

The Case for another Look at the Paleocene Fort Union Formation in the Eastern Greater Green River Basin, Wyoming*

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Abstract

The Paleocene Fort Union Formation in the eastern Greater Green River Basin is a thick succession of shale, sandstone, coal, and siltstone, deposited as syn-orogenic Laramide basin fill. Recent production from the Washakie Basin has demonstrated the viability of the Fort Union Formation as a productive gas reservoir, especially with improved horizontal drilling technology. This begs the question: are there other potentially analogous Fort Union reservoirs that have been overlooked elsewhere in the eastern Greater Green River Basin? In the case of the Washakie Basin, wet gas is produced from the China Butte Member of the Fort Union Formation. This basal member has numerous coal seams interbedded with lenticular sandstones. Gas is believed to be derived in situ, as well as from the deeper Cretaceous-age formations. Production is from approximately 3,048 m (10,000 ft) TVD. Burial history curve analyses and vitrinite reflectance extrapolation suggests 975 m (3,200 ft) of Neogene erosion, reflecting condensate generation at less than 4,023 m (13,200 ft) burial depth (geothermal gradients in this region are not elevated). Regional correlations of the China Butte Member show the succession of coals thickens into the Great Divide Basin, where no Fort Union production is occurring and no drill stem tests are publicly available. Mud logs from wells drilled into the deeper Cretaceous formations show methane gas spikes associated with the China Butte Member, but this coal-rich interval is at maximum depths of approximately 914 to 1,829 m (3,000 to 6,000 ft) TVD. Extrapolation of vitrinite reflectance results suggests 1,676 to 2,103 m (5,500 to 6,900 ft) of Neogene erosion in the Great Divide Basin, placing the China Butte Member at maximum burial depths just shy of those required for in-situ condensate generation in the Washakie Basin. Furthermore, vitrinite reflectance measured from a handful of Fort Union Formation samples in the Great Divide Basin record values approximately 0.4 to 0.7% Ro, significantly less than the >1.2% values from the Washakie Basin. Preliminary data suggest that

although Fort Union Formation coals may not have reached maximum burial depths sufficient for condensate generation in the Great Divide Basin, this coal-rich interval may be methane saturated, at least in places, and could be worth a second look.

References Cited

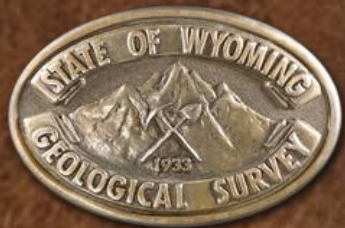
Blakey, R., 2011, Library of Paleogeography: Web Accessed September 7, 2015, www.cpgeosystems.com/paleomaps.html.

Honey, J.G., and R.D. Hettinger, 2004, Geologic map of the Peach Orchard Flat quadrangle, Carbon County, Wyoming, and descriptions of new stratigraphic units in the Upper Cretaceous Lance Formation and Paleocene Fort Union Formation, eastern Greater Green River Basin, Wyoming-Colorado: U.S. Geological Survey Scientific Investigations Map 2835, version 1.1, scale 1:24,000.

Roberts, L.N.R., M.D. Lewan, and T.M. Finn, 2005, Burial History, Thermal Maturity, and Oil and Gas Generation History of Petroleum Systems in the Southwestern Wyoming Province, Wyoming, Colorado, and Utah: in Petroleum Systems and Geologic Assessment of Oil and Gas in the Southwestern Wyoming Province, Wyoming, Colorado, and Utah, U.S. Geological Survey Digital Data Series DDS-69-D, 29 p., Web Accessed September 7, 2015, http://pubs.usgs.gov/dds/dds-069/dds-069-d/REPORTS/69_D_CH_3.pdf.



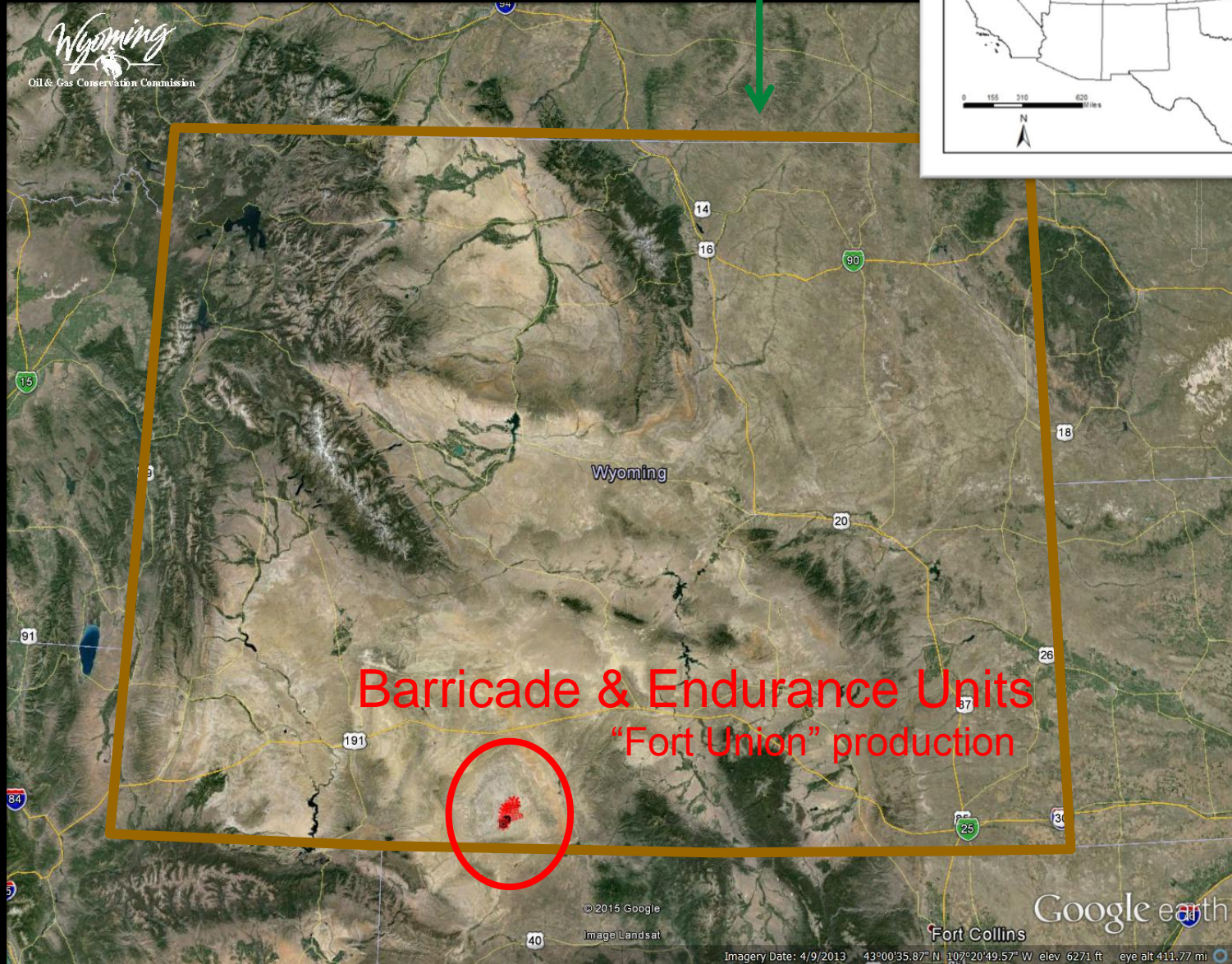
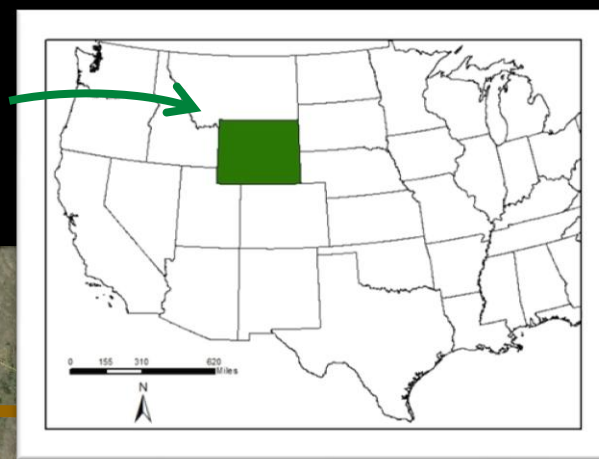
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Ranie Lynds and Chris Carroll

The Problem...

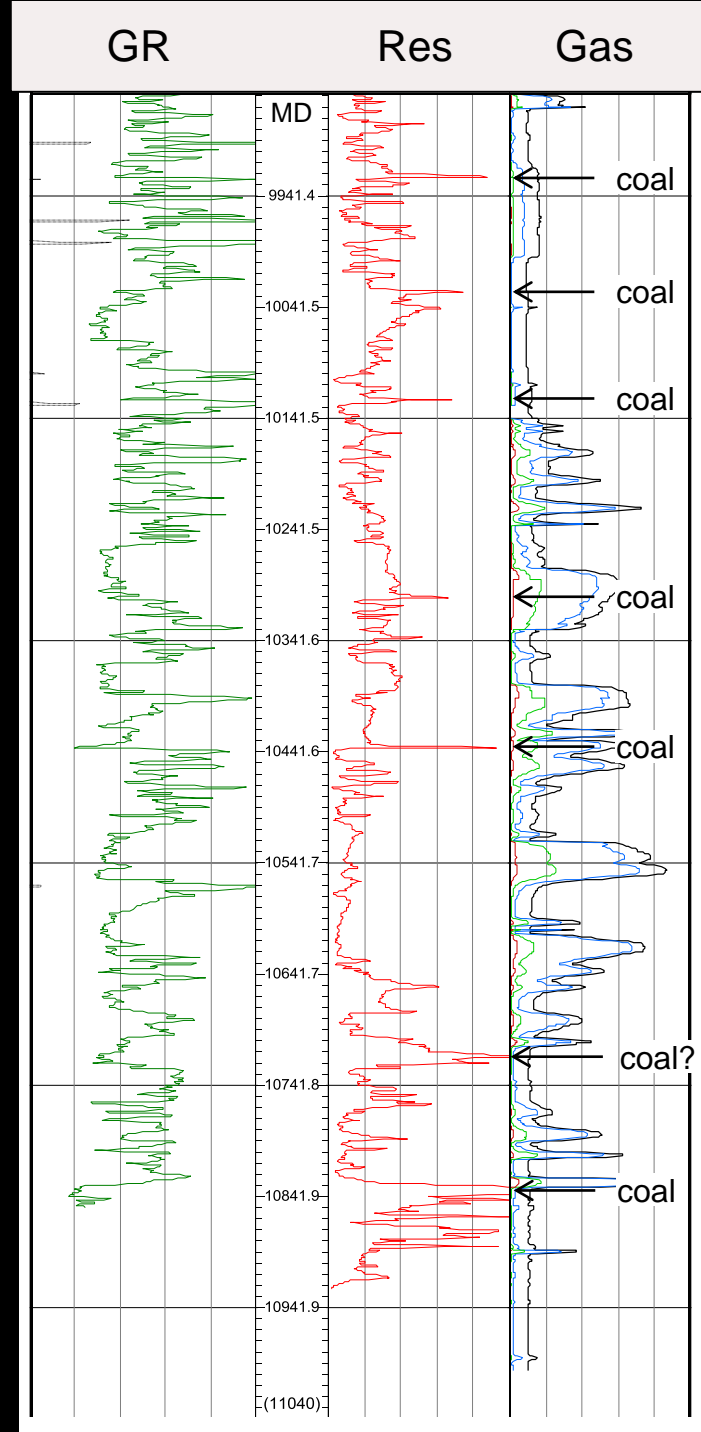
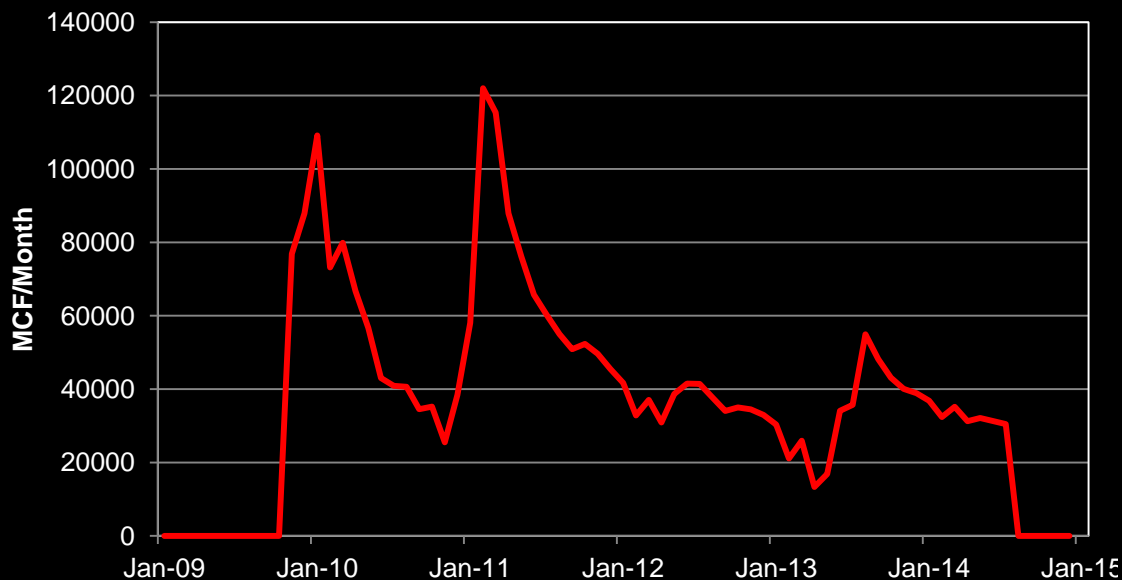
WYOMING



Barricade 14-01V →

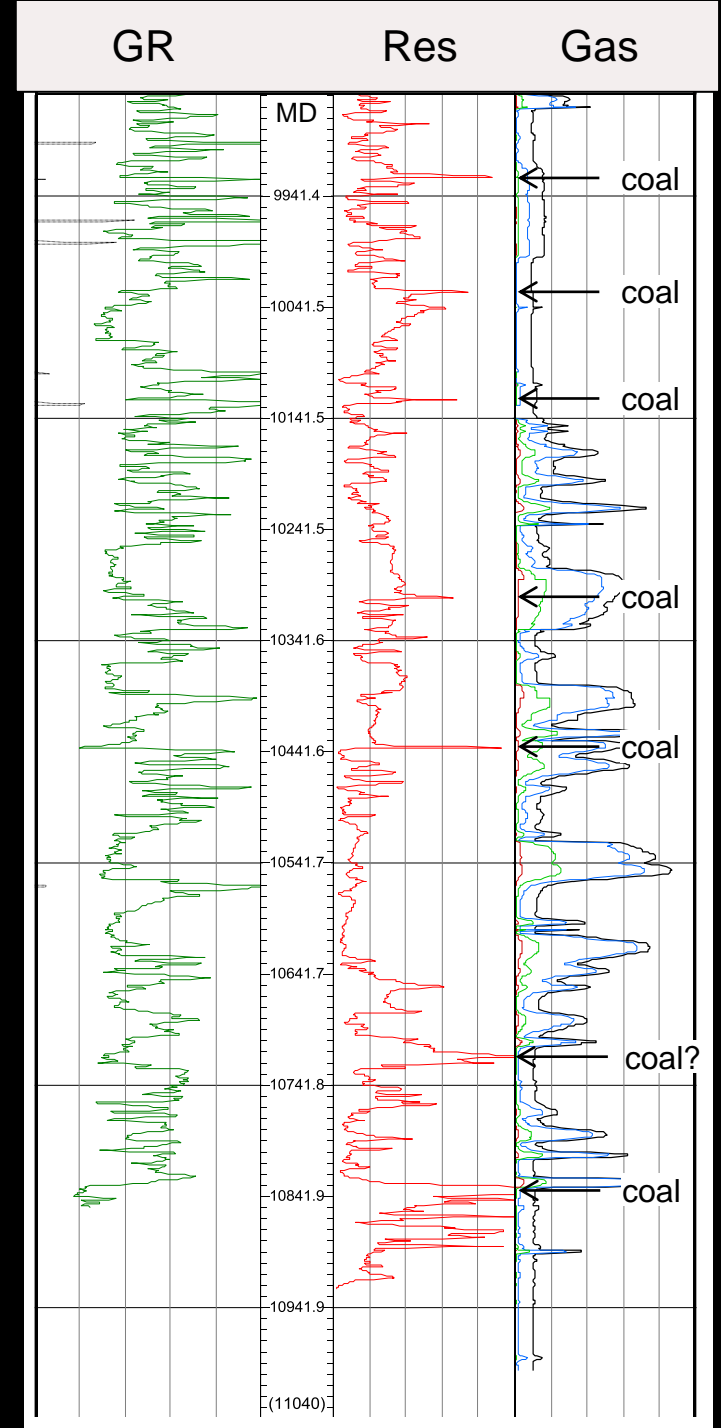
Fort Union production

Endurance Unit

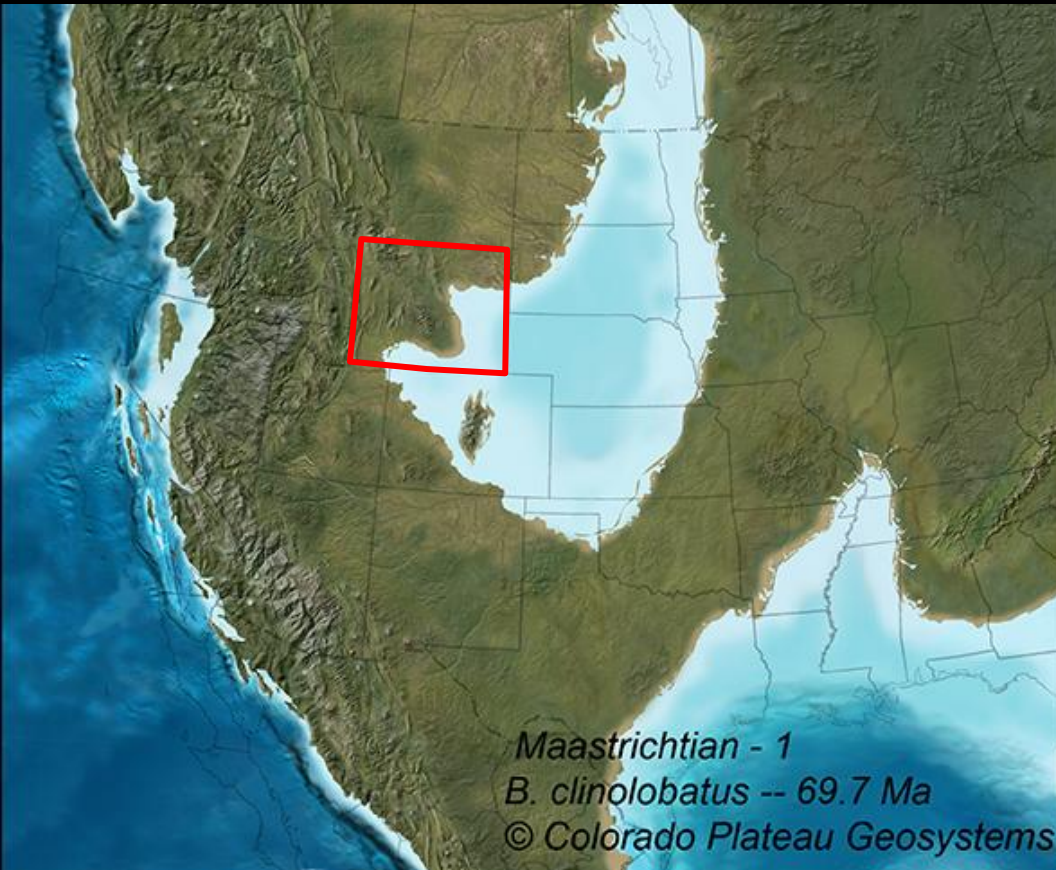


Questions:

1. What is the source of this gas – can it be the Fort Union coals?
2. Could there be more gas in a similar setup elsewhere?



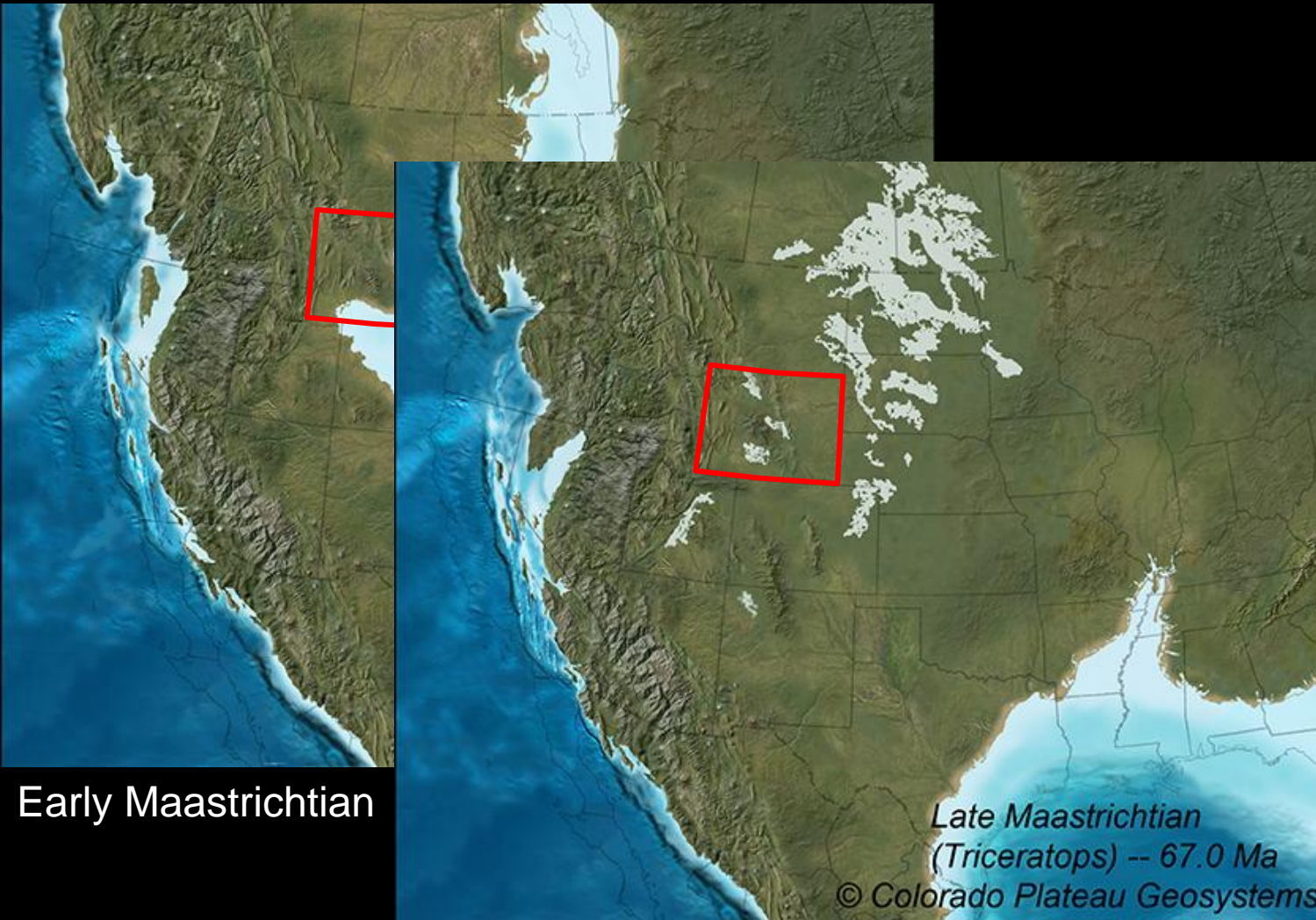
Background: Geologic Setting



Formation	Age (Series)
Wasatch & Battle Spring Formations	Eocene
Fort Union Formation	Paleocene
Lance Formation	Upper Cretaceous
Fox Hills Ss. & Lewis Sh.	

Early Maastrichtian

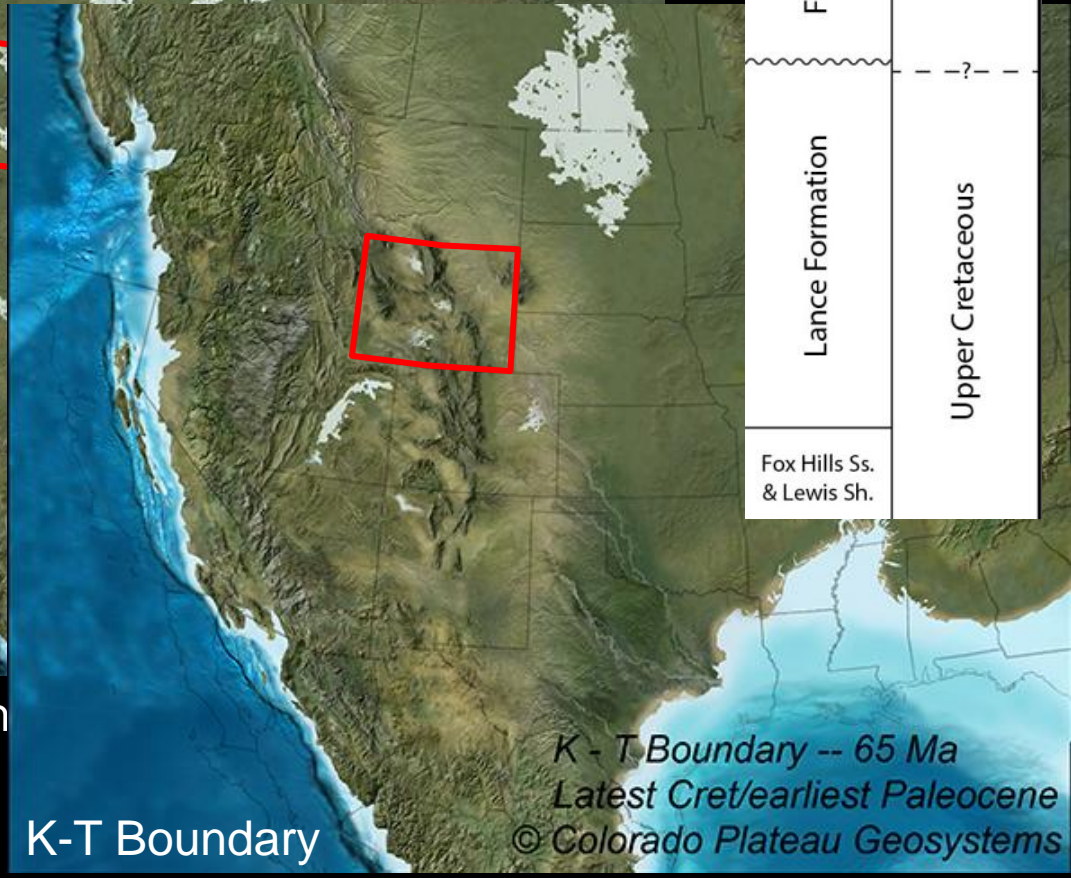
Background: Geologic Setting



Late Maastrichtian

Formation	Age (Series)
Wasatch & Battle Spring Formations	Eocene
Fort Union Formation	Paleocene
Lance Formation	Upper Cretaceous
Fox Hills Ss. & Lewis Sh.	

Background: Geologic Setting



Formation	Age (Series)
Wasatch & Battle Spring Formations	Eocene
Fort Union Formation	Paleocene
Lance Formation	Upper Cretaceous
Fox Hills Ss. & Lewis Sh.	

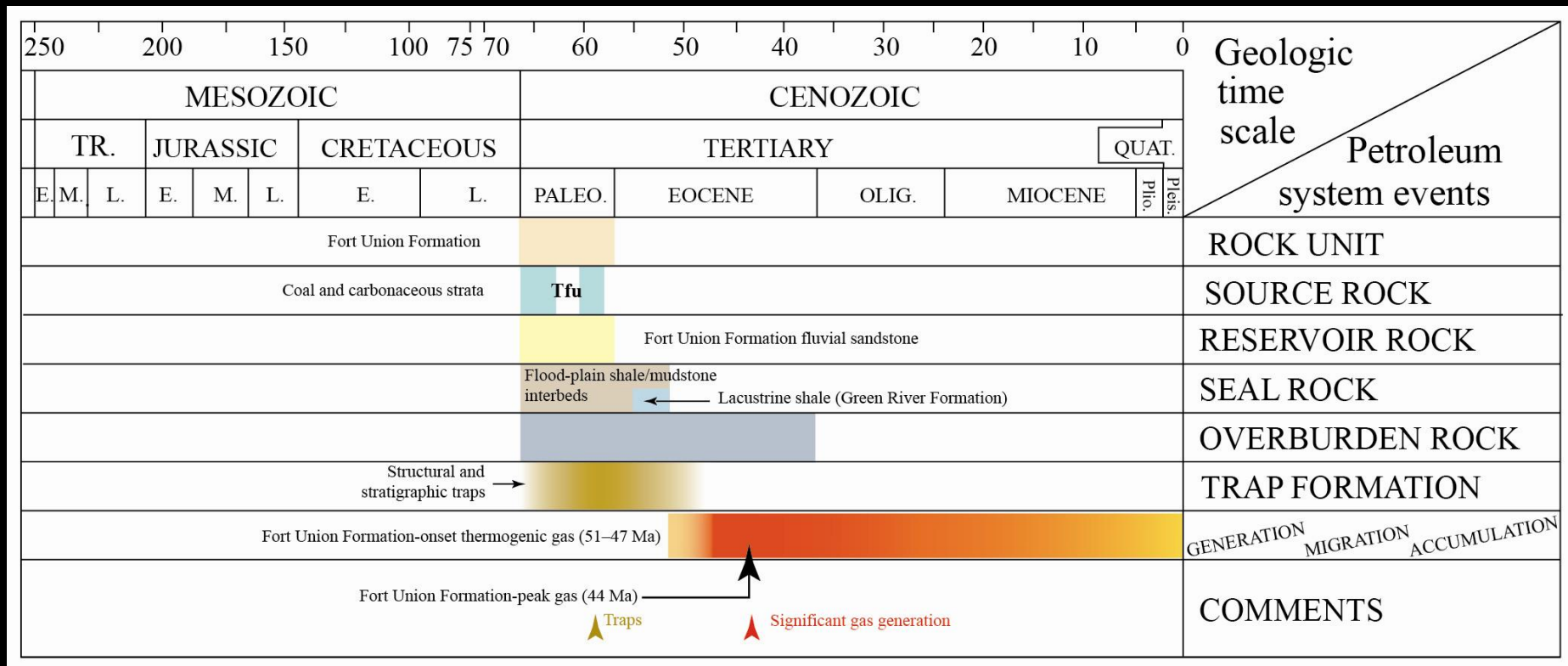
Early Maastrichtian

Late Maastrichtian

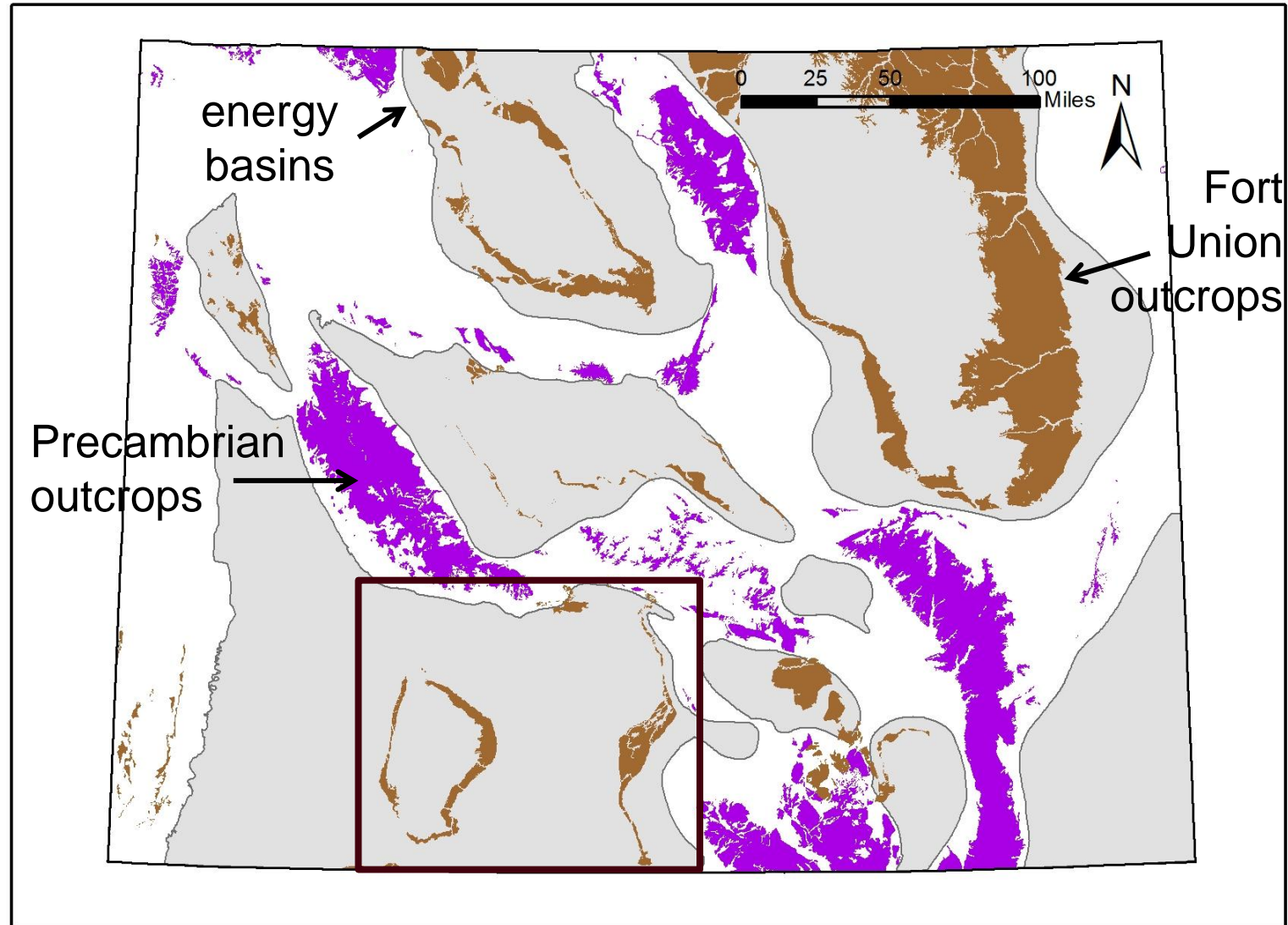
K-T Boundary

K - T Boundary -- 65 Ma
Latest Cret/earliest Paleocene
 © Colorado Plateau Geosystems

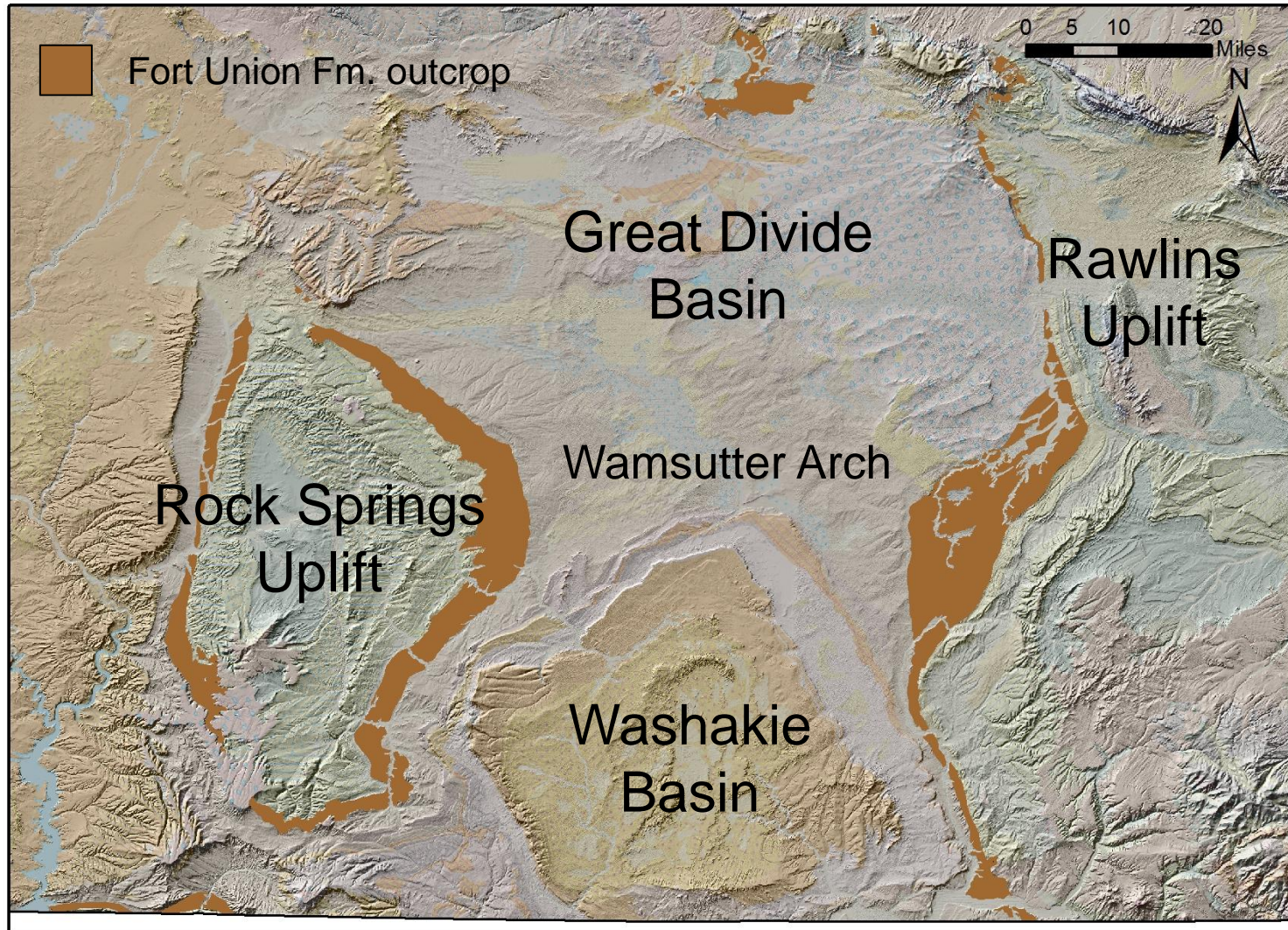
Background: Events Chart

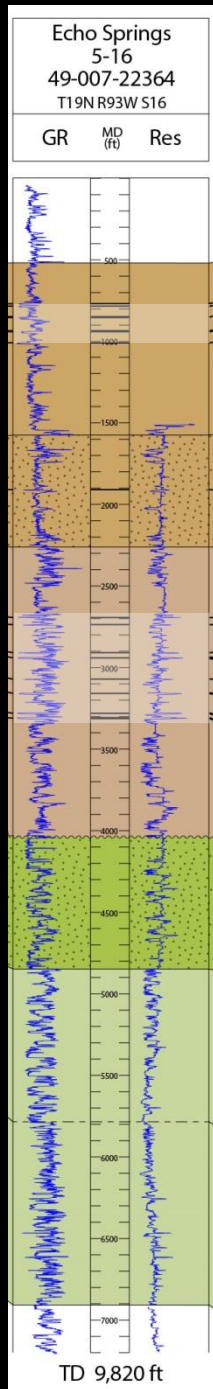


Background: Geologic Setting



Eastern Greater Green River Basin





← Cherokee
Coal Zone

← China Butte
Coal Zone

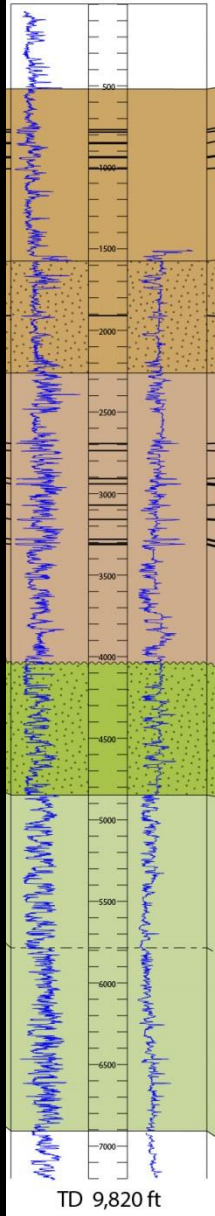
stratigraphy after Honey & Hettinger (2004)

Stratigraphy

	Member	Formation	Age (Series)
		Wasatch & Battle Spring Formations	Eocene
	Overland	Fort Union Formation	Paleocene
	basal sand		
	China Butte		
	Red Rim	Lance Formation	Upper Cretaceous
	upper zone		
	Lower		
	lower zone		
		Fox Hills Ss. & Lewis Sh.	

Echo Springs
5-16
49-007-22364
T19N R93W S16

GR	MD (ft)	Res
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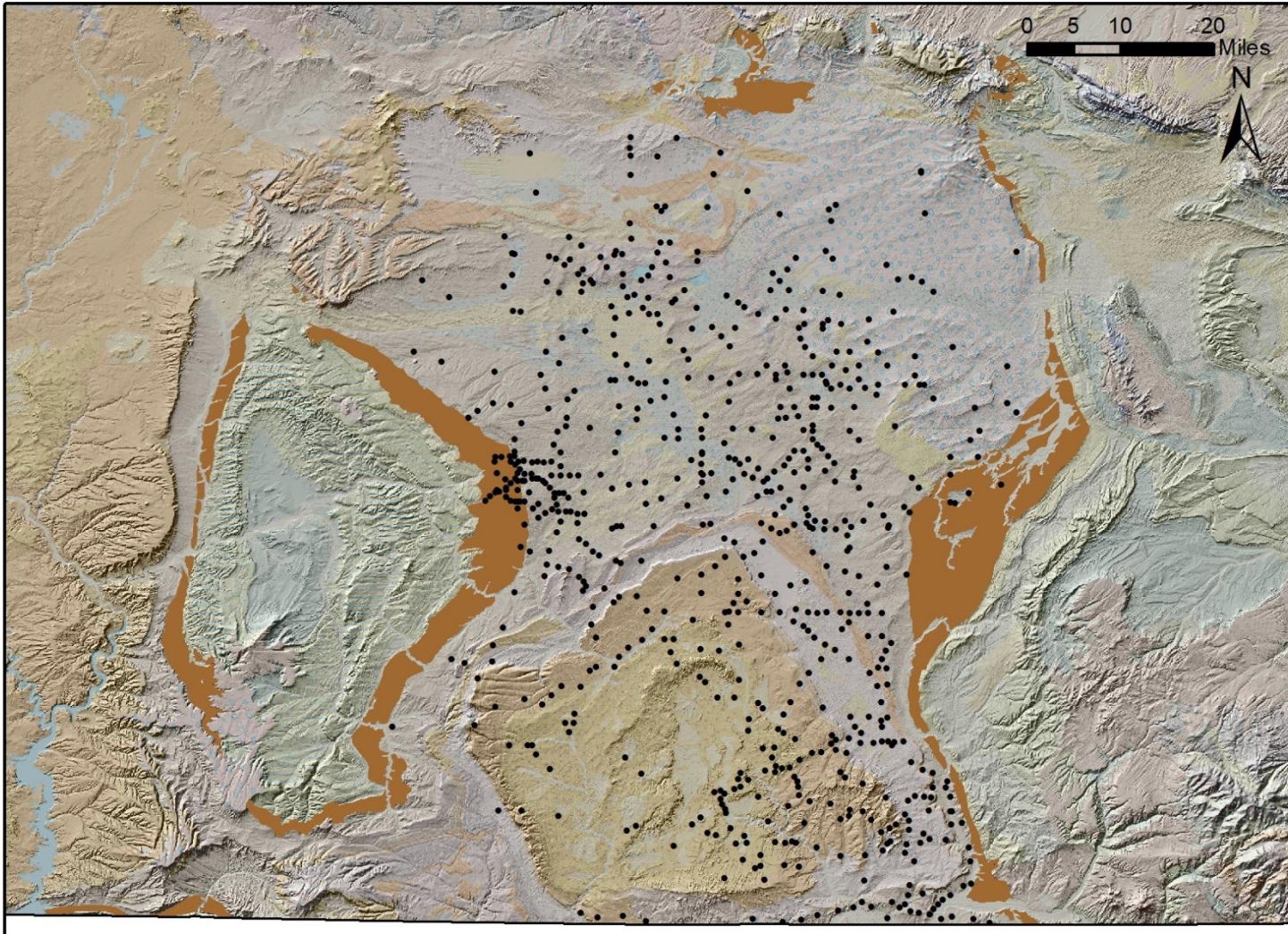
Stratigraphy



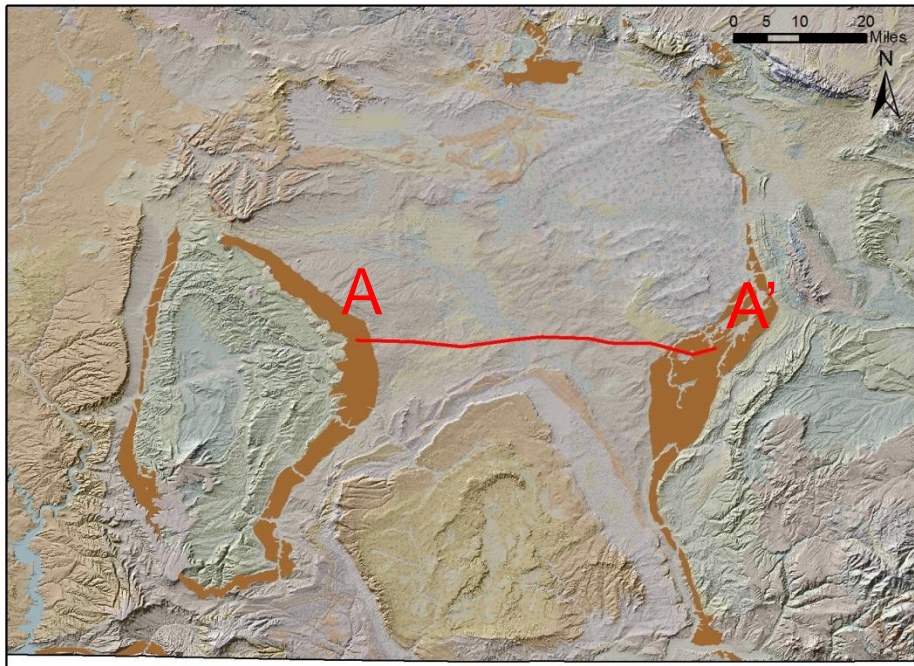
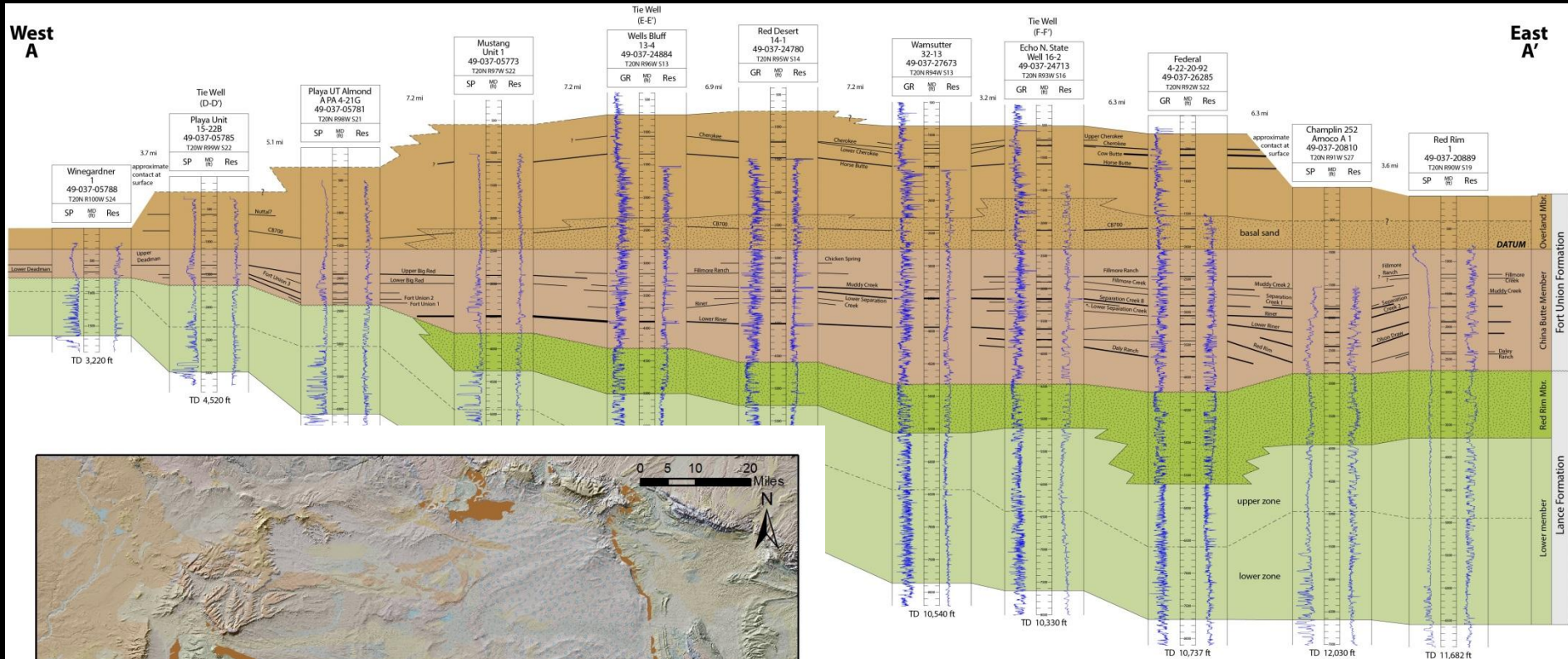
China Butte Member, Fort Union Formation

Procedure: Well Picks

710 wells with strat picks
~5,000 wells with coal picks



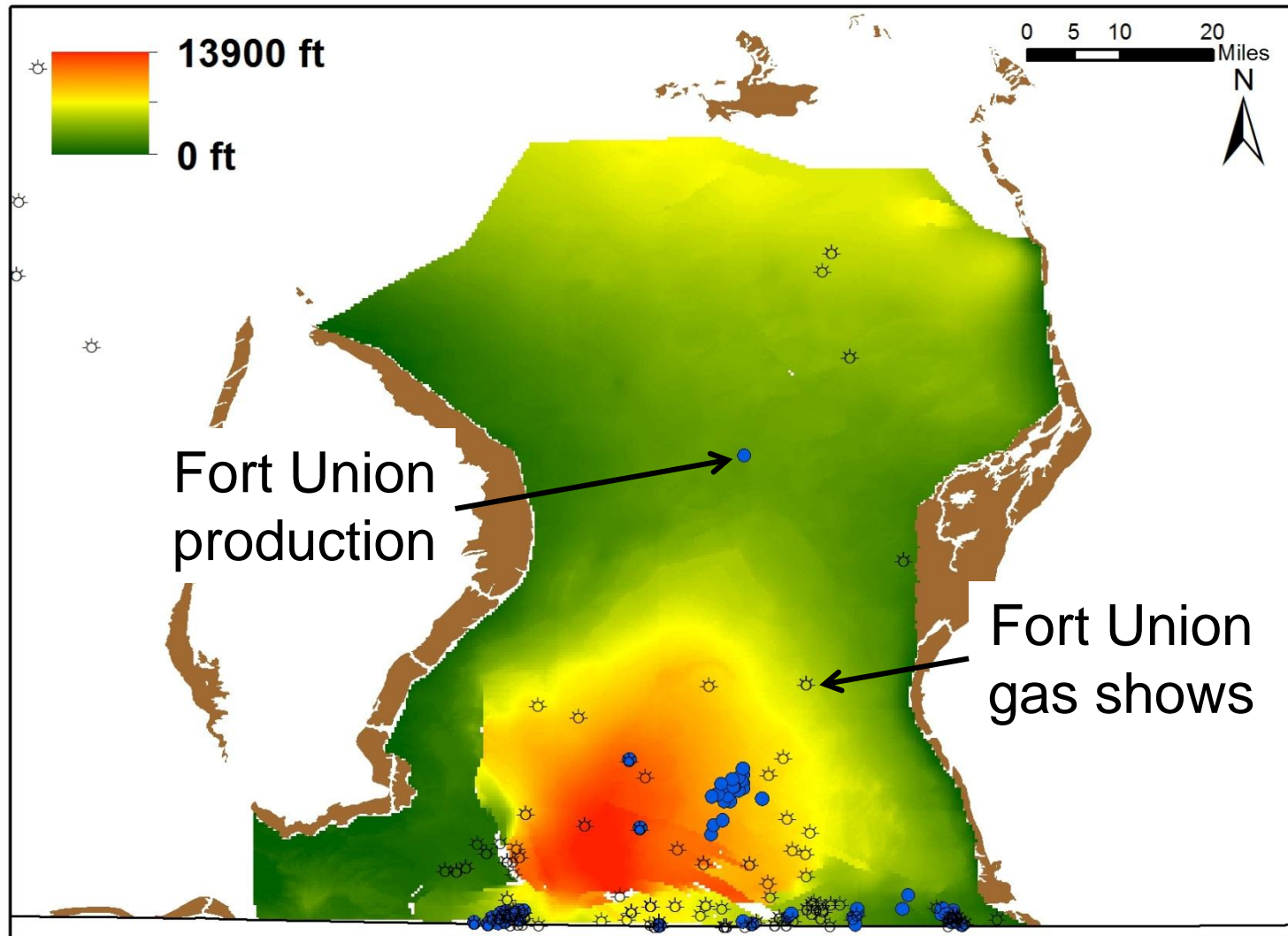
Procedure: Cross Sections



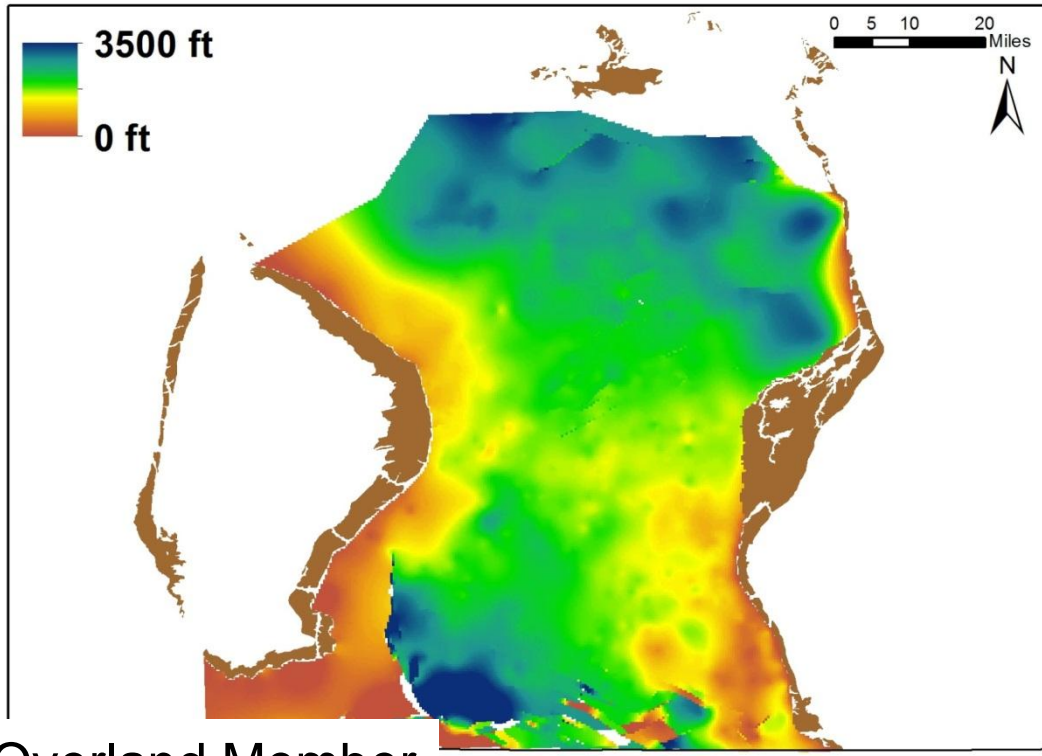
WSGS OFR 15-03
Great Divide Basin
due out soon...

Result: Structure Contour

Top of China Butte Mbr.
Depth below surface

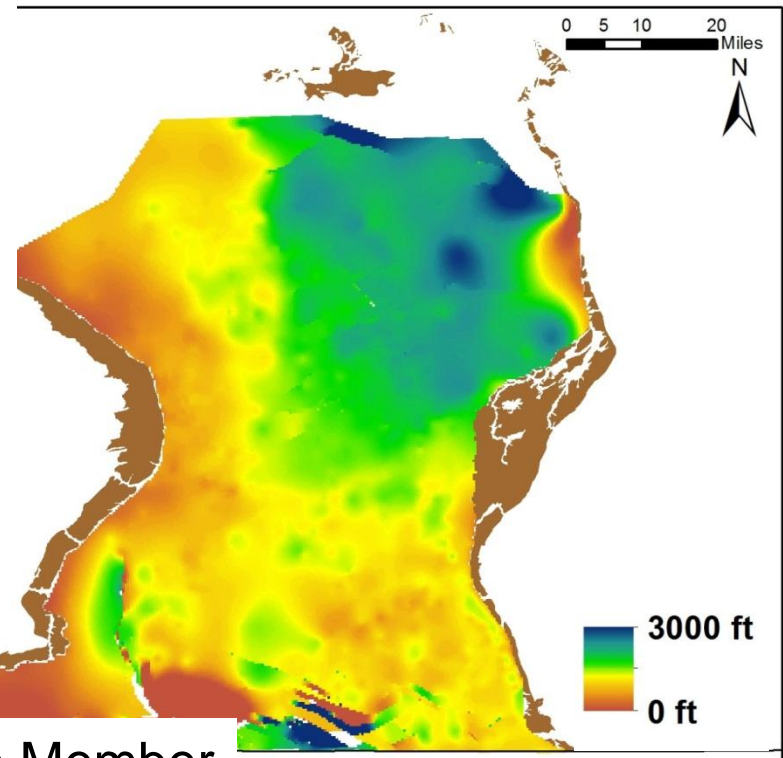


Result: Thickness Maps



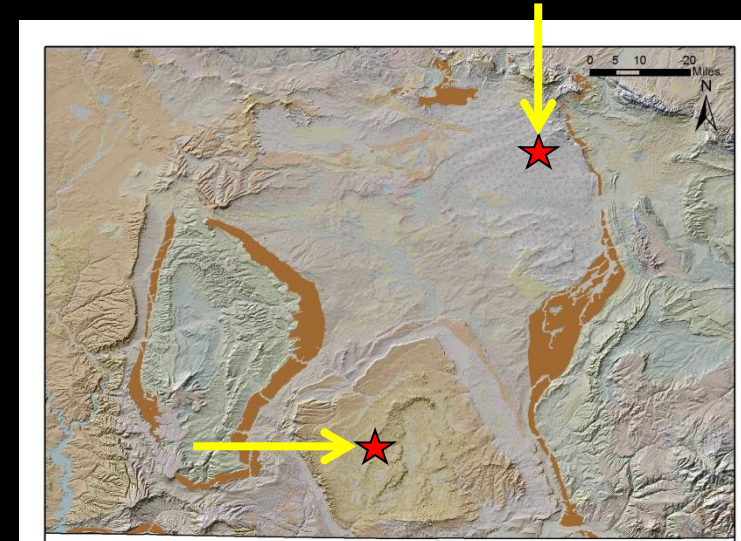
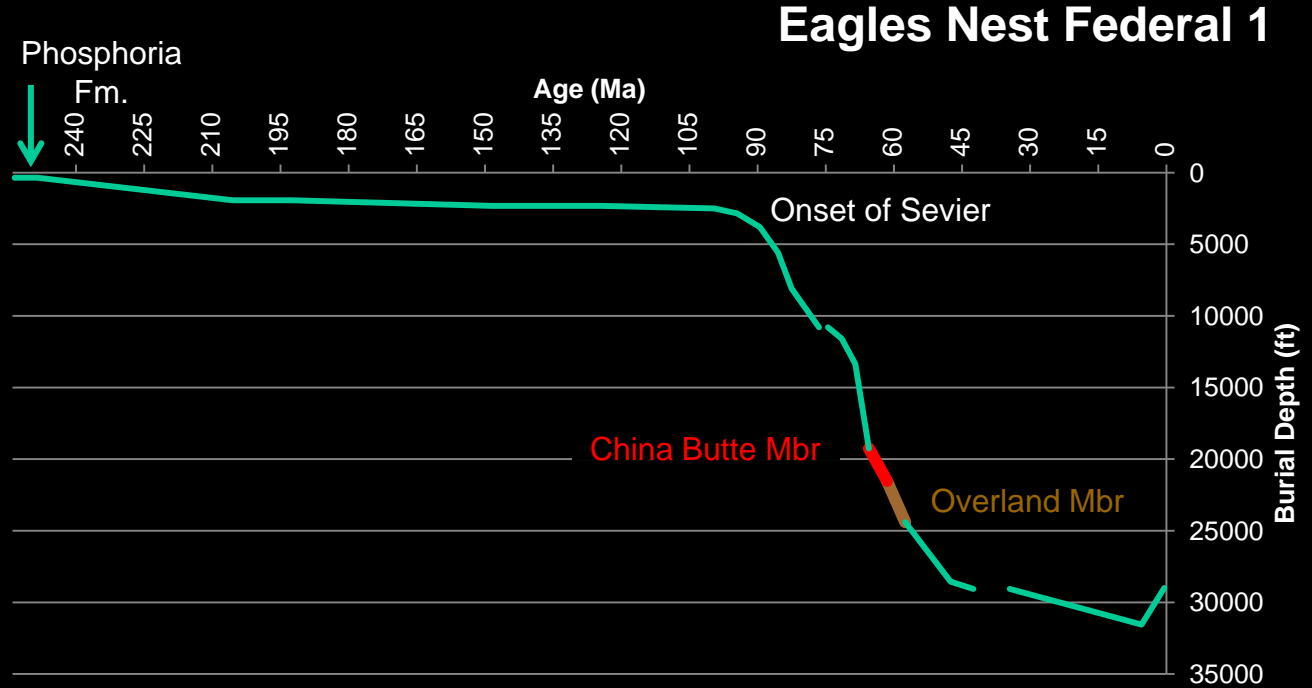
Overland Member

Member	Formation	Age (Series)
	Wasatch & Battle Spring Formations	Eocene
Overland	Fort Union Formation	Paleocene
China Butte		



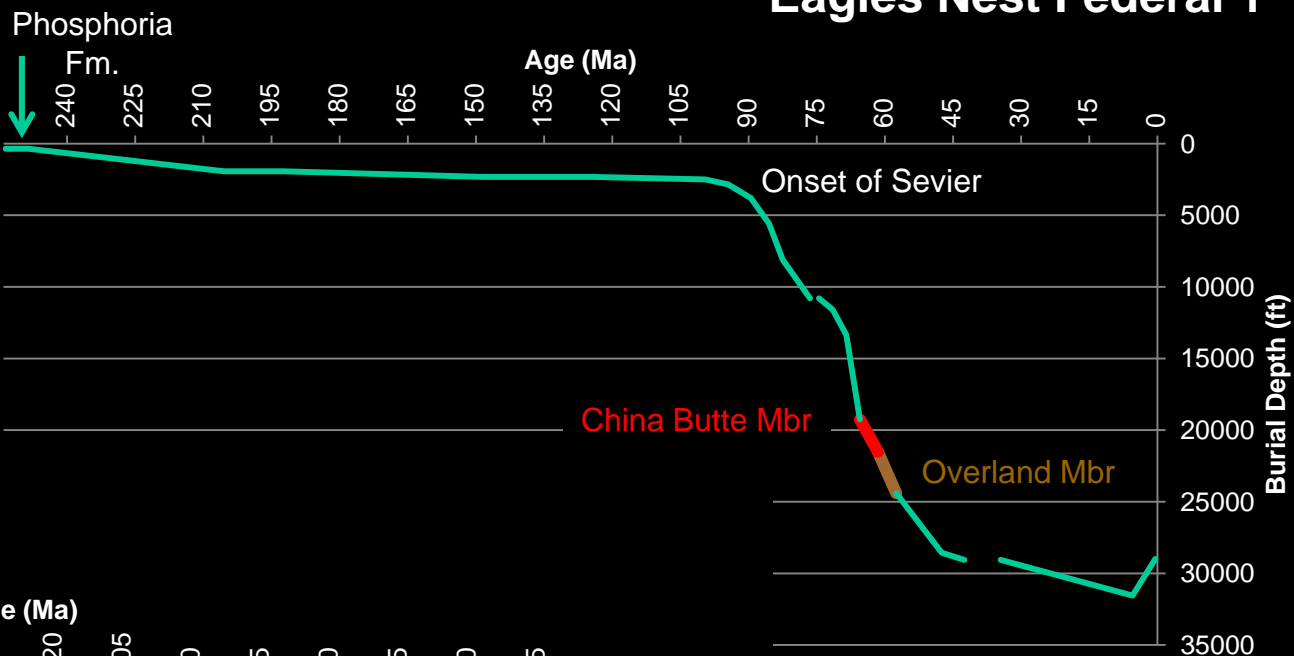
China Butte Member

Washakie Basin

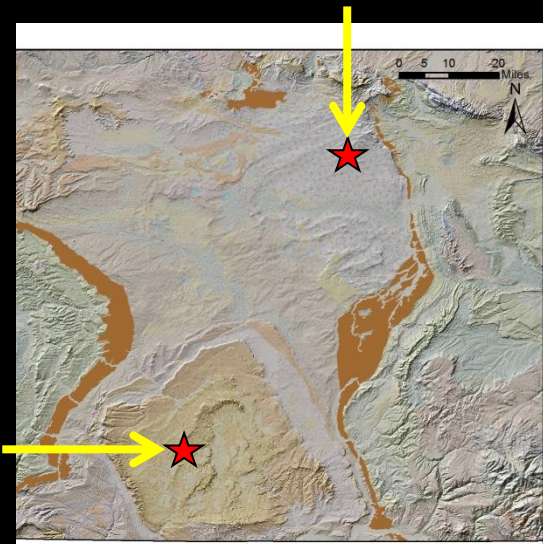
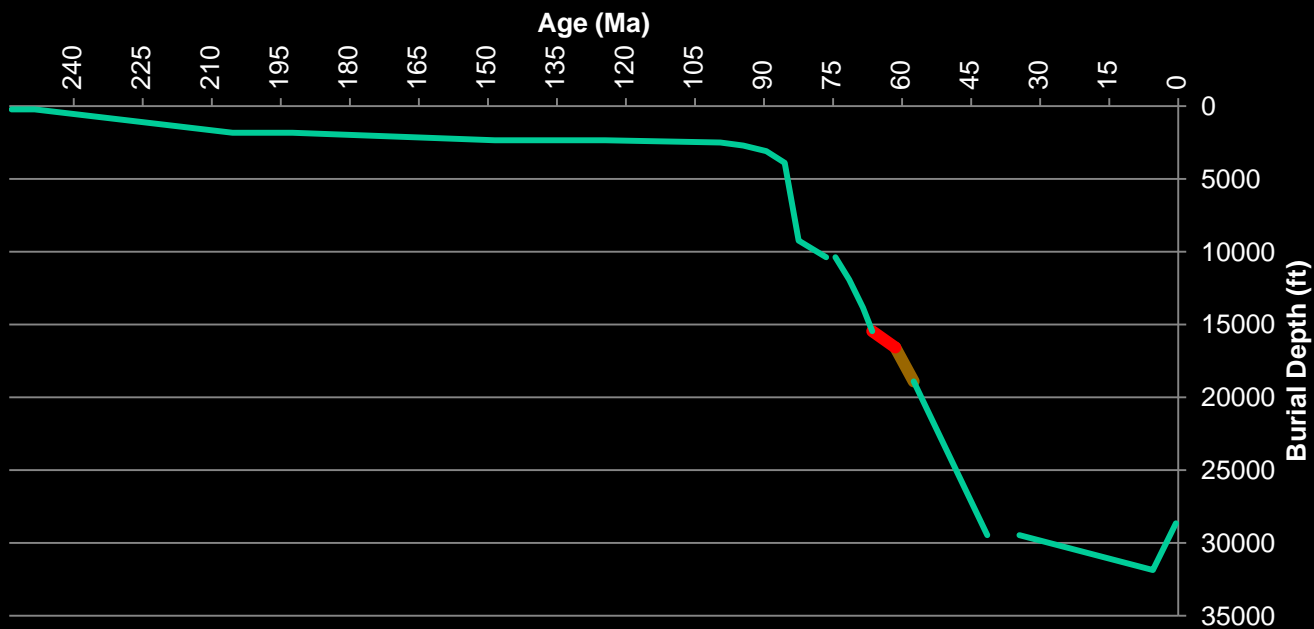


Washakie Basin

Eagles Nest Federal 1



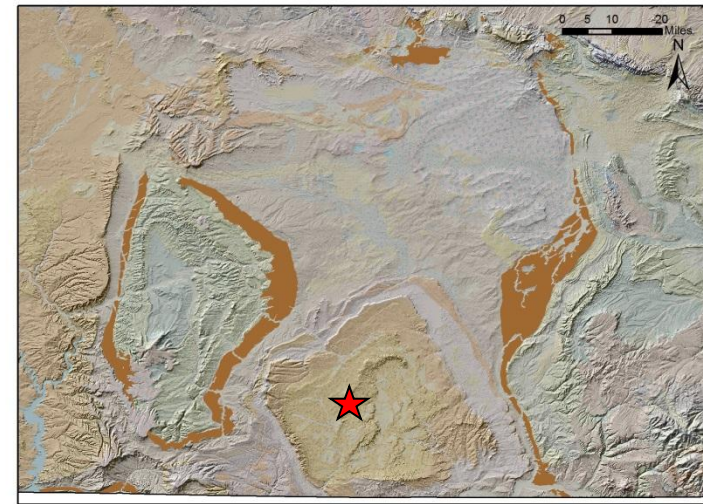
Adobe Town 1



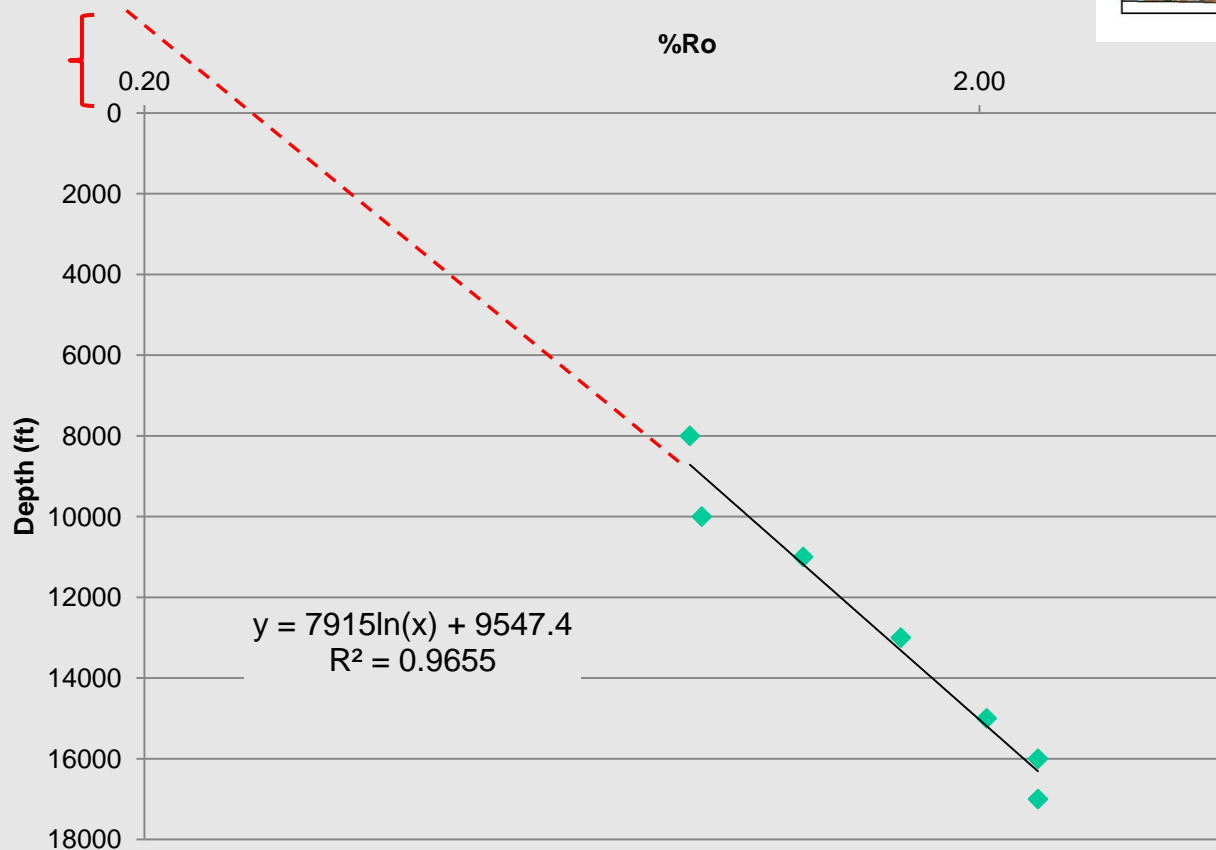
Midway Results (and more questions)

- Gas, and some condensate, is produced from the coal-rich zone in the lower Fort Union, the China Butte Member.
- The China Butte Member is significantly thicker in the Great Divide Basin than in the Washakie Basin.
- But the China Butte Member is much deeper in the Washakie Basin than the Great Divide Basin...
- We also know that the entire region experienced significant Neogene uplift and erosion. How much?
- If we can constrain the magnitude of Neogene erosion, then we can infer the maximum burial depth of the China Butte Member.

Methodology: %Ro extrapolation



ADOBE TOWN 1

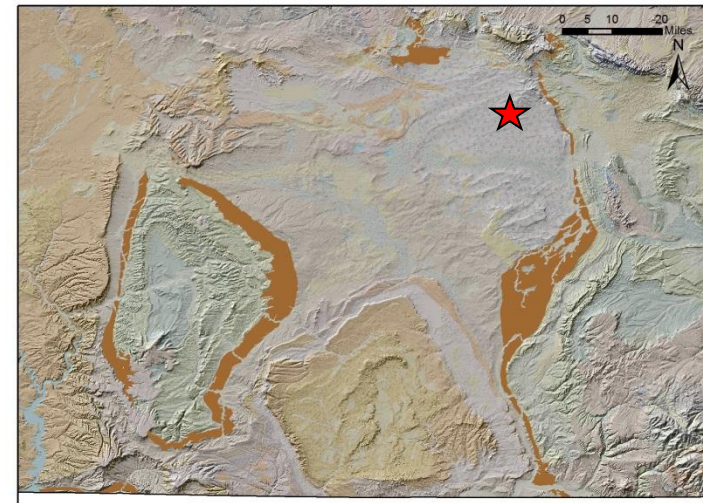


3213 ft of missing section

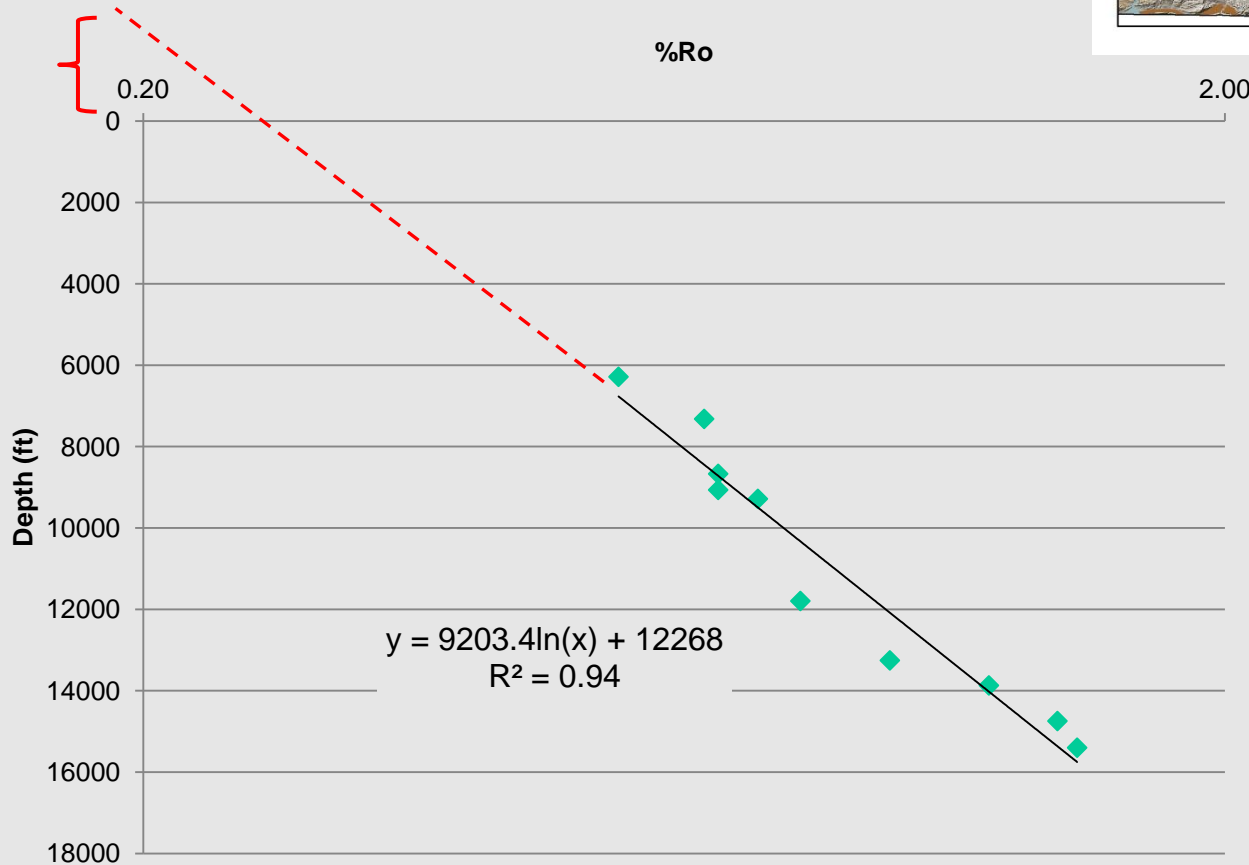
Roberts and others
(2005, USGS)
estimated 3200 ft

Peak gas generation
reached at 12,370 ft

Methodology: %Ro extrapolation



EAGLES NEST FEDERAL 1

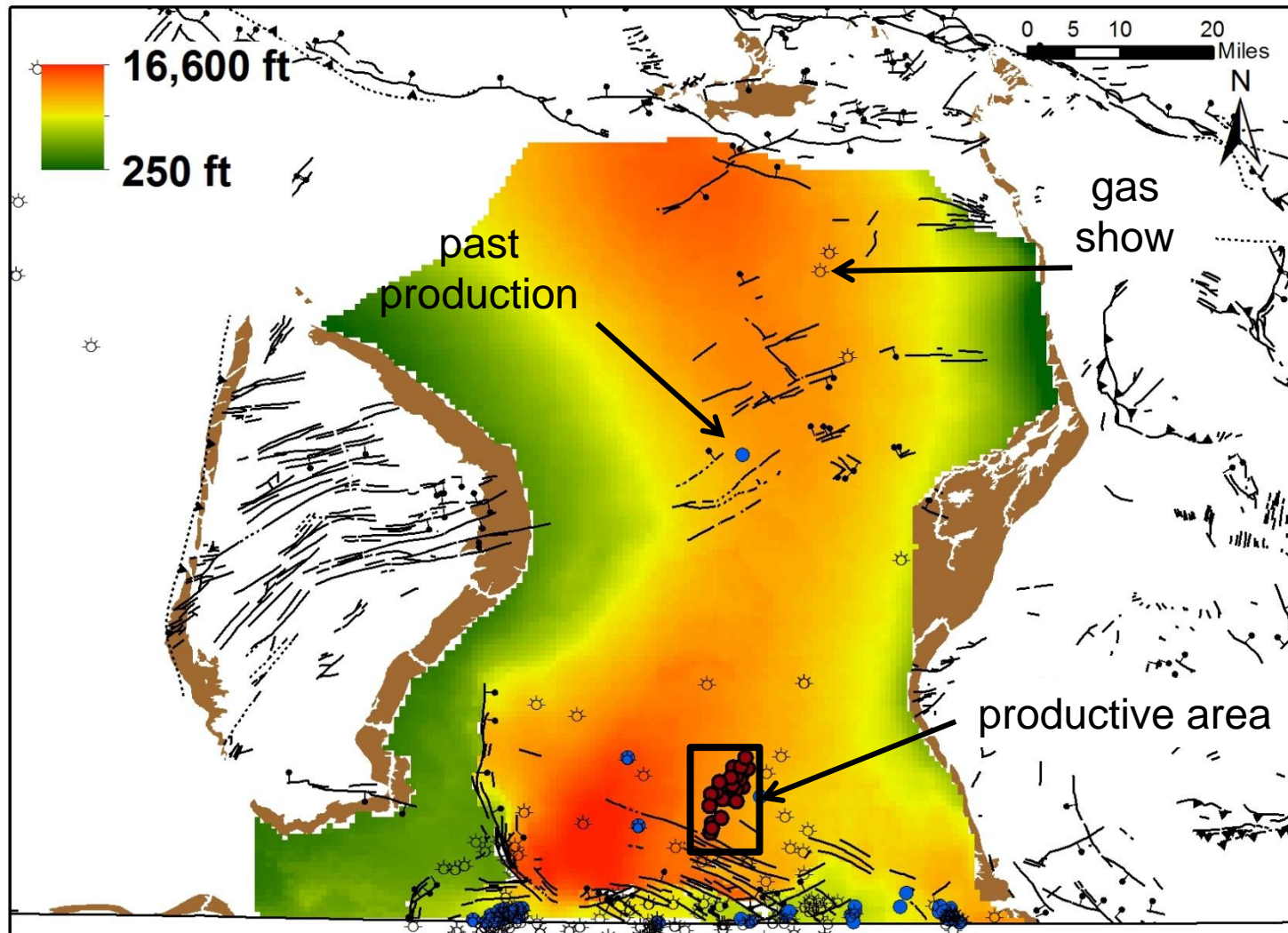


2656 ft of missing section

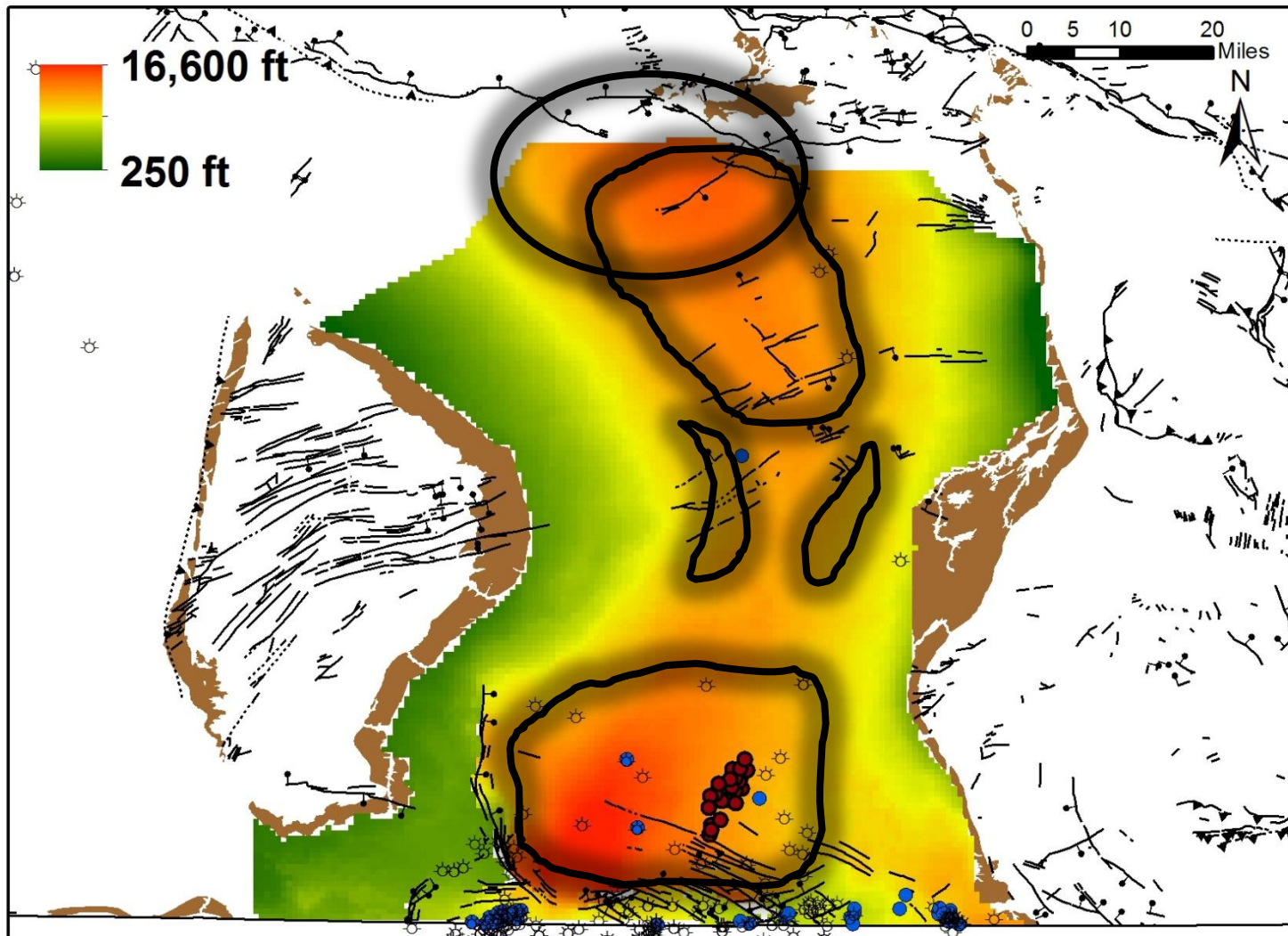
Roberts and others
(2005, USGS)
estimated 3000 ft

Fort Union Fm. never
reached peak gas
generation (0.8% Ro)

Result: Max Burial Depth (top China Butte)



Result: Areas of Interest



Conclusions

1. Fort Union stratigraphy defined by Honey and Hettinger (USGS) can be pulled through the entire Great Divide and Washakie basin region.
2. The Wamsutter arch was not high during China Butte deposition, but became a structural high during Overland deposition. The end of movement on the Wamsutter arch was late, post-Neogene uplift.
3. We expect additional Fort Union production on the flanks and possibly the center of the Washakie Basin, as well as near the center (but not depocenter) of the Great Divide Basin.
4. There is the possibility of a gas play on the west and east sides of the Wamsutter arch, since gas migration occurred before Neogene uplift and (at least the end of) Wamsutter arch folding.
5. The northern flank of the Great Divide Basin needs to be examined in much greater detail, including detailed structural mapping.

Thanks to:

- John Haacke, USGS
- John Hettinger & Mark Kirschbaum, USGS, retired
- Deirdre Ratigan, Elizabeth Cola, Jeffrey Hannon, Jim Rodgers, Suzanne Luhr, WSGS

