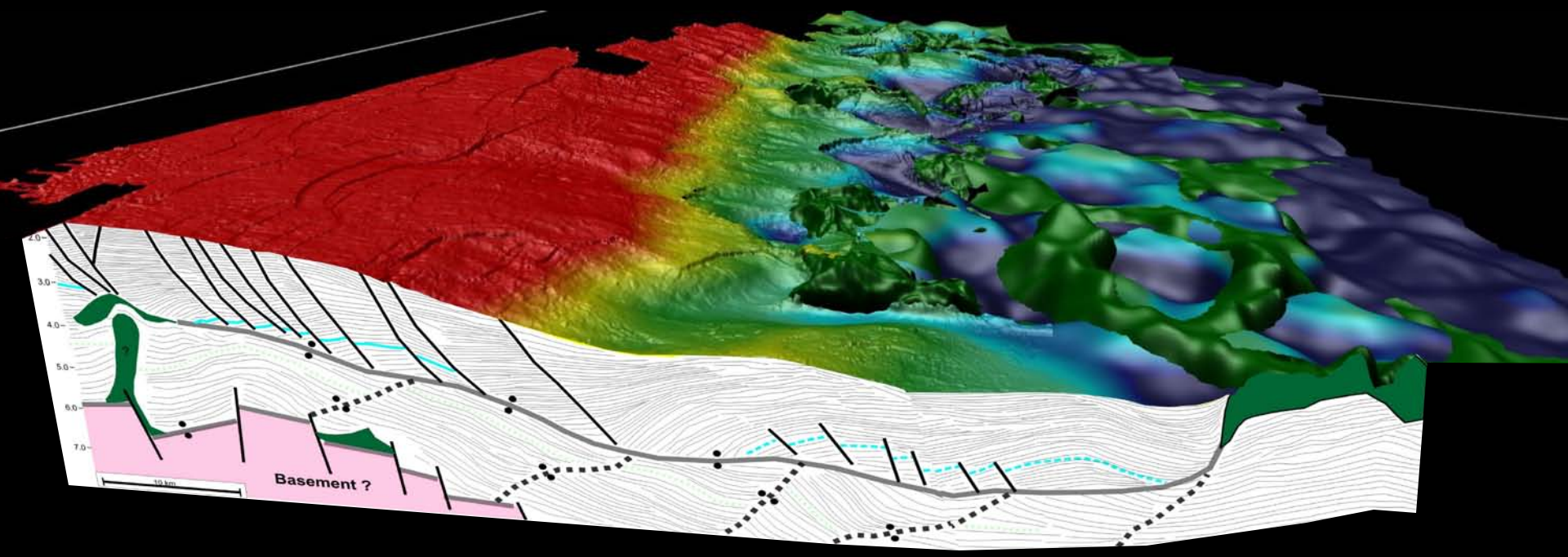
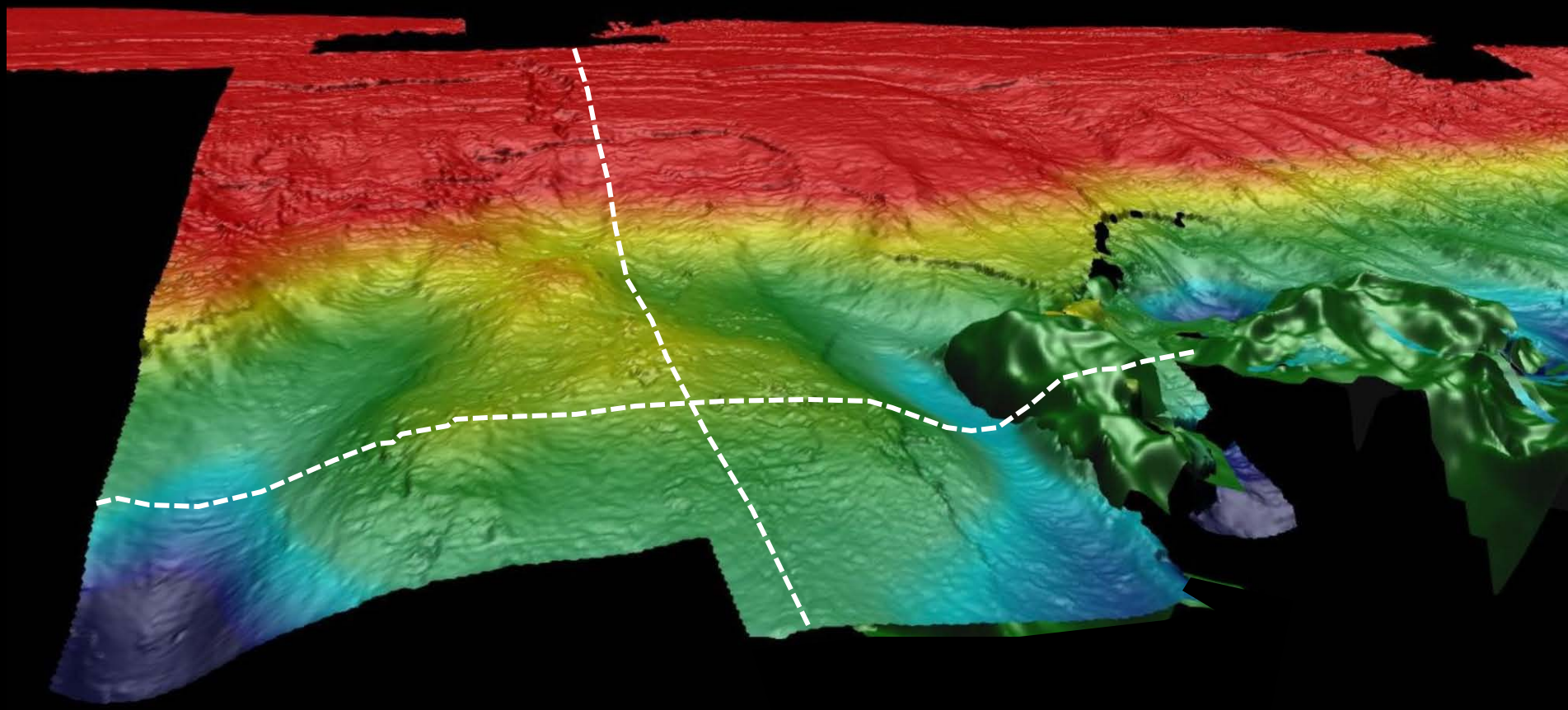


Defining features: series of roller faults, continuous salt weld reflector (~55 km), welded salt feeders beneath the detachment surface and landward dipping reflectors above detachment surface

Transect 1a – Balvenie Roho System (strike)



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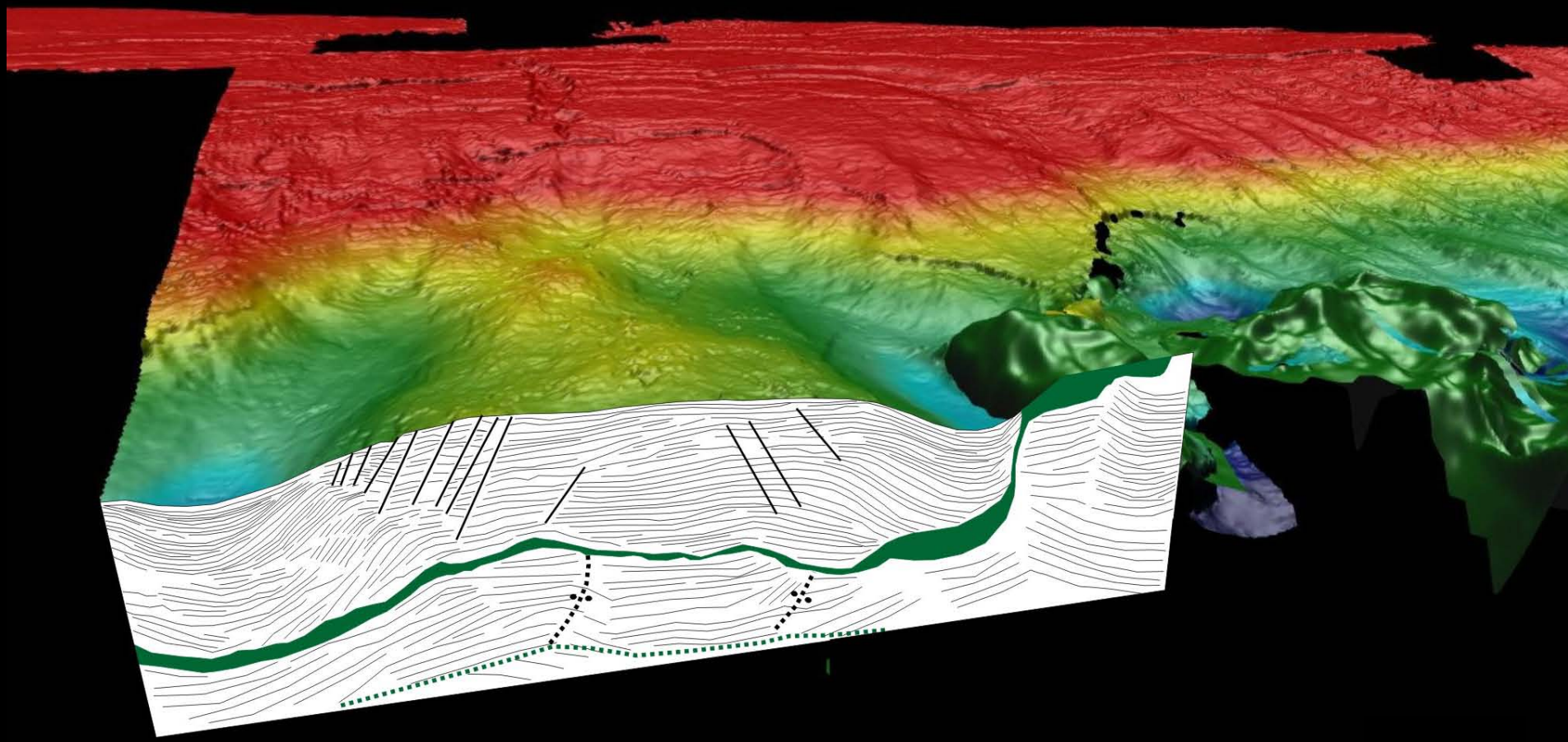
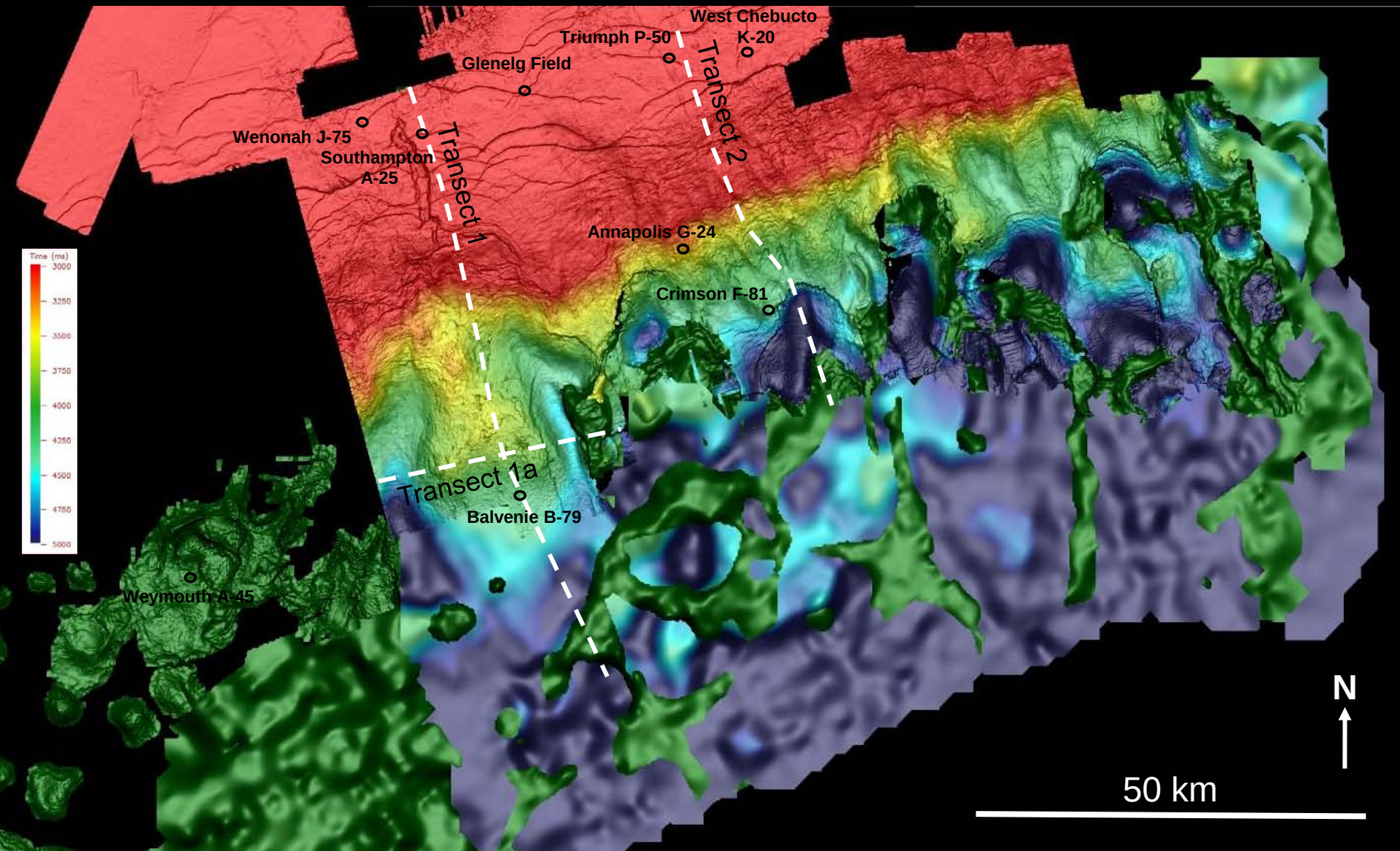
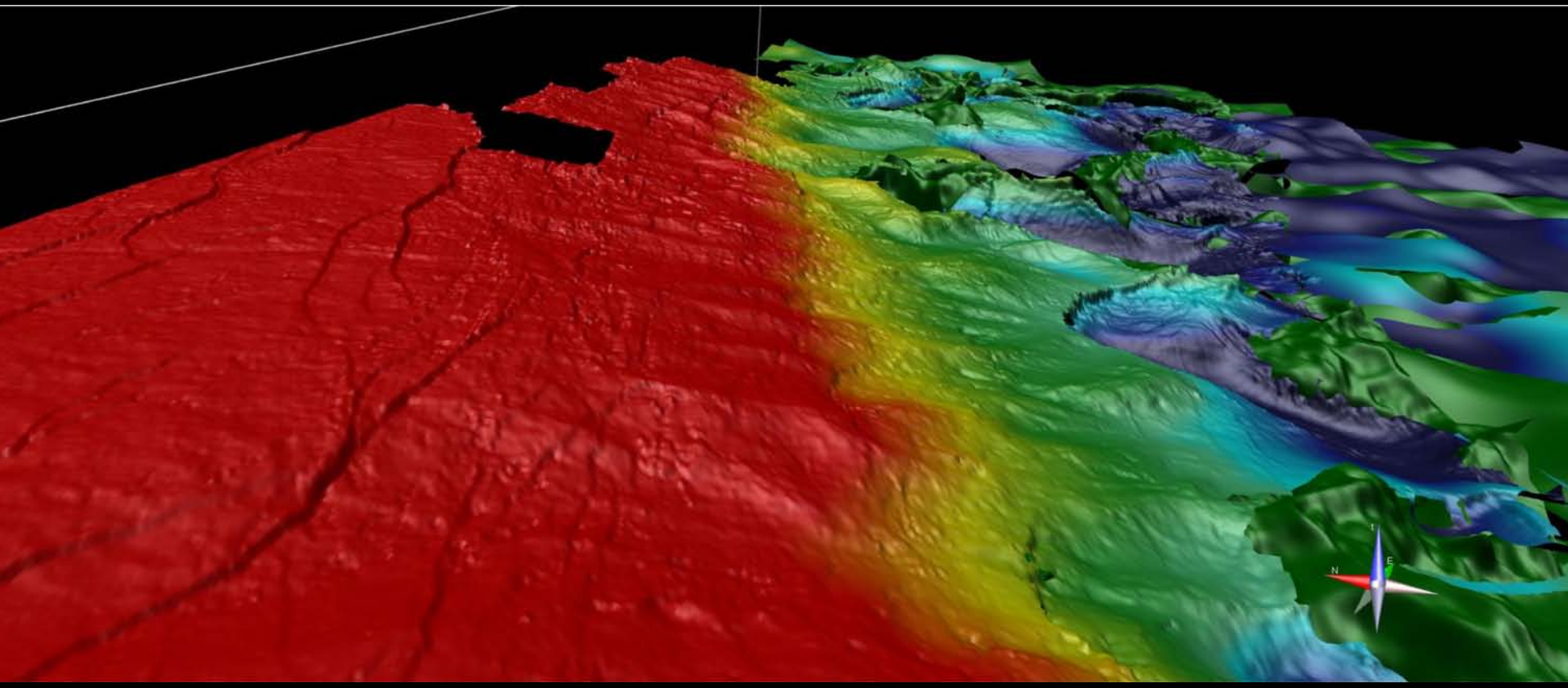


Defining features: **“**concave” reflectors (half turtle), surrounded by younger minibasins (moat), expelling salt laterally as well as basinward.

Late Cretaceous Structure Map with Salt (green)



Transect 2 – Stepped Counter-Regional System



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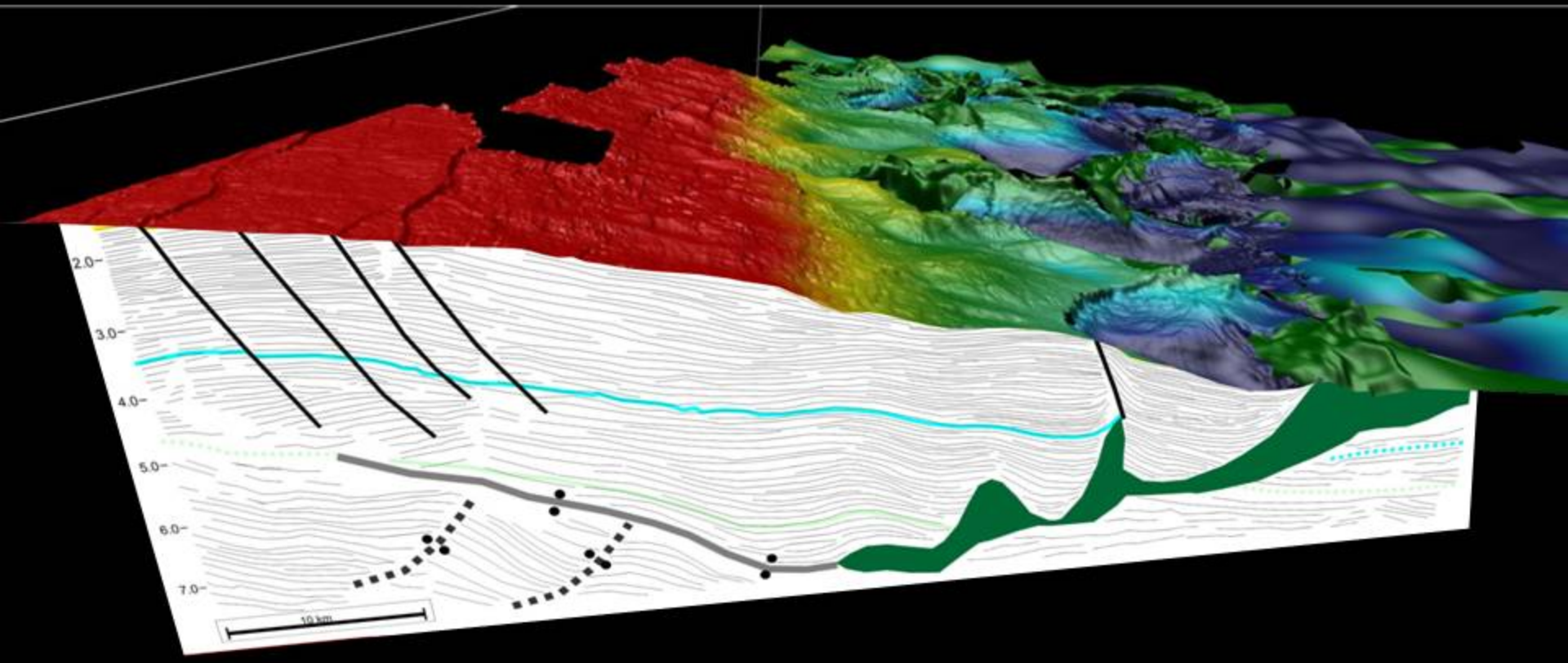
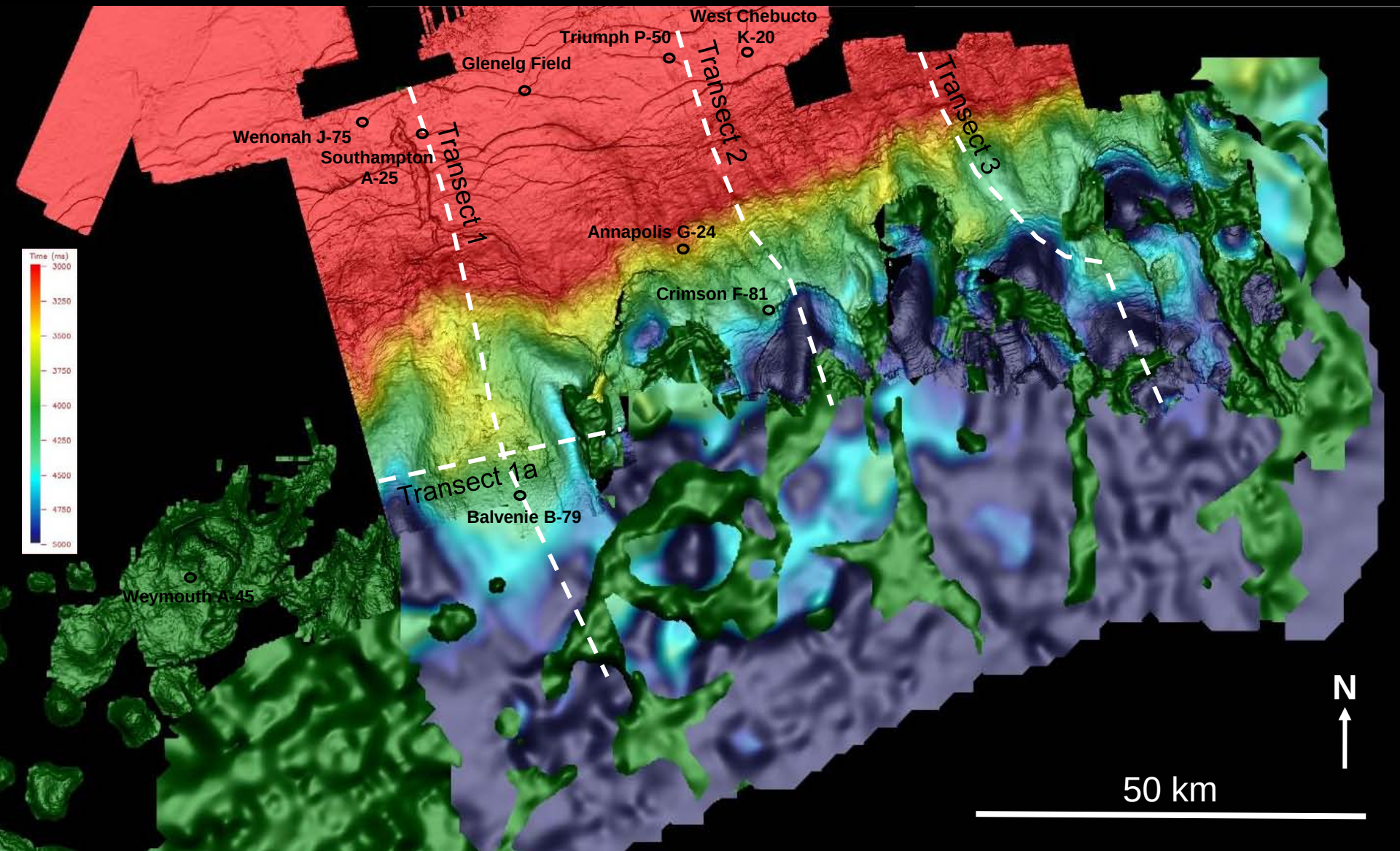
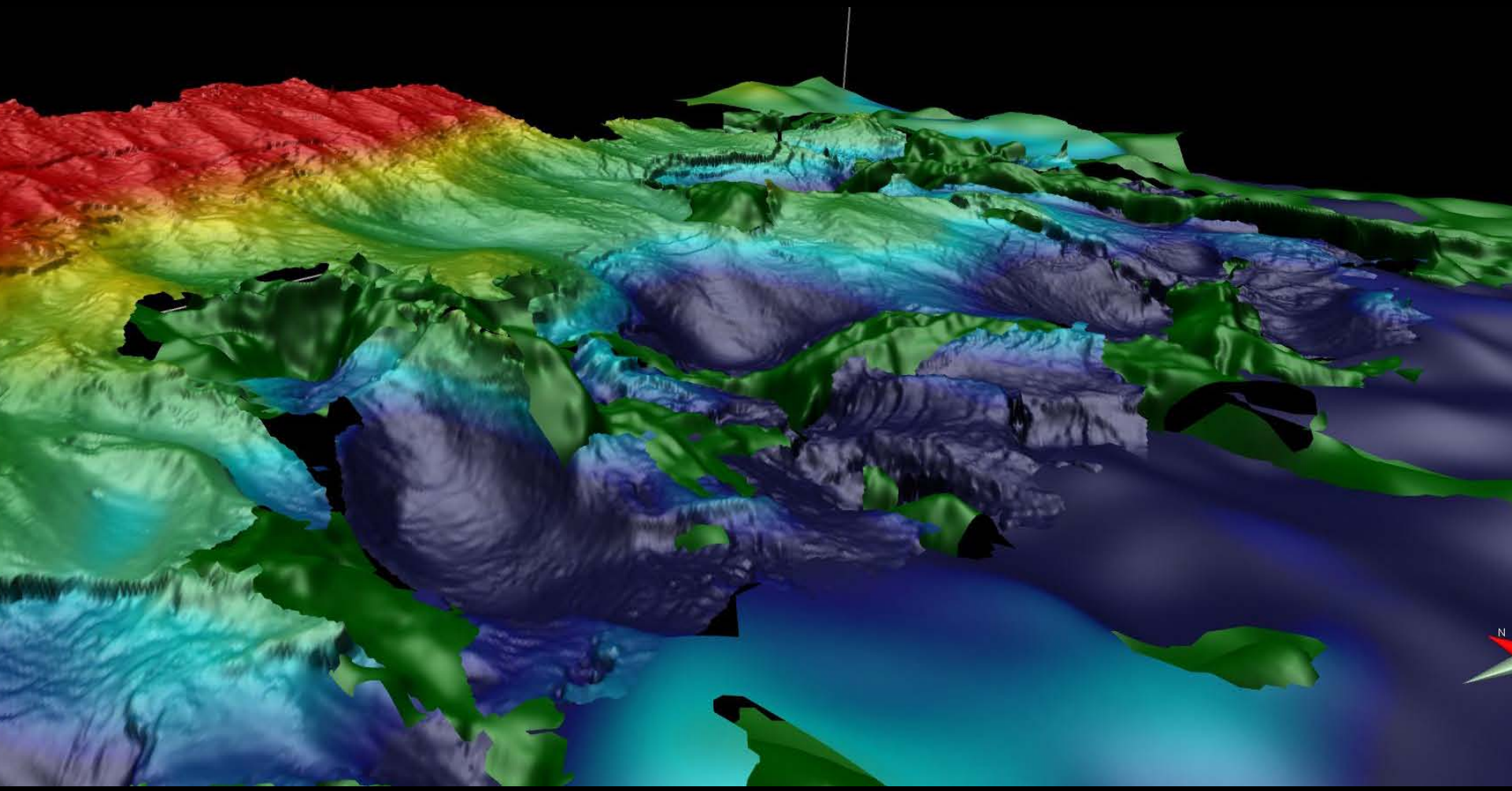


Defining features: basinward dipping reflectors, stepped morphology of advancing allochthonous salt, minor amounts of detachment and roller faults, rollover fault and counter-regional fault (clipped out of diagram- visible in shallower section)

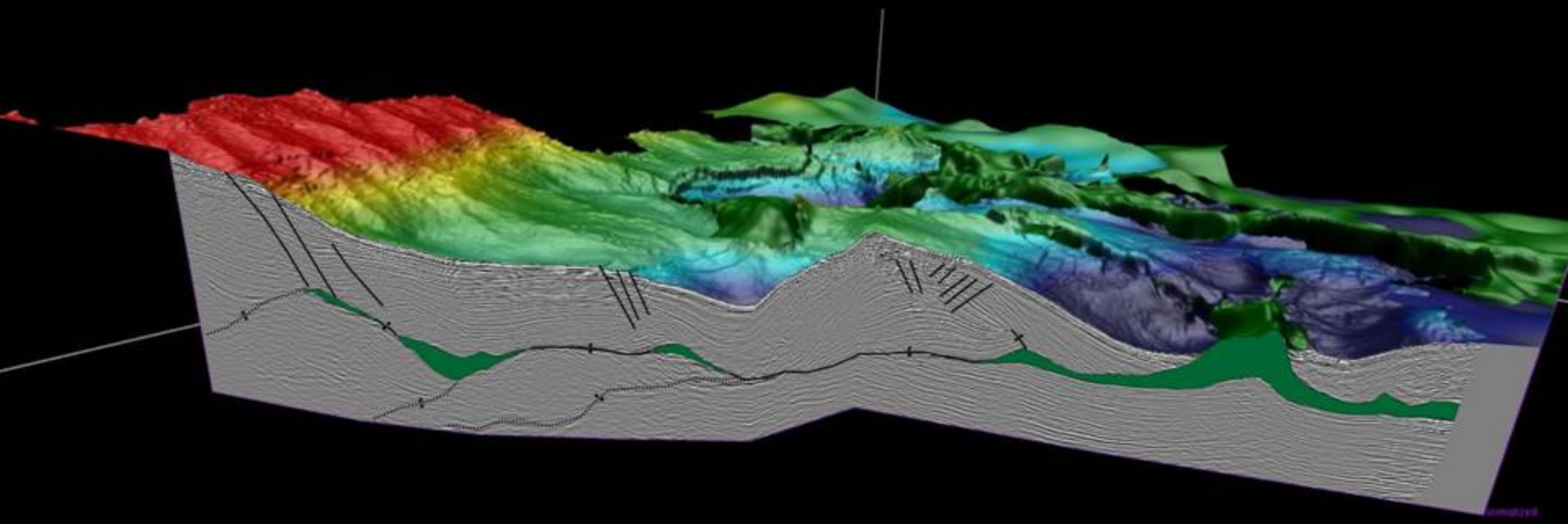
Late Cretaceous Structure Map with Salt (green)



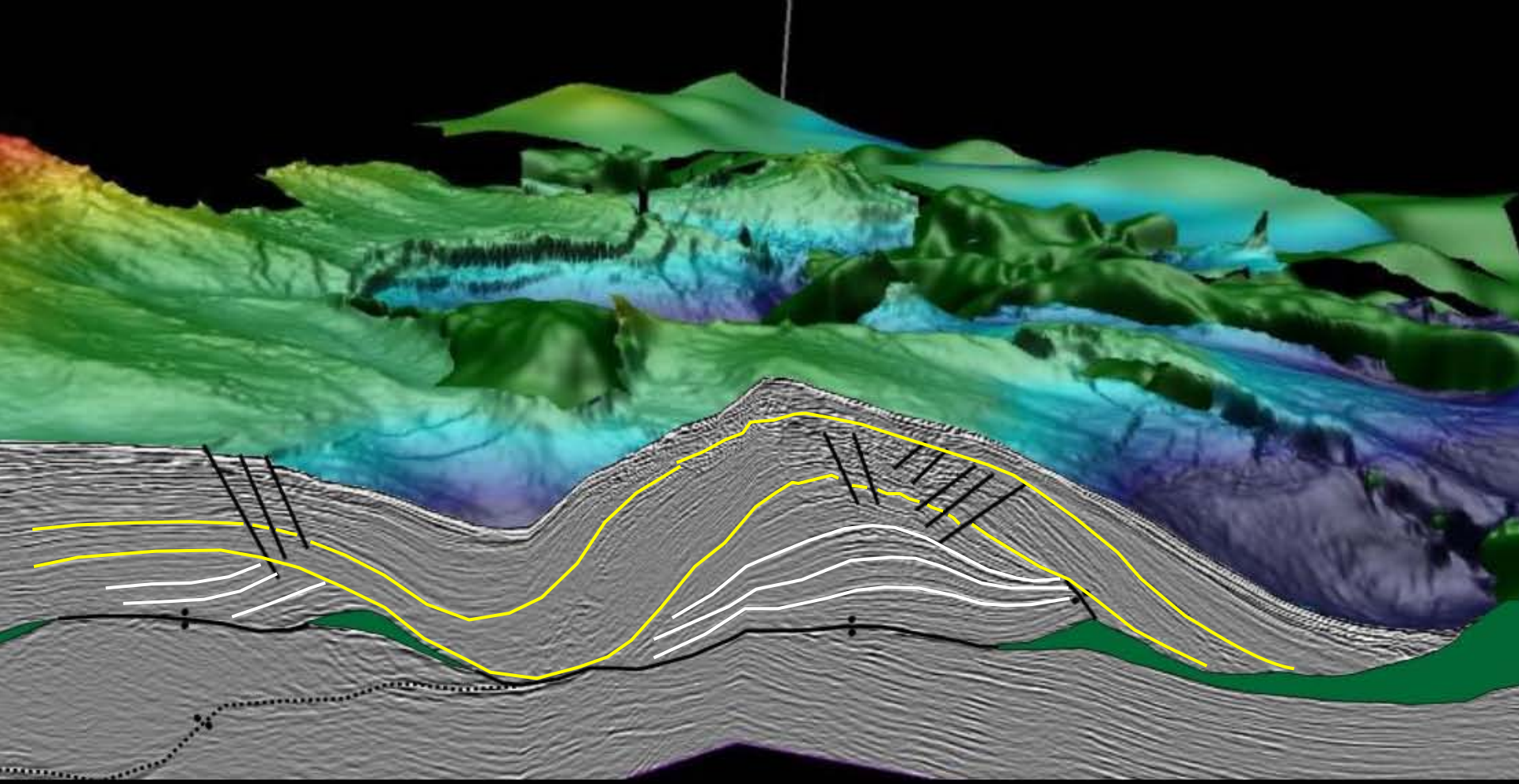
Transect 3 – Canopy loading/Detachment



Transect 3 – Canopy loading/Detachment



Defining features: multiple welded salt feeders, turtle structure, salt withdrawal minibasins, salt nappe and minor amounts of detachment.



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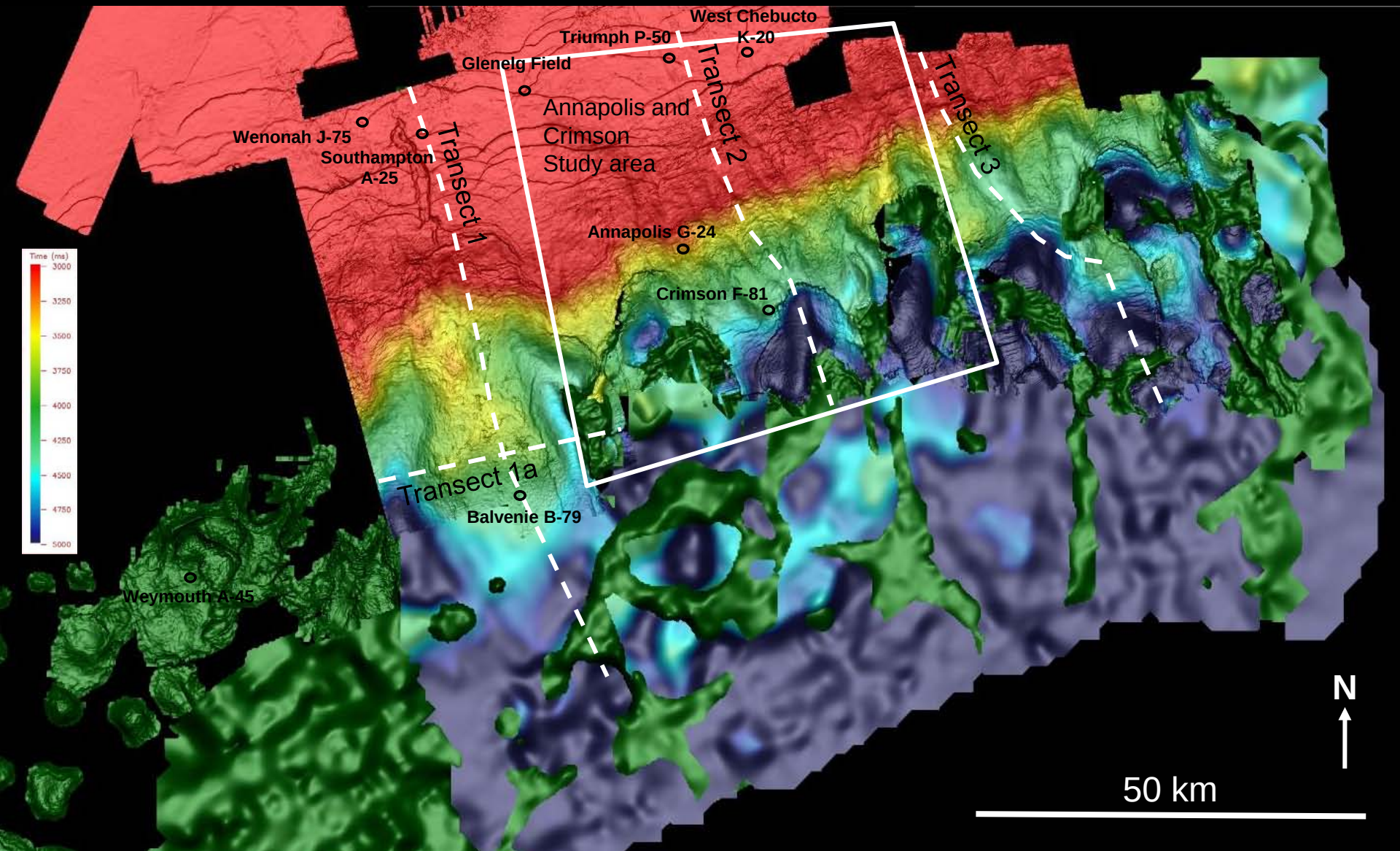

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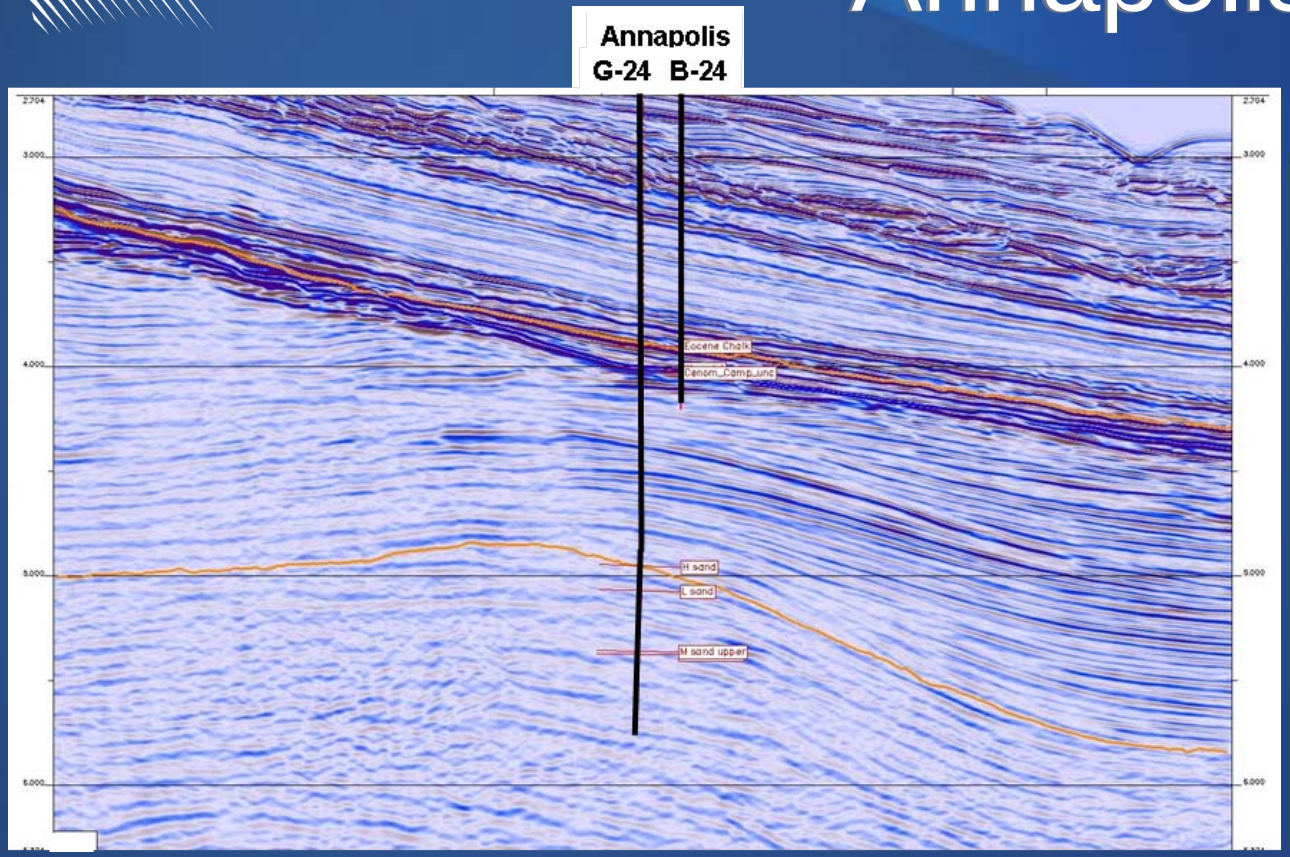
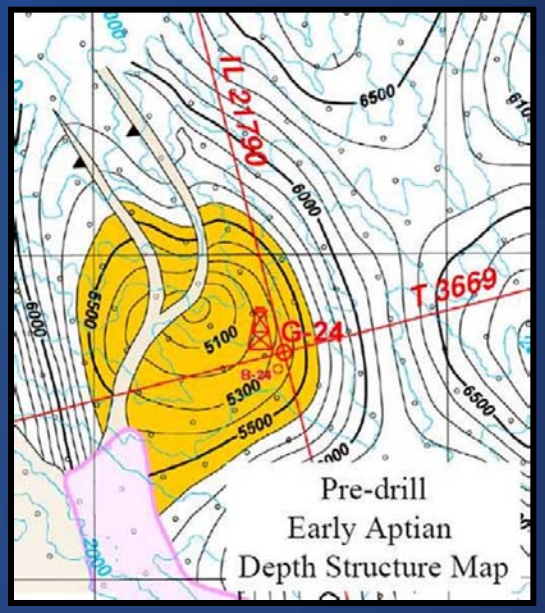
Annapolis G-24





- Drilled by Marathon in 2002, targeting Albian/Aptian turbidite sands within a large structural closure that formed as a result of adjacent salt withdrawal

- Encountered 27 m of net gas pay in Barremian to Hauterivian aged sands

(Kidston et. al, 2007)

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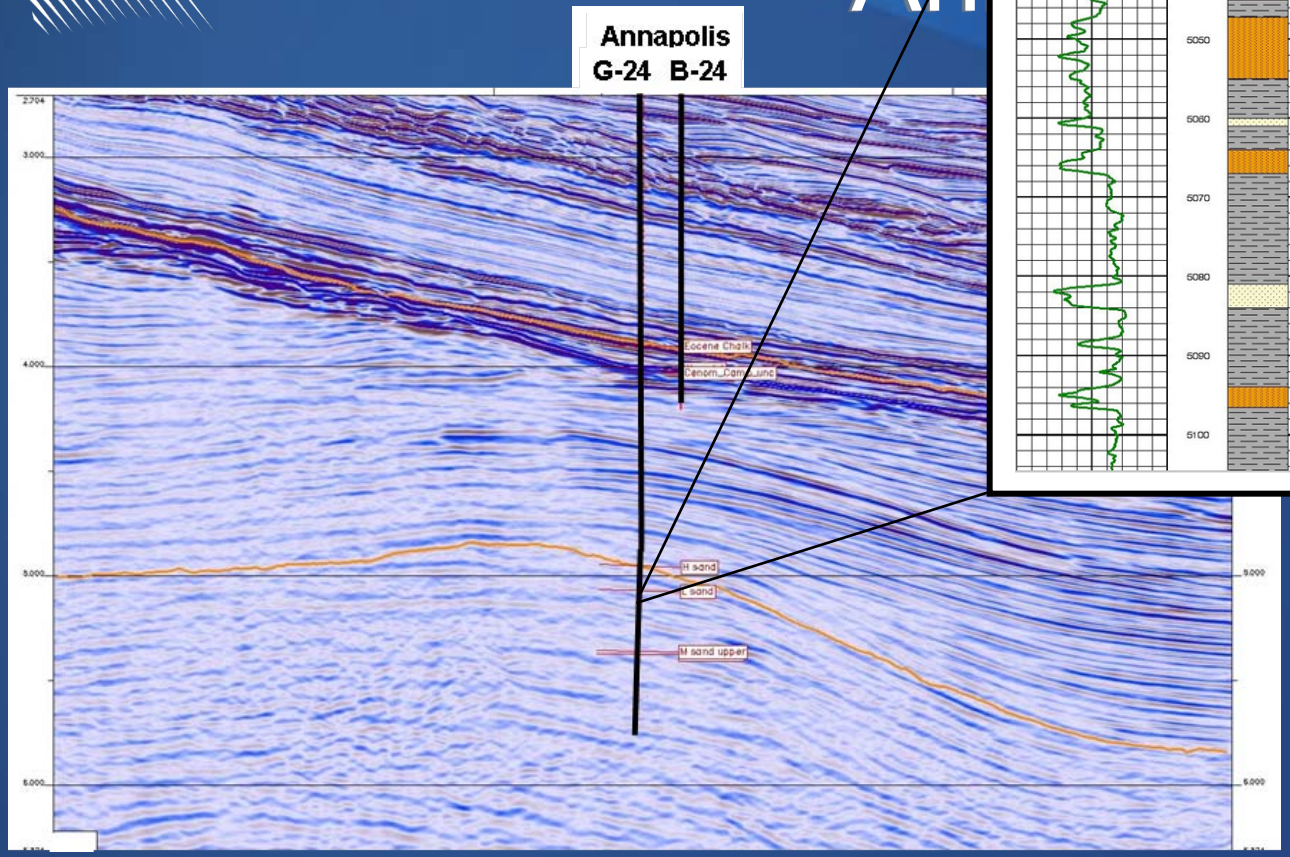

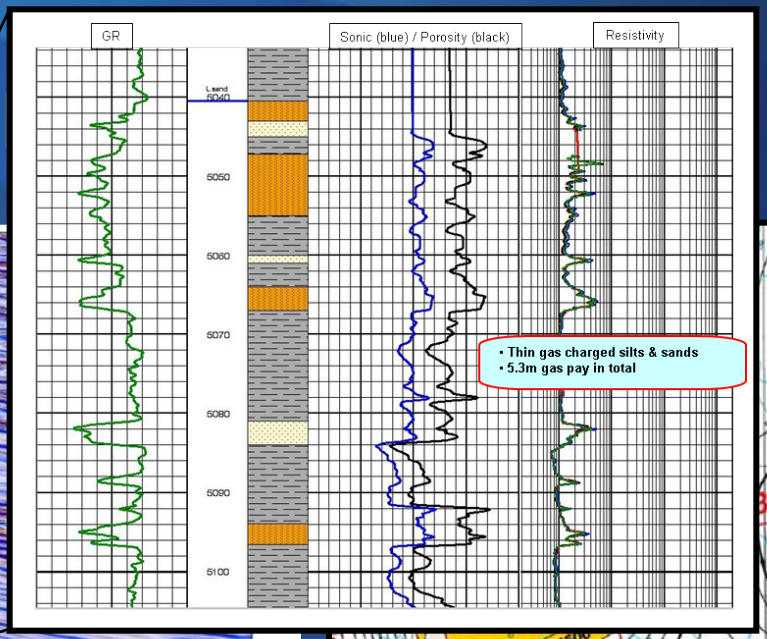

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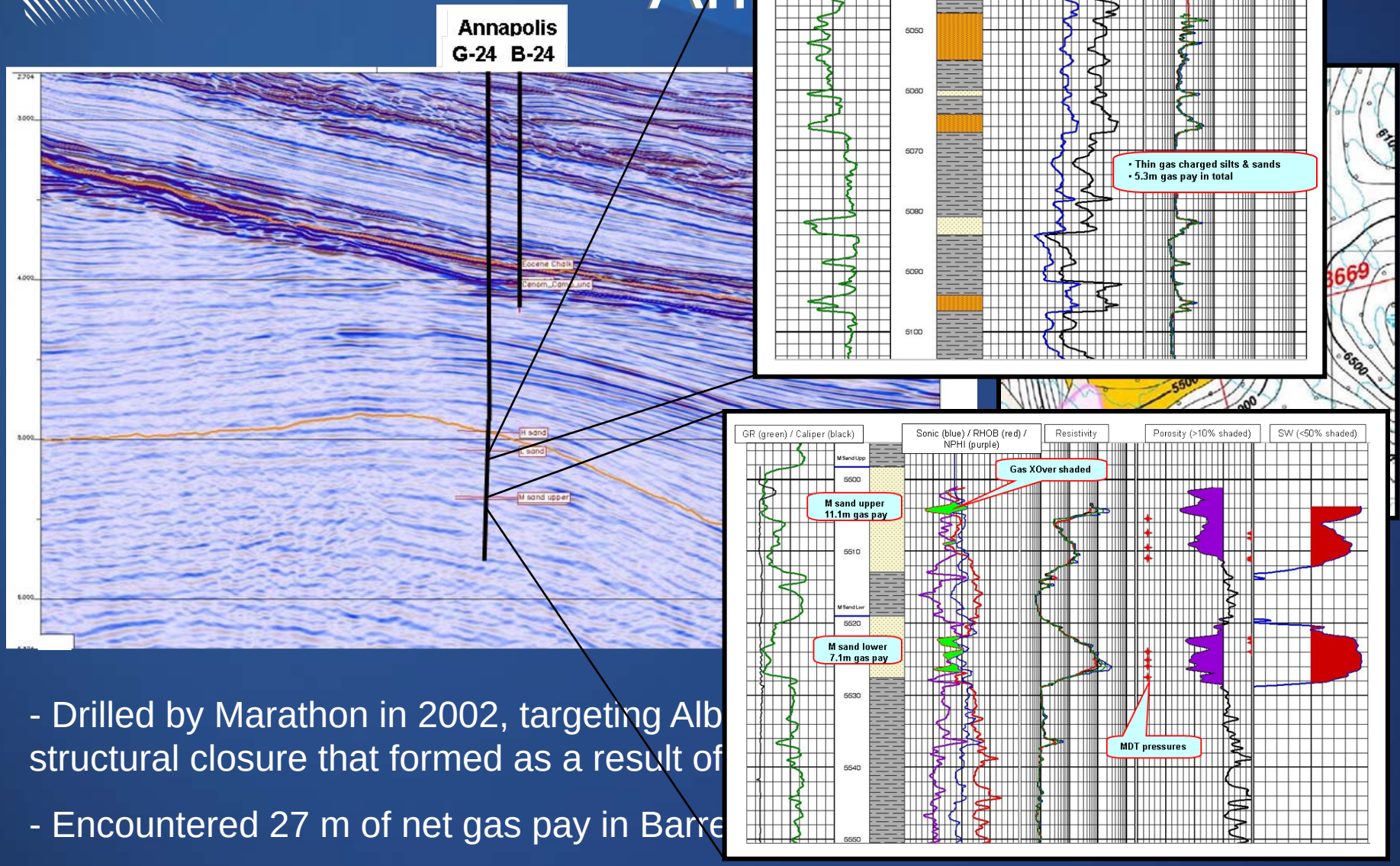

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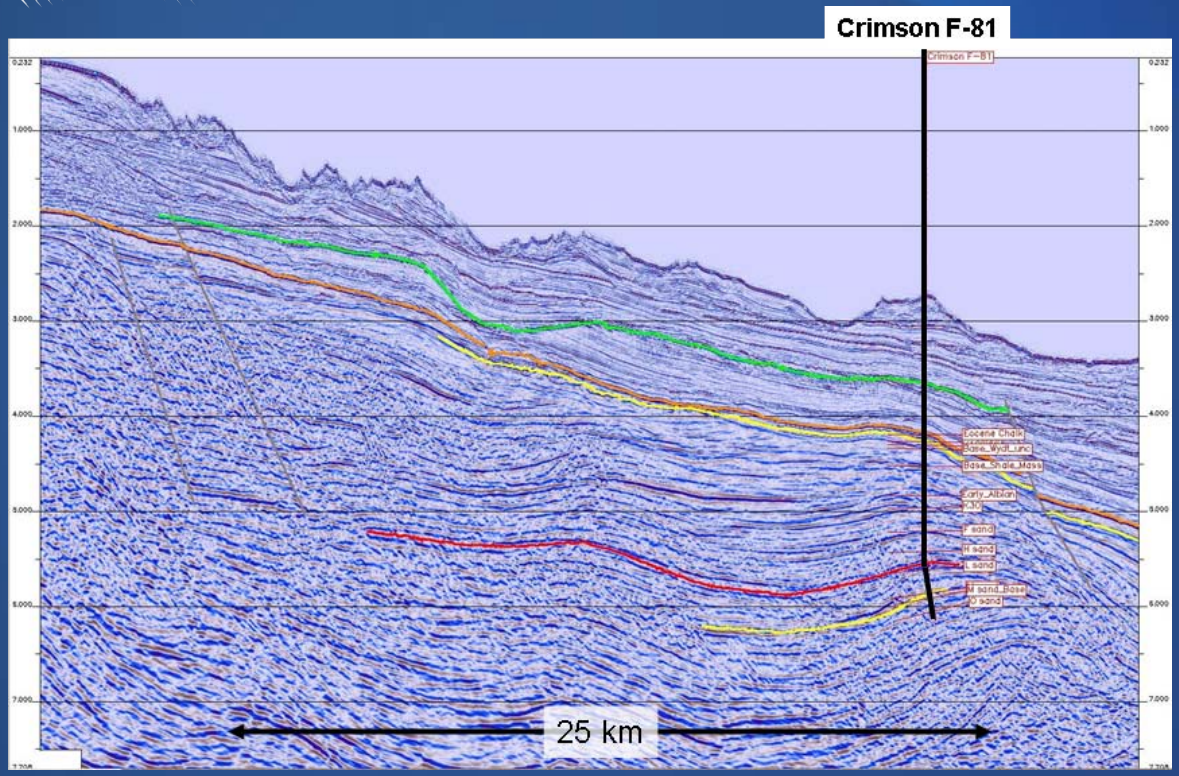
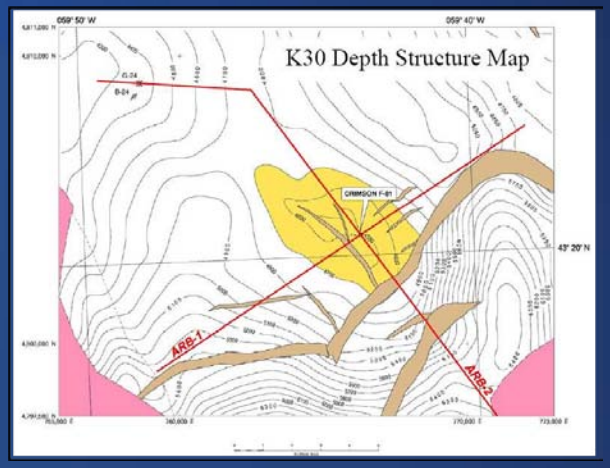
Crimson F-81





Structure dependant on closure against a rollover fault to the southeast

-Follow up well by Marathon in 2004, targeting a faulted anticlinal feature related to salt withdrawal, anticipating better developed H, L and M sand intervals in a “backstop” position against salt.

-H, L and M sands intervals were not well developed within Crimson but a deeper sand interval (O sand ~ 13 m thick) was penetrated. No hydrocarbon charge

(Kidston et. al, 2007)

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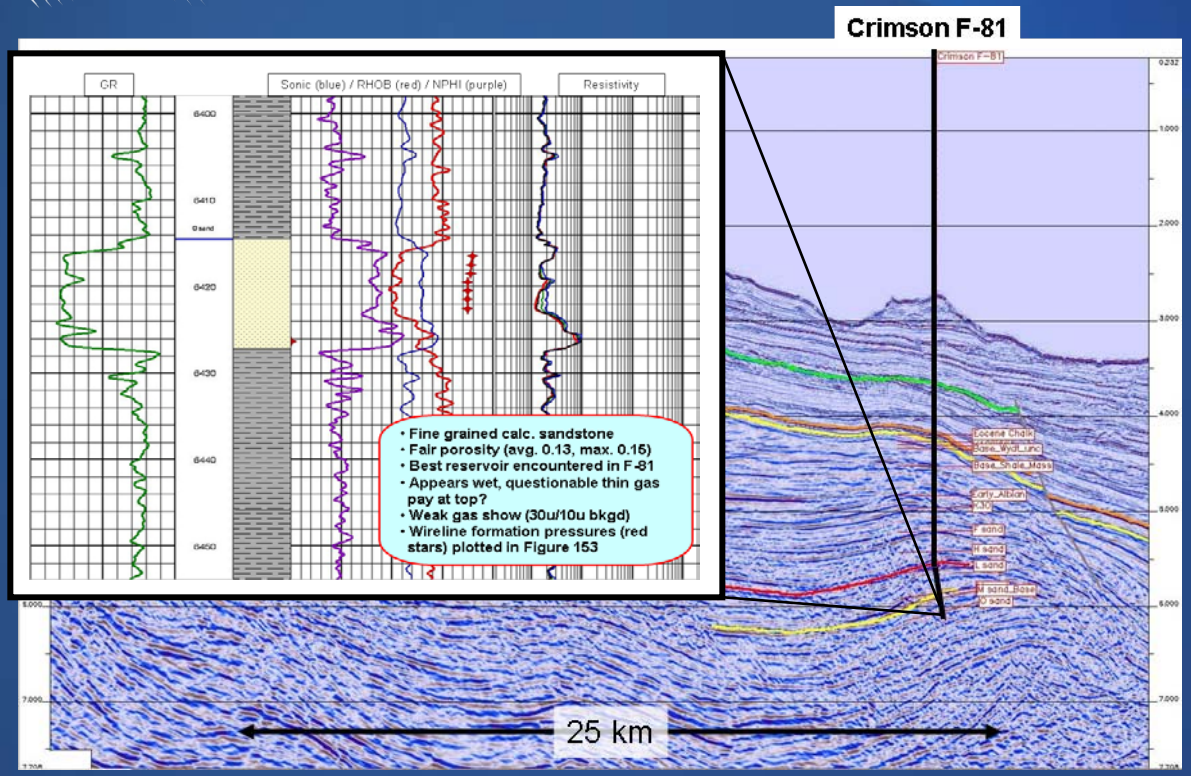
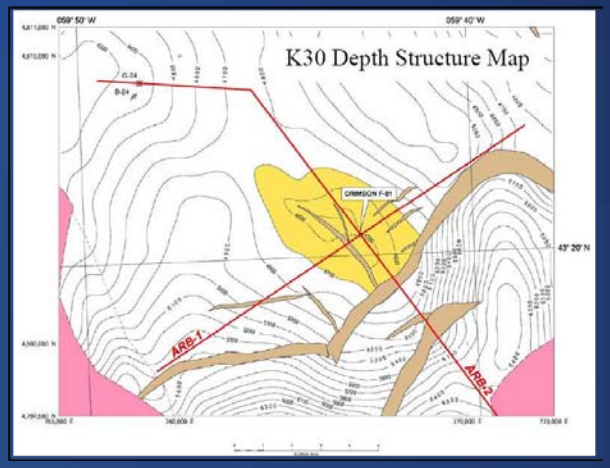
Crimson F-81





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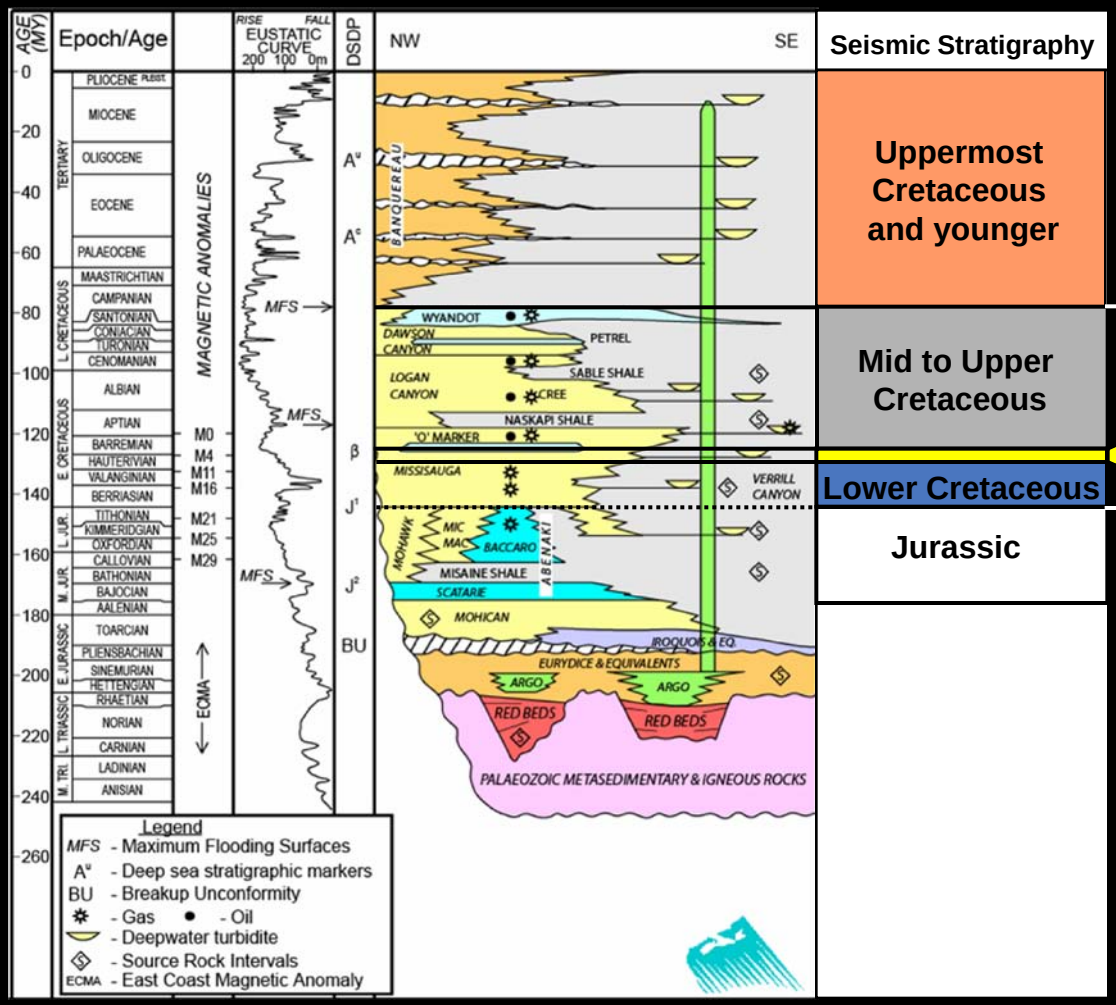
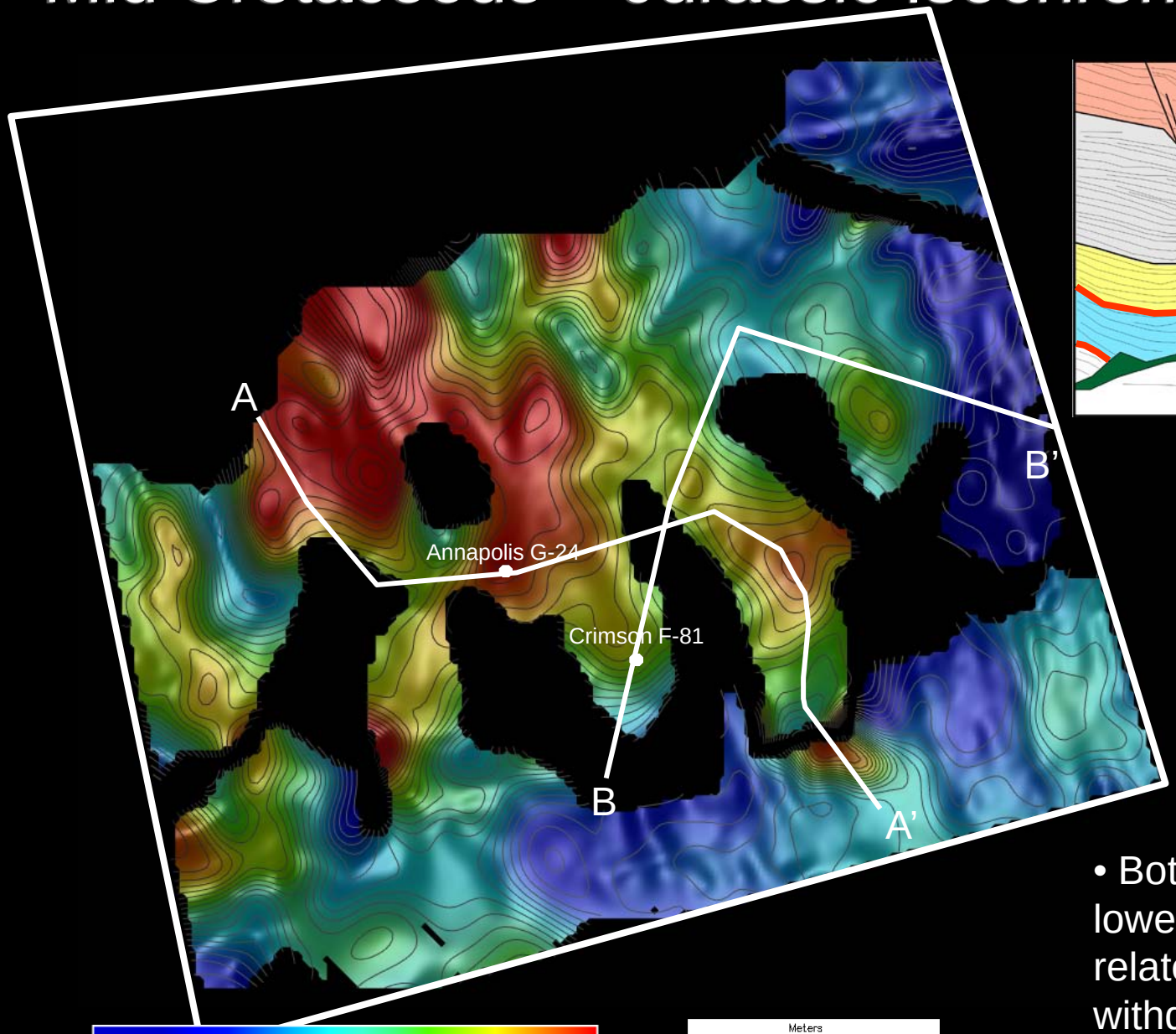
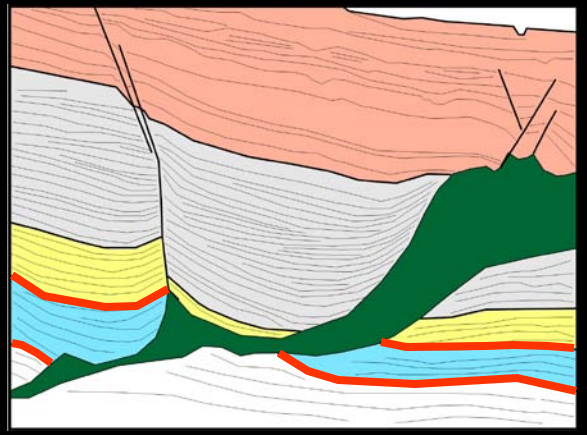
Stratigraphic Column/Seismic Stratigraphy



Stratigraphic column for the Scotian Basin. Stratigraphy modified from Wade 1993,1995). Eustatic curve from Haq et al (1987). Time scale from Palmer and Geismann (1999). The mapped intervals used within this study are shown to right of the diagram in shades of yellow and blue.

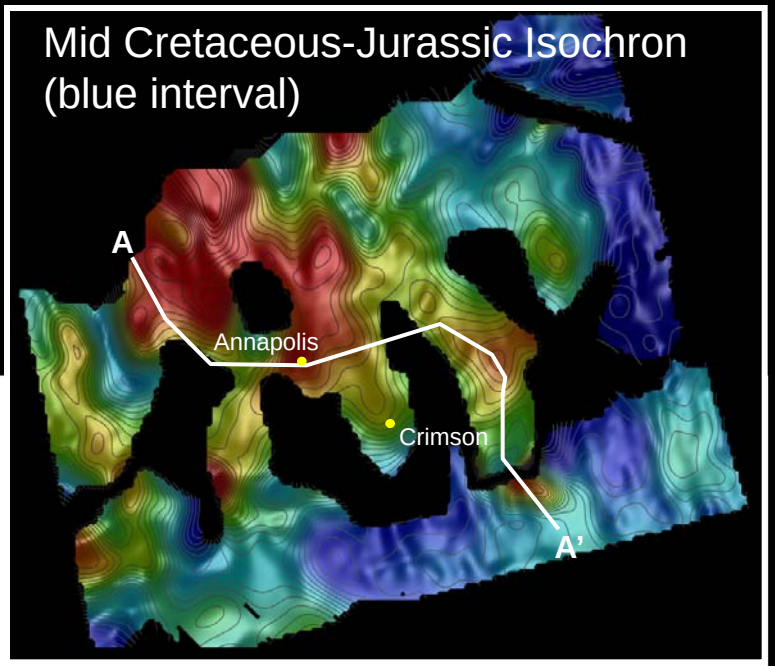
Mid Cretaceous – Jurassic Isochron

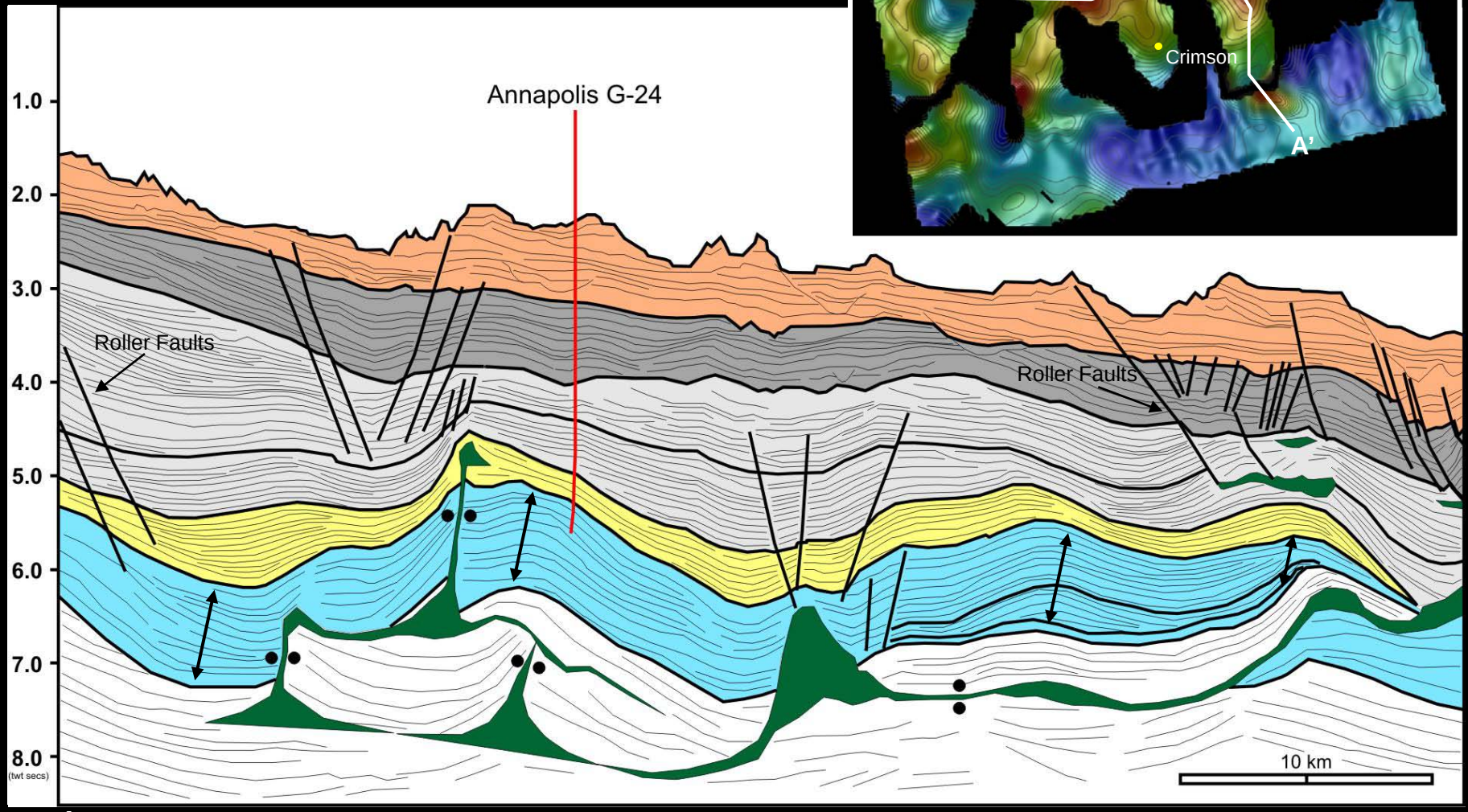




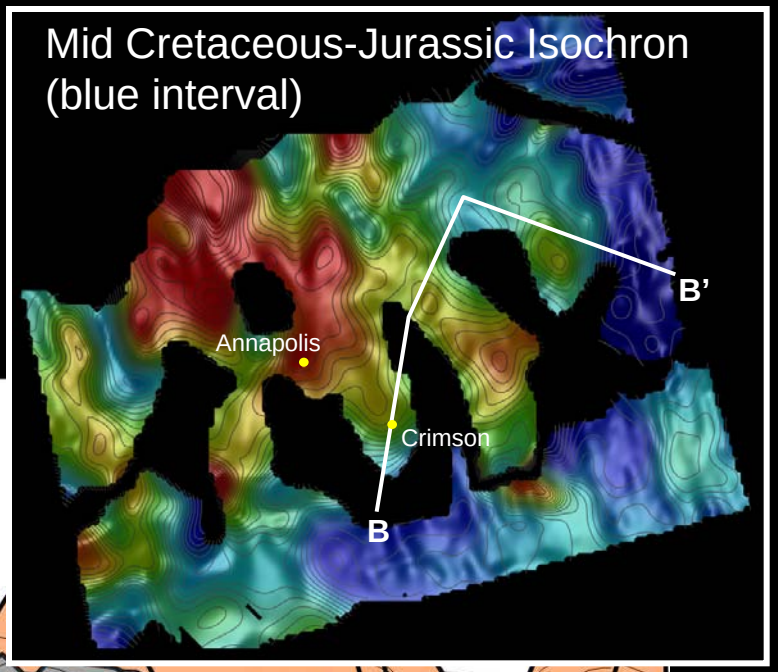
- Both wells drilled lower Cretaceous <u>thicks</u> related to early salt withdrawal

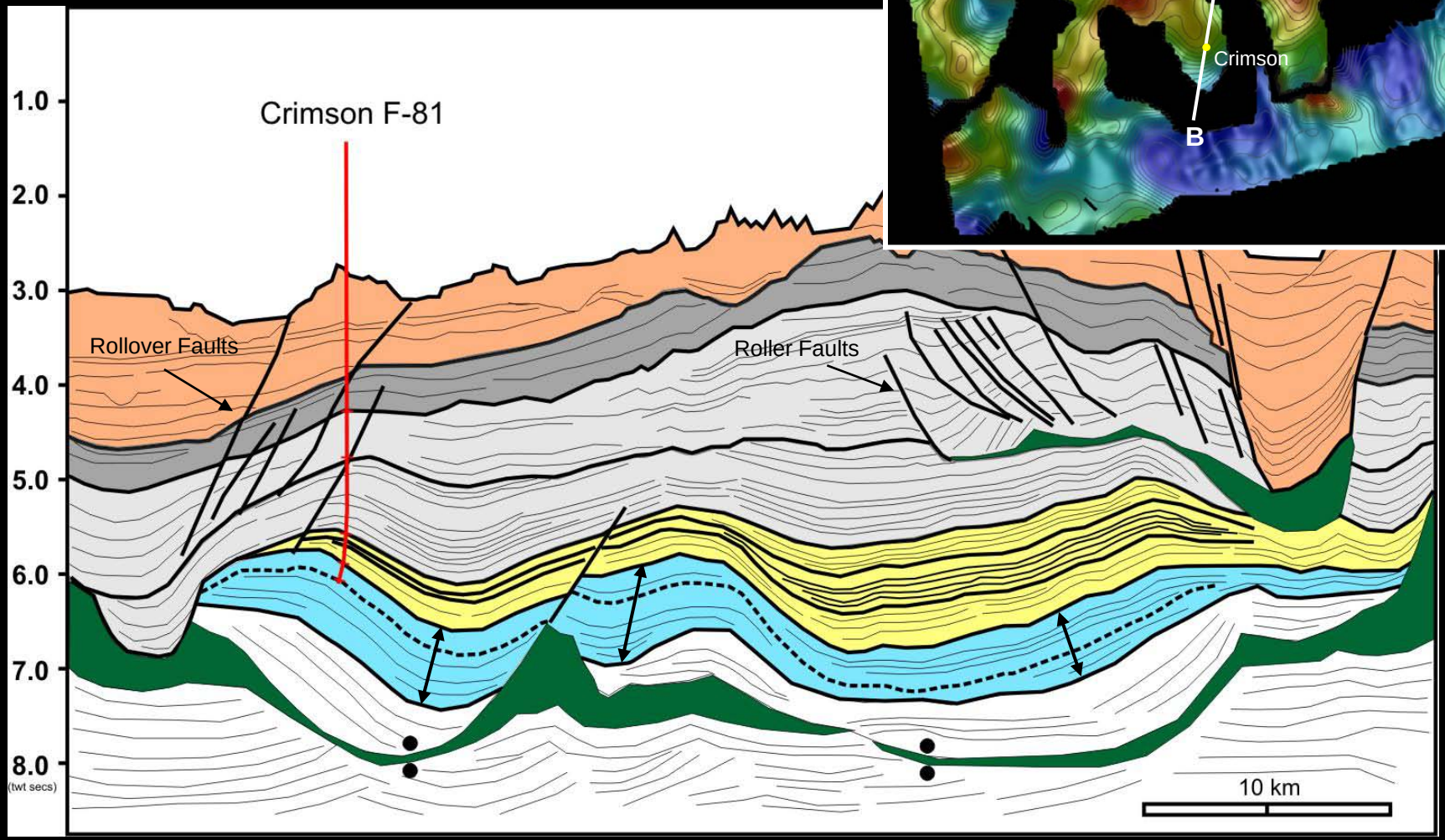
- Annapolis only penetrated the very upper 100-200 m this interval
- Excellent reservoir sands (M sands 18 m net pay) are penetrated at this well location



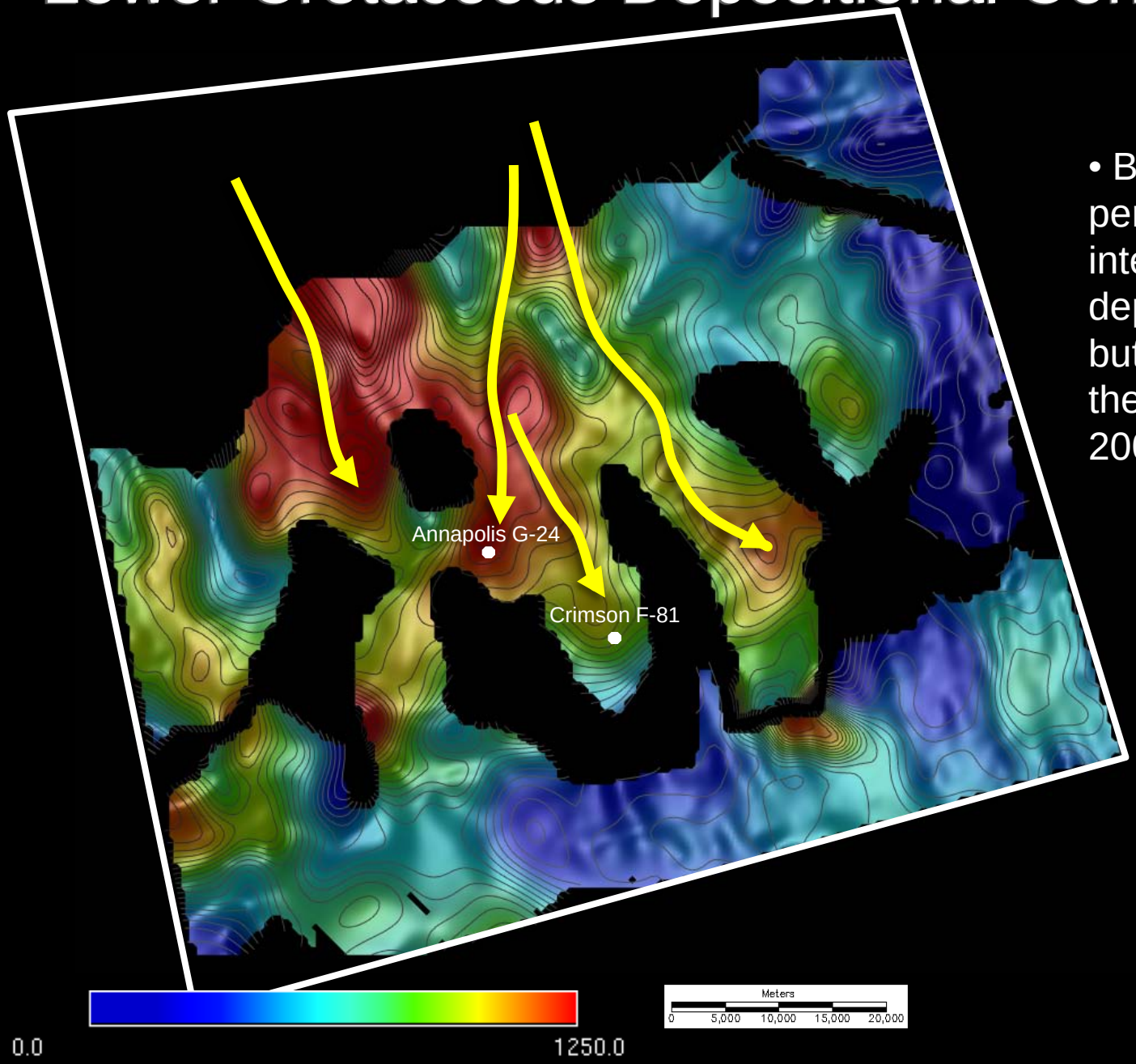


- M sand penetrated at Annapolis is not present here
- A deeper (but wet) sand is encountered, the O sand approx 13 m thick.





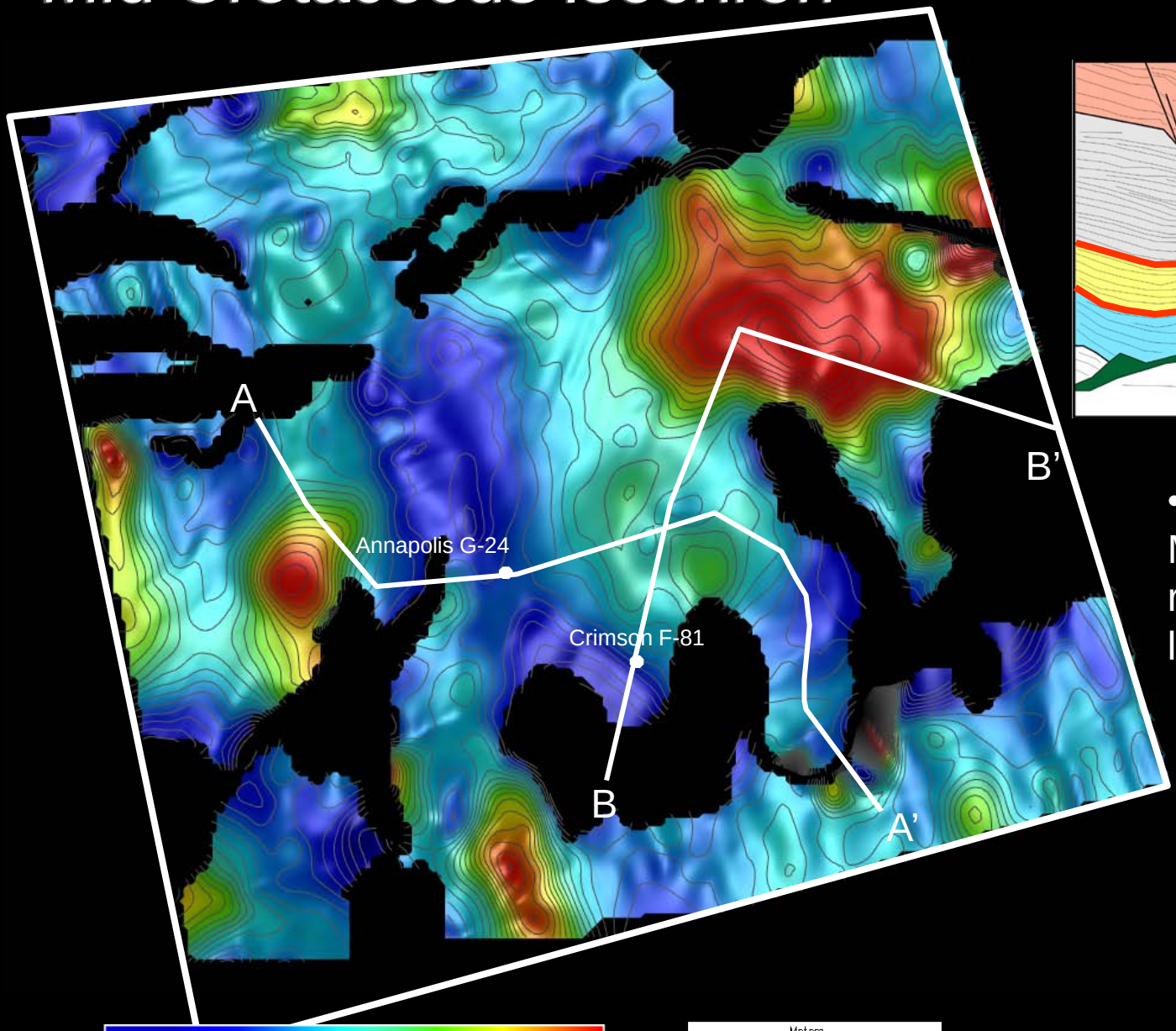
Lower Cretaceous Depositional Corridors

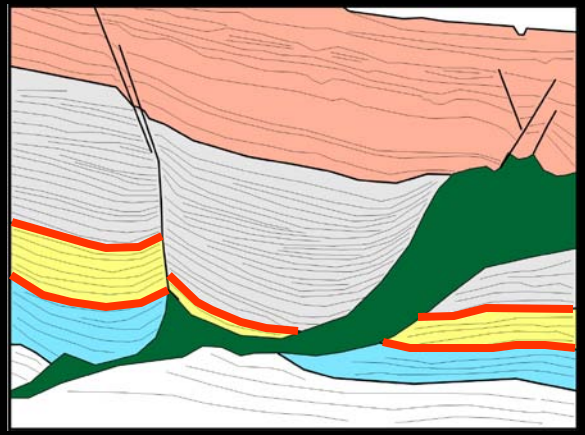


- Both wells penetrate an interpreted depositional corridor, but only penetrate the uppermost 100 - 200 m section

- M sand at Annapolis and O sand at Crimson are the thickest sands encountered to date in deepwater

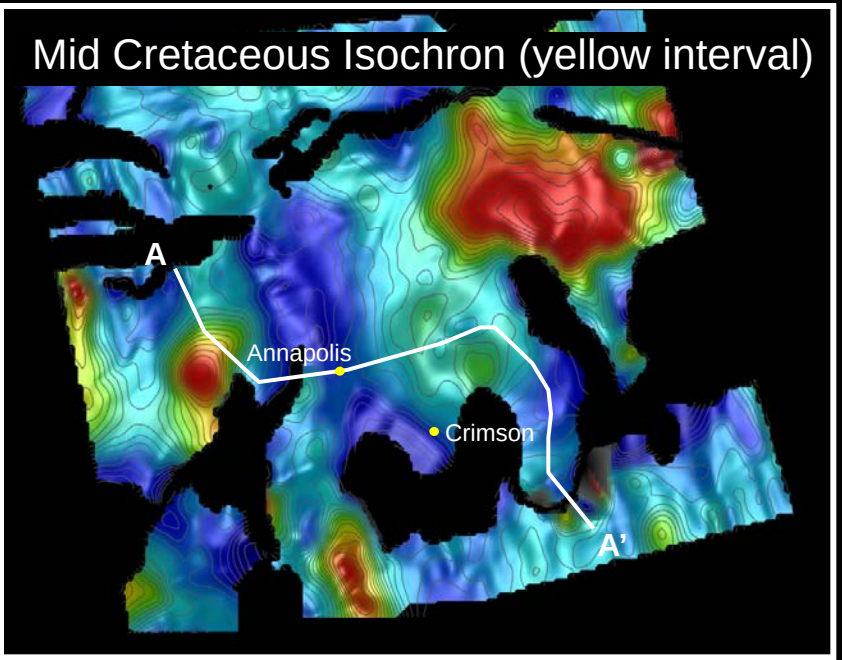
Mid Cretaceous Isochron

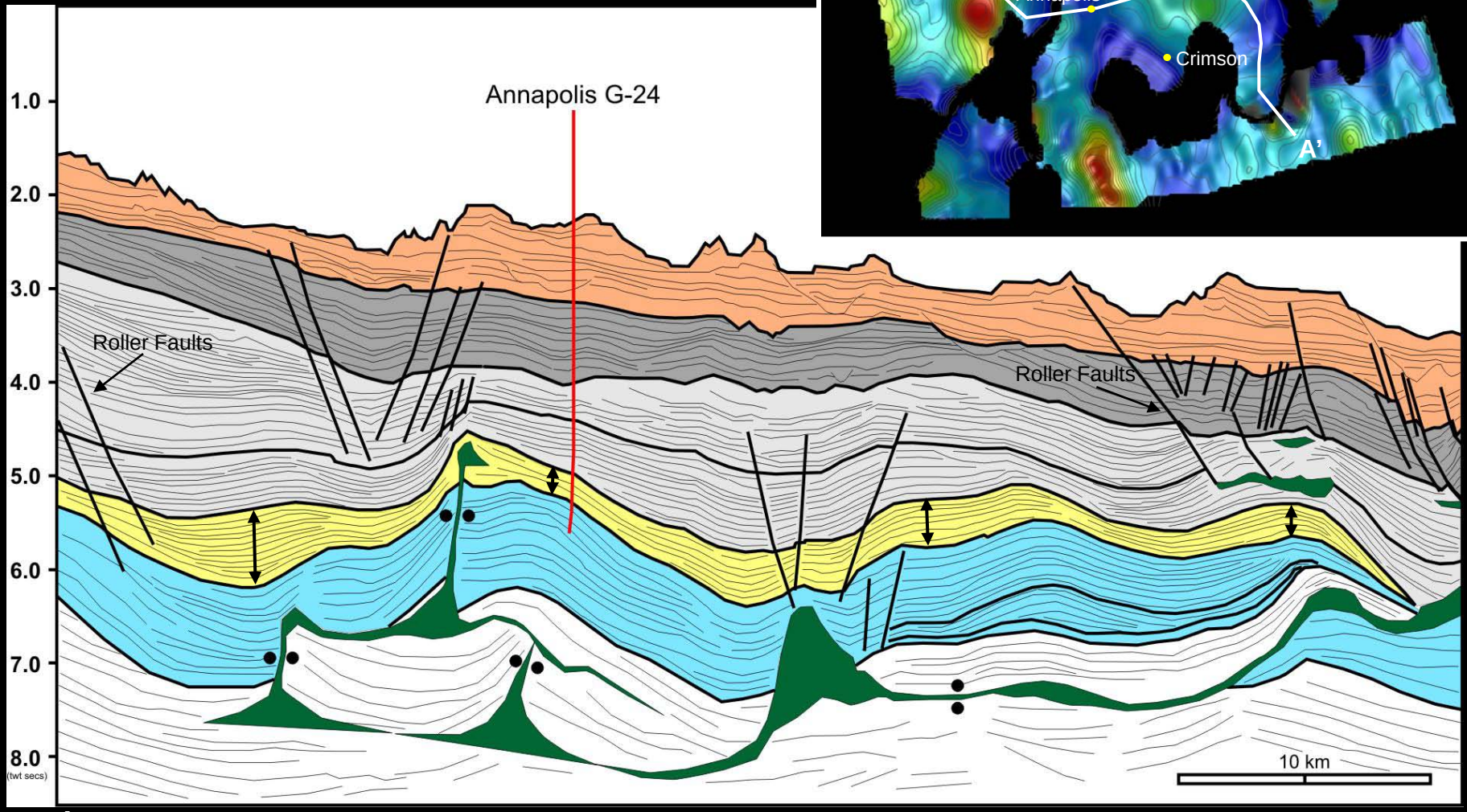




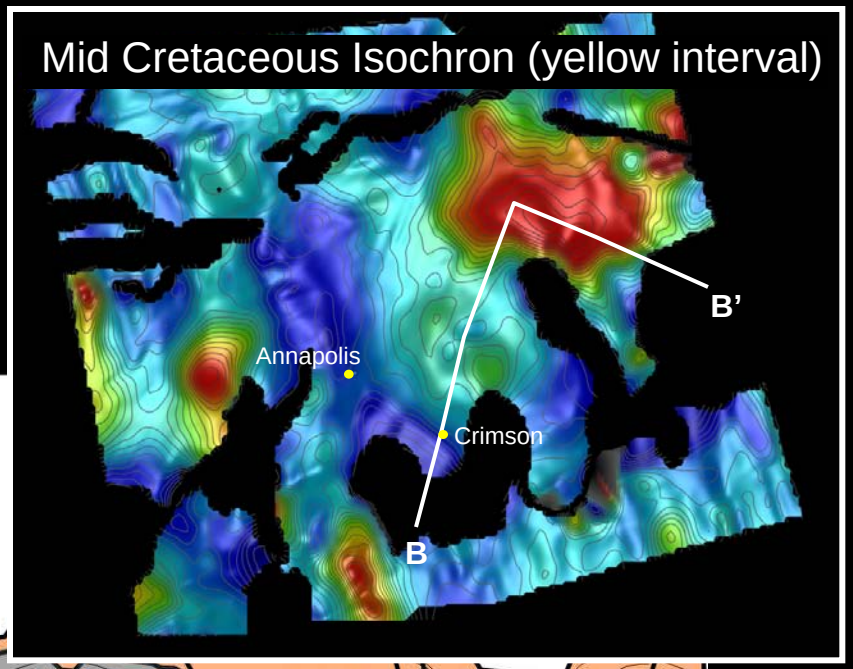
- Both wells drilled Mid Cretaceous <u>thins</u> relative to other locations

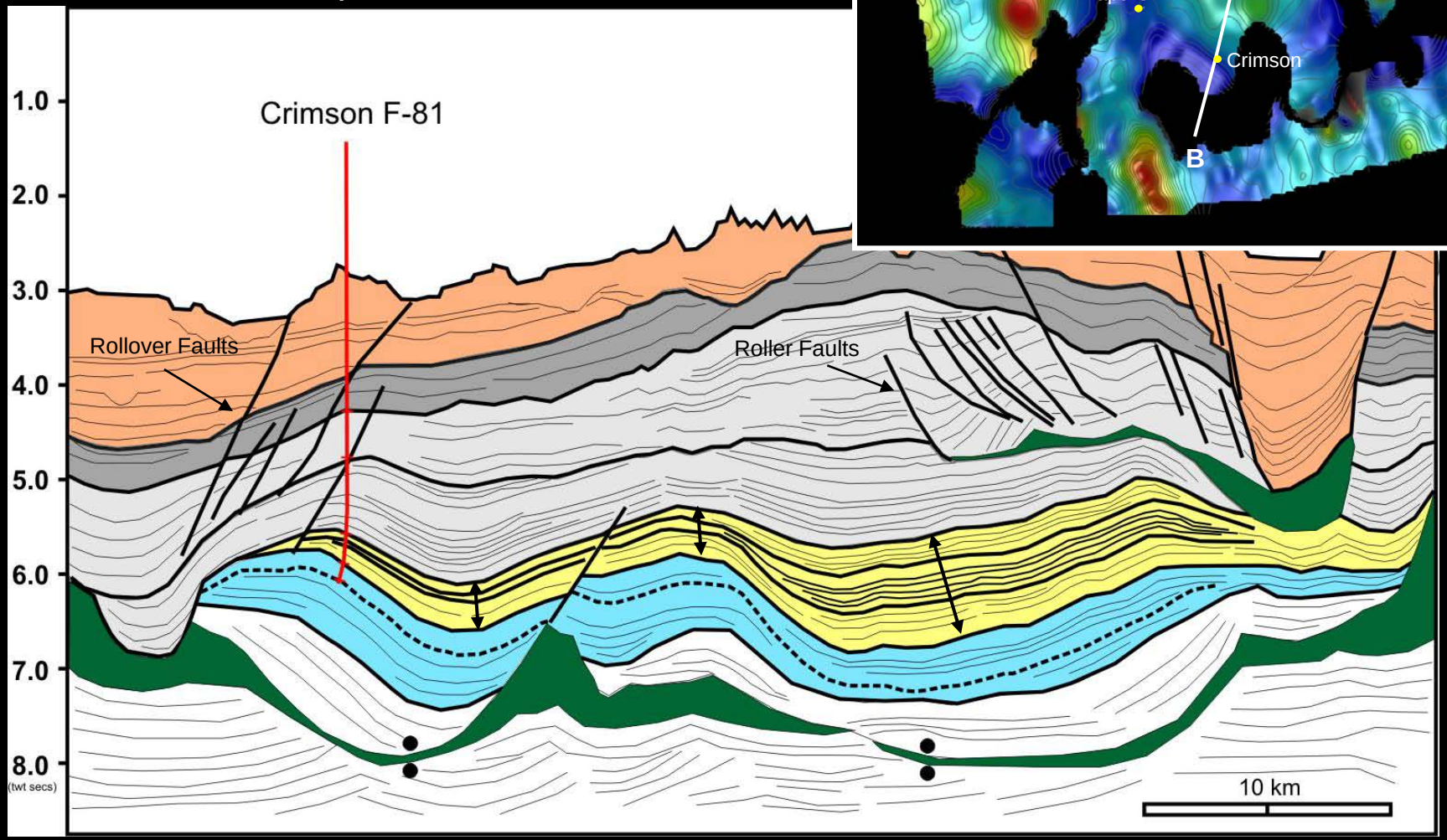
- Annapolis penetrated one of the thinnest sections of this interval
- Encountered both the H and L sands within this interval



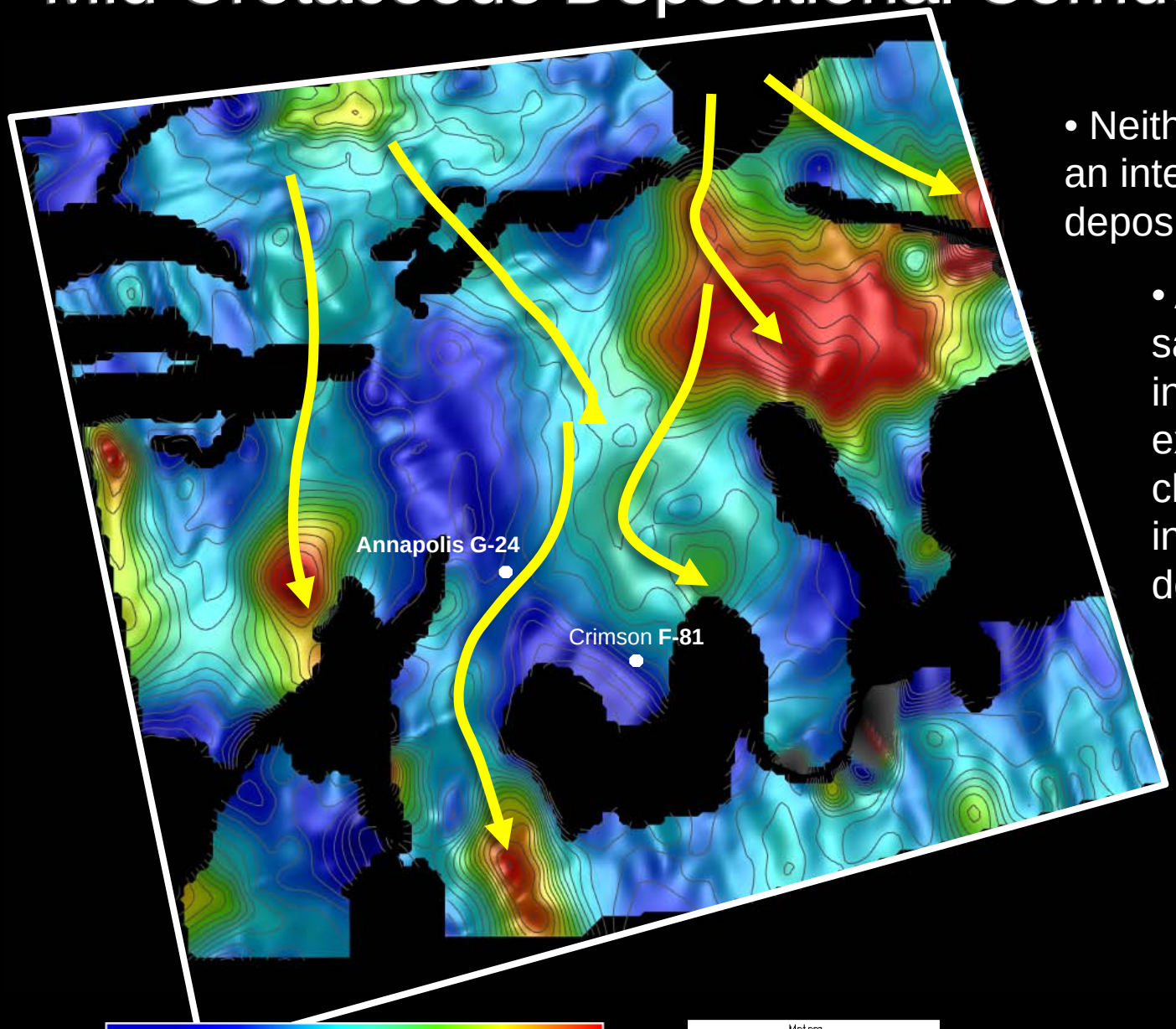


- No sands present within this interval at Crimson
- Expands in thickness to the northeast (approx. 300 m at borehole to greater than 1000 m in the NE)

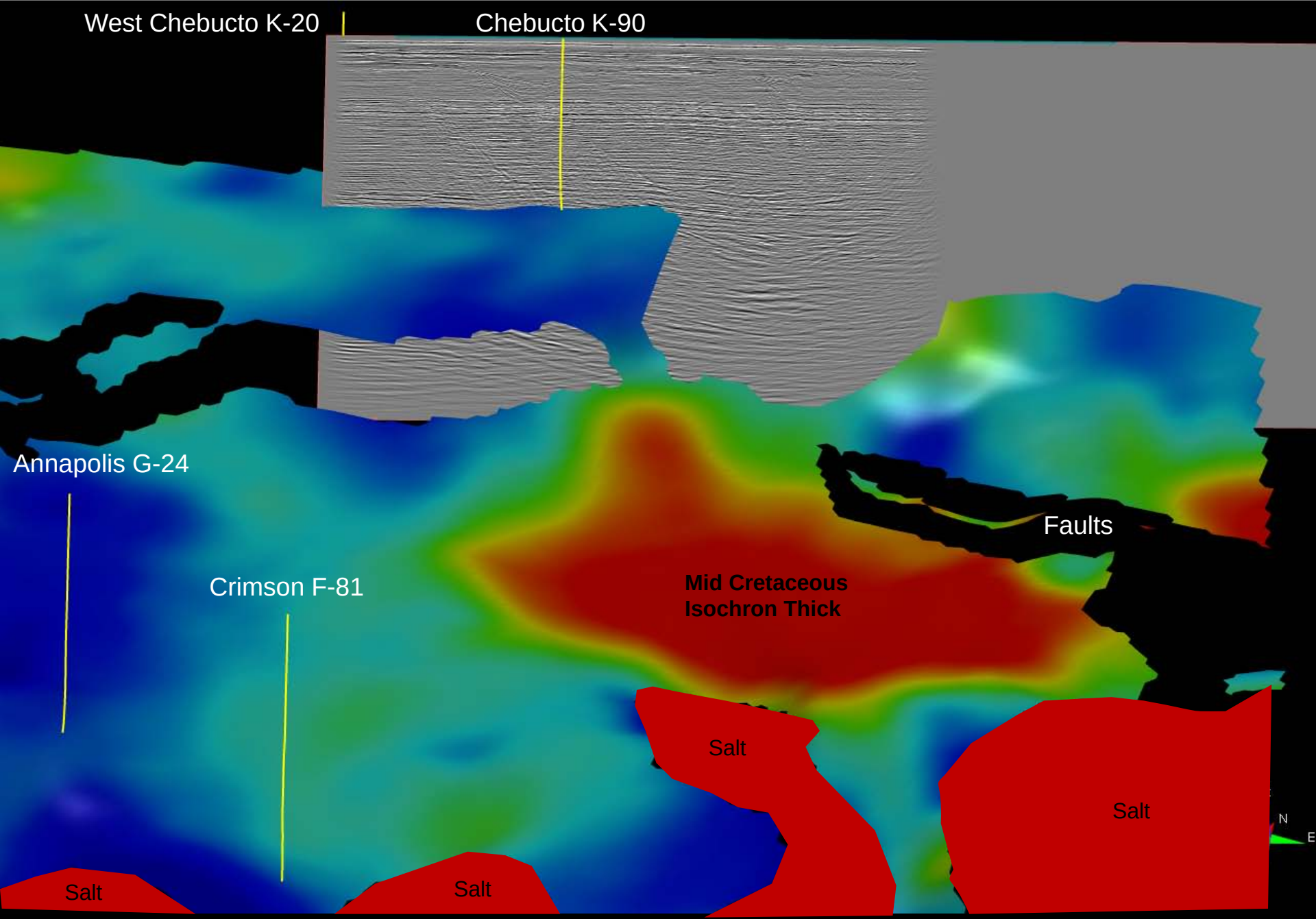


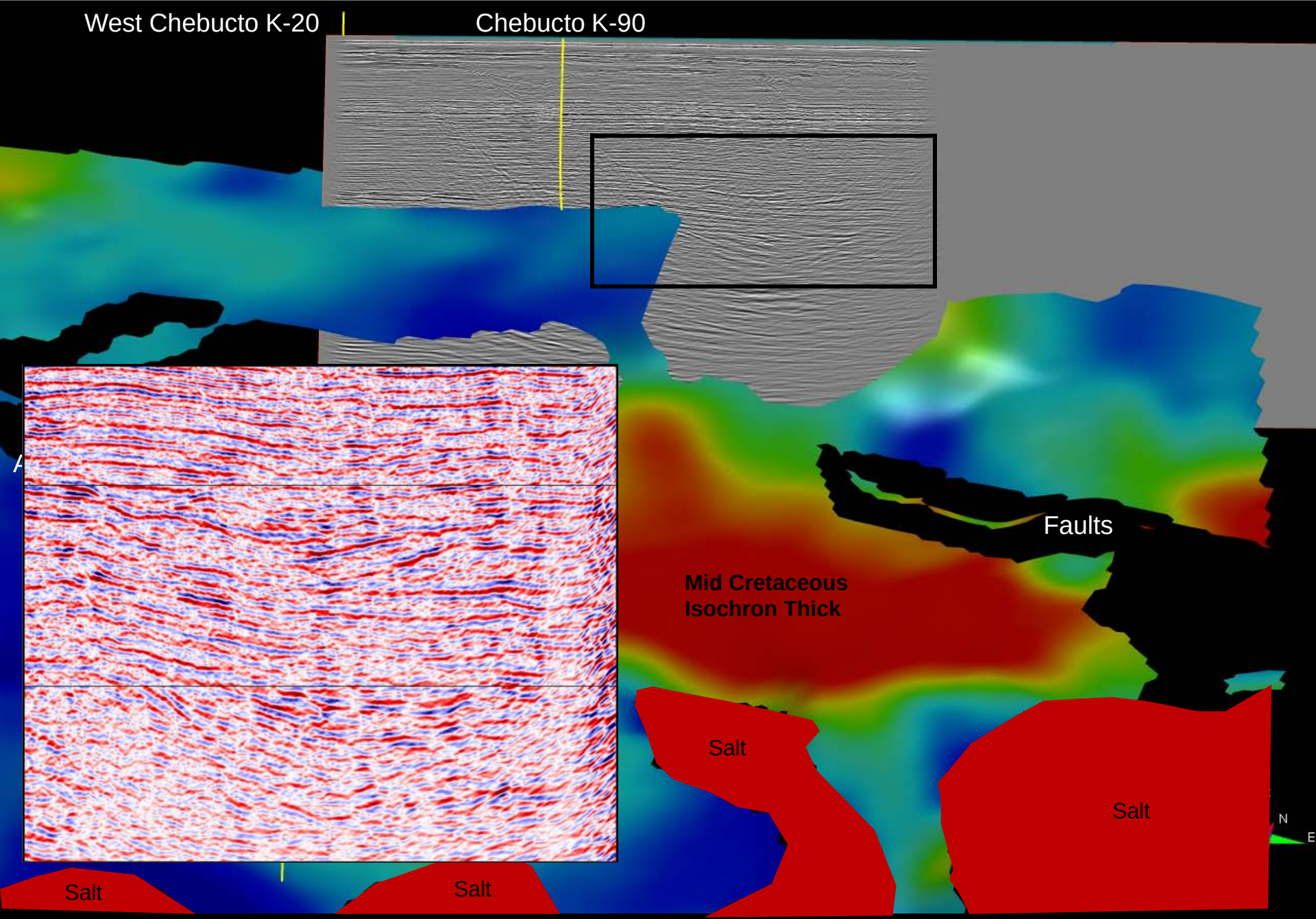


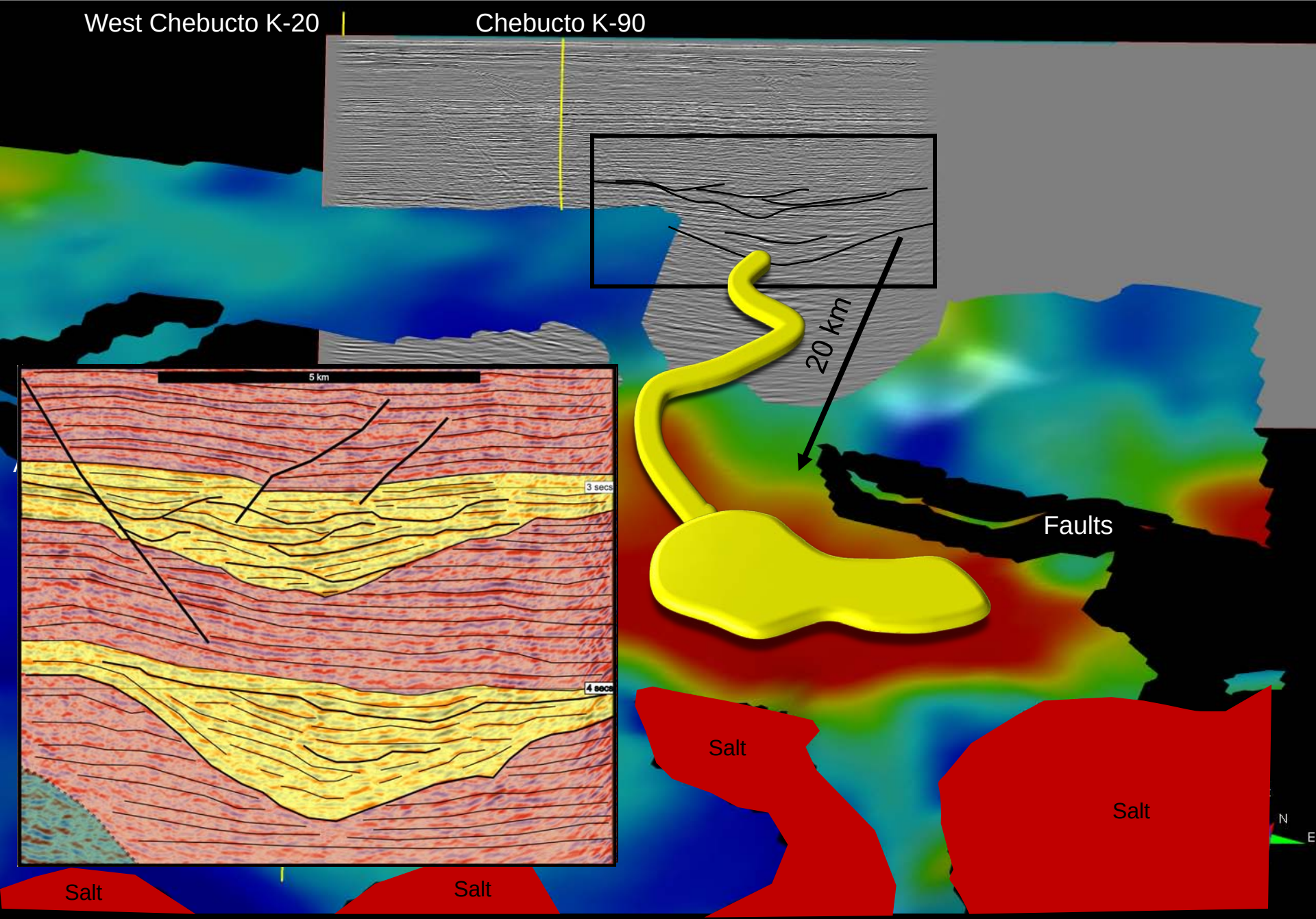
Mid Cretaceous Depositional Corridors



- Neither well penetrates an interpreted depositional corridor
  - Annapolis' H and L sands are within this interval, and may be explained by being in close proximity to the interpreted depositional corridor
  - The thickest mid Cretaceous depocenters have yet to be penetrated


West Chebucto K-20
Chebucto K-90
Annapolis G-24
Crimson F-81
Faults
Mid Cretaceous
Isochron Thick
Salt
Salt
Salt
Salt
N
E


West Chebucto K-20
Chebucto K-90
Faults
Mid Cretaceous
Isochron Thick
Salt
Salt
Salt
Salt
N
E


West Chebucto K-20
Chebucto K-90
20 km
5 km
3 secs
4 secs
Faults
Salt
Salt
Salt
Salt
N
E

Conclusions - *do these wells really provide an accurate test of sand presence in deepwater?*

- Both wells penetrate Lower Cretaceous thicks and were successful in finding sand in those zones (M and O sands), but they are only representative of the upper 100-300 meters of the Lower Cretaceous
- Both wells penetrate Mid Cretaceous thins and are not representative of deepwater deposition during this period, there are ***much*** thicker depocenters to target