

# **Effect of Laramide Structures on the Regional Distribution of Tight-Gas Sandstone Reservoirs in the Upper Mesaverde Group, Uinta Basin, Utah\***

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## **Abstract**

New, basin-scale sequence stratigraphic correlation, syntectonic unconformity mapping and isopach maps indicate multi-phase uplift and development of the San Rafael Swell (SRS) that resulted in partitioning of the Uinta Basin during deposition of Upper Mesaverde Group (UMG). Such partitioning could have implications for tight-gas sand production in the Uinta Basin, Utah. Sequence-stratigraphic correlation of 100 well logs, 20 stratigraphic profiles and 10 outcrop-based gamma ray profiles define four, 3rd order (~3 My duration) depositional sequences within the dominantly fluvial Upper Cretaceous Mesaverde Group in the Uinta Basin. The correlation was constructed using a combination of fluvial facies and stacking patterns, chert-pebble conglomerates that mark periods of longer residence time, and tidally influenced strata that mark flooding surfaces. These surfaces were extrapolated into the subsurface by matching outcrop-based GR profiles with those in the subsurface.

Locally, Sequences 1 (oldest) and 4 (youngest) are entirely truncated across the SRS, whereas sequences 2 and 3 thin towards the SRS. The cycles of truncation and onlap within the sequences represent at least 4 phases of SRS uplift. Local thickening of syntectonic depositional sequences on the northeast side of the SRS, and thinning towards the west of Natural Buttes area suggests sediment ponding on the northeast side of the SRS during times of uplift on the structure. Isopach maps show another thinning trend west of the Natural Buttes area that continues further south to Book Cliffs, possibly caused by an incipient Laramide-style uplift. Paleocurrents are consistent with the interpretation of periodic segmentation and deflection of sedimentation. Regional paleocurrents are generally E-NE-directed in Sequences 1-2, and N-directed in Sequences 3-4. Locally, paleocurrents are highly variable near the

SRS, further suggesting the UMG basin-fill was partitioned by the uplift of the SRS. In conclusion, we suggest that the Uinta Basin was episodically partitioned into several local depo-zones during the deposition of UMG due to the multi-phase uplift of Laramide-style structures in the basin. Understanding the affect of the SRS uplift on the development of depositional sequences and basin-scale facies distribution will aid prediction of the best-producing gas reservoirs.

### **References**

Armstrong, R.L., 1968, Sevier orogenic belt in Nevada and Utah: GSA Bulletin, v. 79/4, p. 429-458.

Bump, A.P., and G.H. Davis, 2003, Late Cretaceous-early Tertiary Laramide deformation of the northern Colorado Plateau, Utah and Colorado: Journal of Structural Geology, v. 25/3, p. 421-440.

DeCelles, P.G., 2004, Late Jurassic to Eocene evolution of the Cordilleran thrust belt and foreland basin system, western U.S.A.: American Journal of Science, v. 304/2, p. 105-168.

Fouch, T.D., T.F. Lawton, D.J. Nichols, W.B. Cashion, and W.A. Cobban, 1983, Patterns and timing of synorogenic sedimentation in Upper Cretaceous rocks of central and Northeast Utah, *in* M.W. Reynolds, and E.D. Dolly, (eds.), Mesozoic paleogeography of the West-Central United States: Rocky Mountain Paleogeography Symposium, v. 2, p. 305-336.

# **EFFECTS OF THE LARAMIDE-STYLE STRUCTURES ON THE REGIONAL DISTRIBUTION OF TIGHT-GAS SANDSTONE RESERVOIRS IN THE UPPER MESAVERDE GROUP, UINTA BASIN, UTAH**

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**AAPG Annual Convention 2012, Long Beach, CA  
25<sup>th</sup> April 2012**

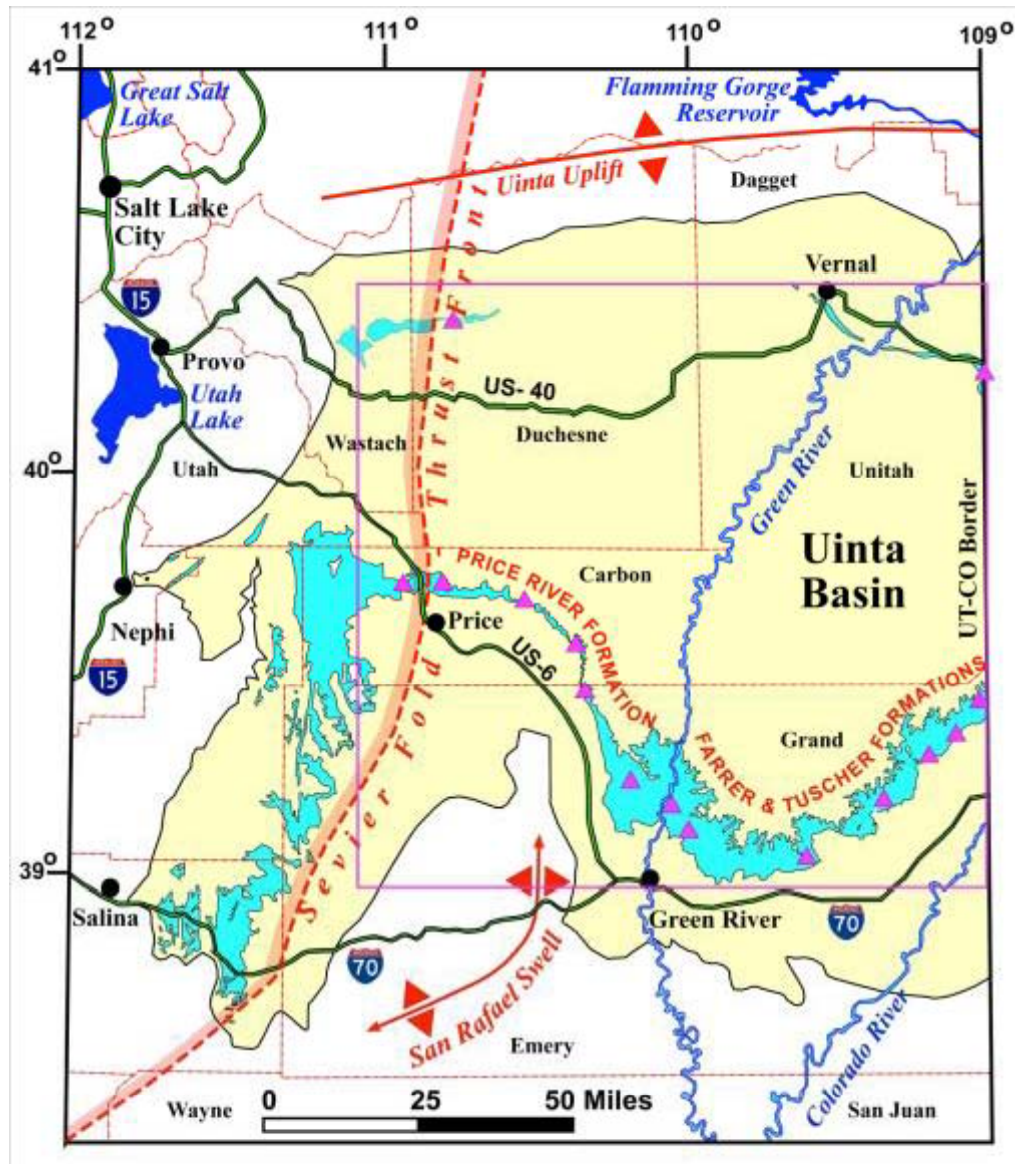
# Problems

- Understanding the effects of the Laramide-style structures on the sedimentation patterns of the punctuated foreland basin system.
- Sequence stratigraphic correlation between the Price River Formation in the west, and the Farrer Formation and Tuscher Formation in the eastern part of Uinta basin.
- Poor understanding of subsurface distribution of litho-facies and correlation between subsurface strata and outcrop exposures.
- Understanding of the kinematics of the Laramide-style structures and their effects on the sedimentation patterns of the upper Mesaverde interval.
- Interpretation of the sedimentary environment for the deposition of the Farrer and Tuscher formation in the eastern, and the Price River Formation in the western part of the basin.

# Hypothesis

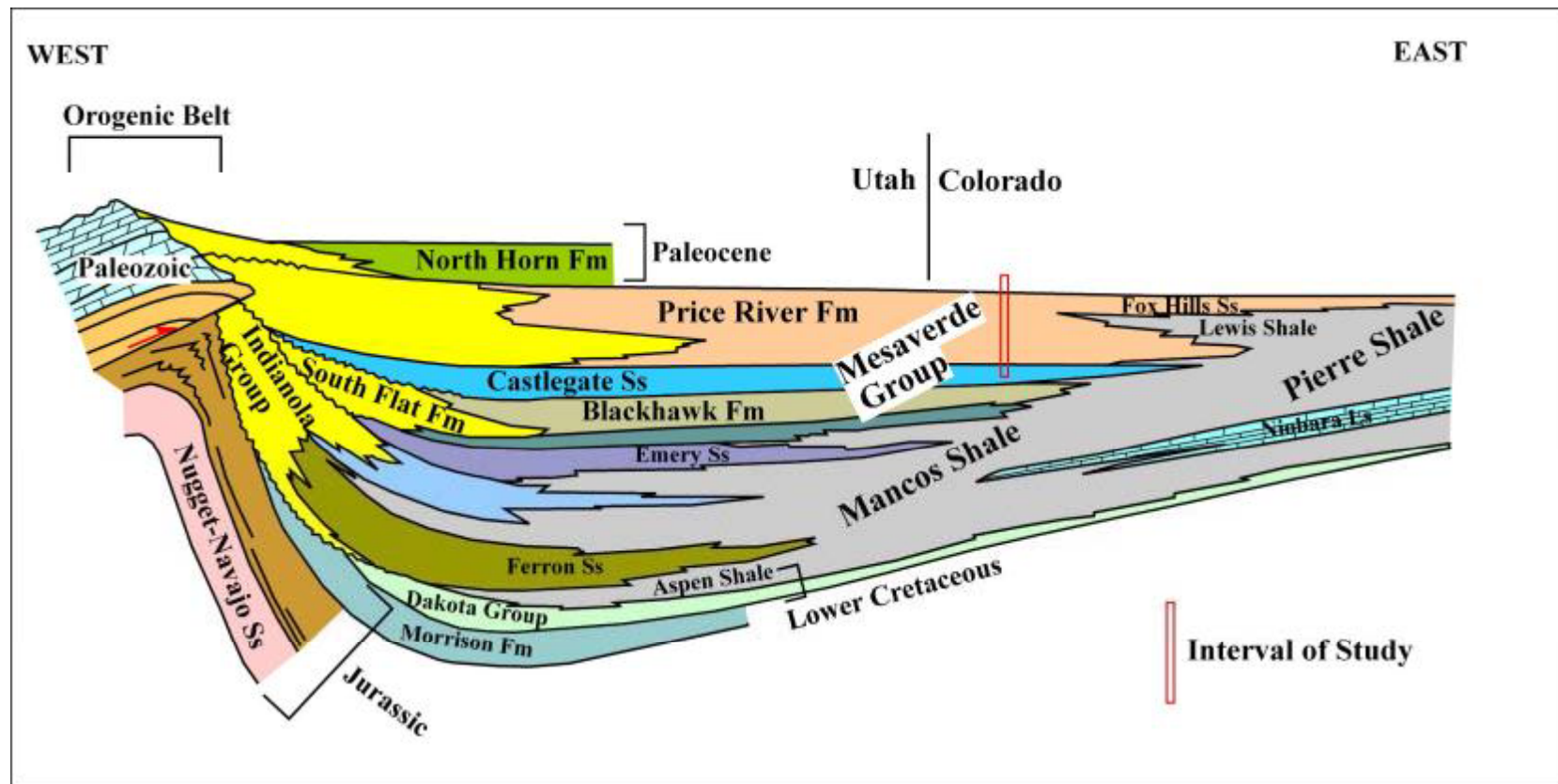
- Uplift of the Laramide-style structures systematically control the distribution of the accommodation and facies in the foreland basin system.
- Growth of the Laramide-style structures completely partitioned the Uinta basin that caused different depositional environment during the deposition of the upper Cretaceous Price River Formation in the west, and the Farrer Formation and Tuscher Formation in the east.

# Geological Background



(modified from Bump and Davis, 2003 and DeCelles, 2004)

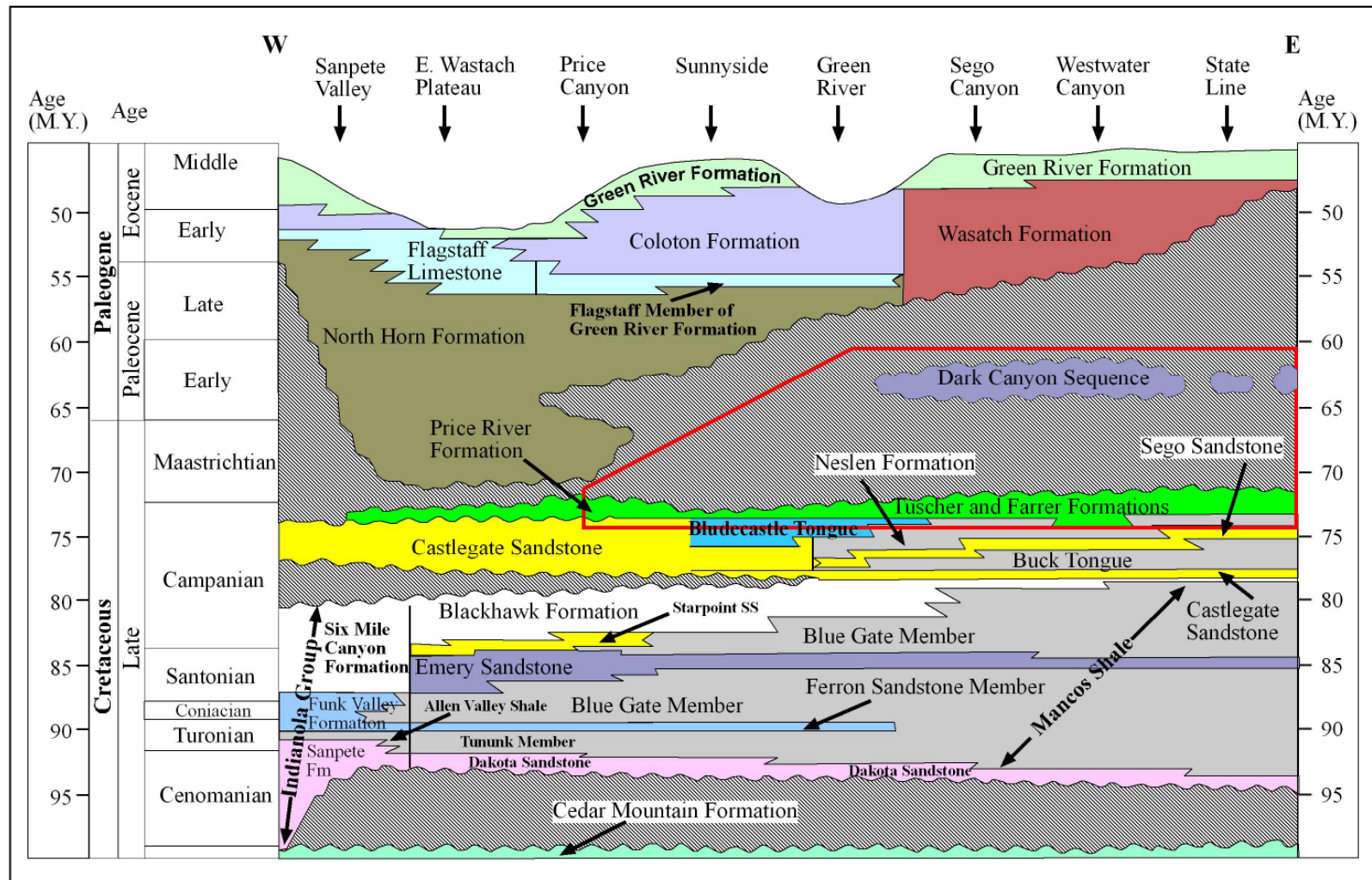
# Geological Background



(modified from Armstrong, 1968)



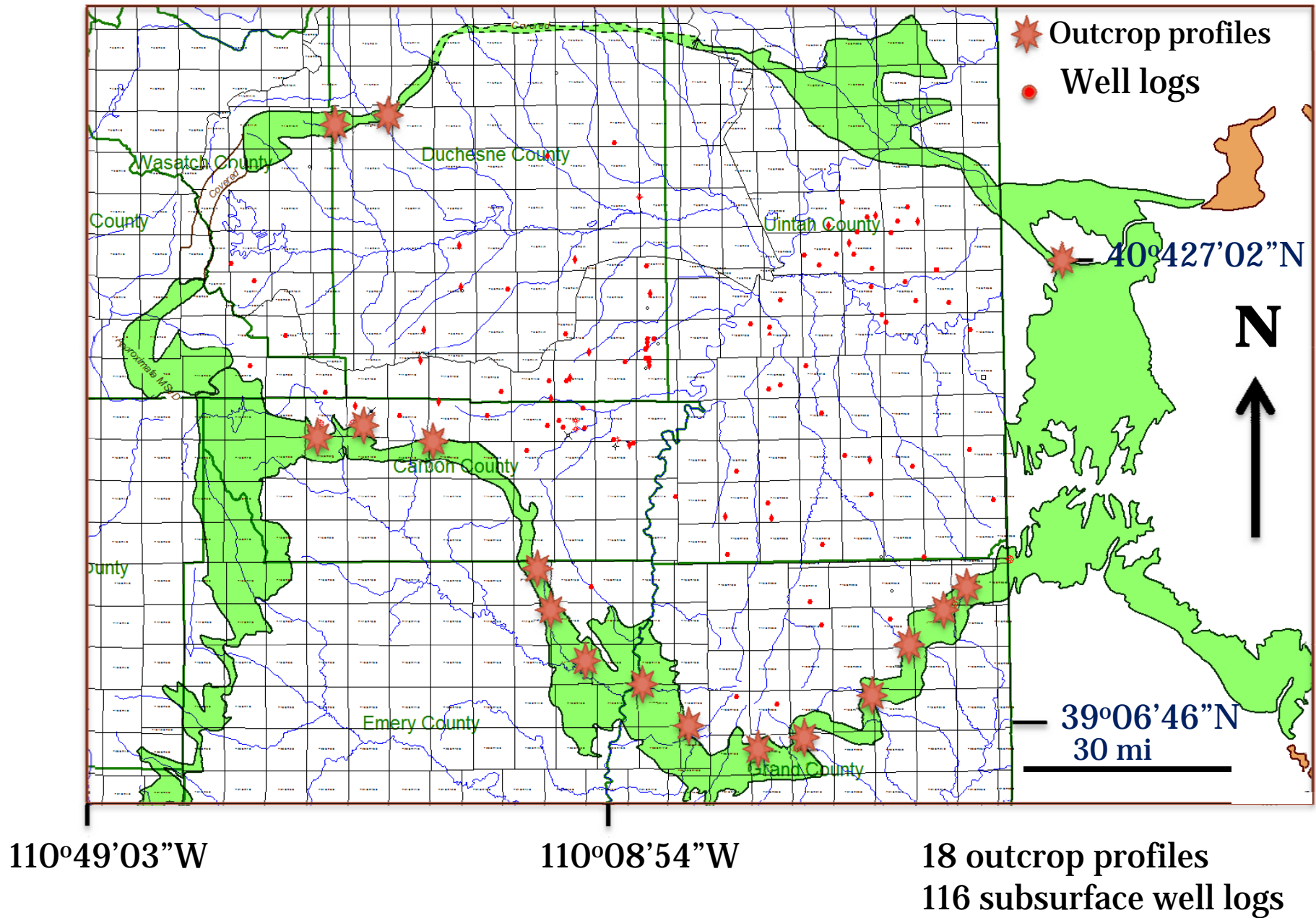
# Geological Background



(modified from Fouch et al., 1983)



# Data Set



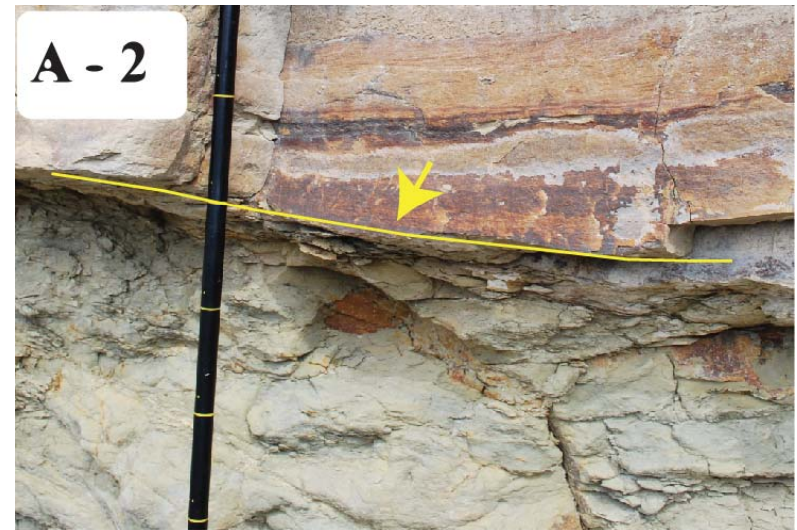
# Facies/Facies Assemblage

## Lithofacies Assemblage A (Mudstone Facies)

### Five Mudstone Facies



Facies A-1: Carbonaceous Mudstone (oxbow lake abandoned channel-fill)



Facies A-2: Pale-green Mudstone (floodplain deposit)

# **Facies/Facies Assemblage**

## **Lithofacies Assemblage B (Heterolithic Facies)**

### **Three Heterolithic Facies**



**Facies B-2: Mud-draped Cross-bedded Sandstone (meandering fluvial channel)**



**Facies B-3: Biderctional Ripple-laminated Sandstone (Tidally influenced fluvial channel)**



# Facies/Facies Assemblage

## Lithofacies Assemblage C (Sandstone Facies)

### Nine Sandstone Facies



Facies C-1: Very thin-bedded sandstone (floodplain uppermost point bar)



Facies C-4: Semi-continuous point bar sandstone meandering fluvial (mid-point bar)



Facies C-5: Meandering fluvial channel sandstone (meandering fluvial lower point bar-thalweg)



Facies C-8: Crevasse splay sandstone (crevasse play associated with anastomosed channel)



Facies C-9: Laterally semi-continuous channel sandstone (anastomosed fluvial channel)

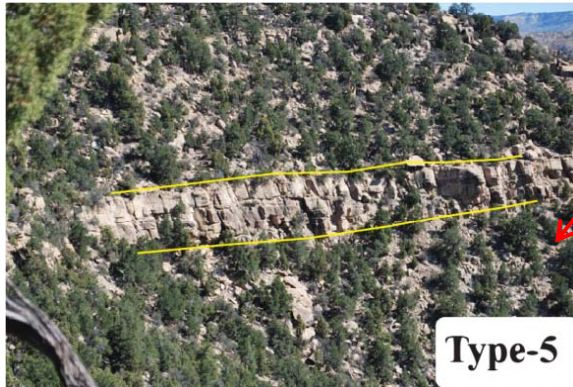


Facies C-11: Gravel- to pebble-sized conglomerate (braided fluvial channel and bar)

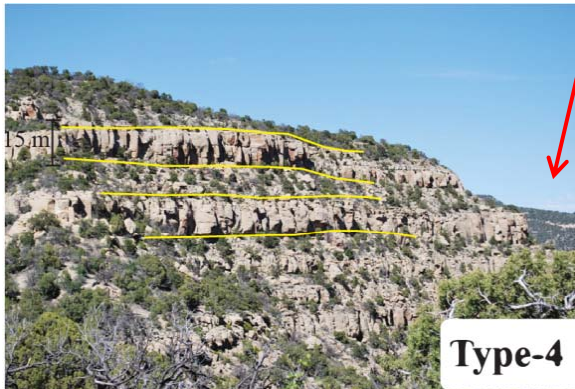


# Sandstone-Body Types

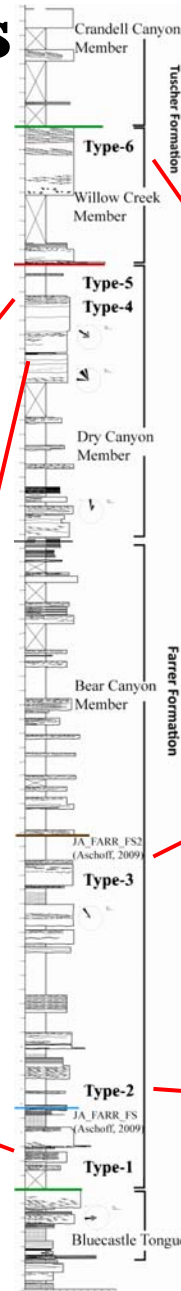
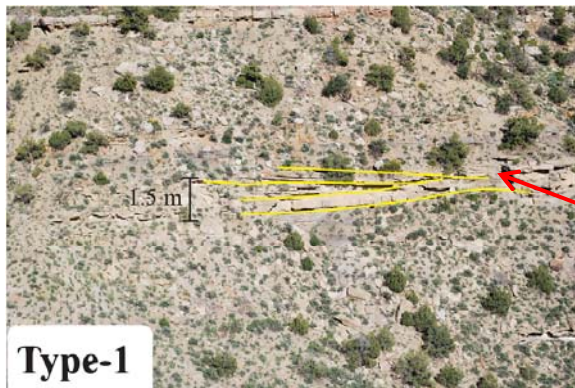
**Braided**



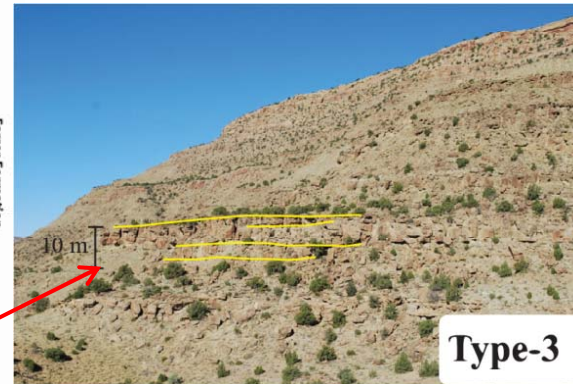
**Multilateral Meandering**



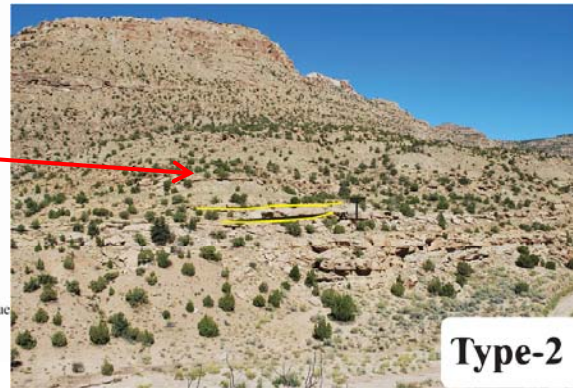
**Single-storied Meandering**



**Anastomosed**



**Multistoried Meandering**



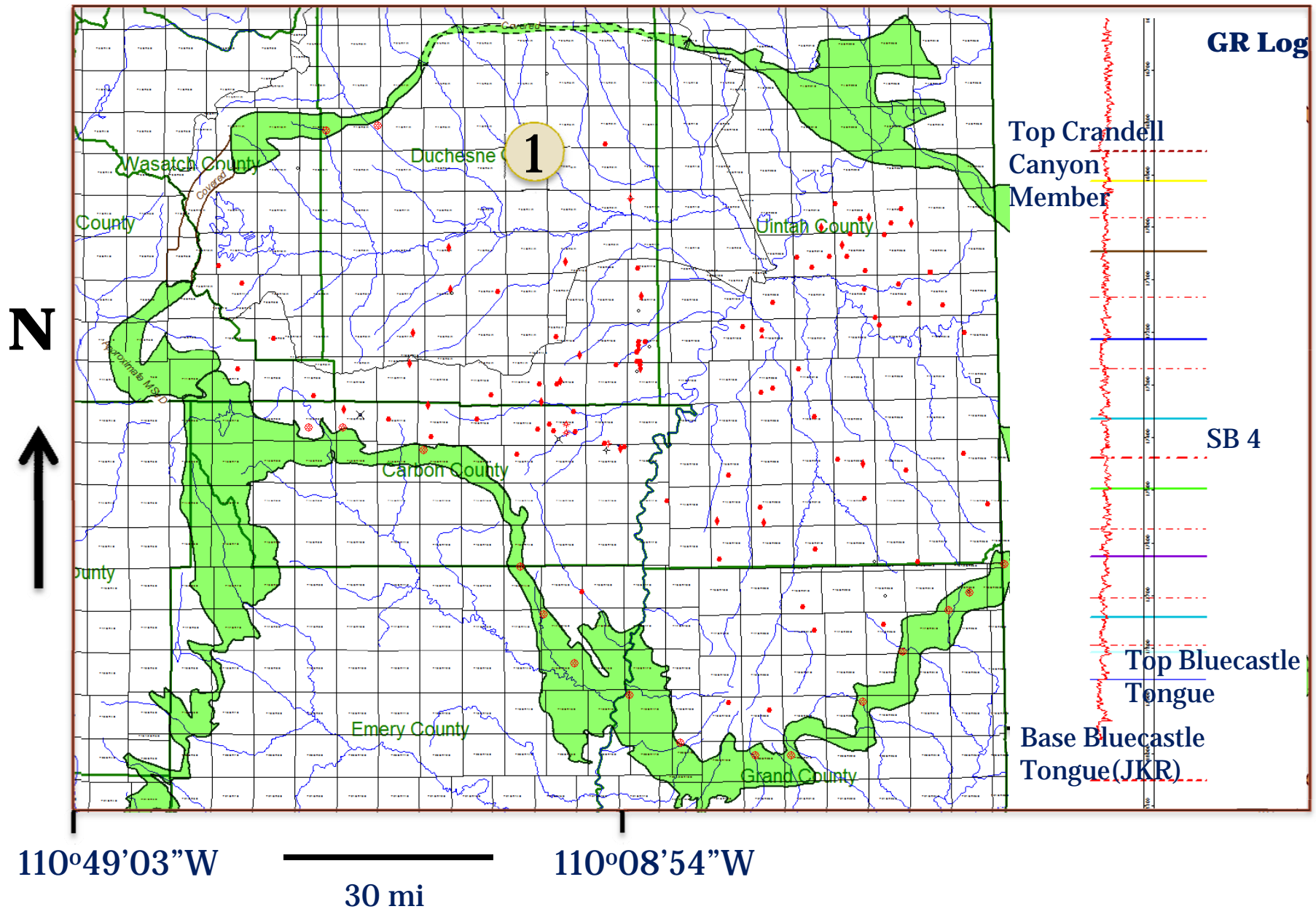
**Tidally-influenced Meandering**

Tuscher Canyon (Book Cliffs)

# Sequence stratigraphic surfaces of the upper Mesaverde Group

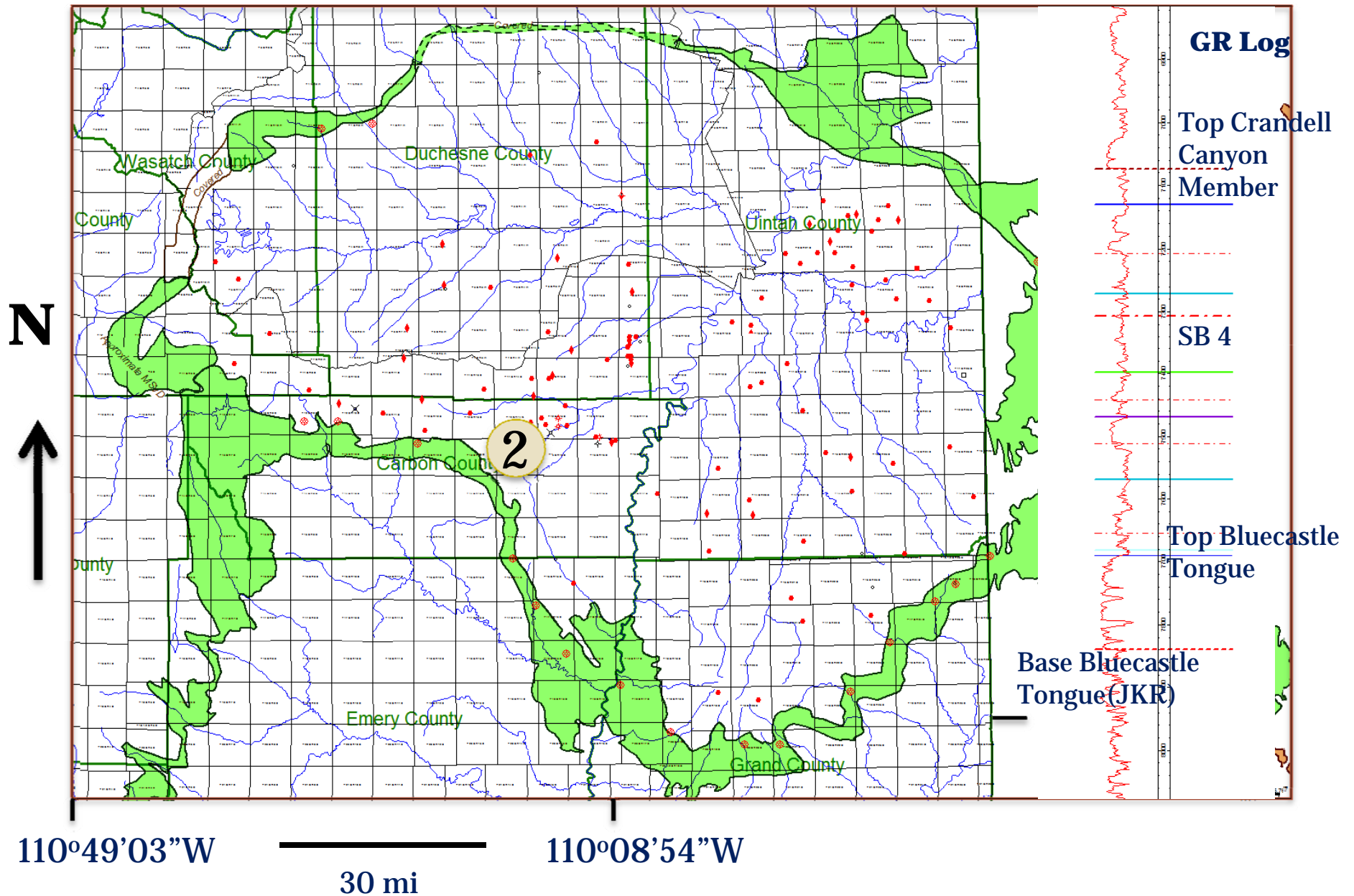
Age	Rock Unit	Surface	
Campanian (Upper Cretaceous)	Tuscher Formation	Top Crandell Canyon	← 3 <sup>rd</sup> Order Sequence Boundary
		FS11	
		SB10	
		FS10	
		SB9	← 4 <sup>th</sup> Order Sequence Boundary
		FS9	
		SB8	
		FS8	
		SB7	
		FS7	
	Farrer Formation	SB6	
		FS6	
		SB5	
		FS5	
		SB4	
		FS4	
		SB3	
		FS3	
		SB2	
		FS2	
		SB1	
		FS1	
		Top Bluecastle	
		Base Bluecastle	
			Total no of 3 <sup>rd</sup> order sequence = 2
			Total no of 4 <sup>th</sup> order sequence = 11
			FS = Flooding Surface
			SB= Sequence Boundary

# Subsurface facies/log patterns

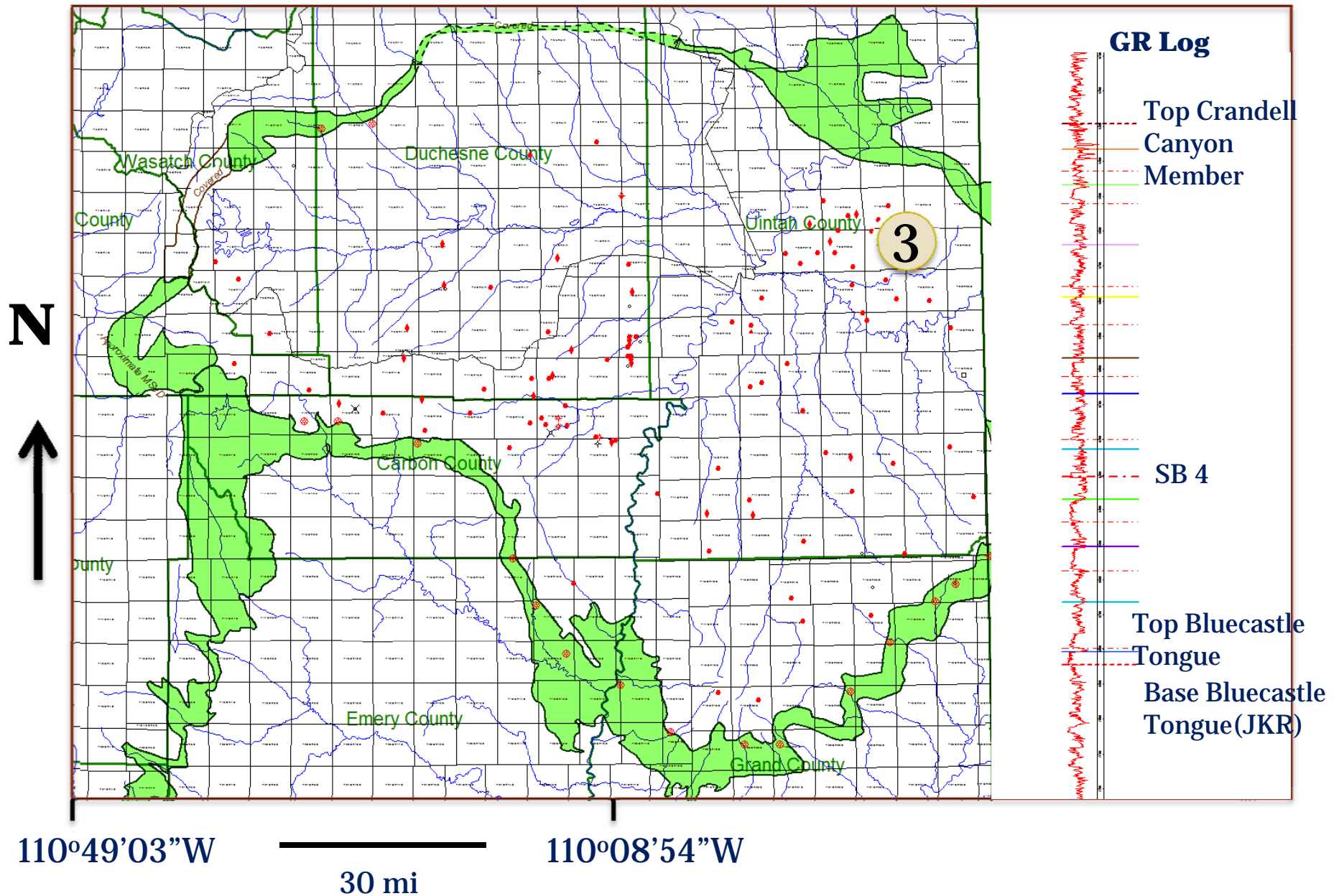




# Subsurface facies/log patterns



# Subsurface facies/log patterns



# Unique Subsurface Facies - Coarsening Upward Packages

GR Log  
Top of Crandell Canyon Member

CU1

CU2

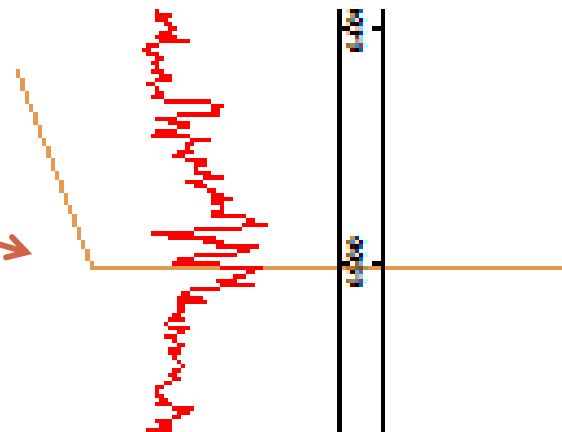
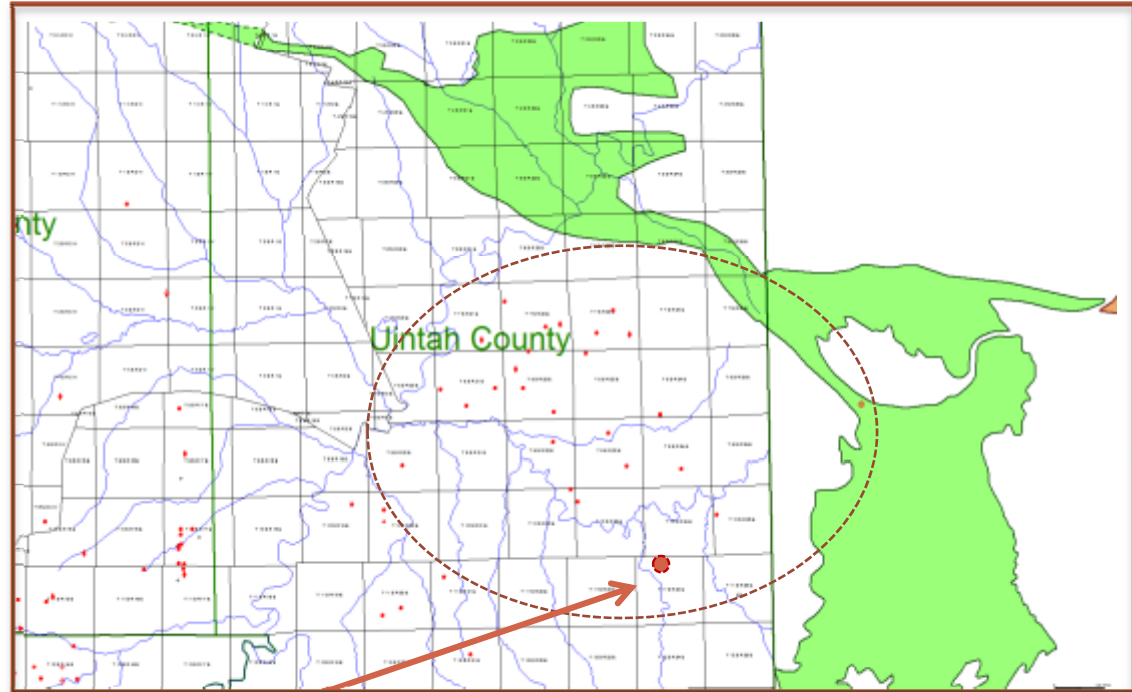
CU3

CU4

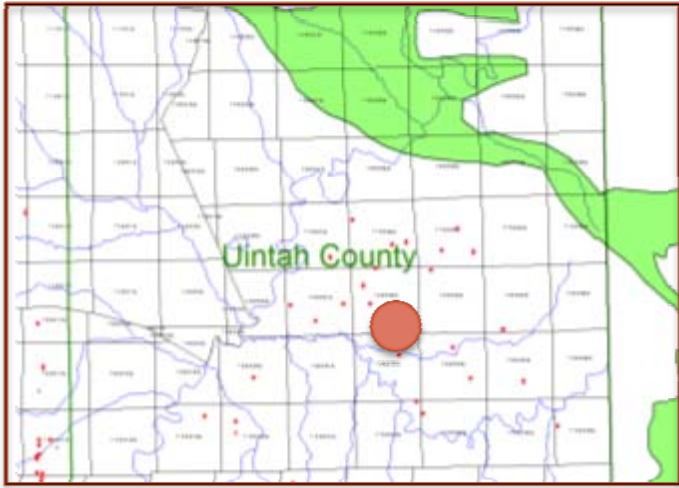
CU5

Top of Bluecastle Tongue

Base of Bluecastle Tongue



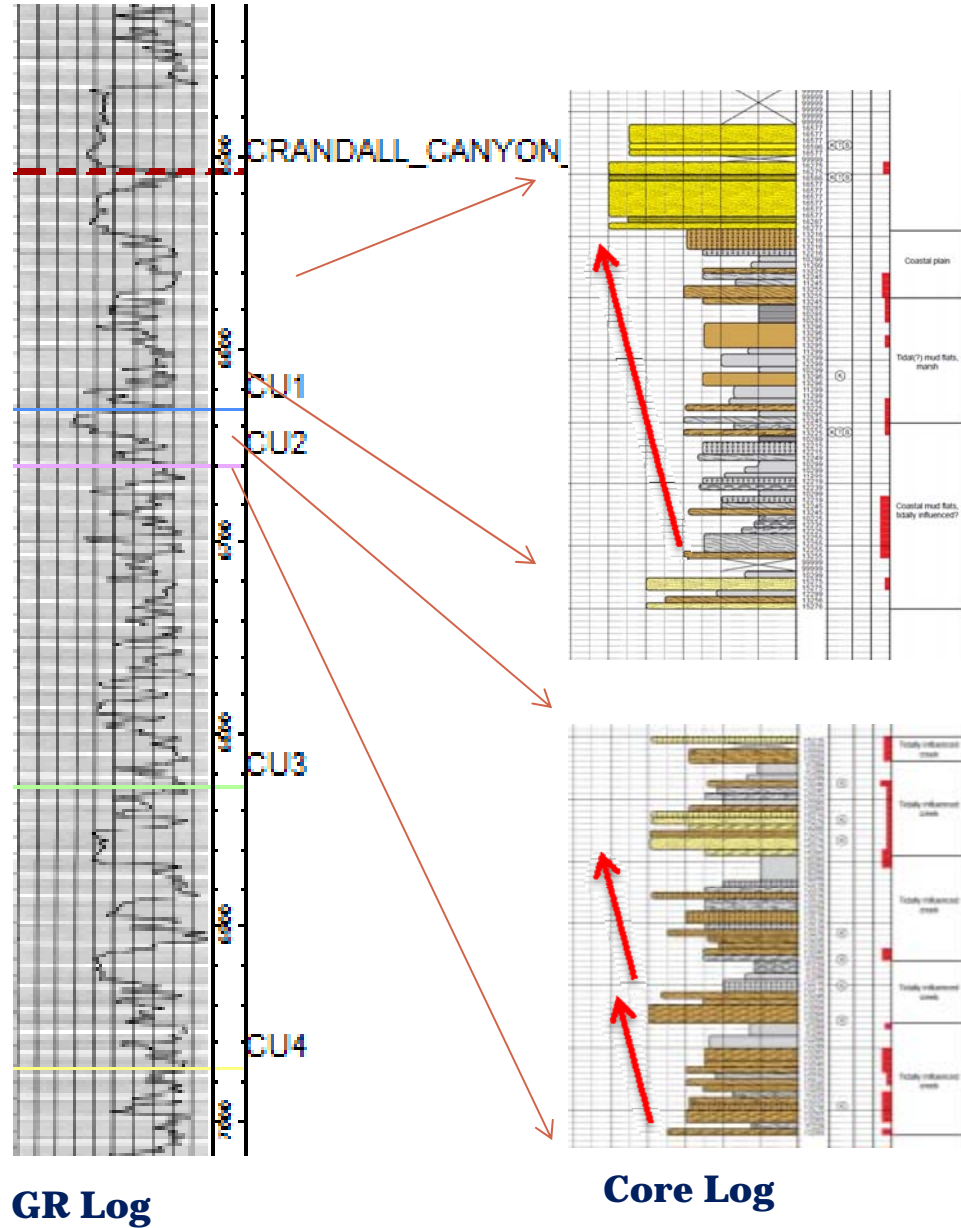
## Unique Subsurface Facies - Coarsening Upward Packages



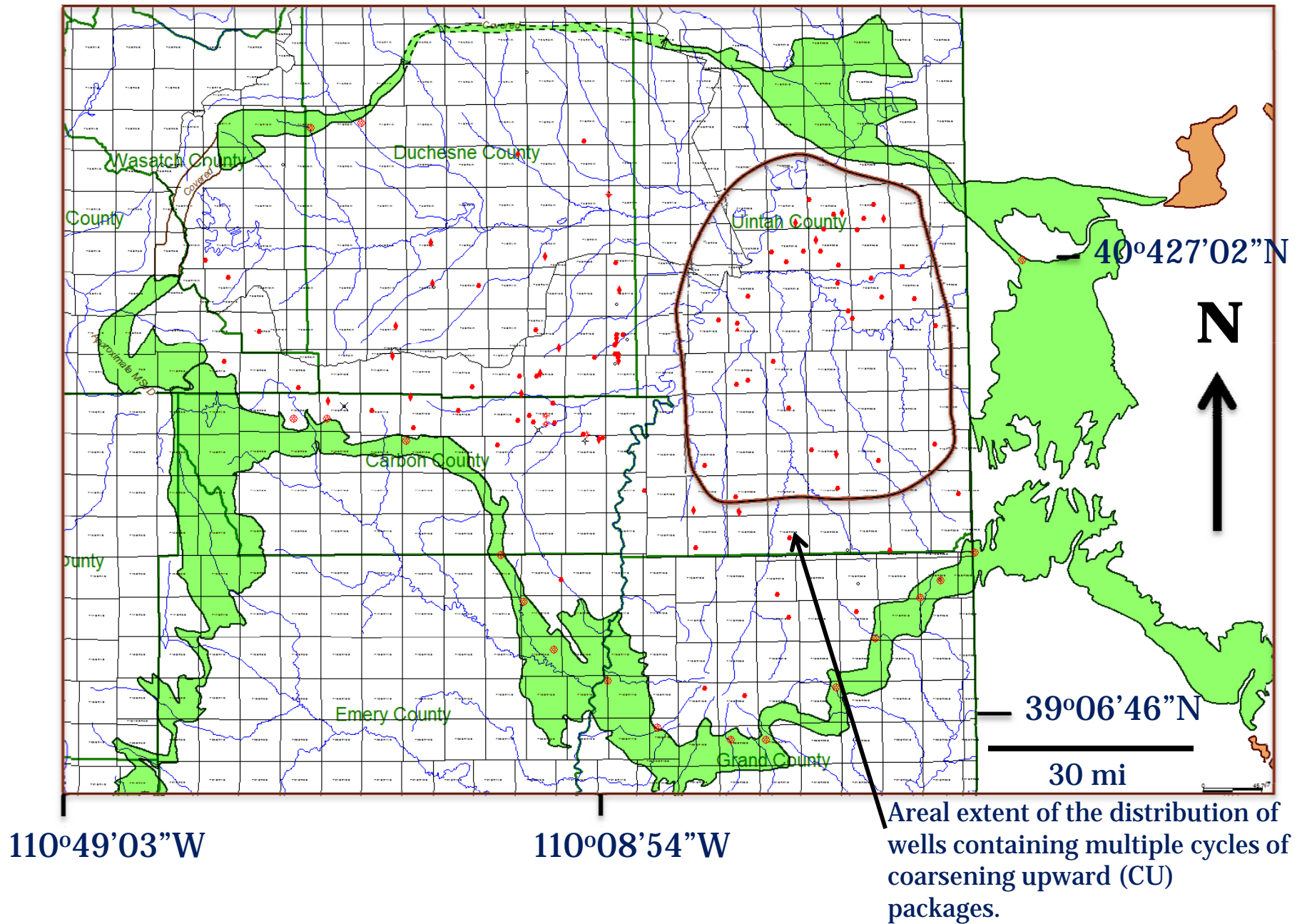
Well no: 4304730545

Well name: FLAT MESA FEDERAL 2-7

Kansas Geological Survey  
(2009)

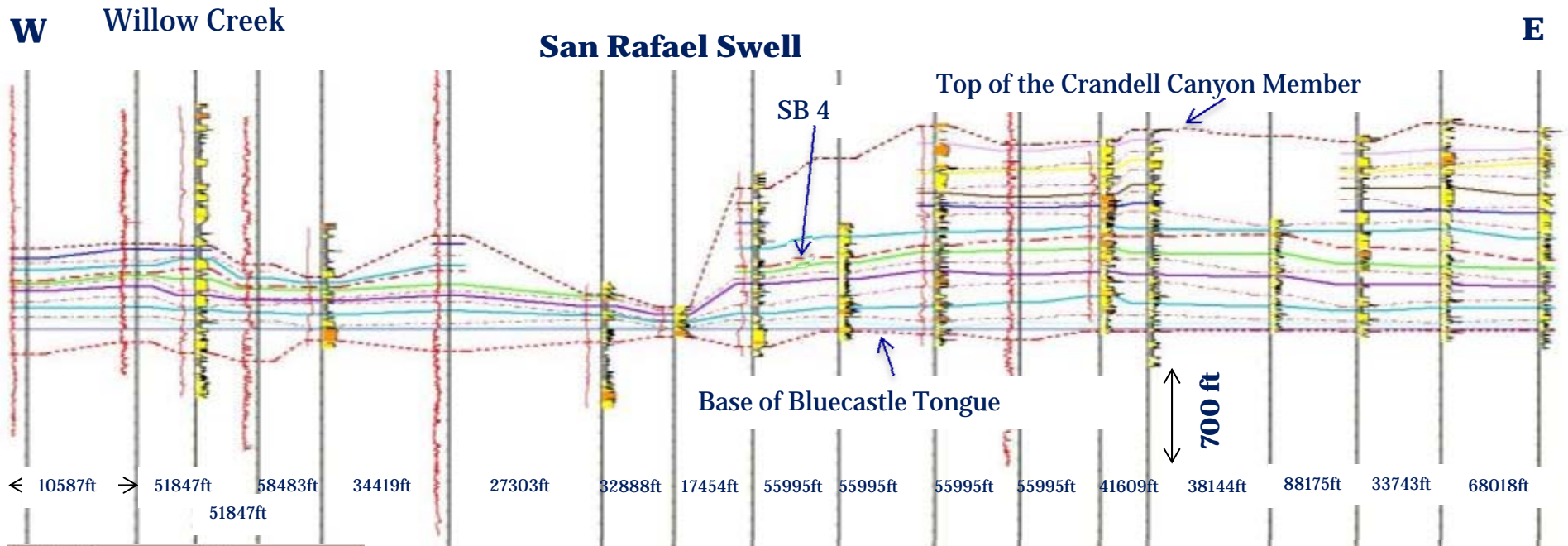


# Unique Subsurface Facies - Coarsening Upward Packages



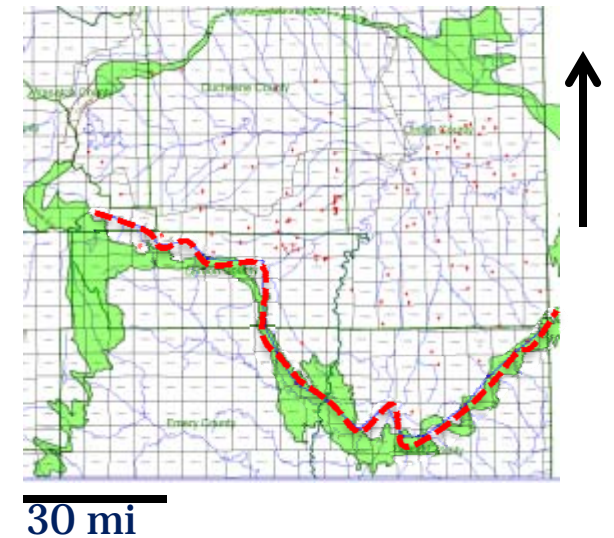


# Stratigraphic Cross Section

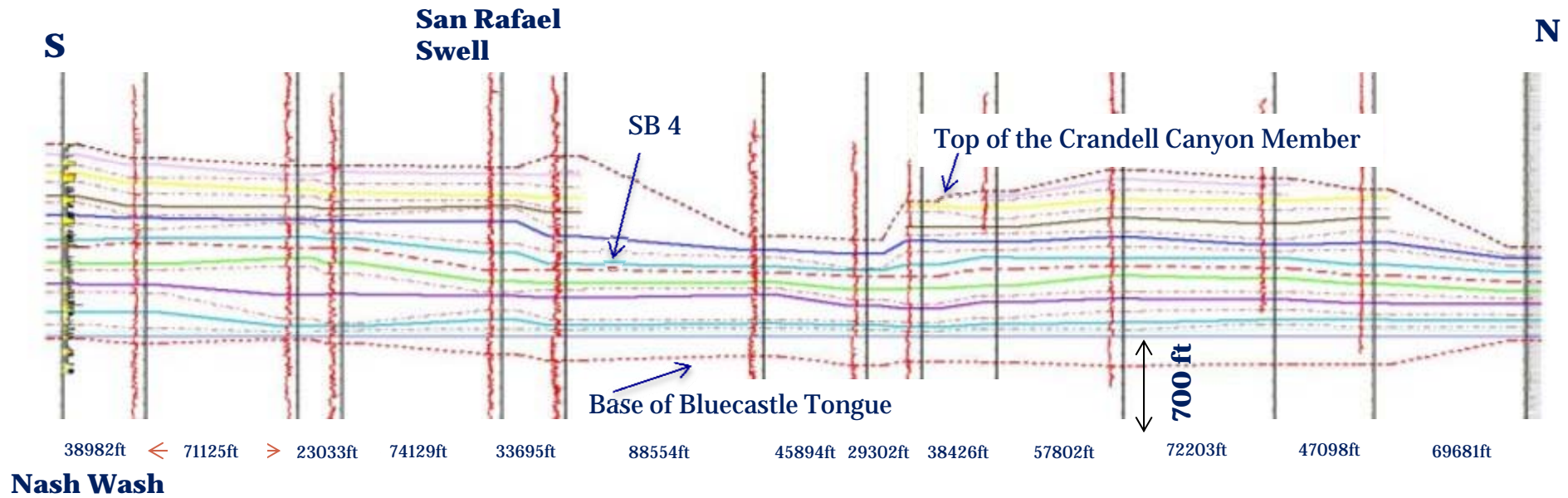


Rock Unit	Surface
	Top Crandell Canyon
Tuscher Formation	FS11
	SB10
	FS10
	SB9
	FS9
	SB8
	FS8
	SB7
	FS7
	SB6
	FS6
Farner Formation	SB5
	FS5
	SB4
	FS4
	SB3
	FS3
	SB2
	FS2
	SB1
	FS1
	Top Bluecastle
	Base Bluecastle

**Datum = Top of Bluecastle Tongue  
(Flooding Surface)**

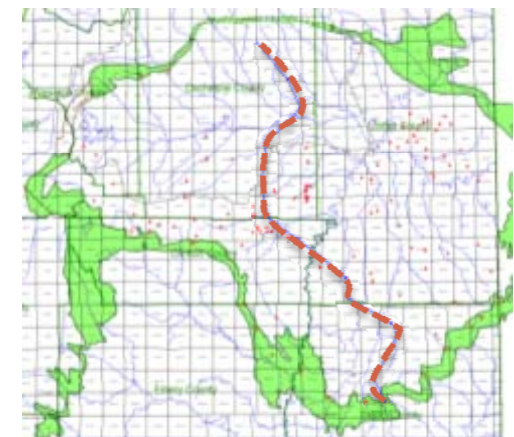


# Stratigraphic Cross Section



Rock Unit	Surface
Tuscher Formation	Top Crandell Canyon
	FS11
	SB10
	FS10
	SB9
	FS9
	SB8
	FS8
	SB7
	FS7
	SB6
Farrer Formation	FS6
	SB5
	FS5
	SB4
	FS4
	SB3
	FS3
	SB2
	FS2
	SB1
	FS1
	Top Bluecastle
	Base Bluecastle

**Datum = Top of Bluecastle Tongue (Flooding Surface)**



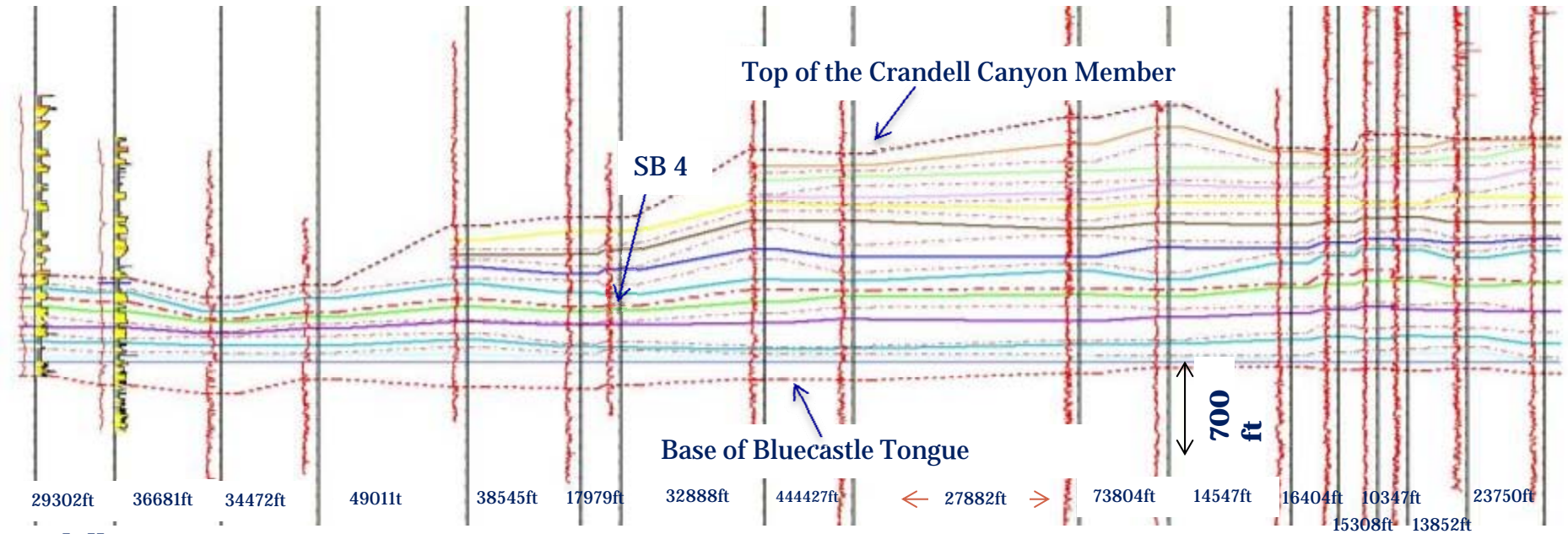
30 mi



# Stratigraphic Cross Section

SW

NE

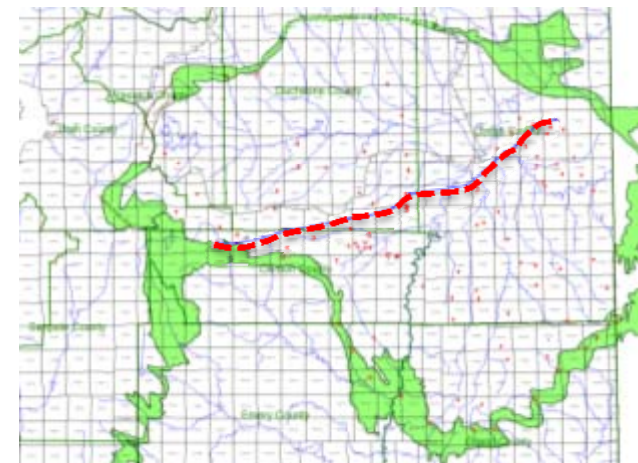


## Crandell Canyon

Rock Unit	Surface
Tuscher Formation	Top Crandell Canyon
	FS11
	SB10
	FS10
	SB9
	FS9
	SB8
	FS8
	SB7
	FS7
	SB6
Farver Formation	FS6
	SB5
	FS5
	SB4
	FS4
	SB3
	FS3
	SB2
	FS2
	SB1
	FS1
	Top Bluecastle
	Base Bluecastle

Datum = Top of Bluecastle Tongue (Flooding Surface)

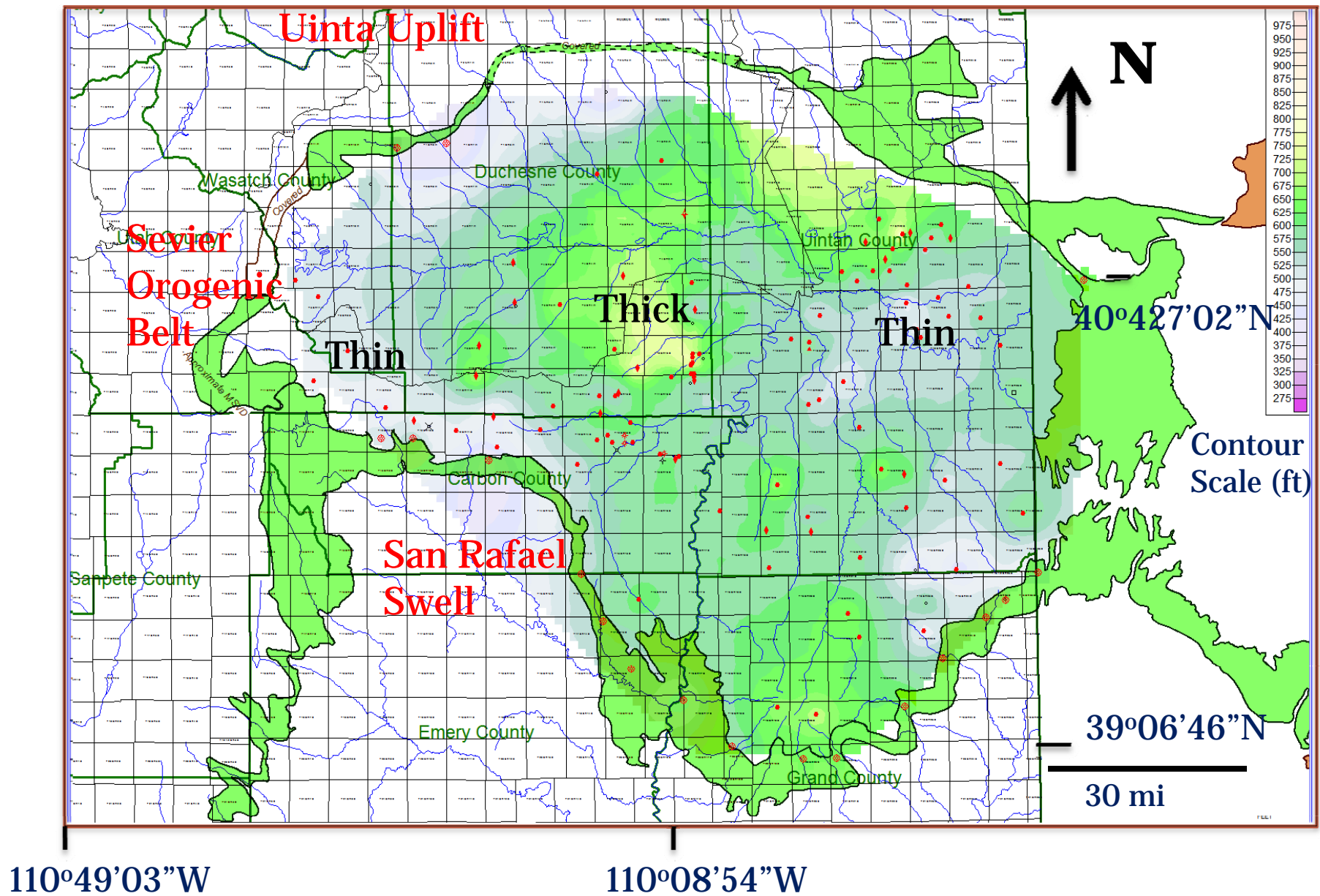
Natural Buttes



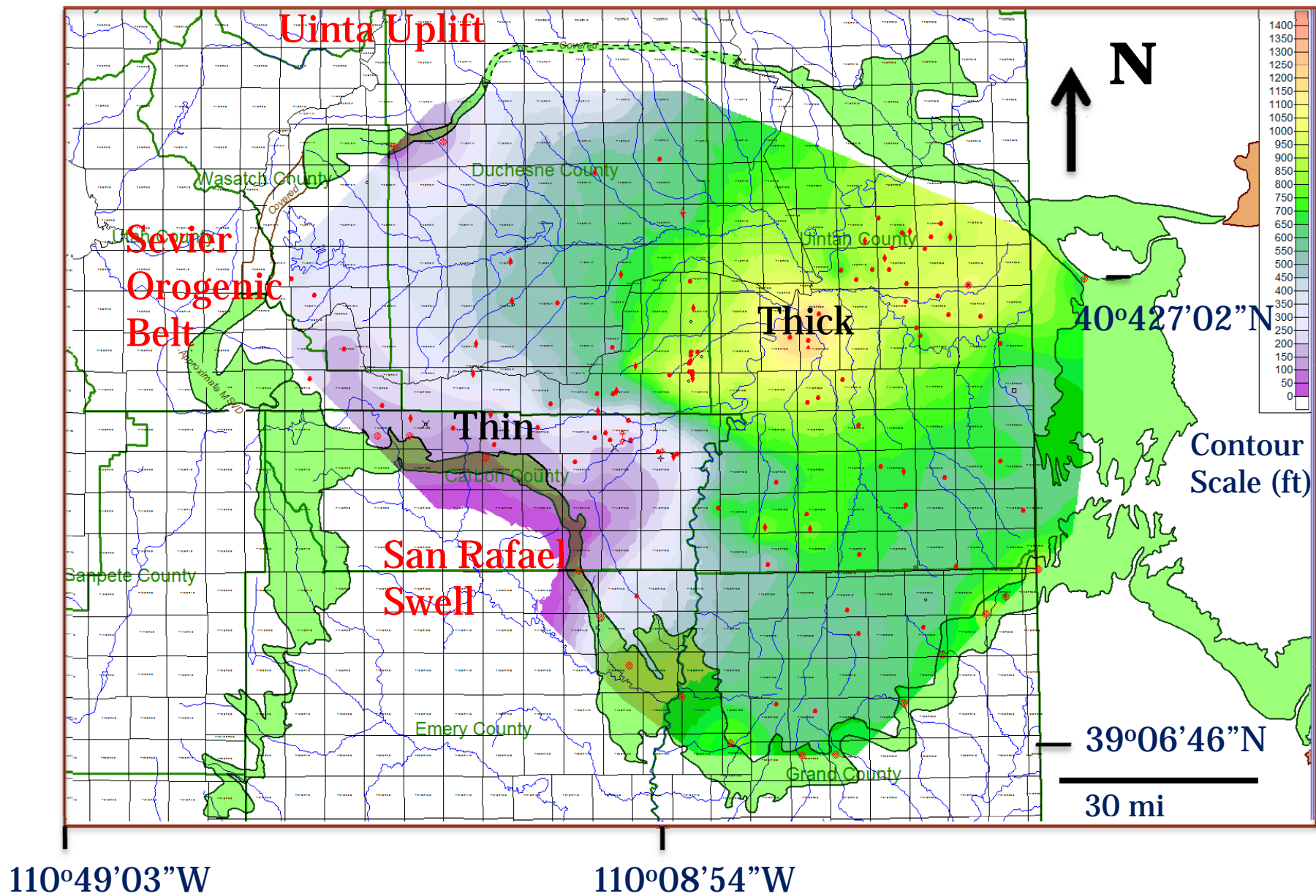
30 mi



# Isopach Map – Farrer Interval

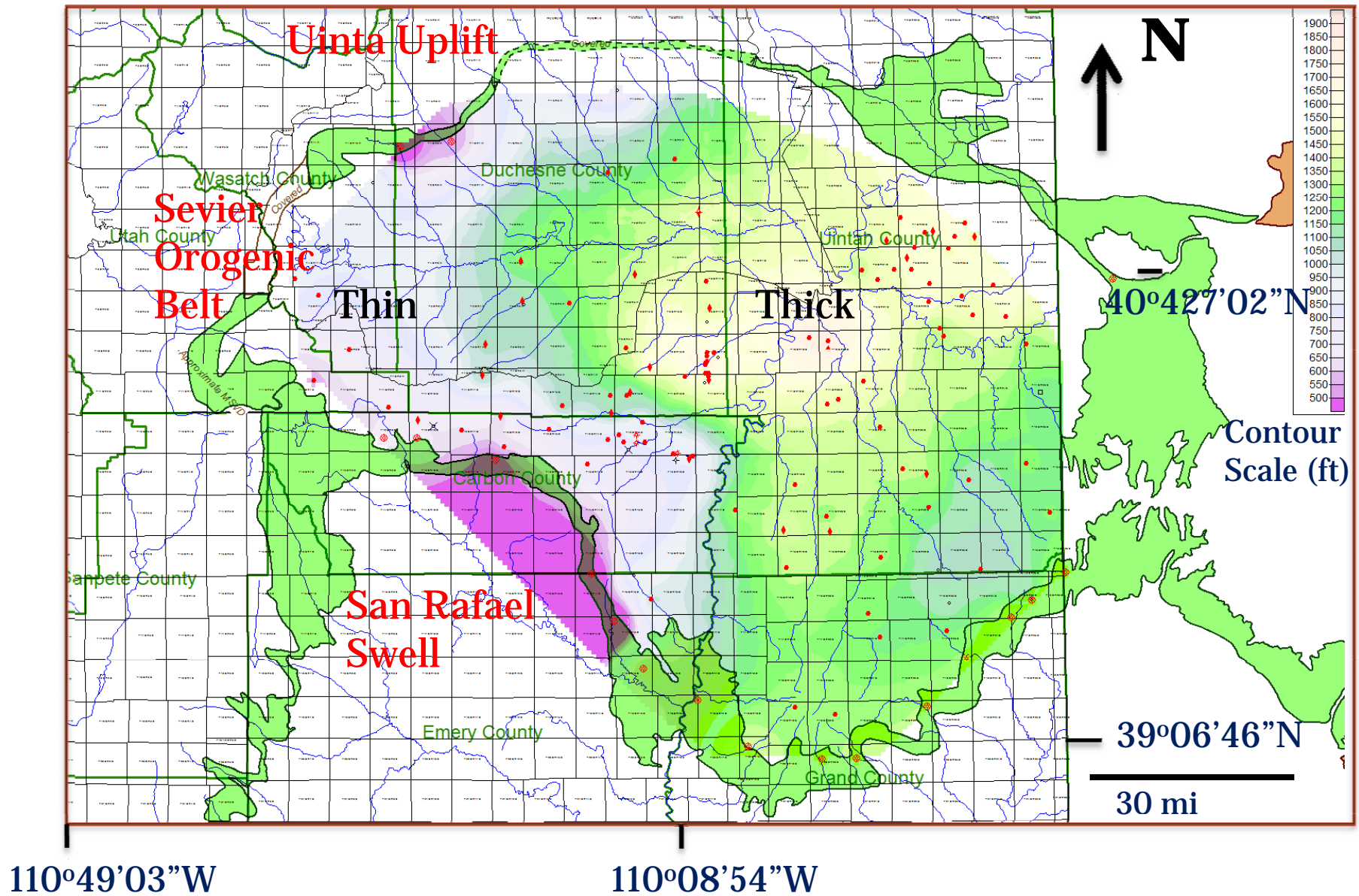


# Isopach Map - Tuscher Interval

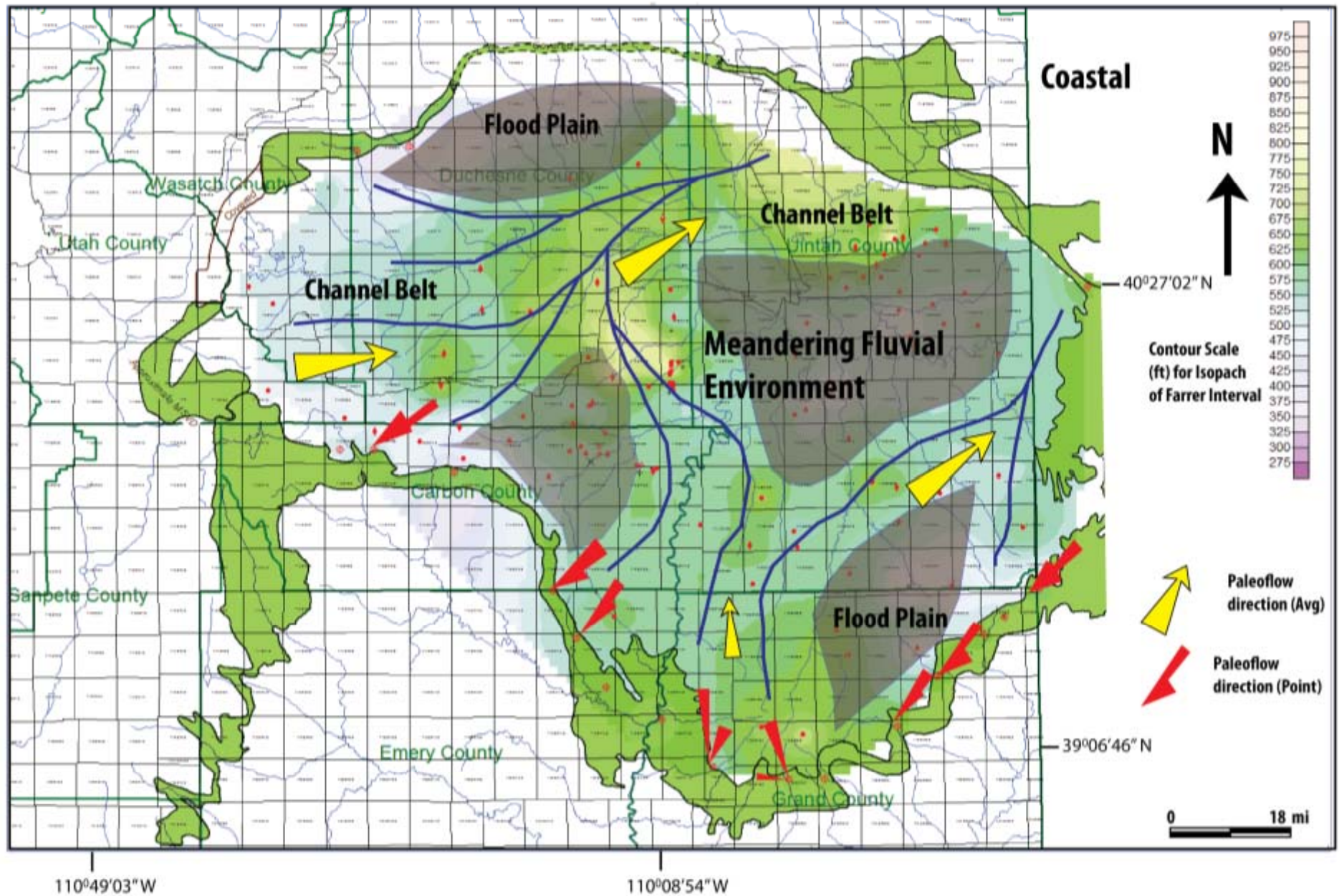




# Isopach Map – Upper Mesaverde Interval

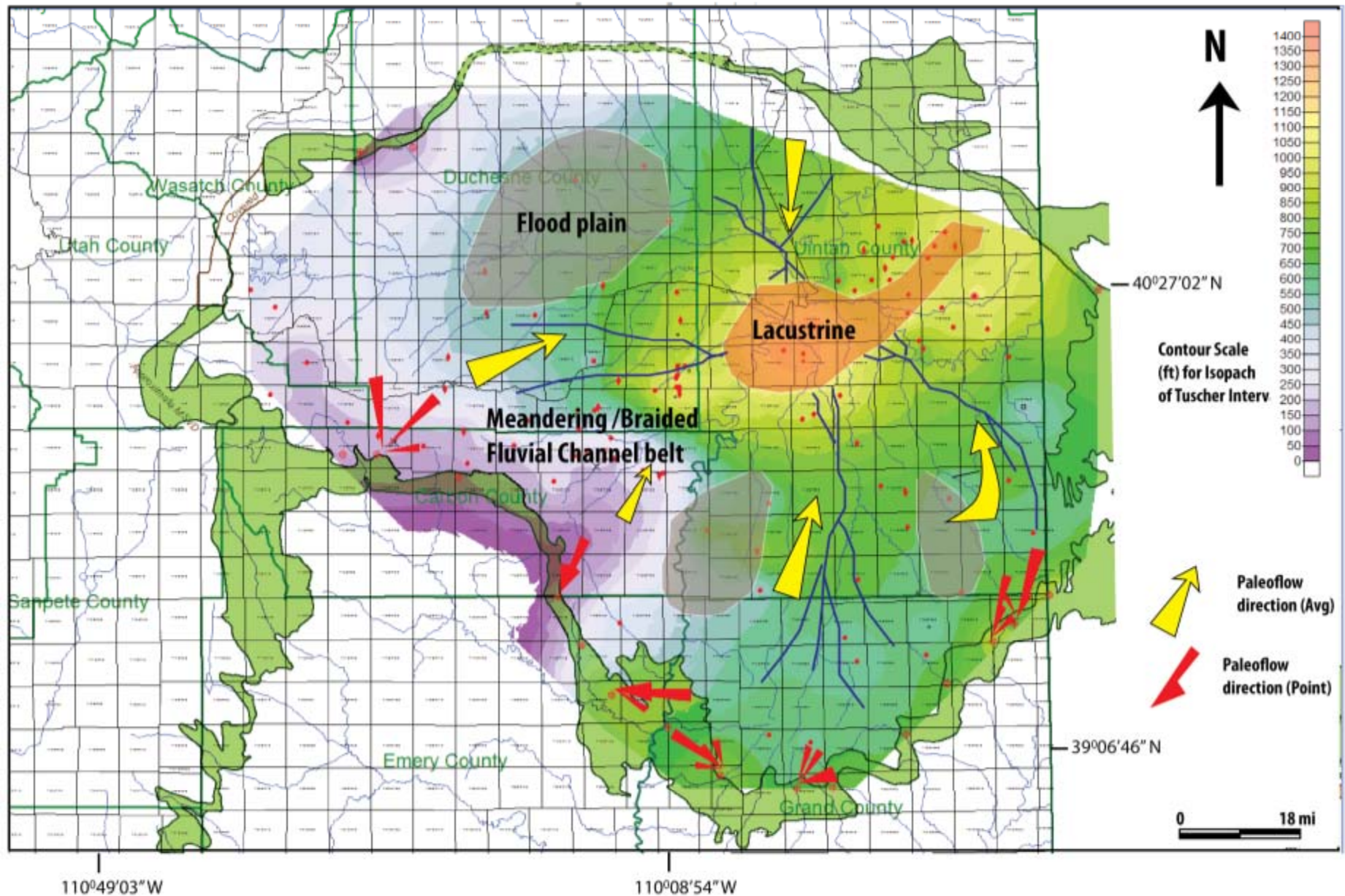


# Paleo-environment map - Farrer Interval





# Paleo-environment map- Tuscher Interval



# Conclusions

- Two 3<sup>rd</sup> order and eleven 4<sup>th</sup> order stratigraphic sequences are identified in the dominantly fluvial succession of the upper Mesaverde Group, Uinta basin.
- Both the San Rafael Swell and the Uinta Uplift (Laramide-style structures) were active during the deposition of the Upper Mesaverde Group in the Uinta basin.
- Uinta basin was episodically partitioned during the deposition of upper Mesaverde Group due to uplift of the San Rafael Swell and Uinta Uplift in the basin.



# Conclusions

- Previously unreported lacustrine facies in the northeastern part of the basin could have aided on the accumulation of the natural gas in the northeastern part of the basin (Natural Buttes area)
- The accommodation of the Uinta basin was localized in the northeastern part during the late stage of Upper Mesaverde Group deposition.