Influence of the Kingak Formation Ultimate Shelf Margin on Frontal Structures of the Brooks Range in National Petroleum Reserve, Alaska*

Natalie Stier[1], Christopher Connors[1], and David Houseknecht[2]

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[1]Washington and Lee University, Lexington, VA (stiern12@mail.wlu.edu)
[2]United States Geological Survey, Reston, VA

Abstract

Well and seismic data in the National Petroleum Reserve in Alaska (NPRA) demonstrate that the Jurassic-Lower Cretaceous Kingak Shale is present throughout NPRA. Several southward-offlapping depositional sequences within the Kingak culminate in an ultimate shelf margin in southern NPRA, across which the formation thins dramatically. However, the exact limit of the formation is obscured by frontal structures associated with Brooks Range tectonism.

We propose that these changes in Kingak facies and stratigraphic architecture influenced the frontal structures of the Brooks Range foothills during Brookian thrusting and folding. The ultimate Kingak shelf margin is arcuate, reaching its most southern point in southwest NPRA. Here, this shelf margin controls an abrupt change in detachment level, stepping up from the top of Shublik Formation (Upper Triassic) to the top the Kingak Shale. The ramp in this area appears to be associated with the shelf margin because the Kingak is thicker in the footwall of the thrust system than in the hanging wall. This imbricate of repeated Kingak through Nanushuk Formation (Albian) underlies the Carbon Creek anticline. This prominent northwest-southeast-trending fold marks a change in structural grain in the foothills region of southwestern NPRA from east-west-trending anticlines to the south. We propose that the abrupt change in structural grain is the result of northward-verging thrust sheets impinging obliquely on the ultimate shelf margin of the Kingak in southwest NPRA. In southeast NPRA there is a more gradual thinning of the Kingak with the shelf margin lying farther to the north. Here the detachment at the top of the Shublik Formation gently rises to the top of the Kingak, and into the Aptian-Albian Torok Formation. Low-relief folds form over this detachment, and involve Brookian strata, where the Carbon Creek anticline plunges to the southeast.

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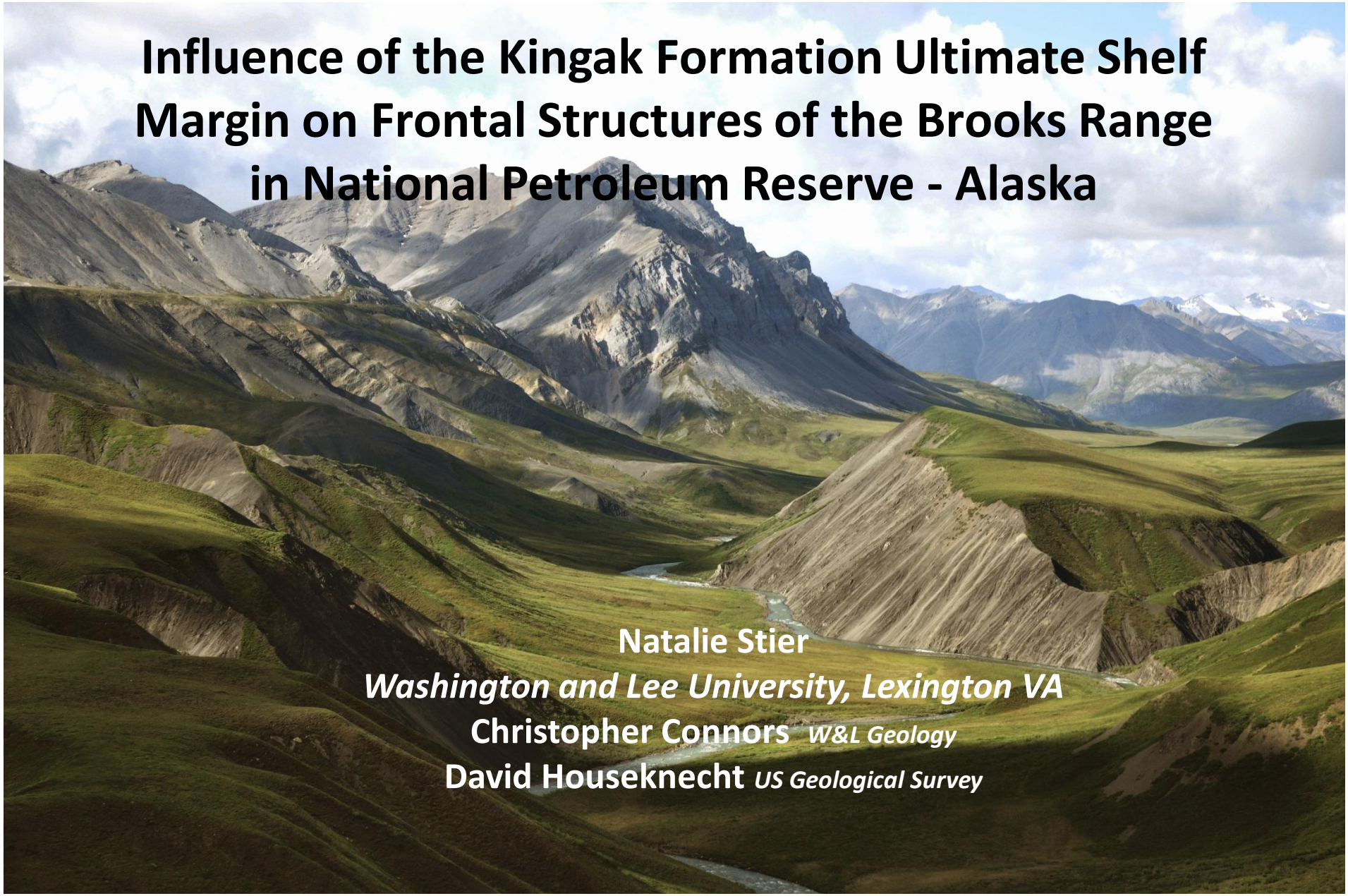
Influence of the Kingak Formation Ultimate Shelf Margin on Frontal Structures of the Brooks Range in National Petroleum Reserve - Alaska



Natalie Stier
Washington and Lee University, Lexington VA
Christopher Connors ***W&L Geology***
David Houseknecht ***US Geological Survey***

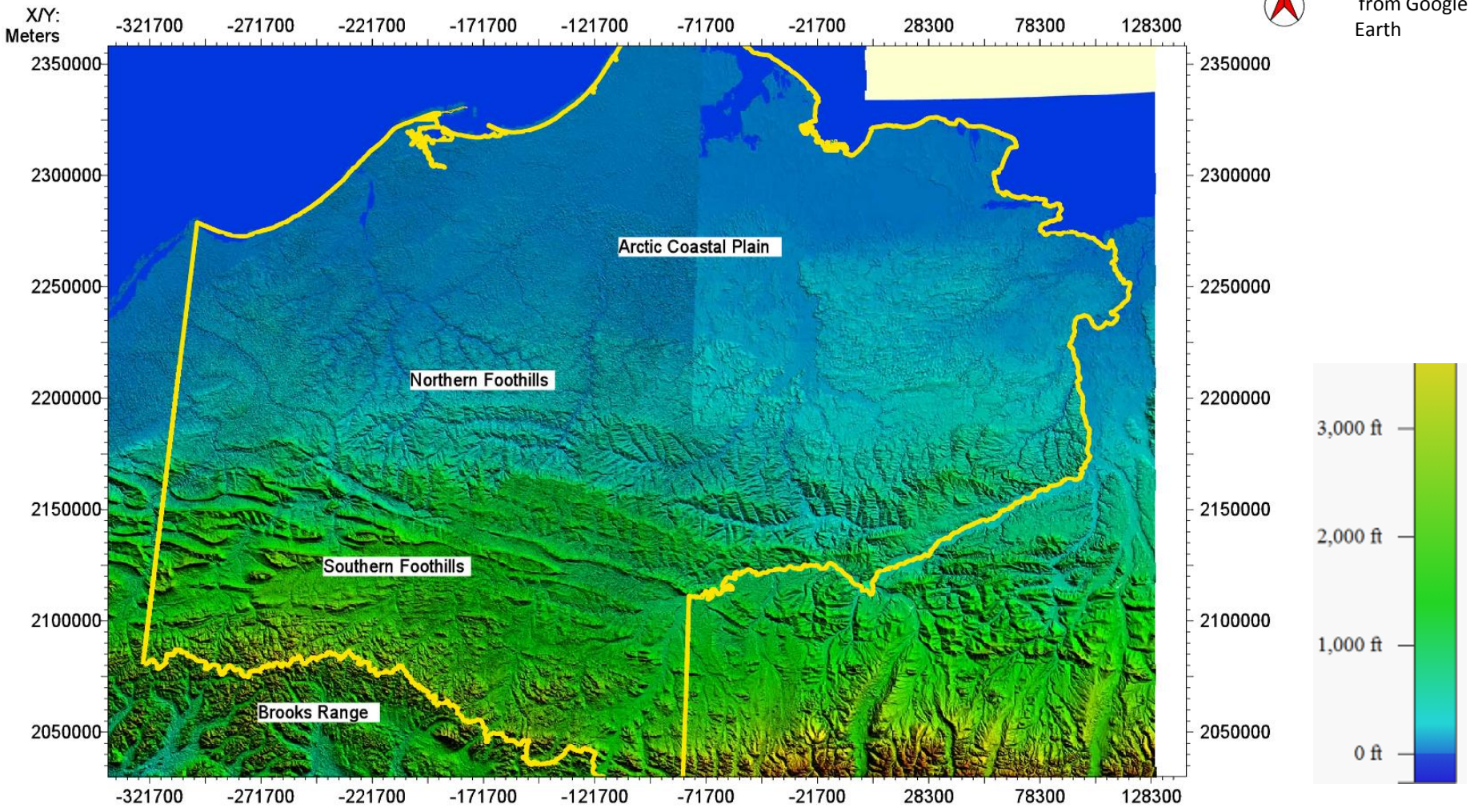
Atigun Gorge *Photo taken by Chris Connors, 2011.*

Study Area

National Petroleum Reserve Alaska (NPRA)

N

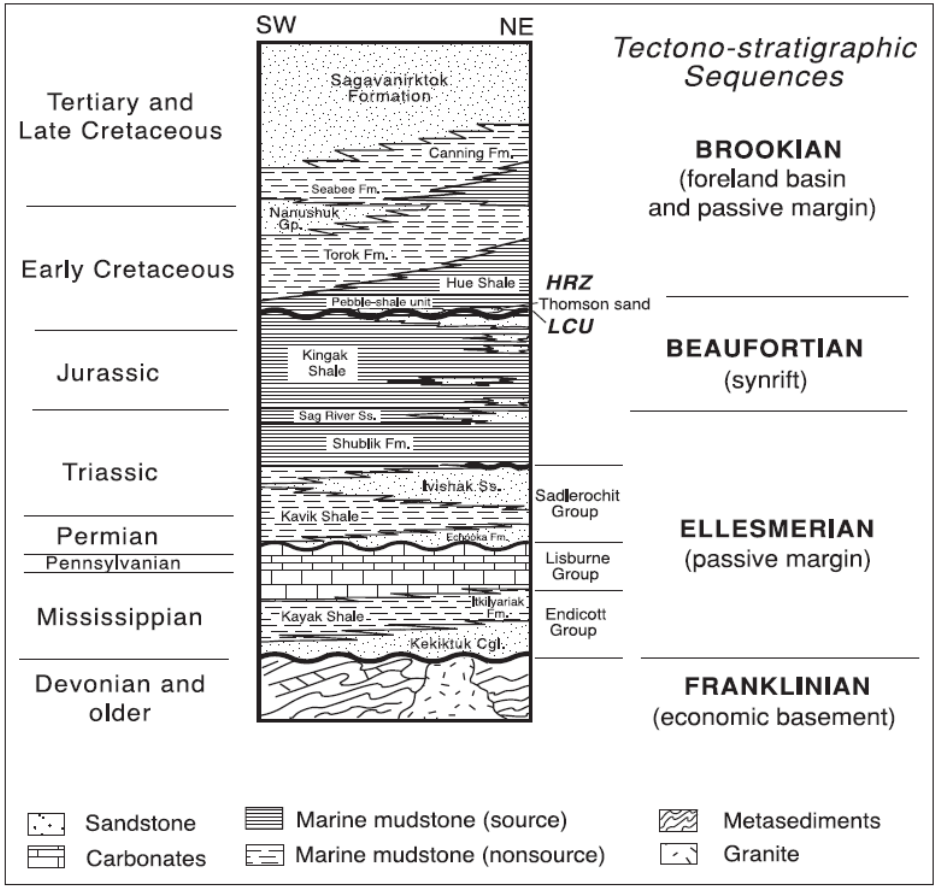
Image from Google Earth



DEM from NASA Aster data.

Regional Stratigraphy

- The Brookian Orogeny, along with the Chukotka Orogeny, is responsible for the deposition of the Brookian tectonostratigraphic sequence.
- Beaufortian strata represent forced regressions related to rift shoulder uplift related to the opening of the Canadian Basin.
- The Ellesmerian sequence includes lower graben-filling succession and upper passive margin succession.
- The Ellesmerian, Beaufortian, and Brookian tectonostratigraphic sequences were deposited over Franklinian basement.
- Franklinian basement rock is mostly low-grade metamorphic rock resulting from the Ellesmerian Orogeny.



from Bird, 2001

(Hubbard et al., 1987; Moore et al., 1994; Colpron and Nelson, 2009; Houseknecht and Bird, 2011)

Stratigraphy of the Foothills

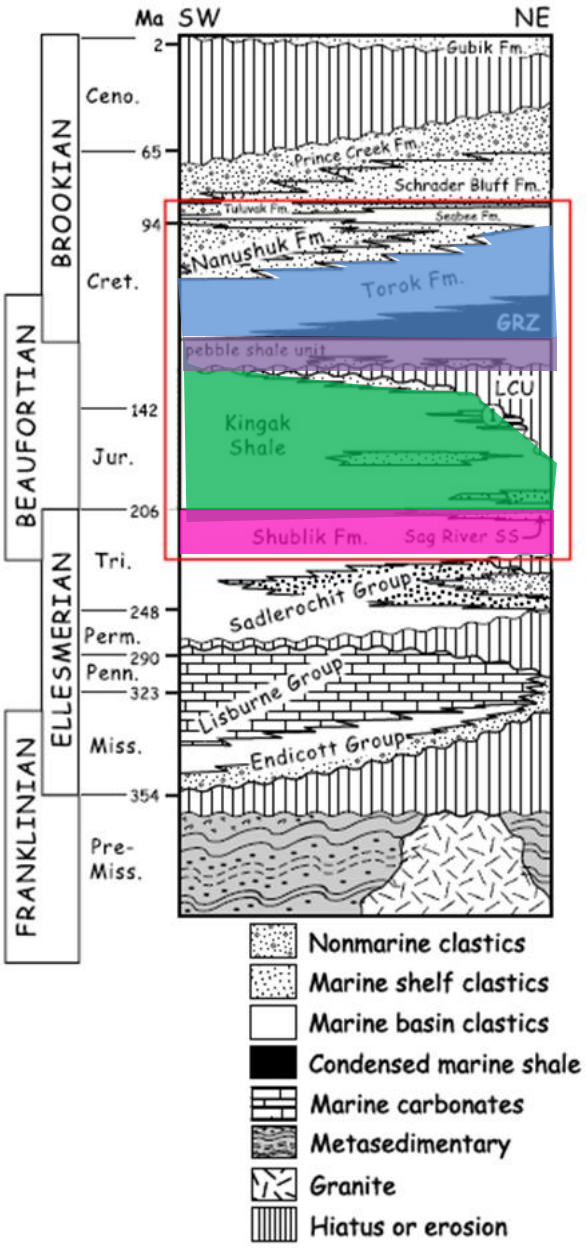
Torok Fm – Clinoform depositional sequences composed of dark marine shales and sandstones (Lower Cretaceous)

Pebble shale and GRZ(gamma ray zone of Hue Shale) – A thin organic rich black shale that lies unconformably on the Kingak Shale (Lower Cretaceous)

Kingak Shale – Deposited in a succession of sequences (K1-K4) during southward progradation of the shelf margin across Arctic Alaska (Lower Jurassic to Lower Cretaceous)

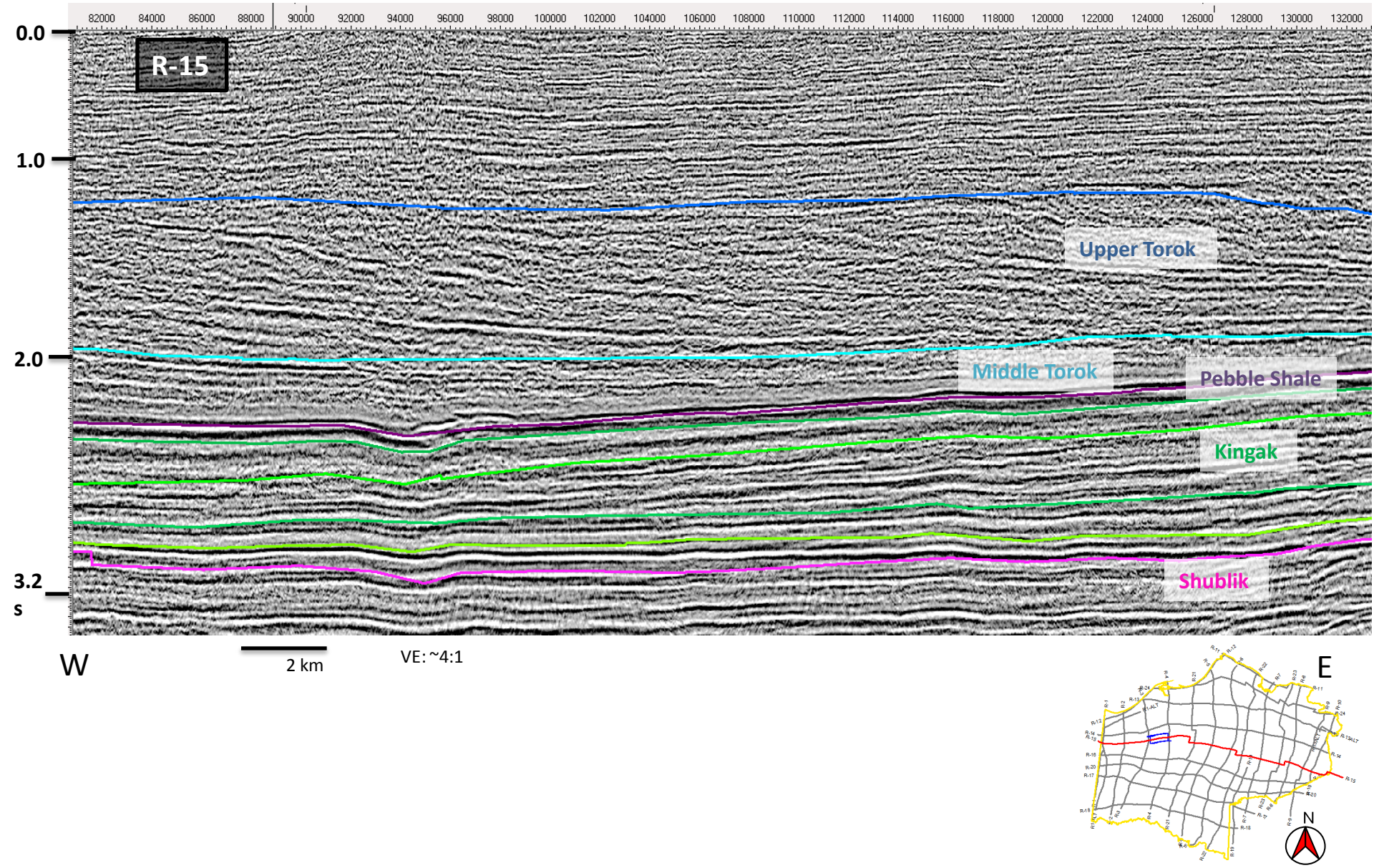
Shublik Fm – A mixture of carbonate, mudstone, shale, and sandstone deposited on a southward sloping margin and represents a regional marine transgression (Upper Triassic)

(Moore et al., 1994; Houseknecht et al., 2009; Houseknecht and Bird, 2009; Houseknecht and Bird, 2011)

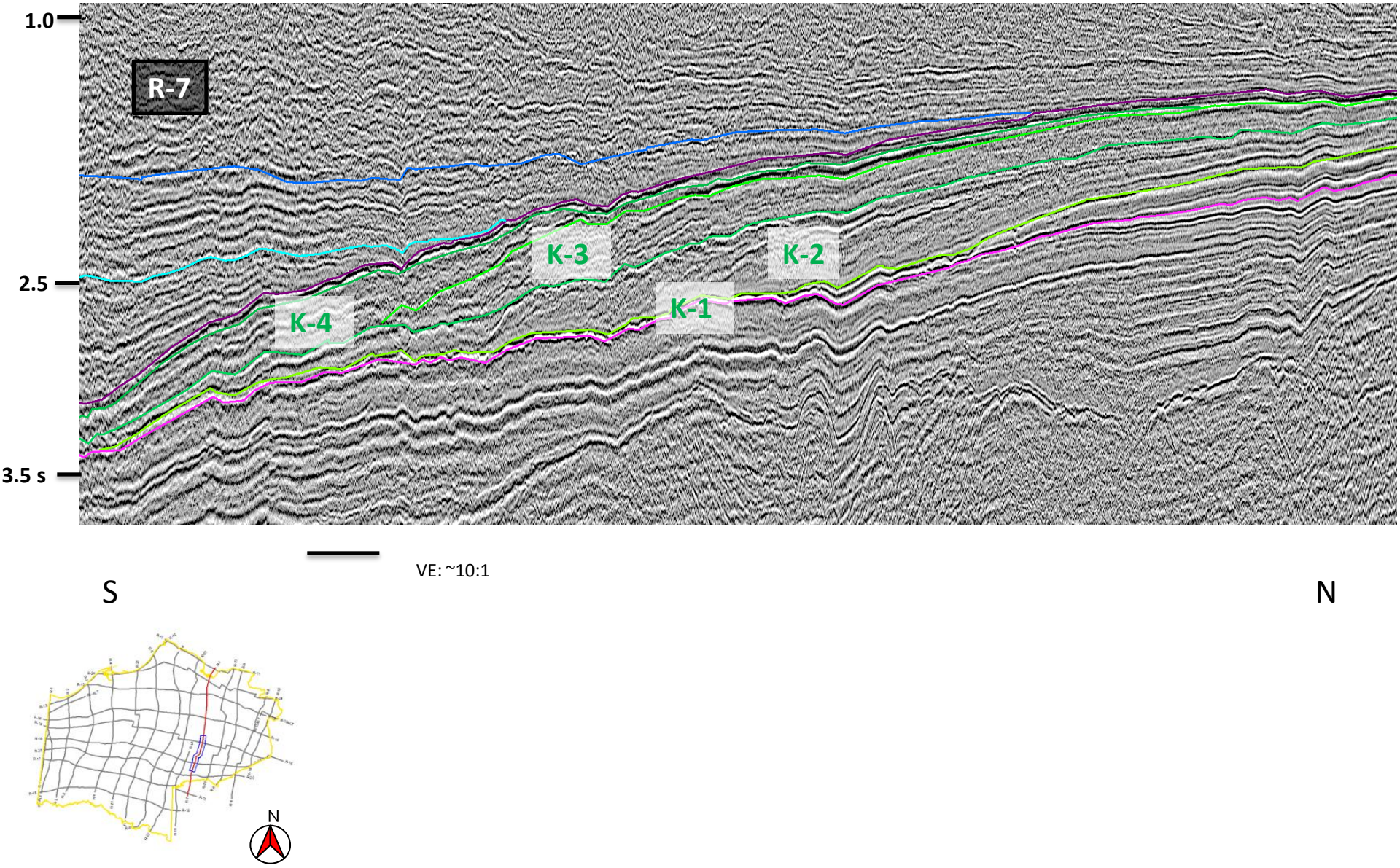


Modified from Houseknecht and Bird, 2009

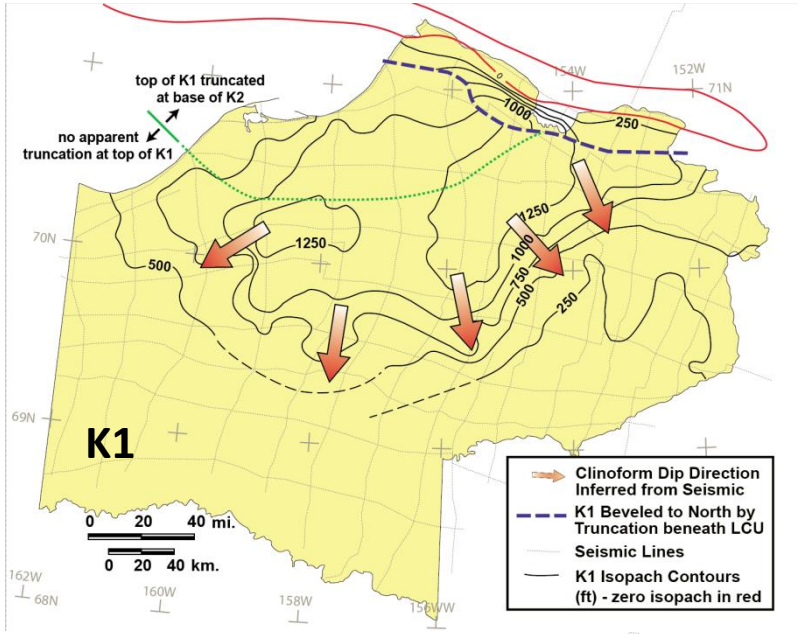
Interpreted Horizons

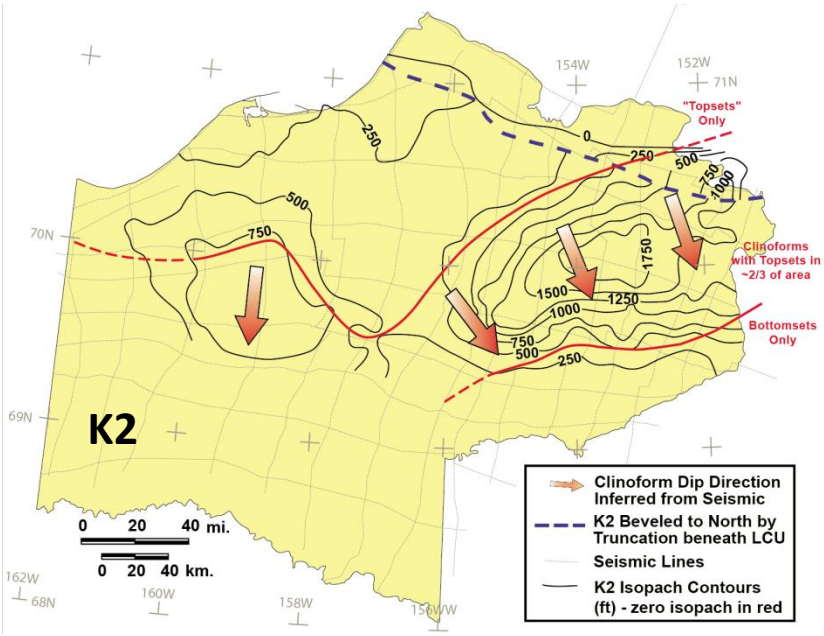


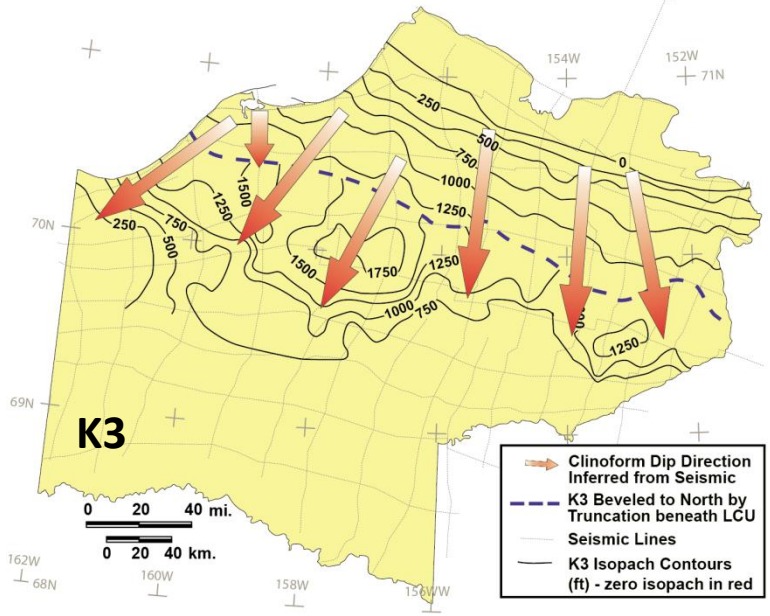
Clinoforms in the Kingak

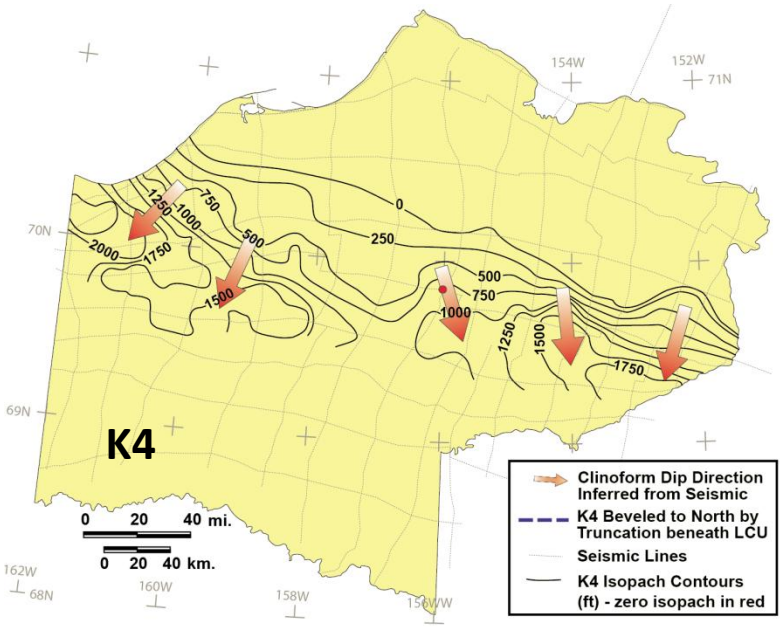


Kingak Sediment Flow Direction



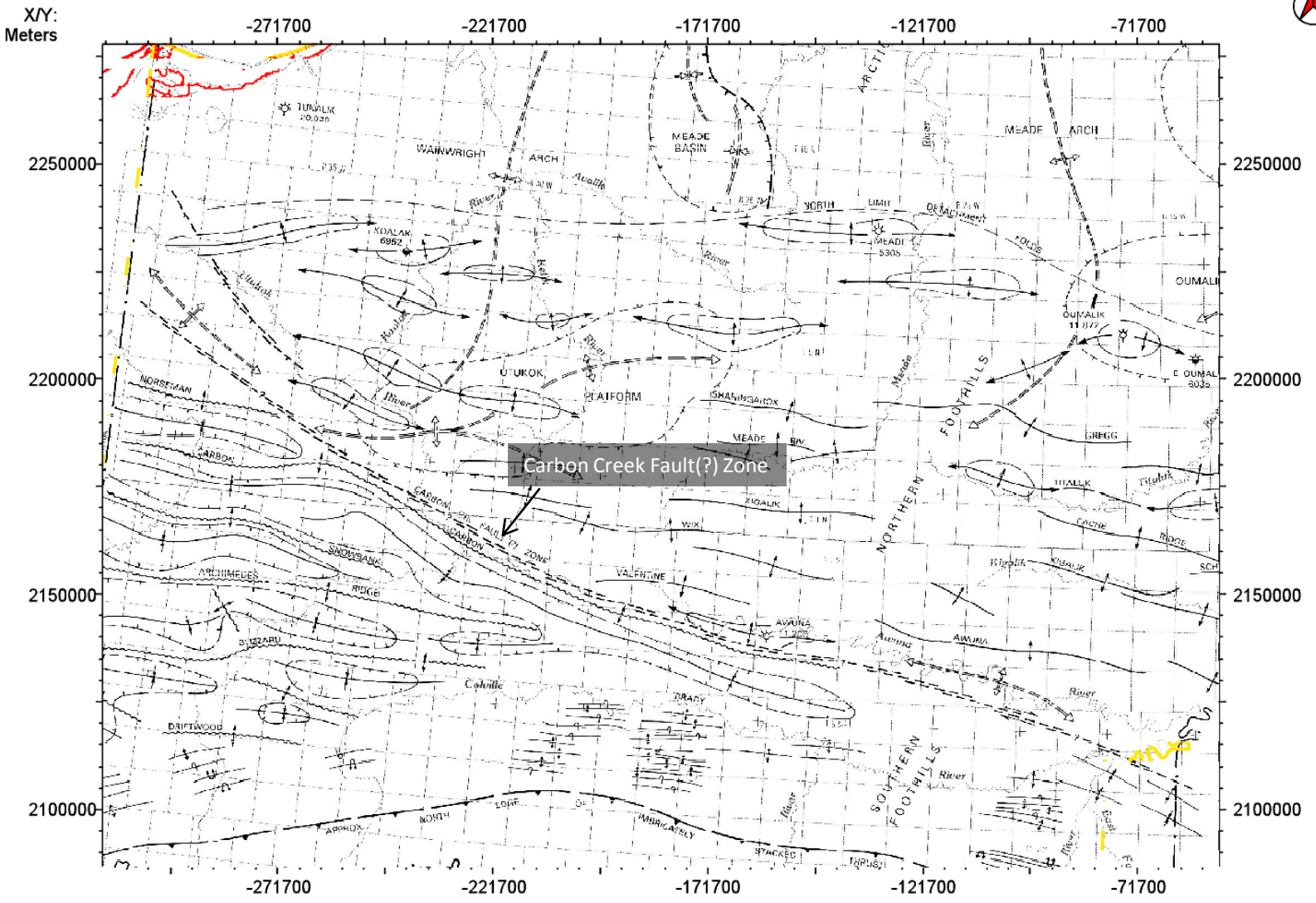






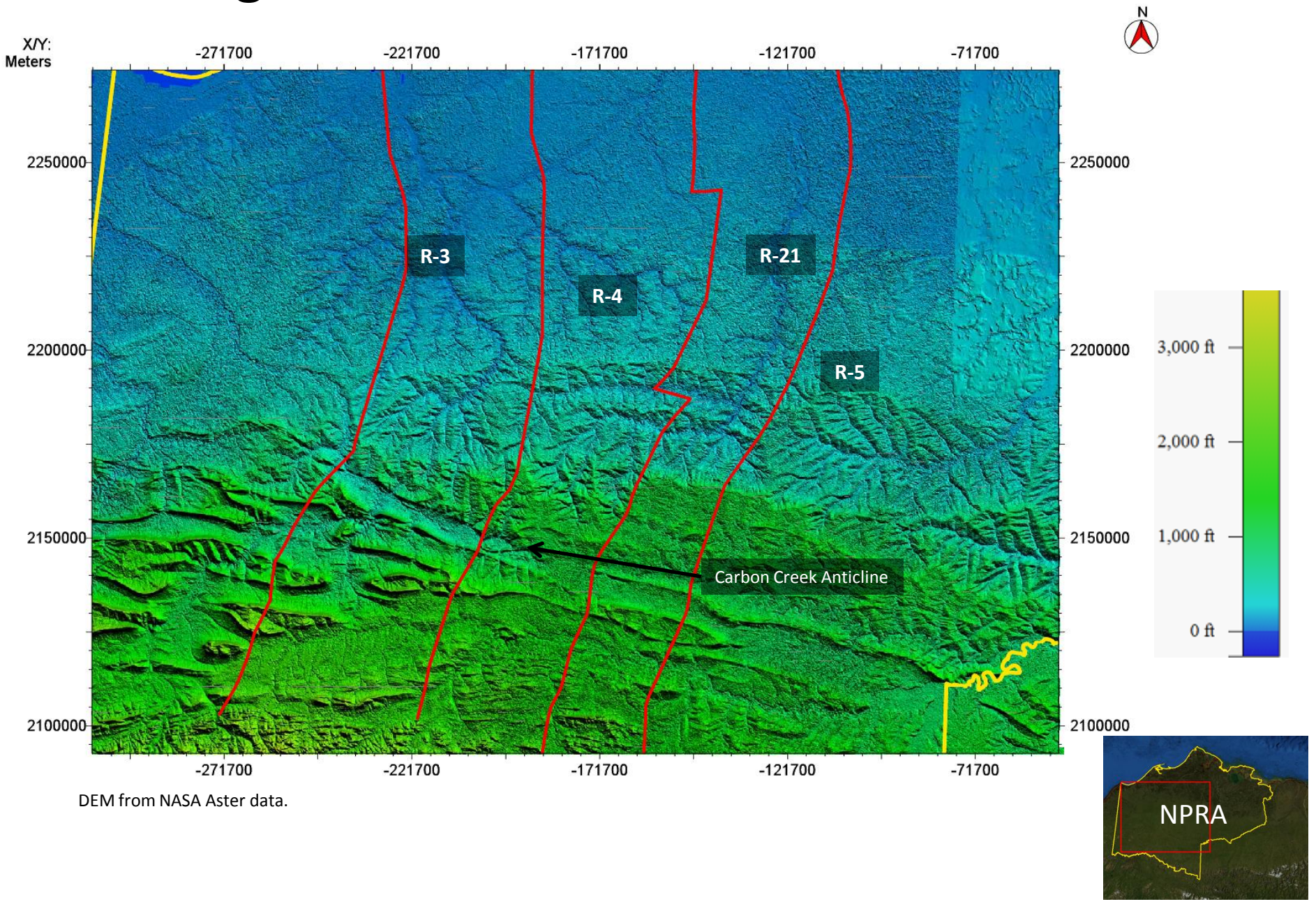
Modified from Houseknecht and Bird, 2007

Structural Features in the Foothills

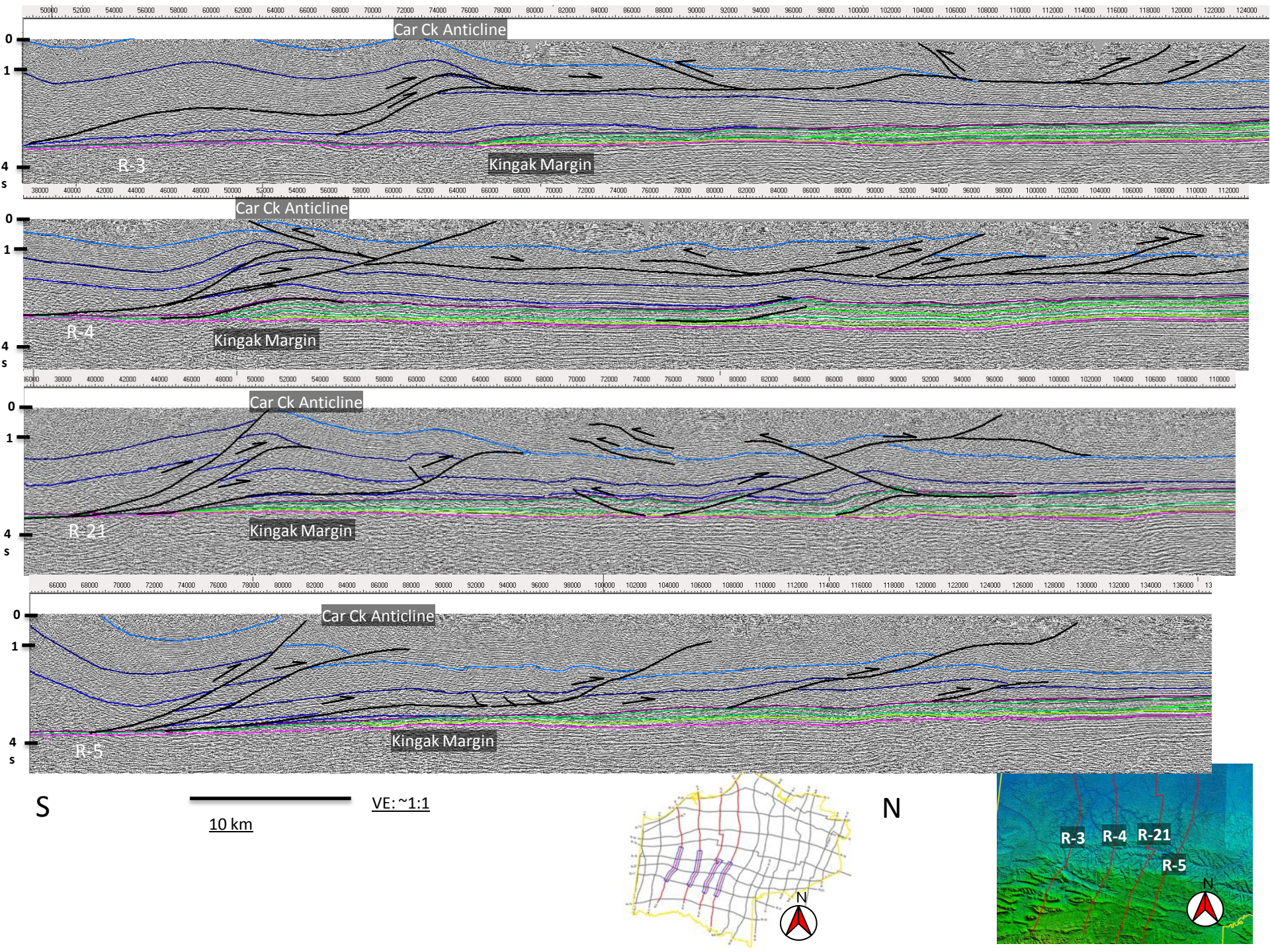


Modified from Kirschiner et al., 1987

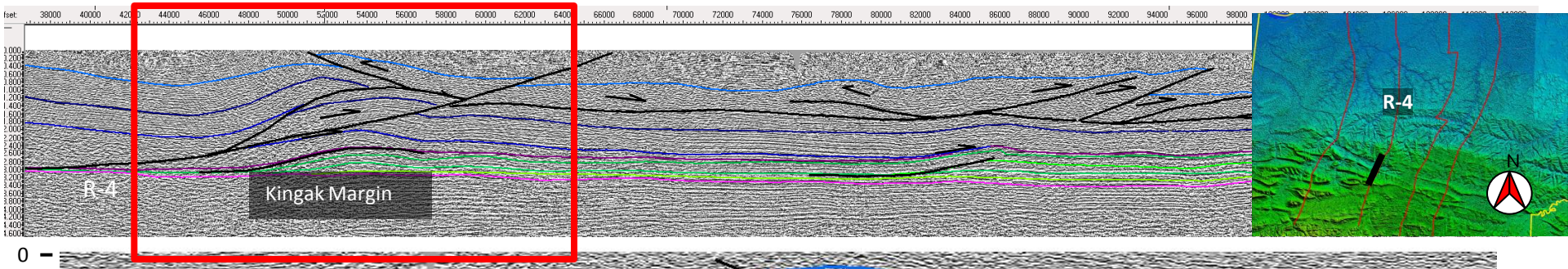
Digital Elevation Model of the Foothills

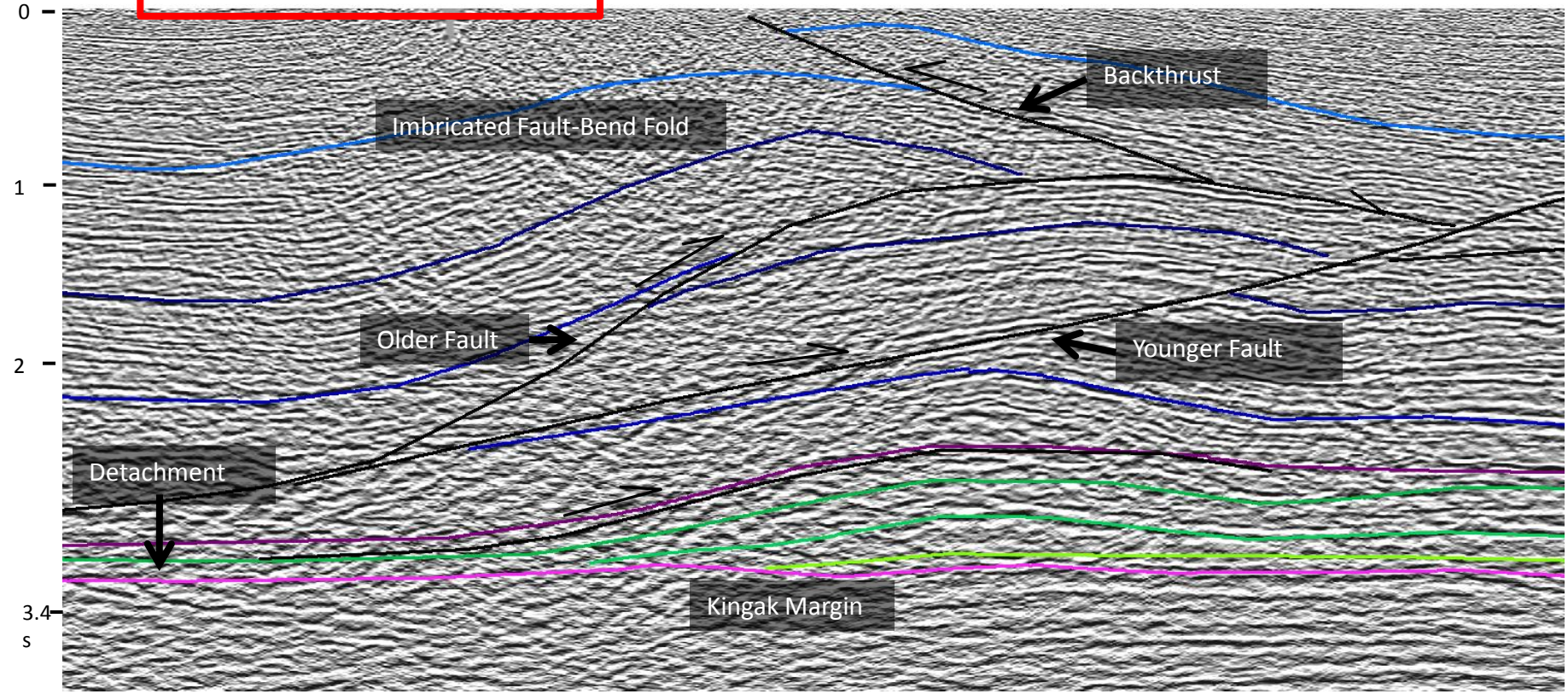


DEM from NASA Aster data.


Car Ck Anticline
R-3
Kingak Margin
Car Ck Anticline
R-4
Kingak Margin
Car Ck Anticline
R-21
Kingak Margin
Car Ck Anticline
R-5
Kingak Margin
0
1
4
s
S
10 km
VE: ~1:1
N
R-3
R-4
R-21
R-5
N

Carbon Creek Anticline, an Imbricate Fault Bend Fold





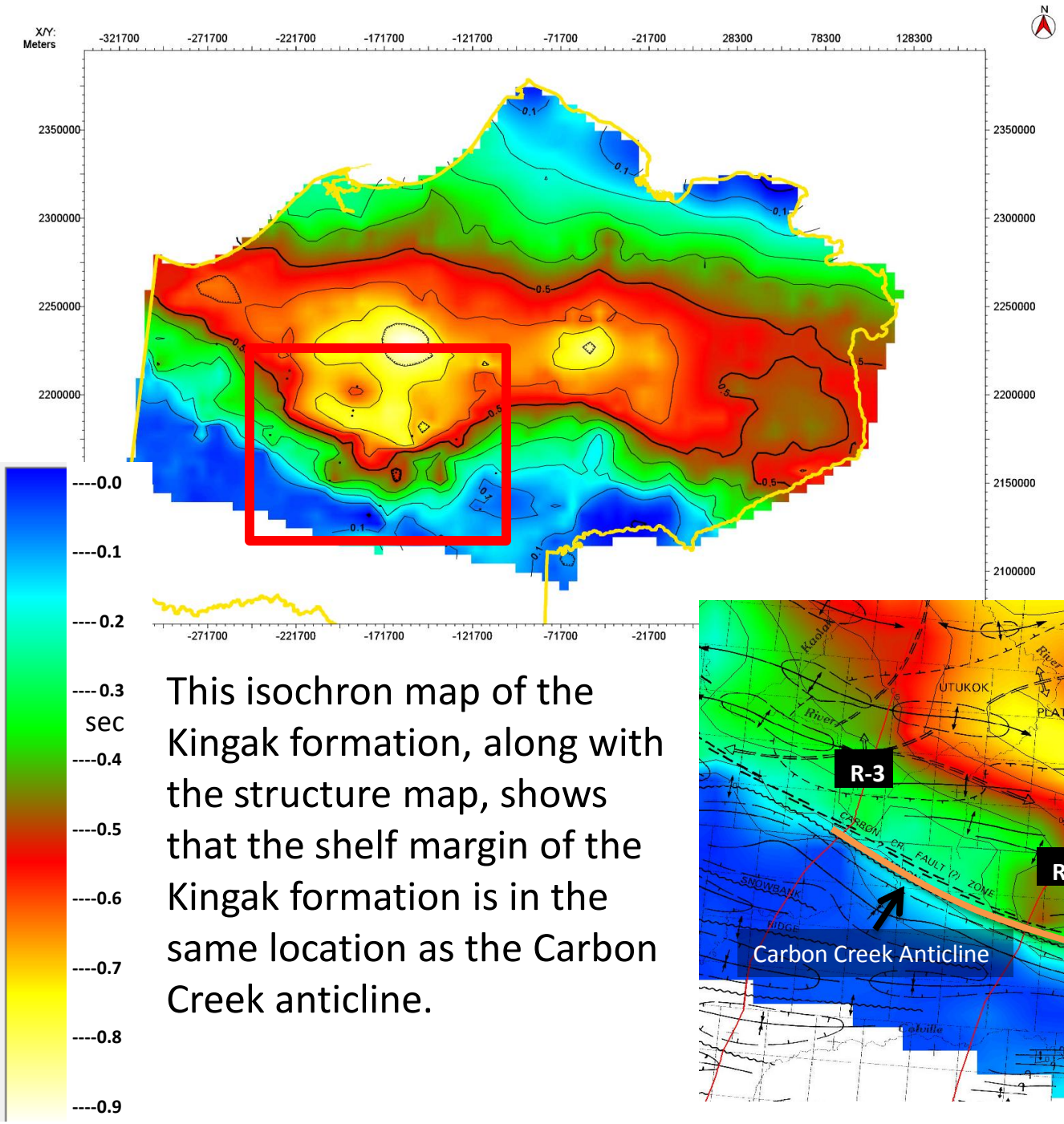
S

2 km

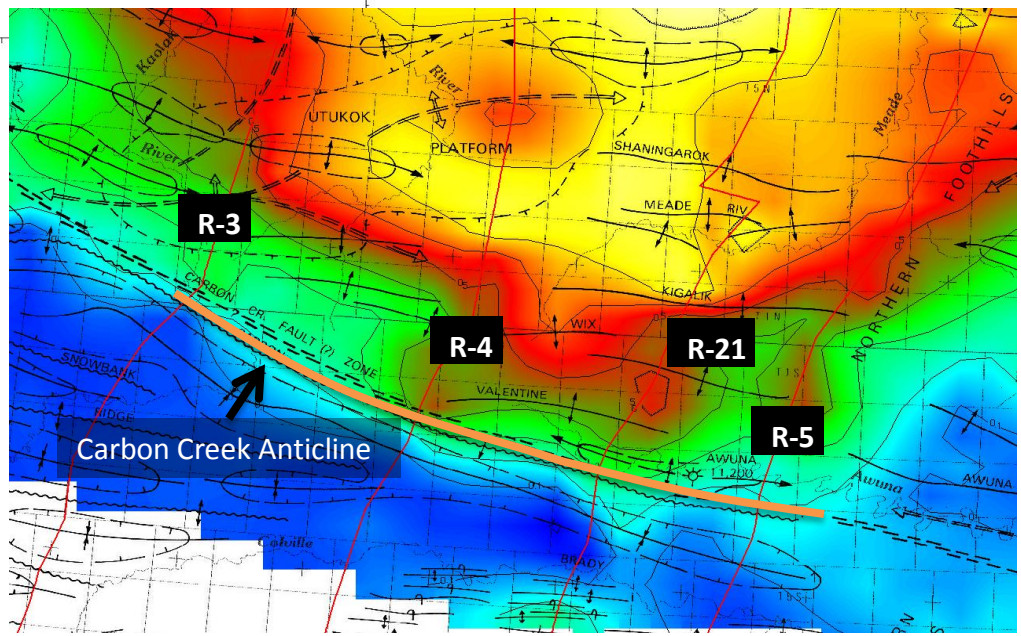
VE: ~1:1

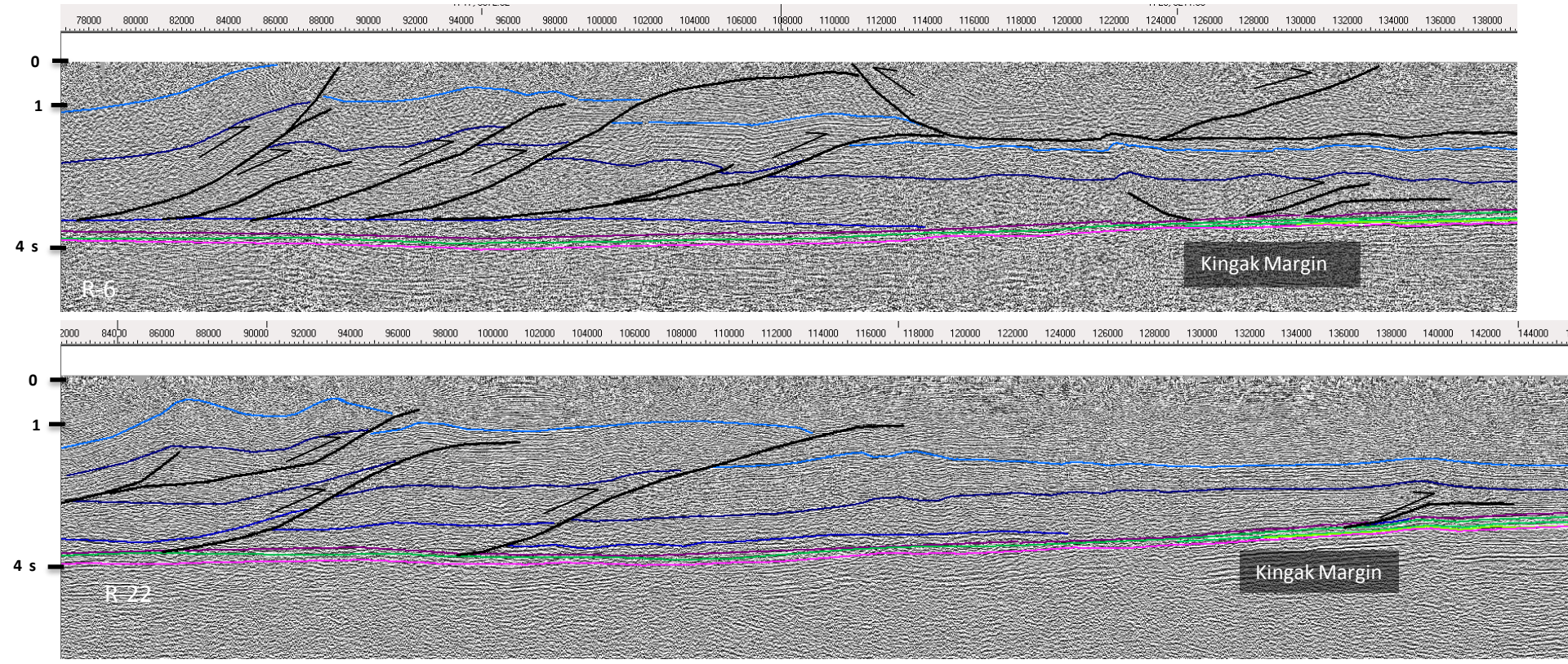
N

Kingak Isochron Map (northwest)



This isochron map of the Kingak formation, along with the structure map, shows that the shelf margin of the Kingak formation is in the same location as the Carbon Creek anticline.

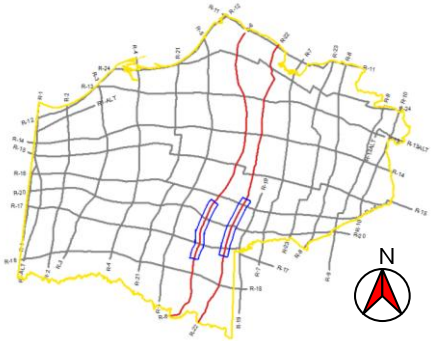


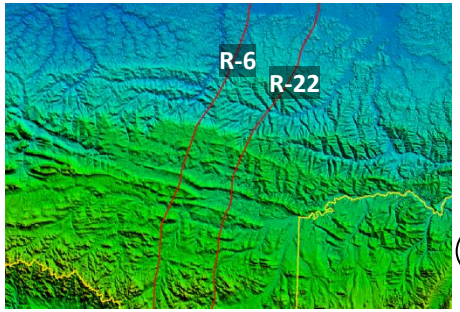


S

10 km

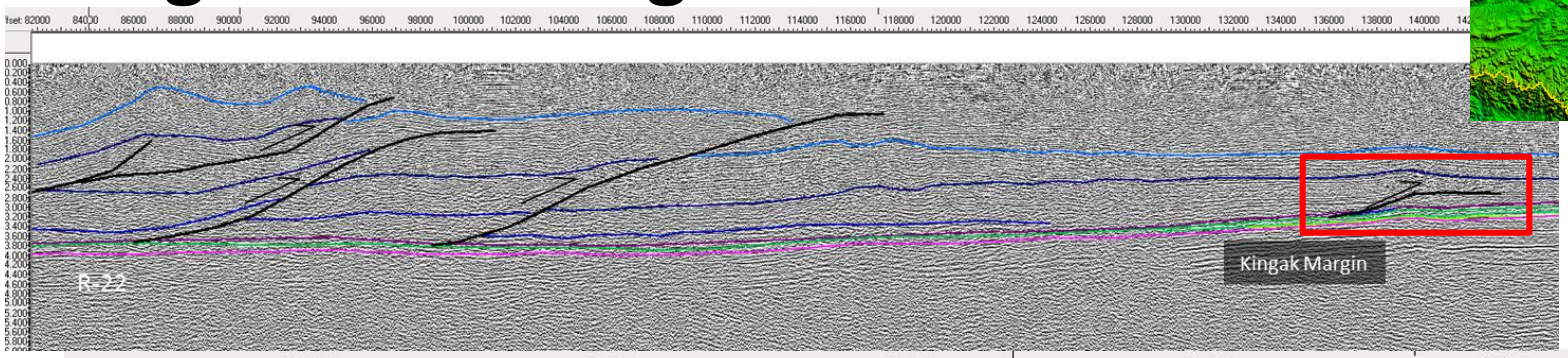
VE: ~1:1

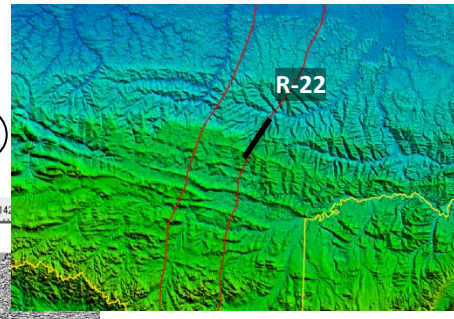


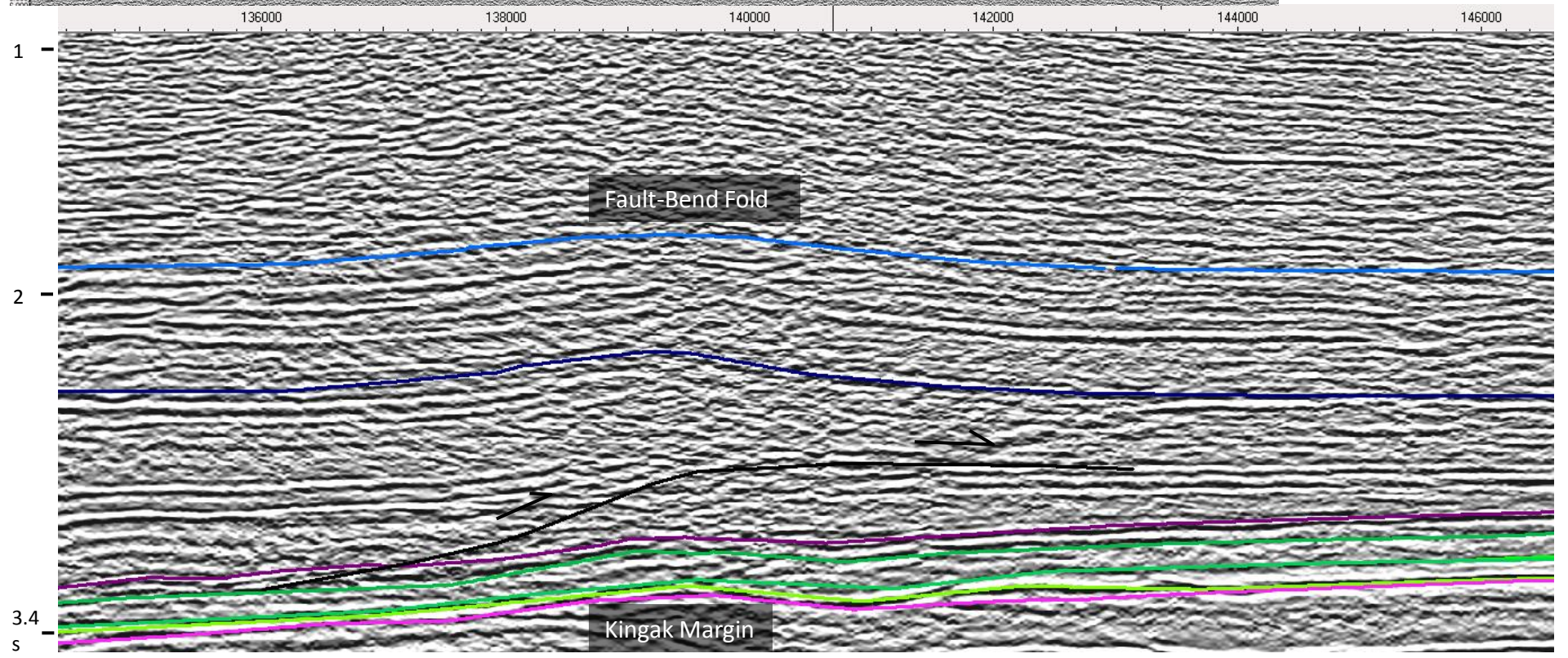


N

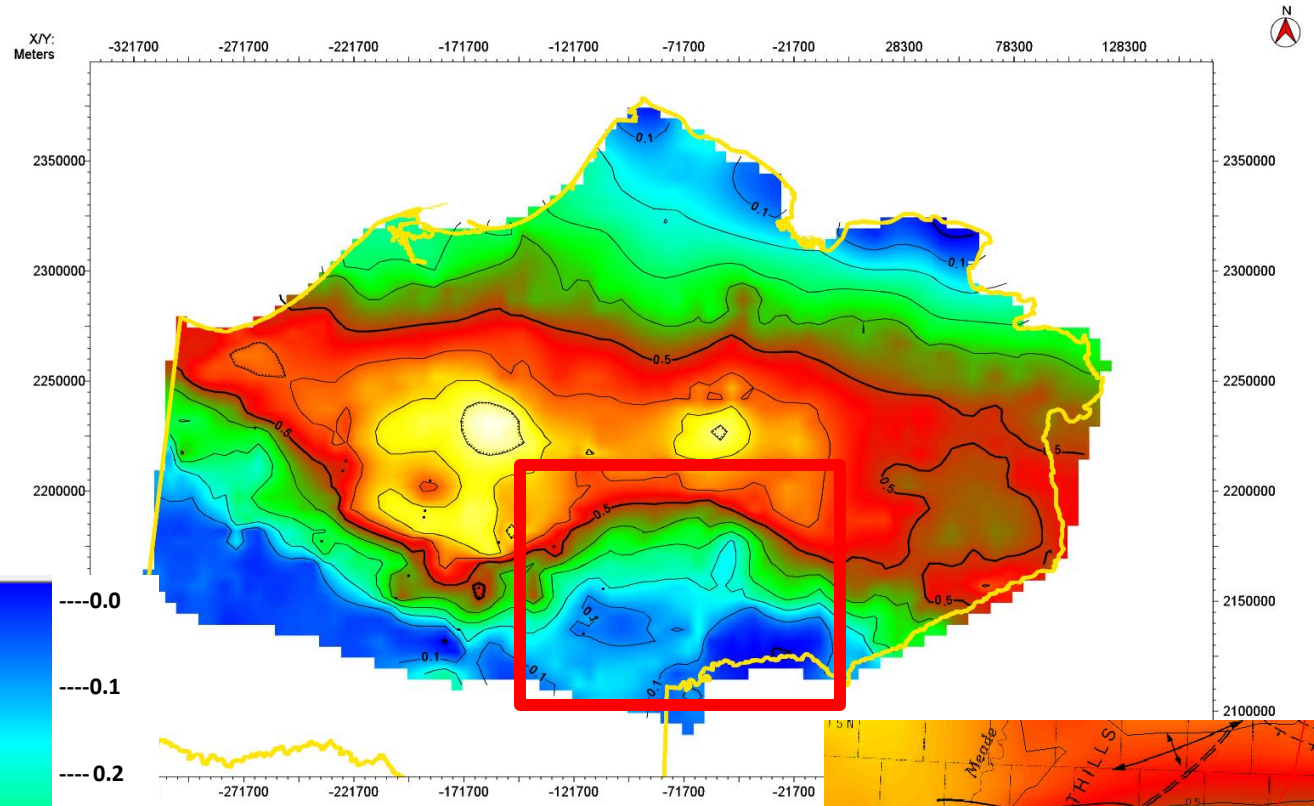
Deformation associated with the Kingak Shelf Margin

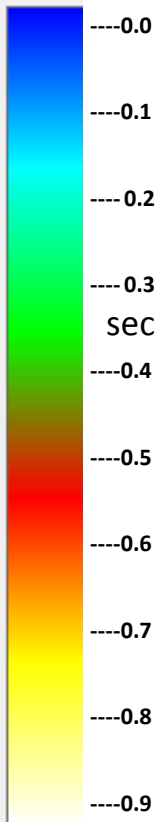




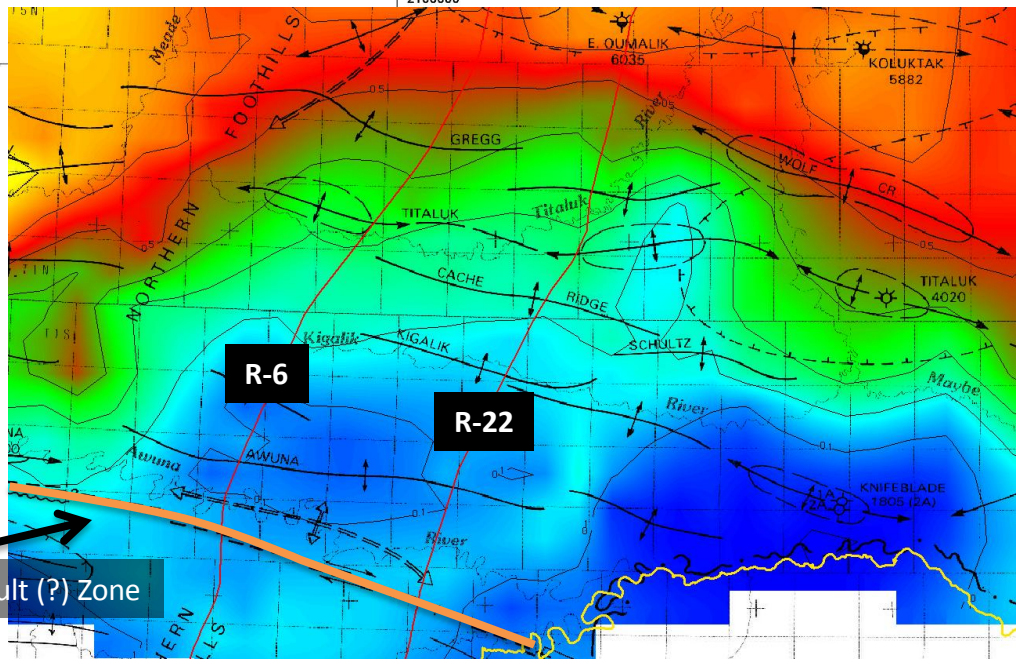


Kingak Isochron Map (southeast)





In the southeast portion of the Carbon Creek Fault (?) Zone the structural break is south of the Kingak shelf margin.



Conclusions

- The major detachment is the basal condensed section
  - This is made up of the Shublik, Kingak, and the pebble shale
  - Thrusts then step up to another Kingak horizon or into the Torok
- The structural style is imbricate fault-bend folding
  - There is some fault propagation and detachment folding
  - Thrust with large amounts of displacement in some places incorporate backthrusting to form a wedge in order to accommodate the slip
- The stratigraphy has a major influence on the structure
  - The Kingak ultimate shelf margin is ideal for thrust to ramp-up on
  - Thrust faults detach on sequence boundaries in the Torok
  - There is more that one detachment in the Torok
- The obliqueness of the Carbon Creek Anticline is due to the Kingak shelf margin
  - In SW NPRA the Kingak shelf margin is oblique to the general strike of the structures of the foothills in this area; therefore, thrusting influenced by the margin becomes structurally oblique
  - In SE NPRA the Kingak shelf margin is north of most of the major deformation
  - Therefore, the major thrusting is not influenced by the Kingak shelf margin and is not oblique to other structures

Future Work

- Balanced cross-sections
  - If the cross-sections balance, then it improves the validity of the interpretation
- Further definition of sequences within the Torok
  - This would help constrain where in the section the upper detachments reside
  - The interplay of thrusting as the Torok thins to the east could also be constrained
- Retrodeformed Torok clinoform sets with their original thicknesses could then be delineated

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