Forcing Mechanisms on Late Cretaceous Carbonate Sedimentation: The Austin Chalk Group of Central Texas*

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Abstract

Despite the widespread occurrence of Upper Cretaceous chalk deposits in shallow and deep marine settings around the world, their paleoenvironmental significance still needs to be constrained to accurately reconstruct the dynamics of past oceans that may, in turn, constrain reservoir heterogeneities. We aim to elucidate forcing mechanisms that control chalk deposition by investigating facies in the Austin Chalk Group preserved in central Texas, to capture the interplay of key environmental parameters affecting these unique carbonate deposits. We hypothesize that local mechanisms controlled regional scale depositional patterns, whereas global phenomena contributed to the development of phosphatic hardground surfaces. In particular we: (1) establish a high-resolution stratigraphic framework to evaluate the timing of sea level changes, (2) document the influence of environmental parameters on carbonate facies by monitoring geochemical proxies, and (3) determine the sequence stratigraphic and environmental significance of phosphatic hardgrounds within the Austin Chalk Group through their detailed diagenetic study.

First, the integration of outcrop and subsurface data from central Texas provides an integrated stratigraphic framework that reveals a migration of depocenters during the deposition of the Austin Chalk Group. This is inferred to reflect movements of the basement highs (e.g. San Marcos Arch) and sags that modulate eustatic sea level changes, and lead to the deposition of coarse upper Austin Chalk facies in the San Antonio area, whereas coeval sedimentation was deeper and finer grained in west Texas.

Second, geochemical proxies indicate that muddy facies of the lower Austin Chalk Group were deposited under oligotrophic (low nutrient input) conditions with moderate terrigenous contribution from land, whereas coarser, oyster-rich facies of the upper Austin Chalk Group represent an adaptation of carbonate producing ecosystems to mesotrophic waters where brief suboxic periods developed.

Third, at least three hardground surfaces in the upper Austin Chalk Group have a high amount of glauconitic grains which maturity is assessed by their potassium concentration. These hardground surfaces developed on top of oyster-rich beds, and record periods of strong winnowing of the seafloor, favoring potentially enhanced porosity and permeability in the coarse oyster-rich facies.

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Motivation and goals

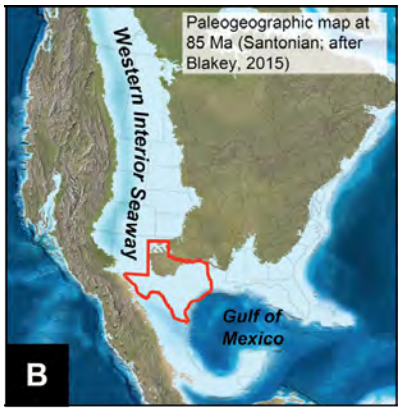
Statement

- Austin Chalk: **lateral variations** in facies and thickness
- **In Bexar County**: thin series (ca. 40 m vs. 120 m in Travis County), coarse facies separated by bored hardgrounds

Aim

- Integrate surface and subsurface data in a stratigraphic framework to **explore depositional patterns / geometries** and their **controlling factors**

Lithostratigraphic framework



Stage	Calcareous Nannofossils (Jiang, 1989)	Planktic Foraminifera (Pessagno, 1969)	Molluscs (Young & Marks, 1952)	Ammonites (Young, 1985)	Austin Chalk (Type Section, Travis County)	Lithologic Column	meters
Lower Campanian	*C. aculeus*	*A. blowi*		*Delawarella sabinalensis*	Sprinkle Formation (Taylor Group)	Calcareous Claystone	
	Aspidolithus parcus	*G. fornicata*	*Ostrea travisana*	*Delawarella delawarensis*	Pflugerville Formation	Chalky Marl w/ *Exogyra ponderosa*	120
	Phanulithus obscurus		*Ostrea centerensis*	*Submortoniceras vanuxemi*	Burditt Fm.	Marl	
Santonian Upper	*Lucianorhabdus cayeuxii*		*Gryphaea aucella*	*Submortoniceras tequesquitense*	Dessau Formation	White chalk with thick marl interbeds & *Exogyra ponderosa*	90
			Texanites internodosus	*Bevahites bevahensis* Upper	Jonah Formation	Arenaceous skeletal packstone w/ marl	
			Hemiaster texanus	*Texanites texanus gallica* Lower		Chalky wackestone w/ diverse fossils	
Santonian Lower	*Reinhardtites anthophorus*		*Inoceramus undulatoplicatus*	*Texanites texanus texanus*	Vinson Formation	Massive white chalk, thick chalk-marl interbeds w/ *Inoceramus undulatoplicatus*	60
				Texanites stangeri			
Coniacian Upper	*Micula decussata*	*M. concavata*	*Gryphaea wratheri*	*Prionocycloceras gabrielense* Upper	Atco Formation	Medium bedded chalks & marls	30
Coniacian Lower	*Marthasterites furcatus*		*Inoceramus subquadratus*	*Peroniceras westphalicum* *Peroniceras haasi* Lower		Thin bedded chalks & marls	0

In Austin, Travis County

Taylor

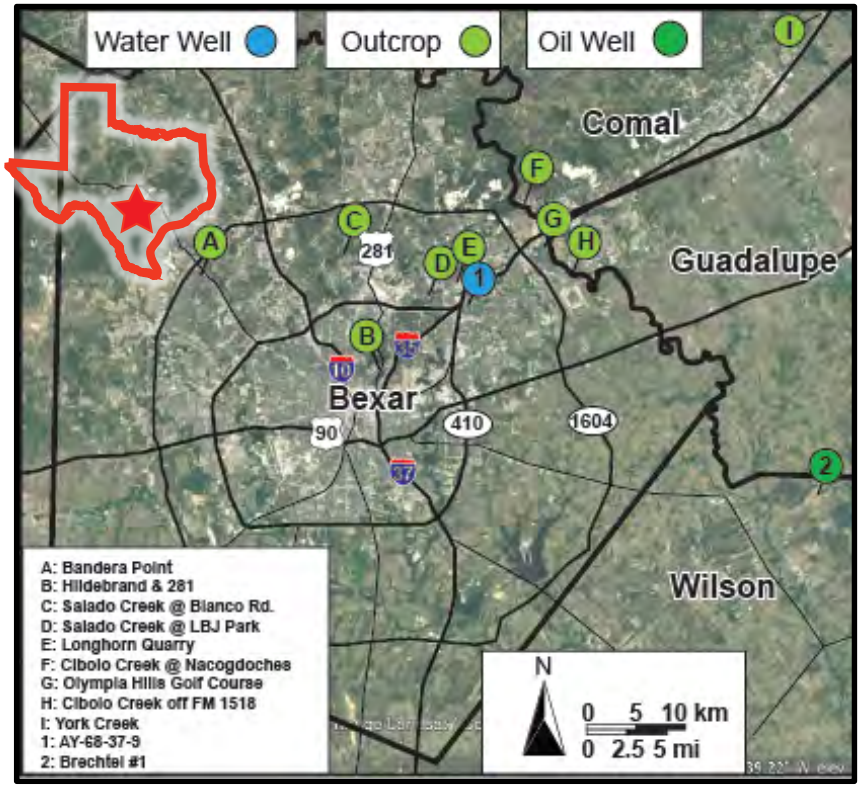
Upper Austin

Lower Austin

Eagle Ford

Modified from Lundquist (2000)

Lithostratigraphic framework



Cooper (2017):

- 8 outcrops in Bexar Co, 1 in Comal Co
- Gamma ray values obtained at each study location
- Marker horizons identified
- Composite section tied to water well AY-68-37-9 (*blue dot labelled 1*)

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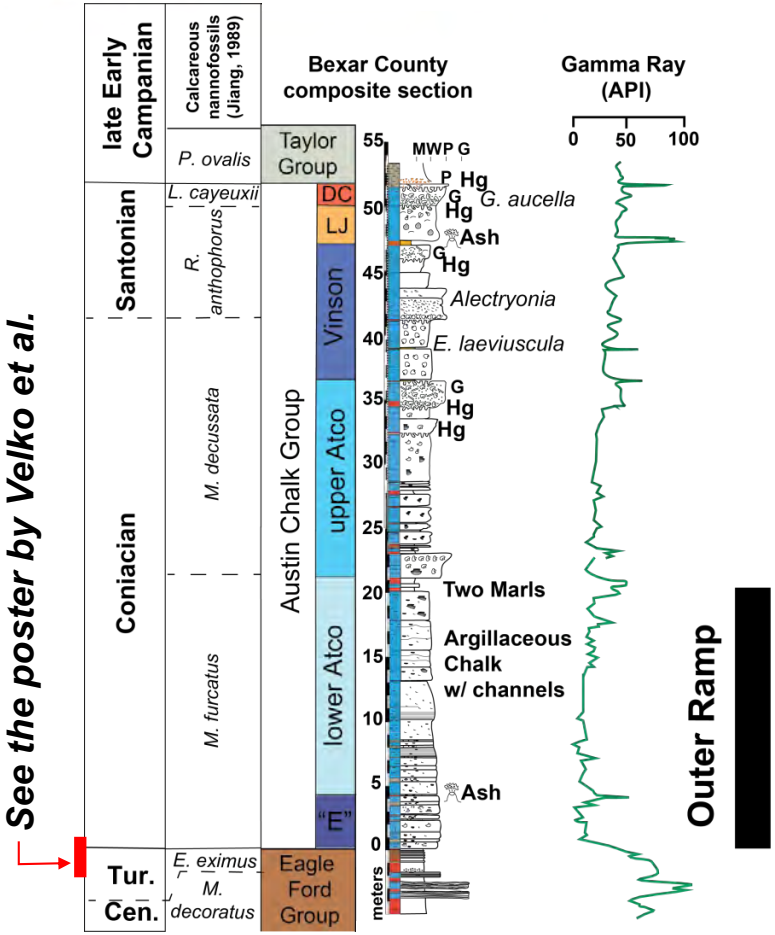
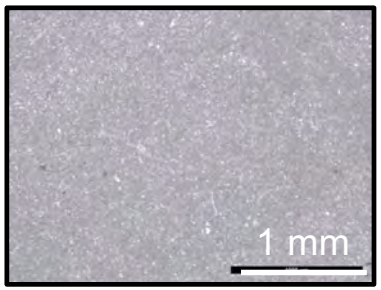
Facies Association: *Outer Ramp*

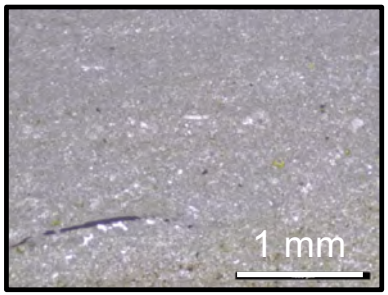


See the poster by Velko et al.

Lime mudstone with *Planolites* burrows

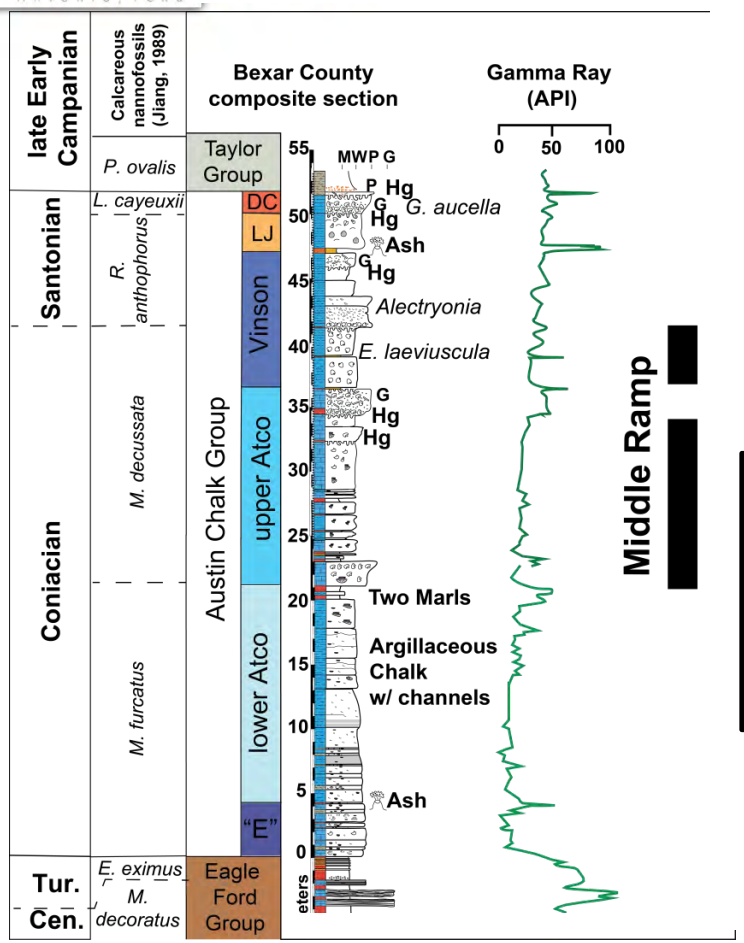


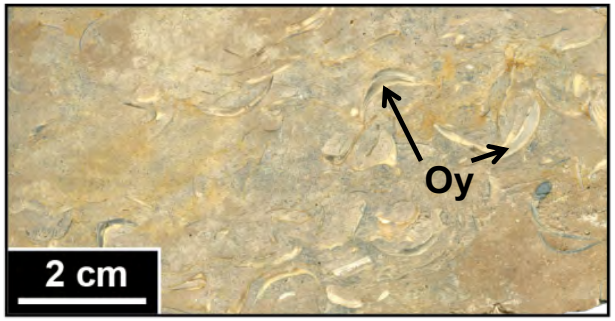
Foraminiferal mudstone



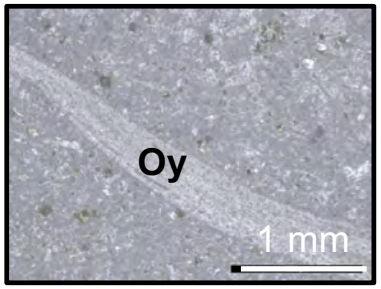
Foraminiferal mudstone with pyrite

Facies Association: *Middle Ramp*

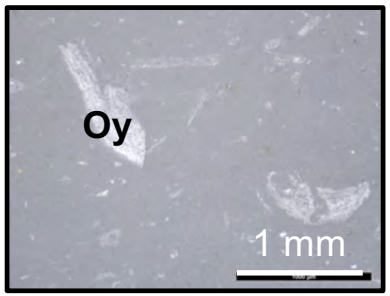




Oyster floatstone

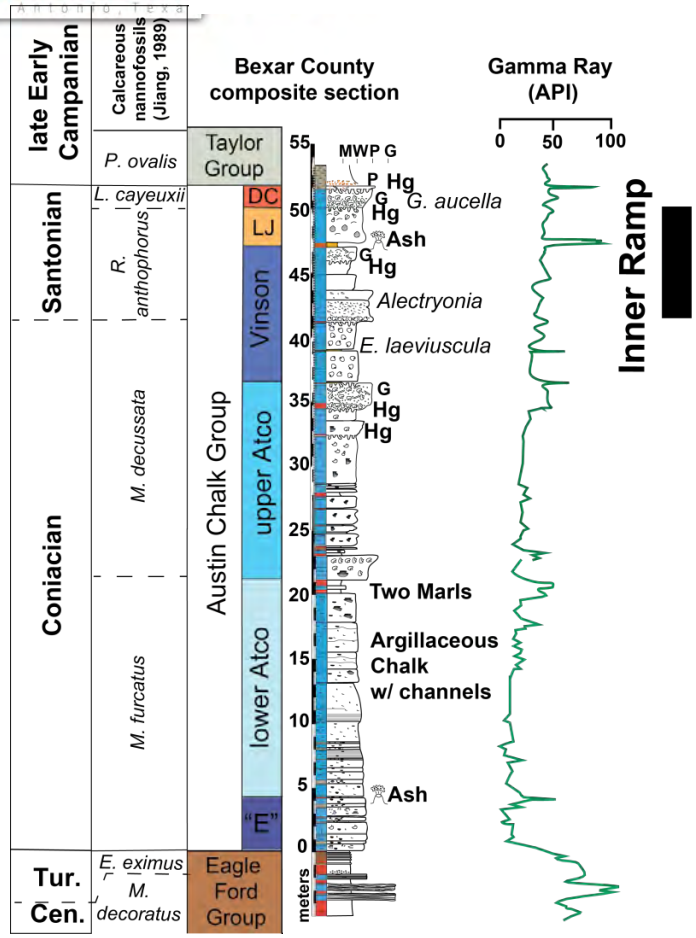


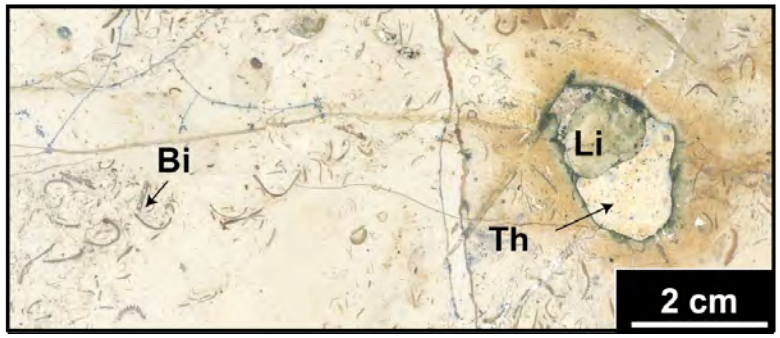
Foraminiferal oyster floatstone



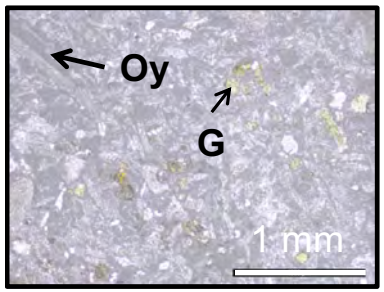
Oyster wackestone

Facies Association: *Inner Ramp*

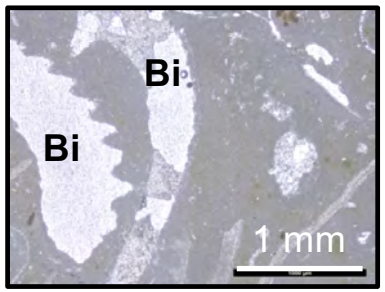




Bivalve wackestone with *Thalassinoides*

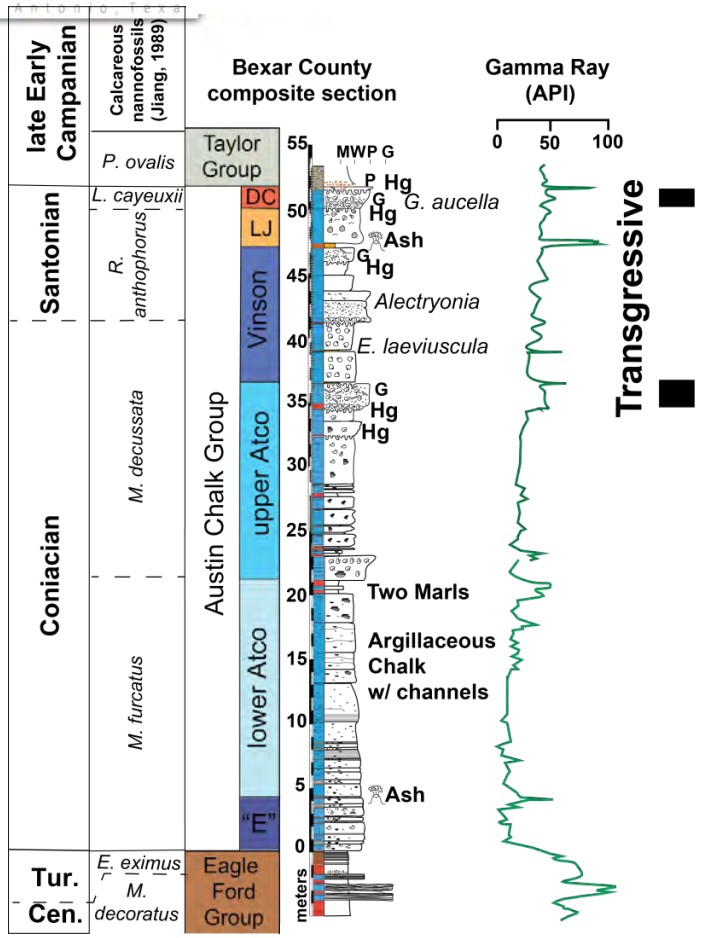


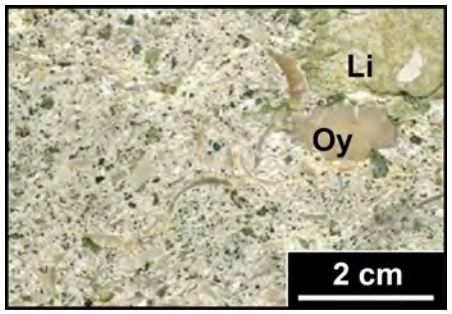
Skeletal packstone



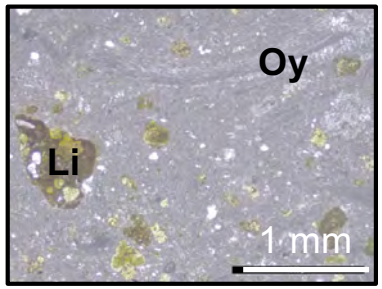
Bivalve wackestone

Facies Association: *Transgression*

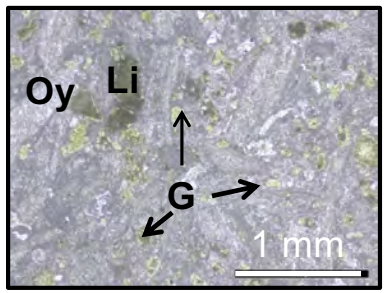




Glauconitic oyster packstone w/ lithoclasts

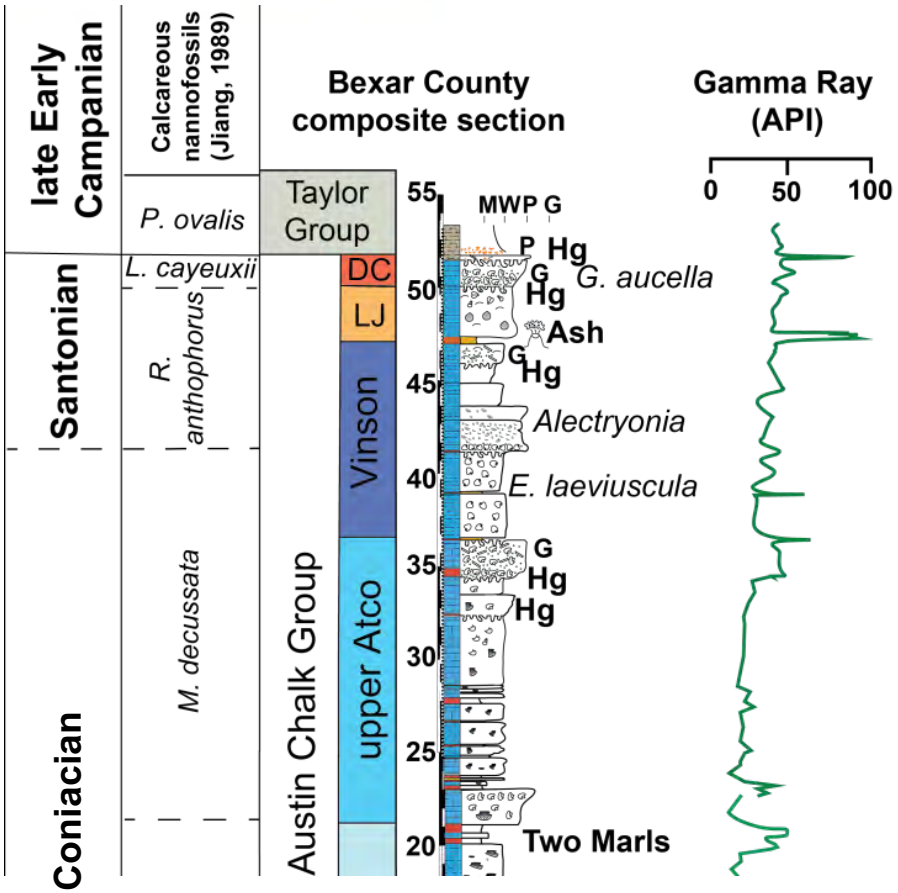


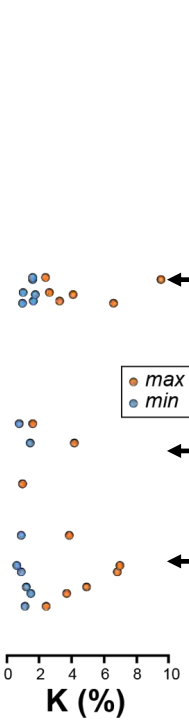
Lithoclastic oyster floatstone

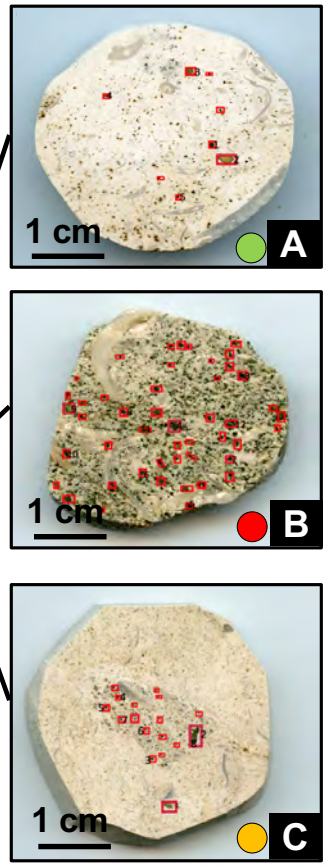


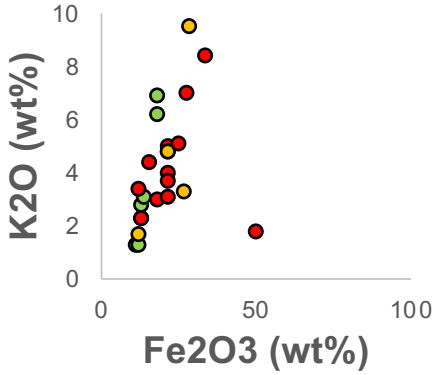
Glauconitic oyster inoceramid packstone

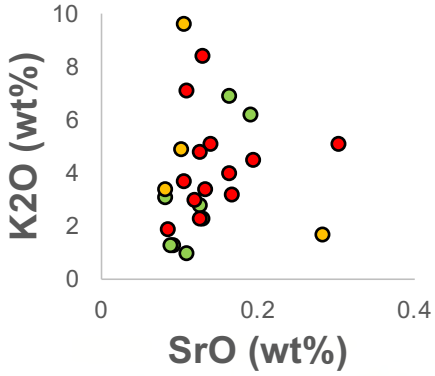
Facies Association: *Transgression*



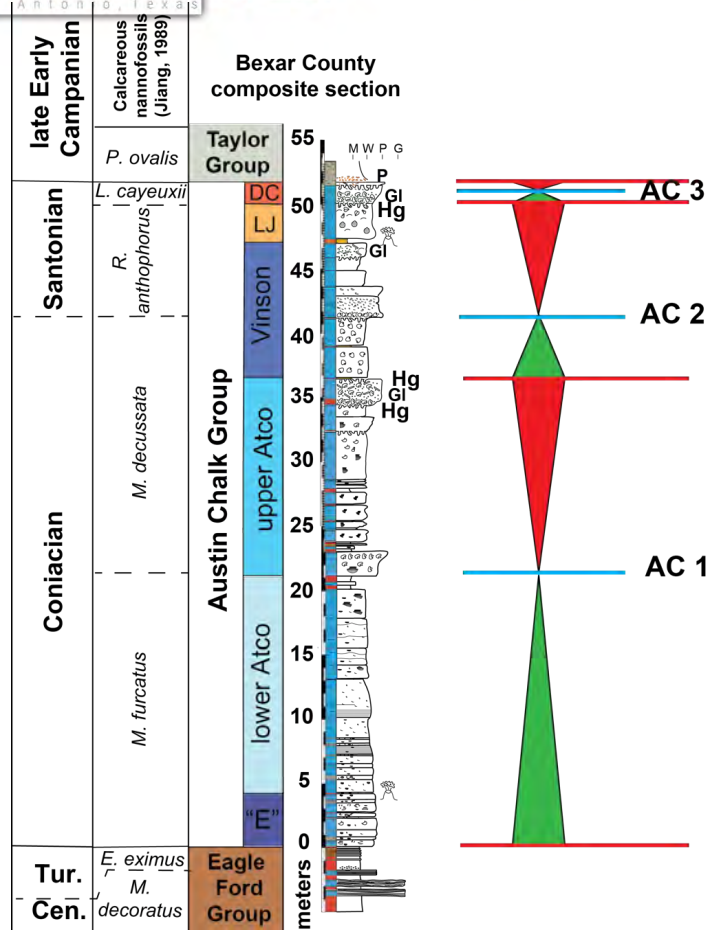








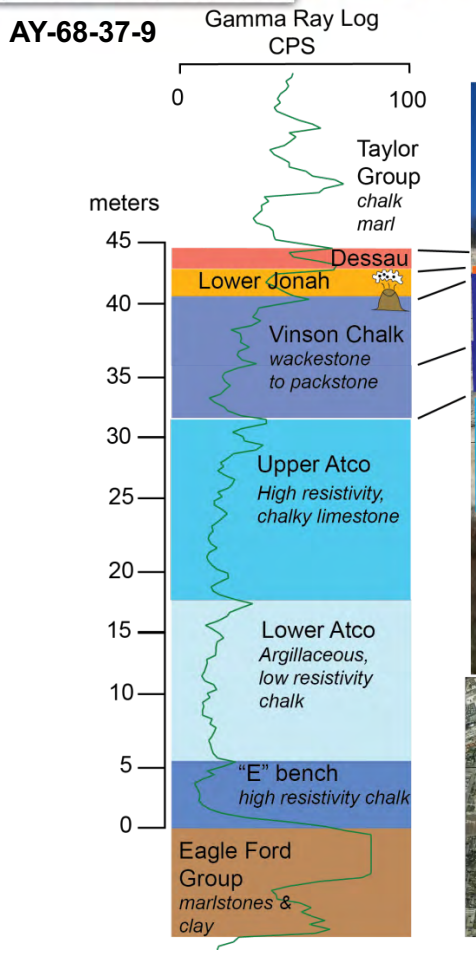
Facies Association: *Sequence Stratigraphy*

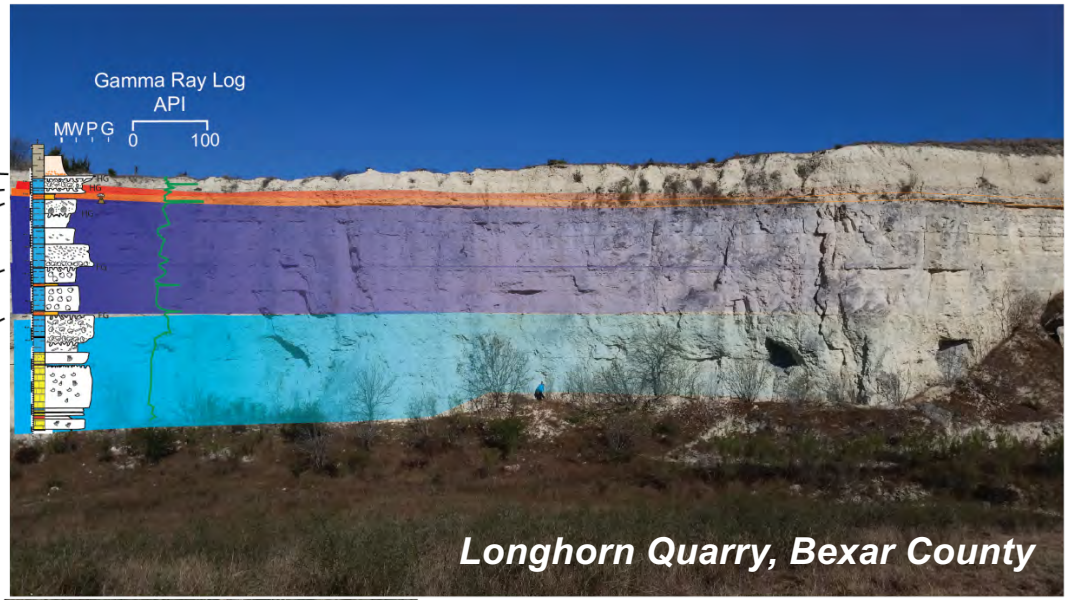


Phosphatic hardgrounds (HG): ***sequence boundaries***

Outer ramp facies: ***maximum flooding surfaces***

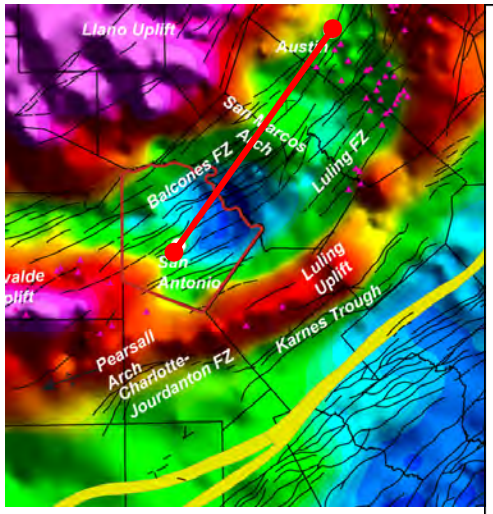
Outcrop to subsurface correlation

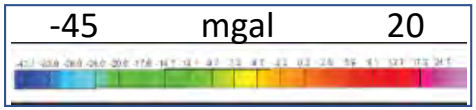


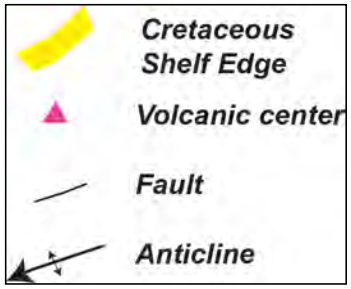


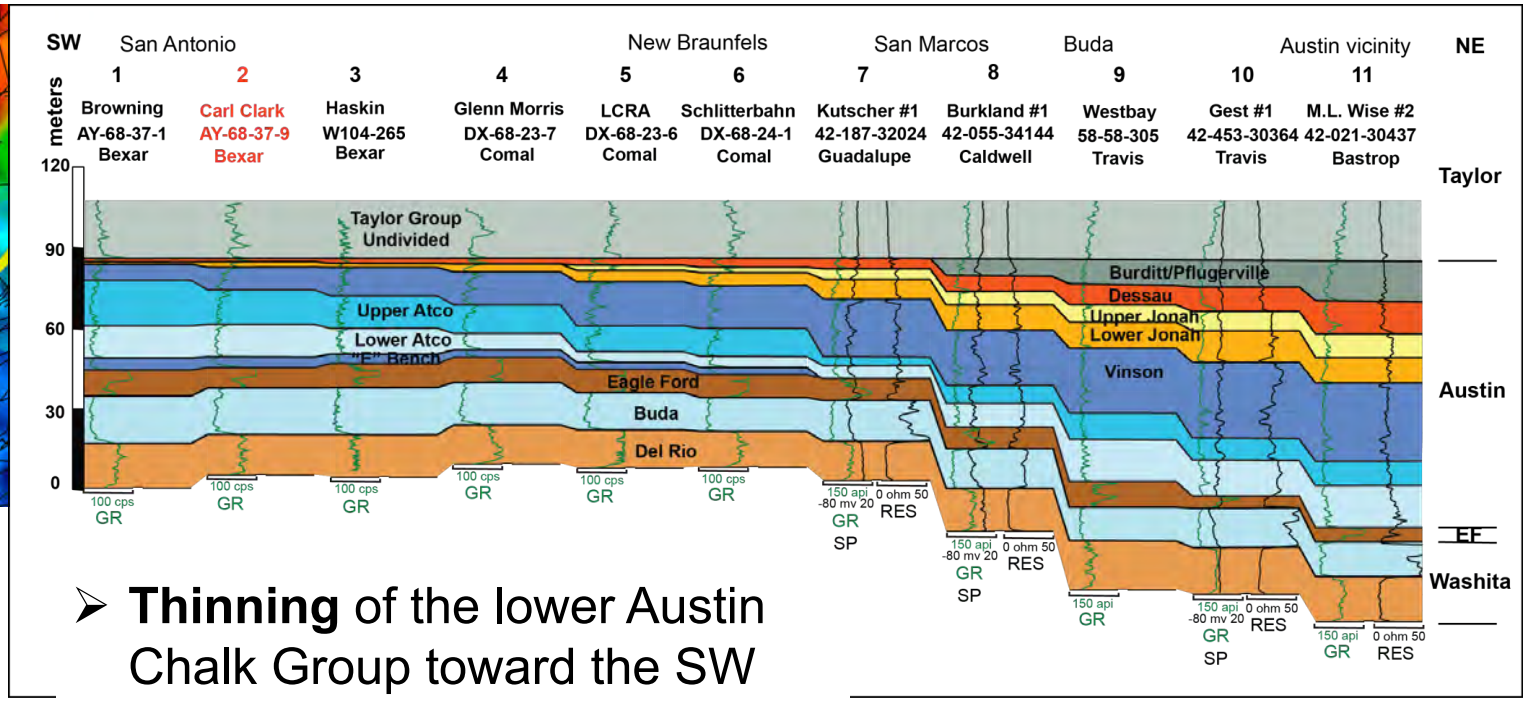
Surface to subsurface correlation based on GR curves

Subsurface geometries



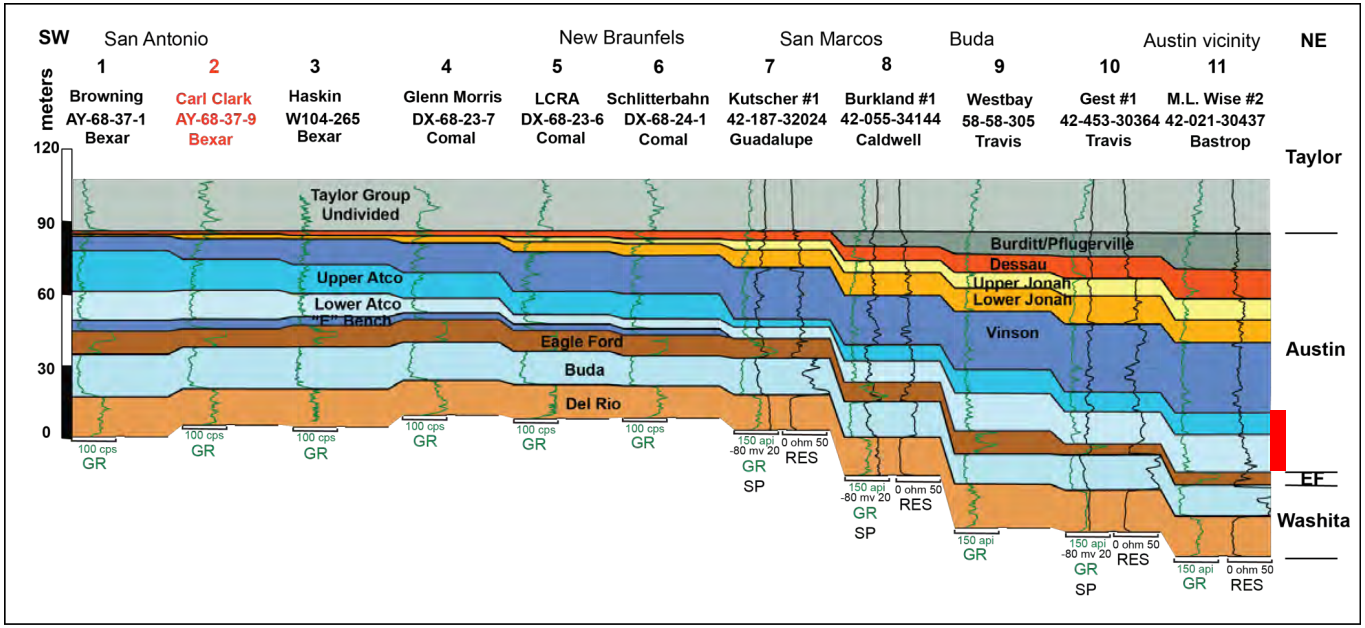


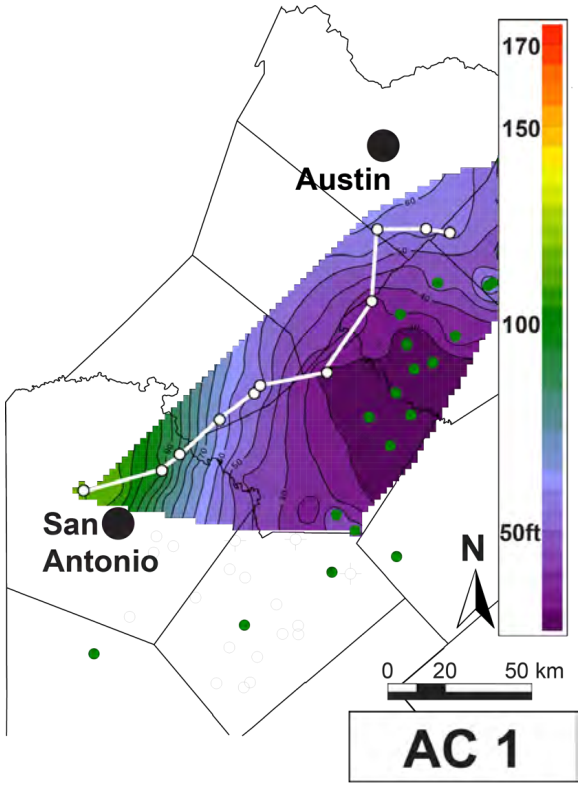




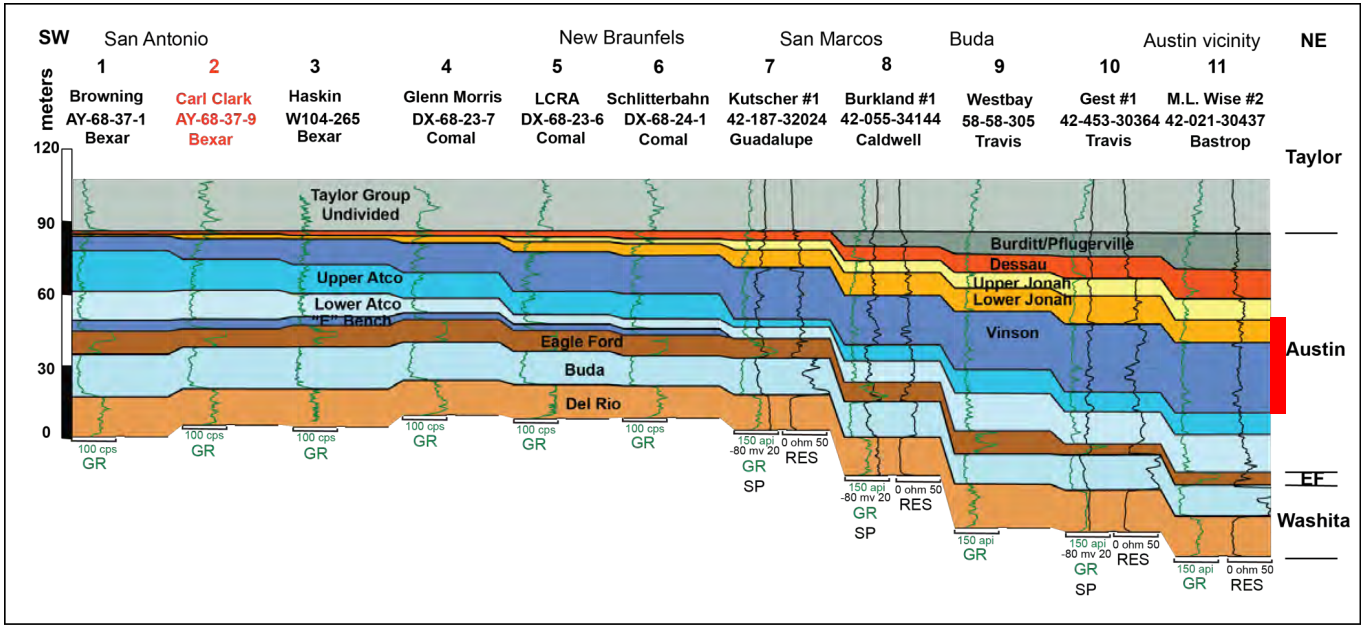
- **Thinning** of the lower Austin Chalk Group toward the SW
- **Thickening** of the upper Austin Chalk Group toward the NE

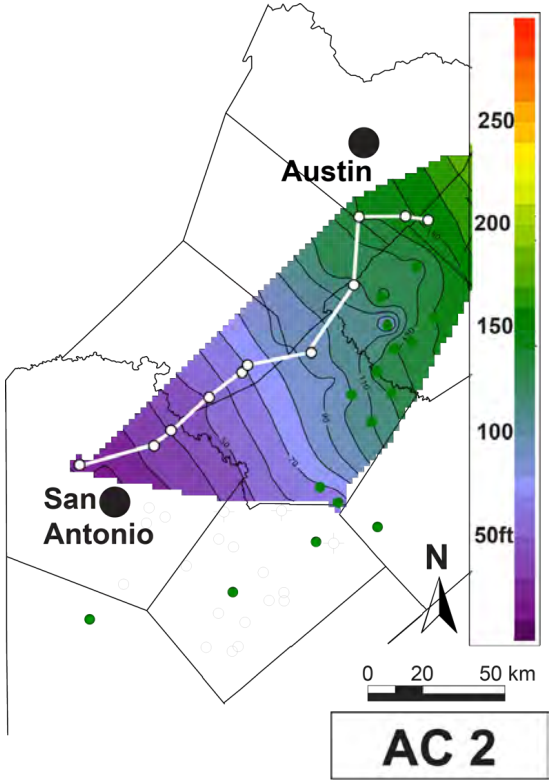
Subsurface geometries



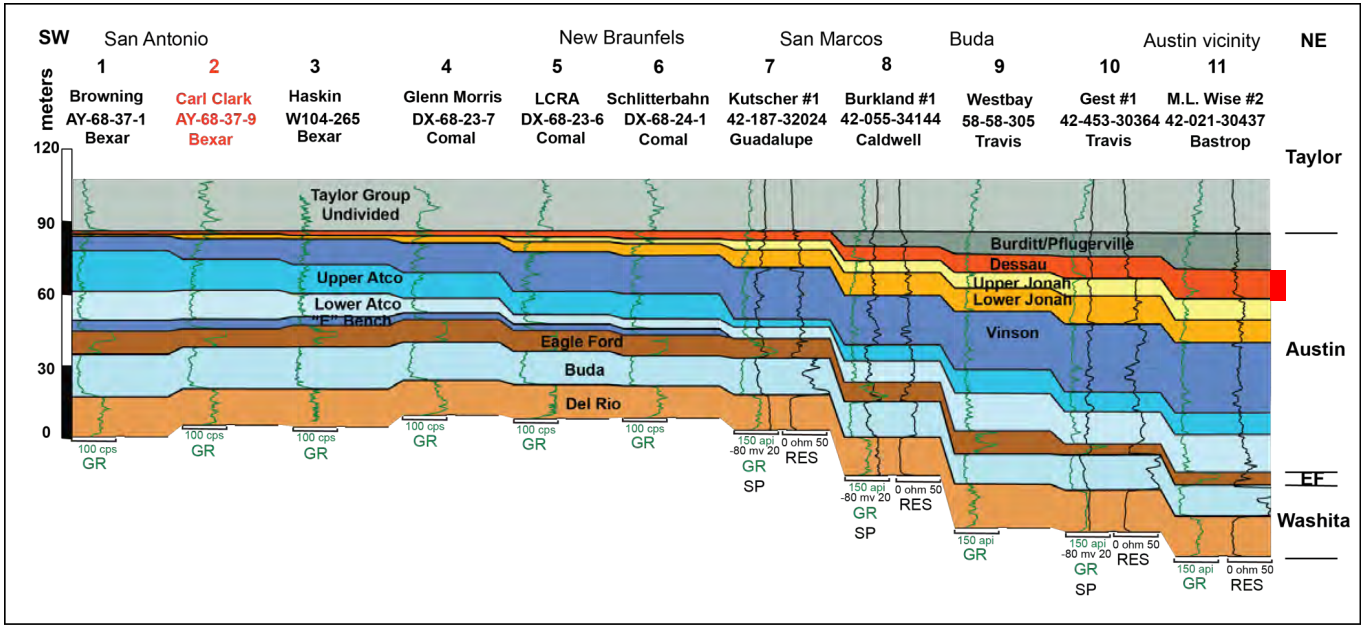


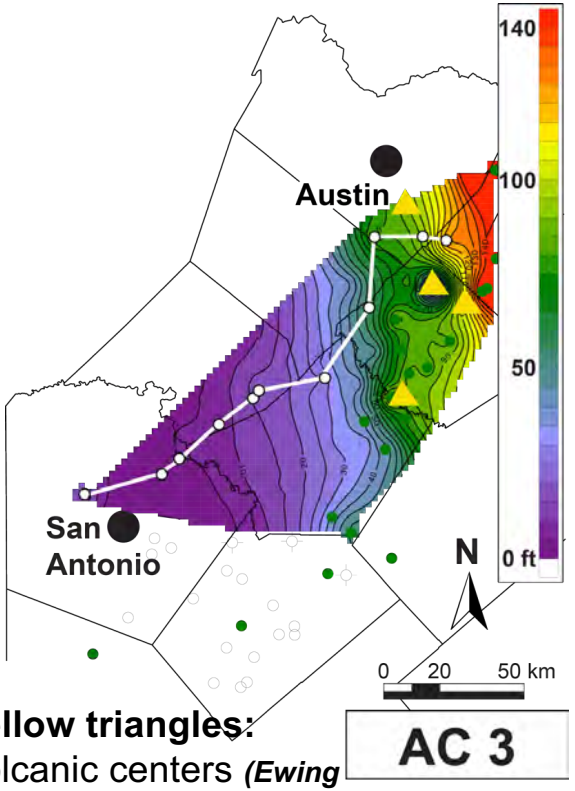
Subsurface geometries





Subsurface geometries



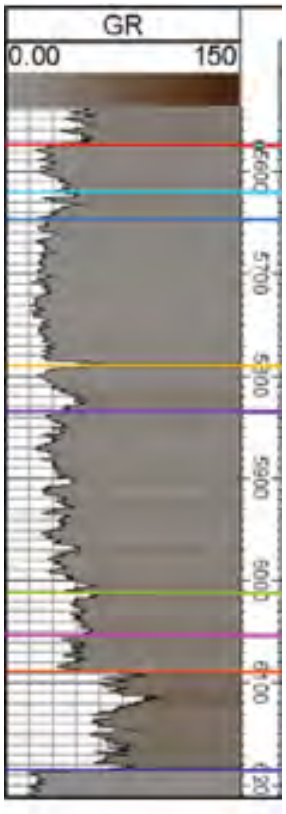


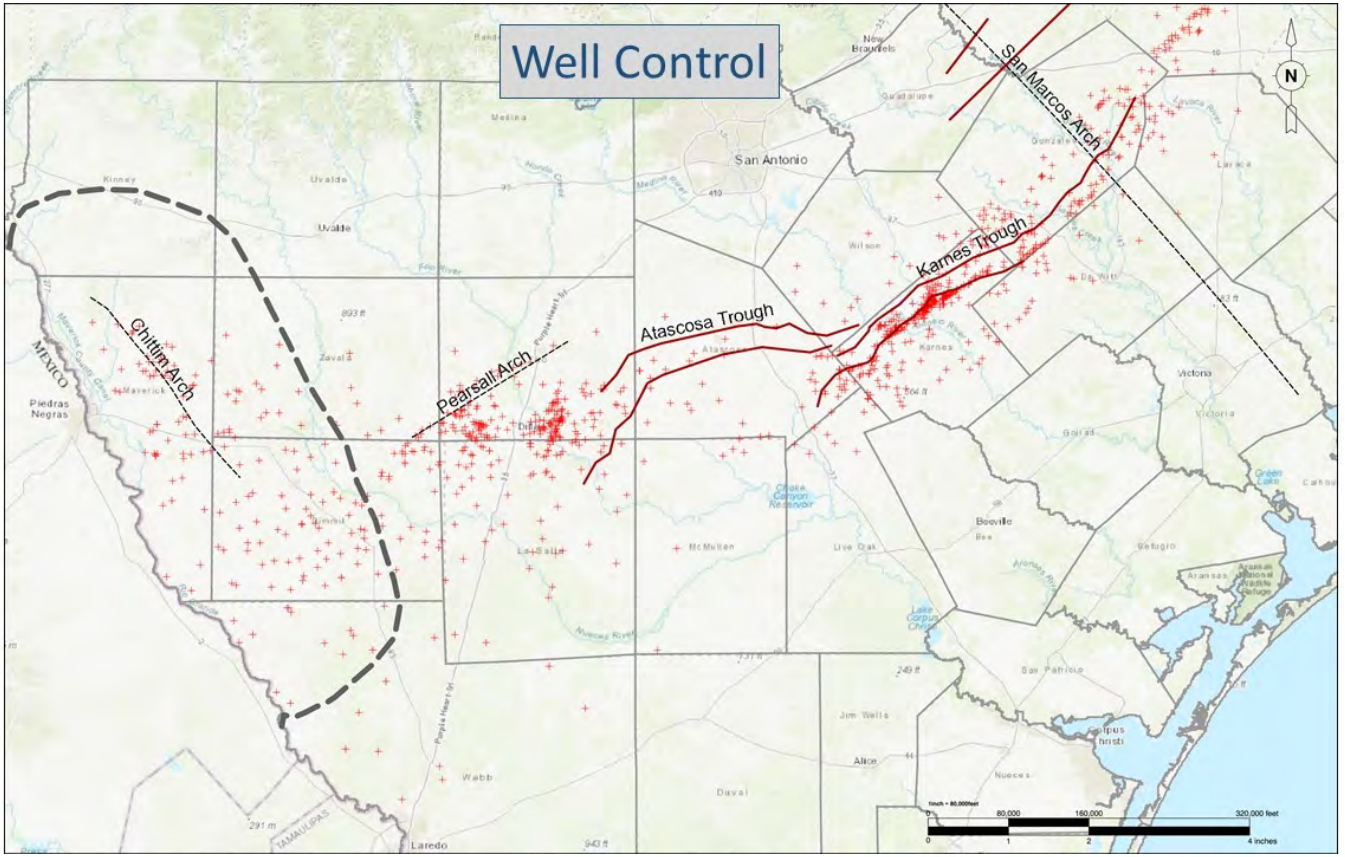
San Marcos Arch: forcing mechanism on depositional geometries in the Austin Chalk?

Yellow triangles: Volcanic centers ***(Ewing & Caran, 1982)***

Regional correlation

J.Calvert#1

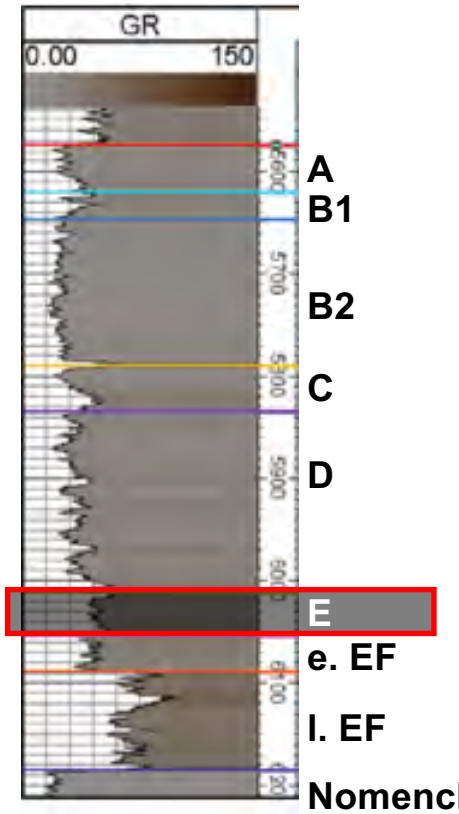




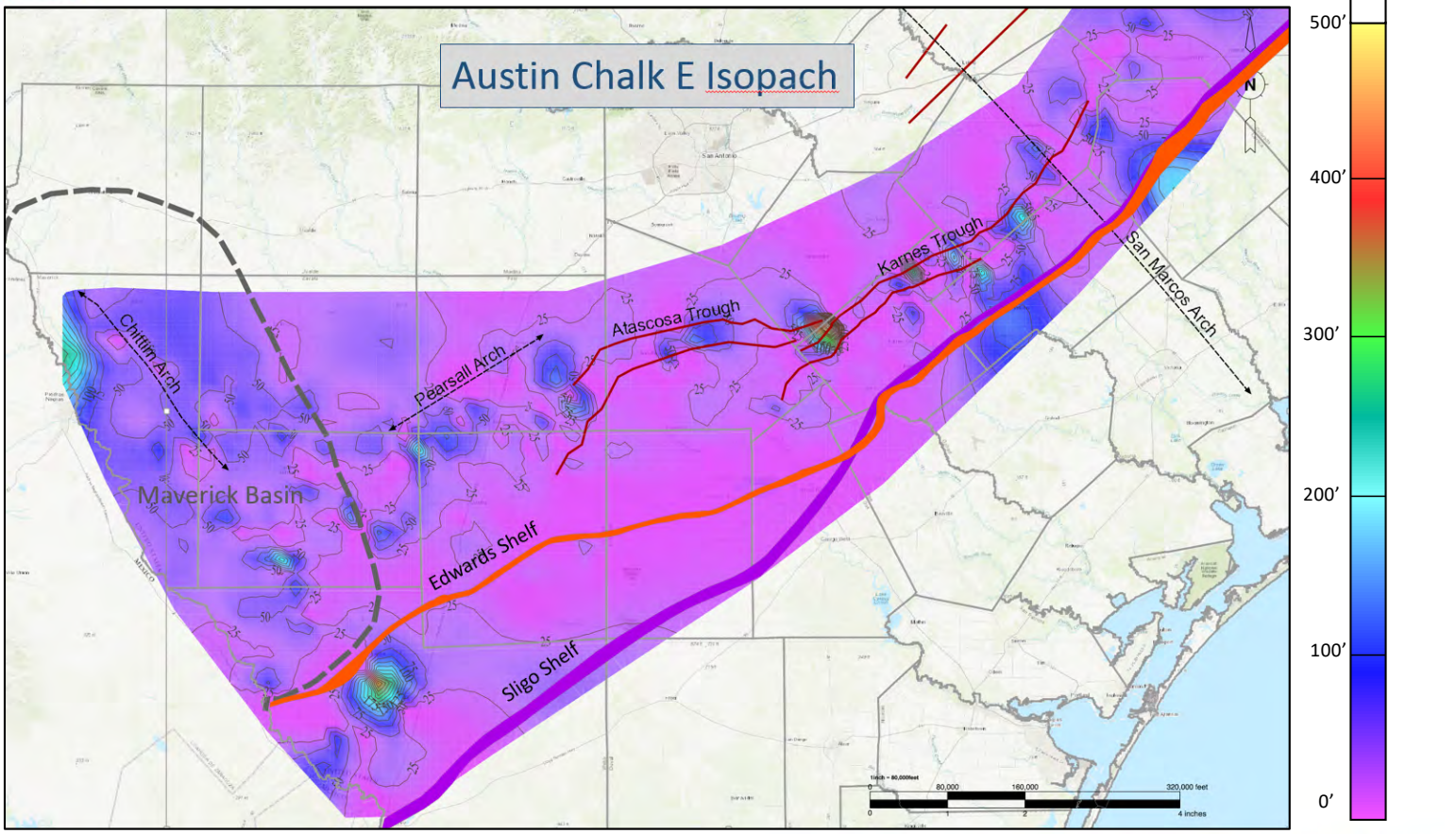
Nomenclature of Ewing (2013)

Regional correlation

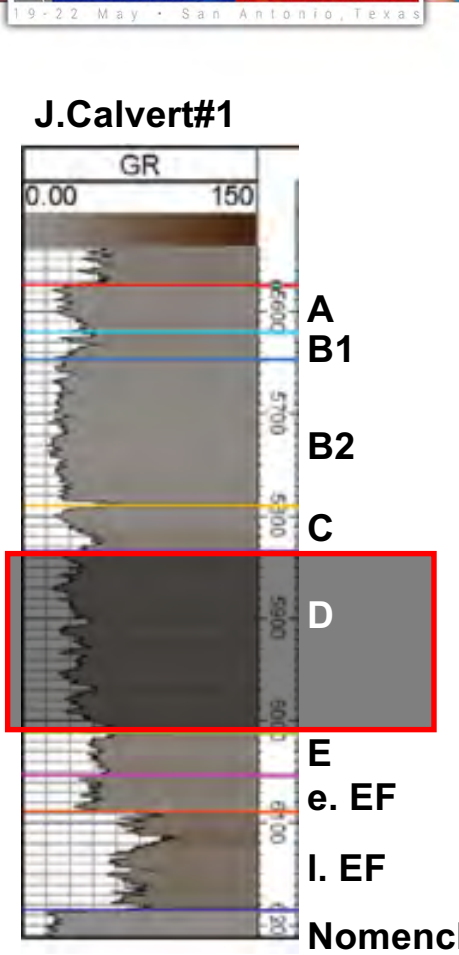
J.Calvert#1



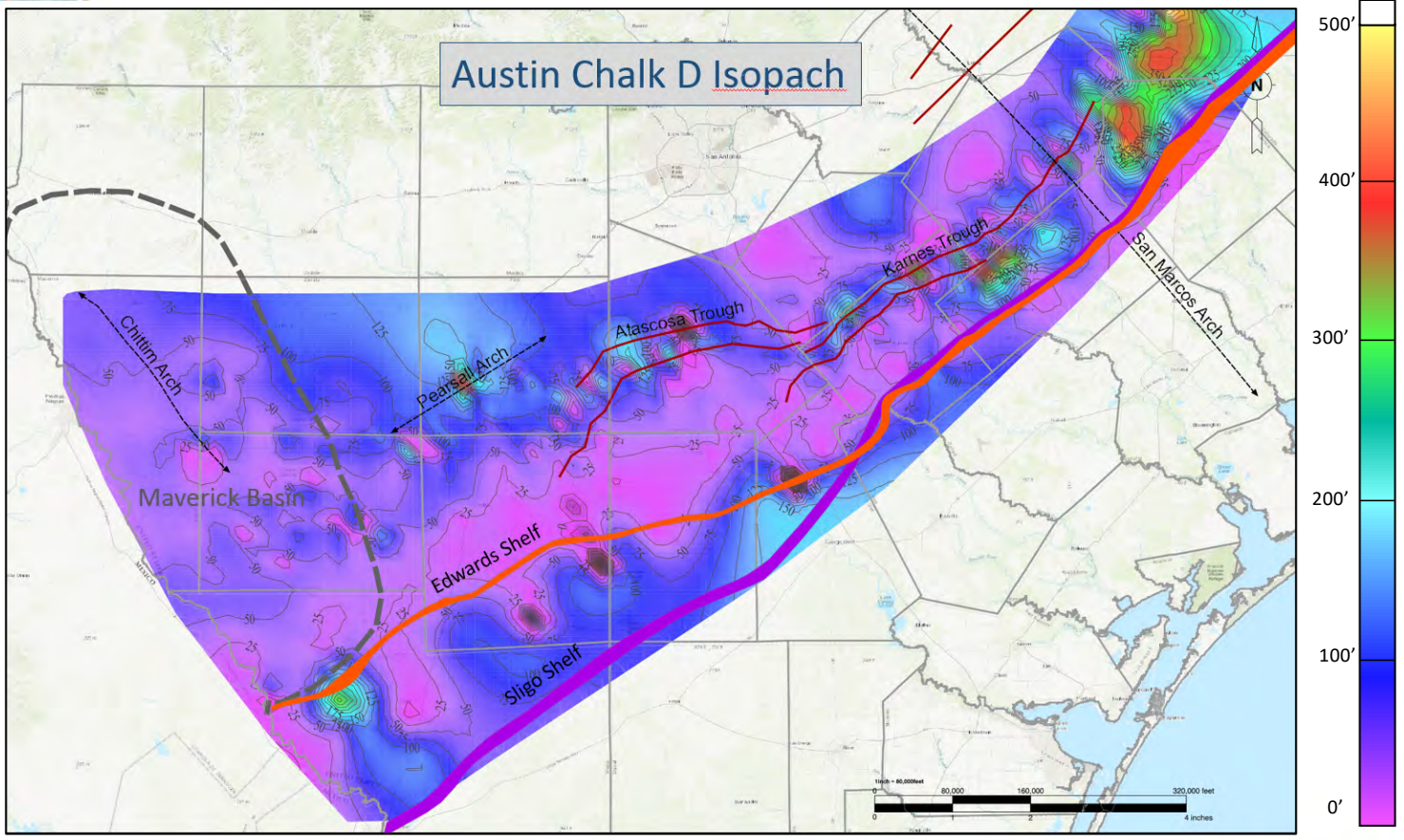
Nomenclature of Ewing (2013)



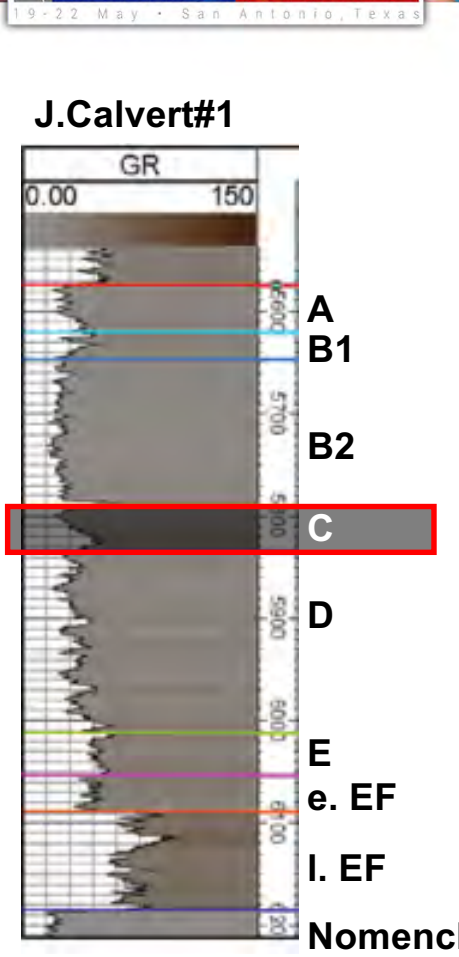
Regional correlation

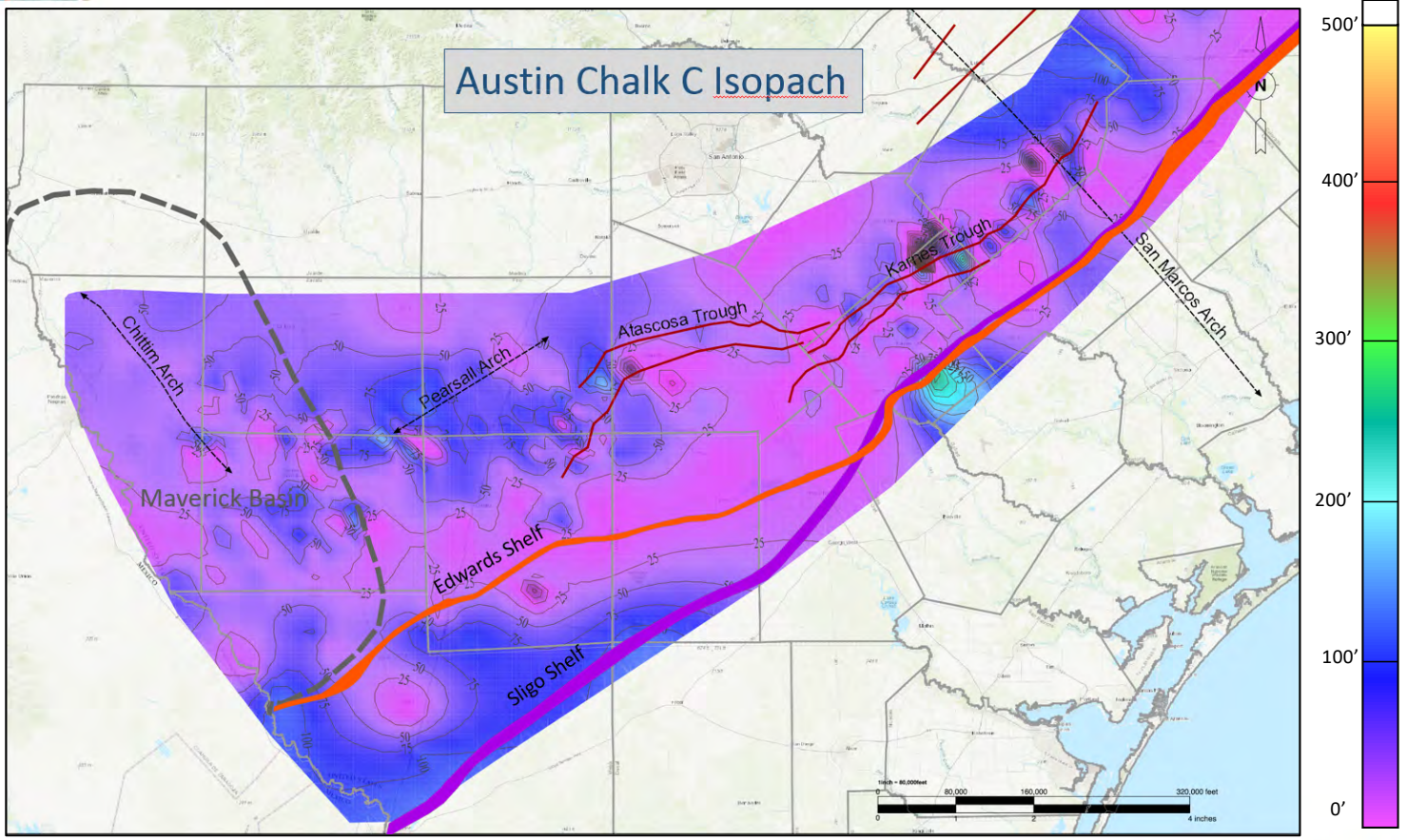


Nomenclature of Ewing (2013)



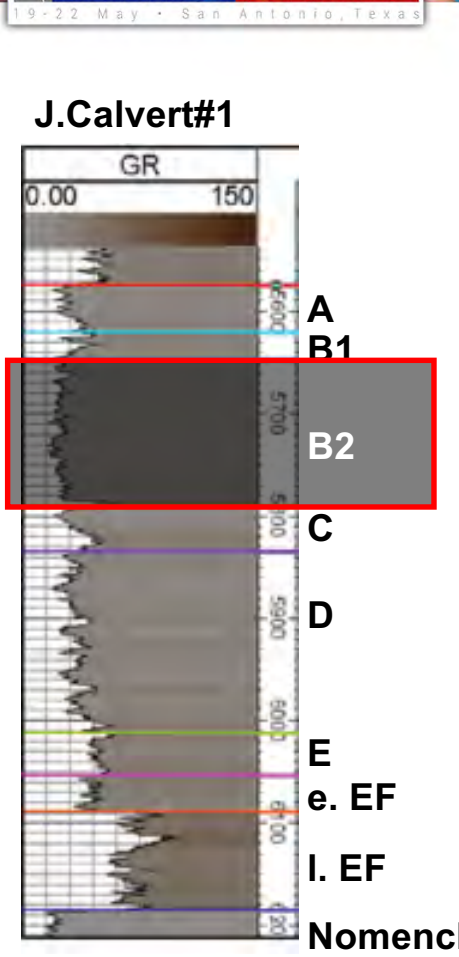
Regional correlation



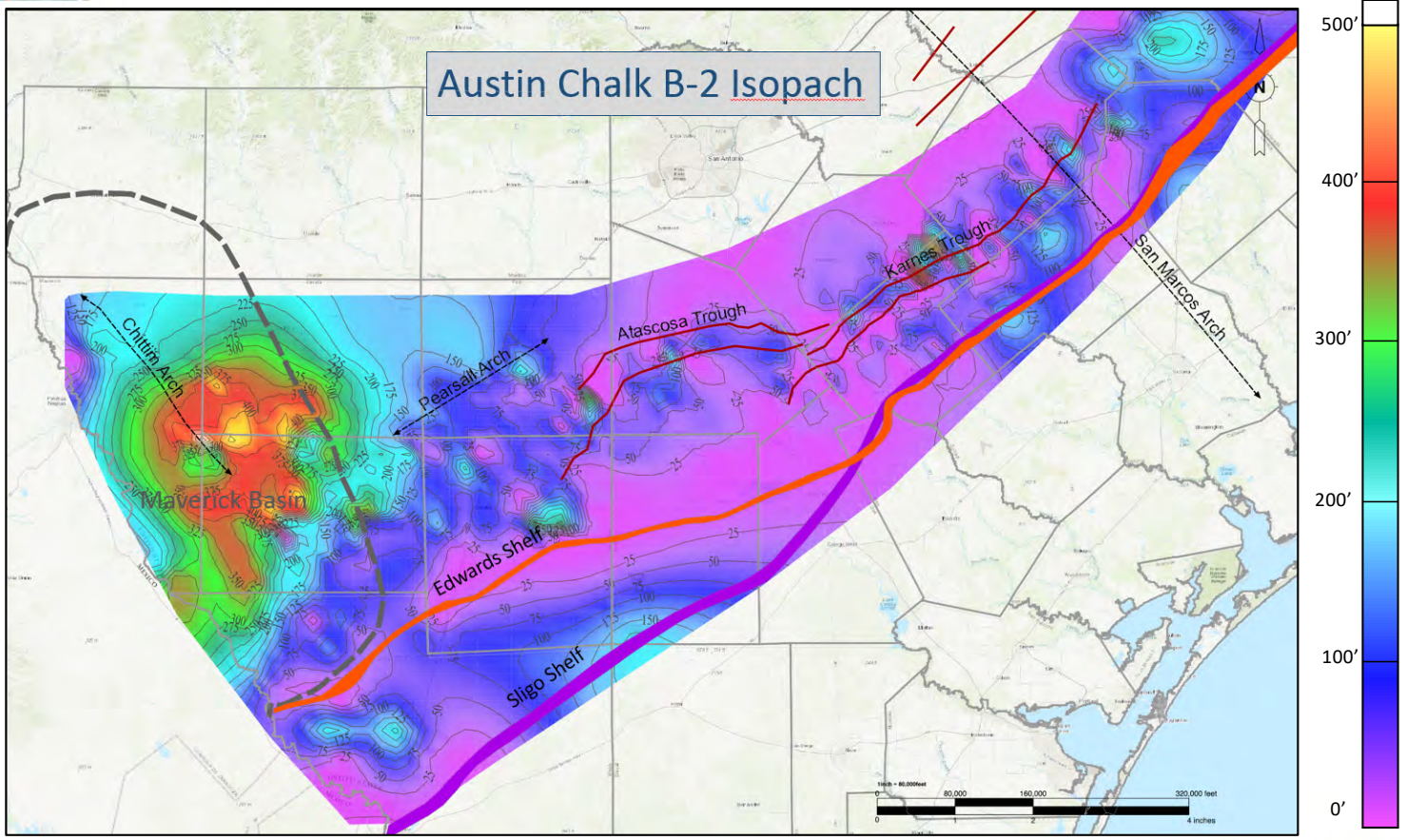


Nomenclature of Ewing (2013)

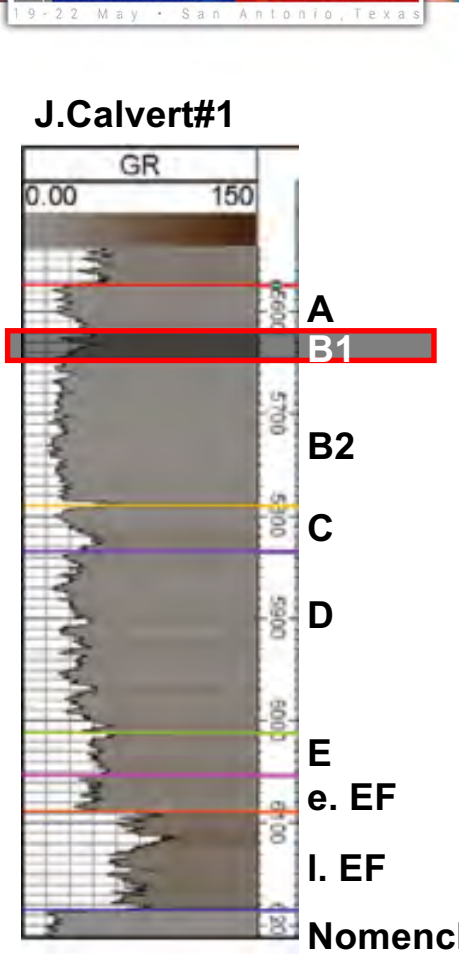
Regional correlation



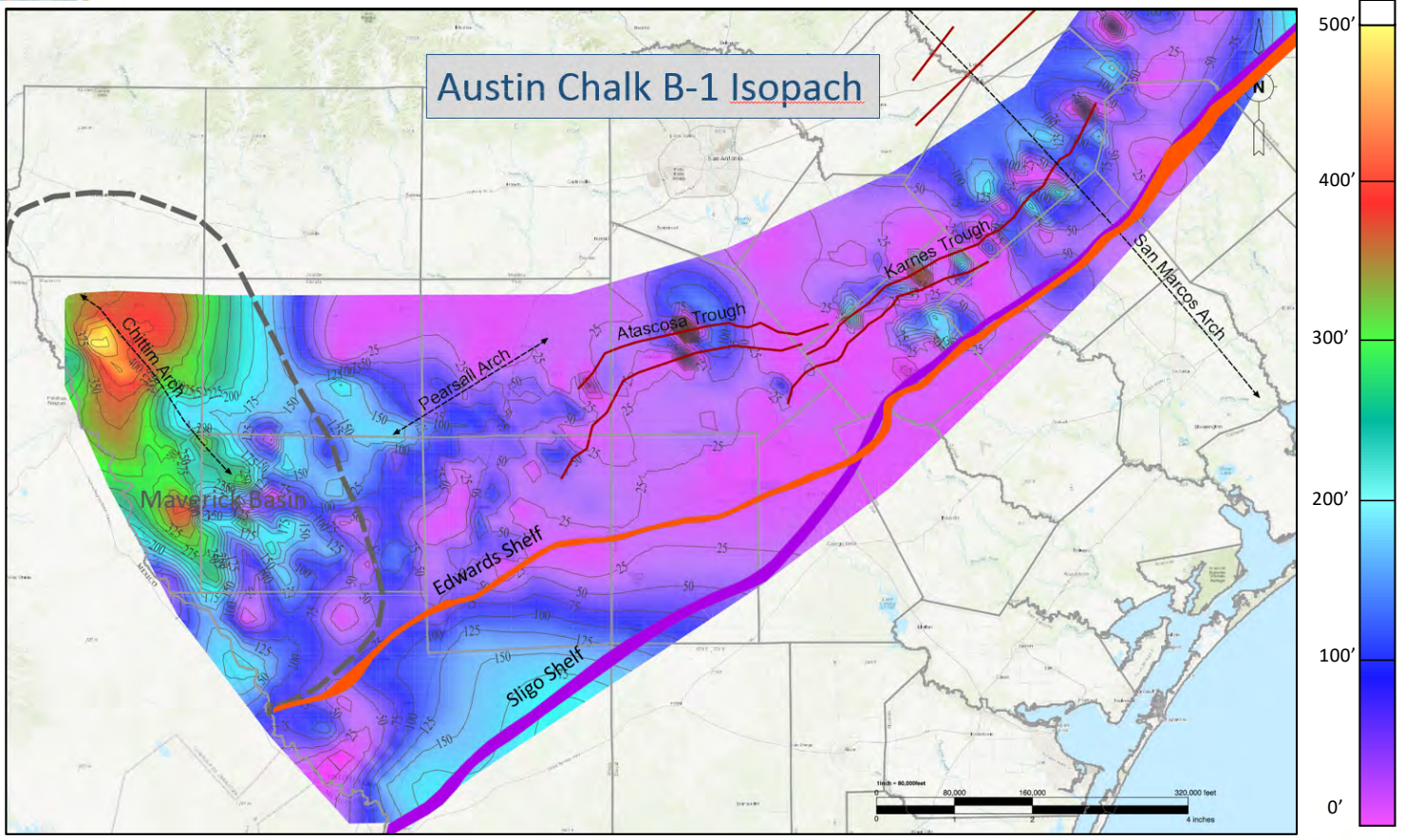
Nomenclature of Ewing (2013)



Regional correlation

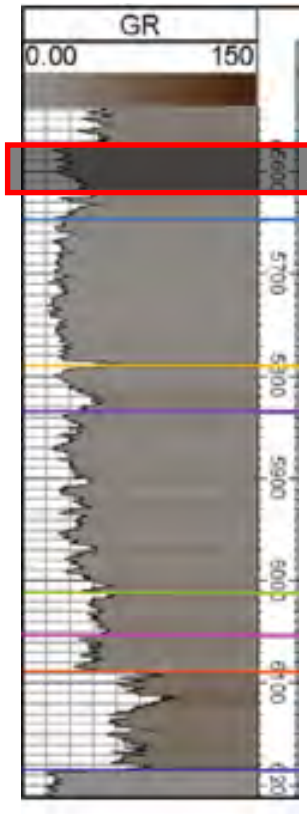


Nomenclature of Ewing (2013)



Regional correlation

J.Calvert#1



A

B1

B2

C

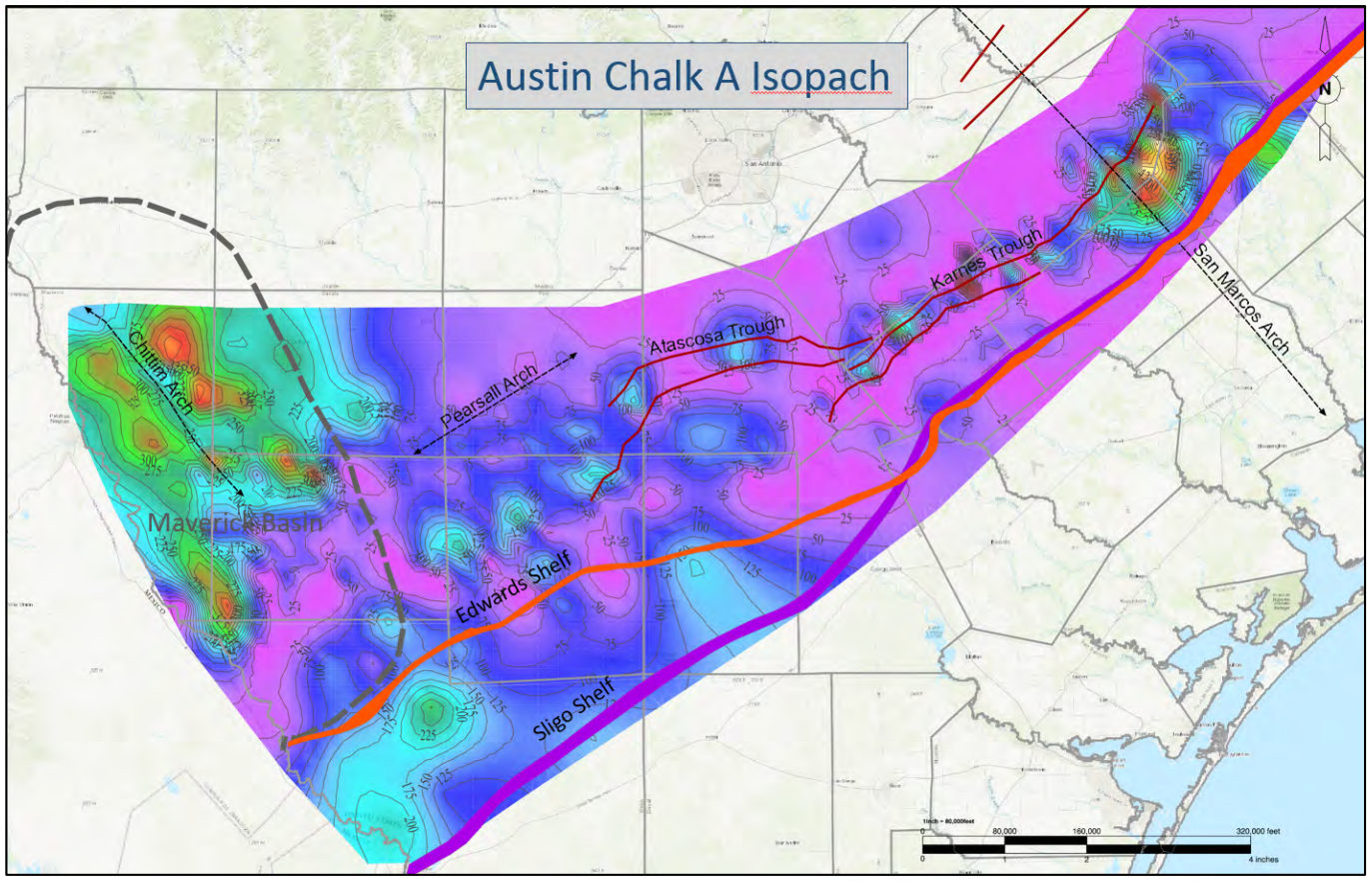
D

E

e. EF

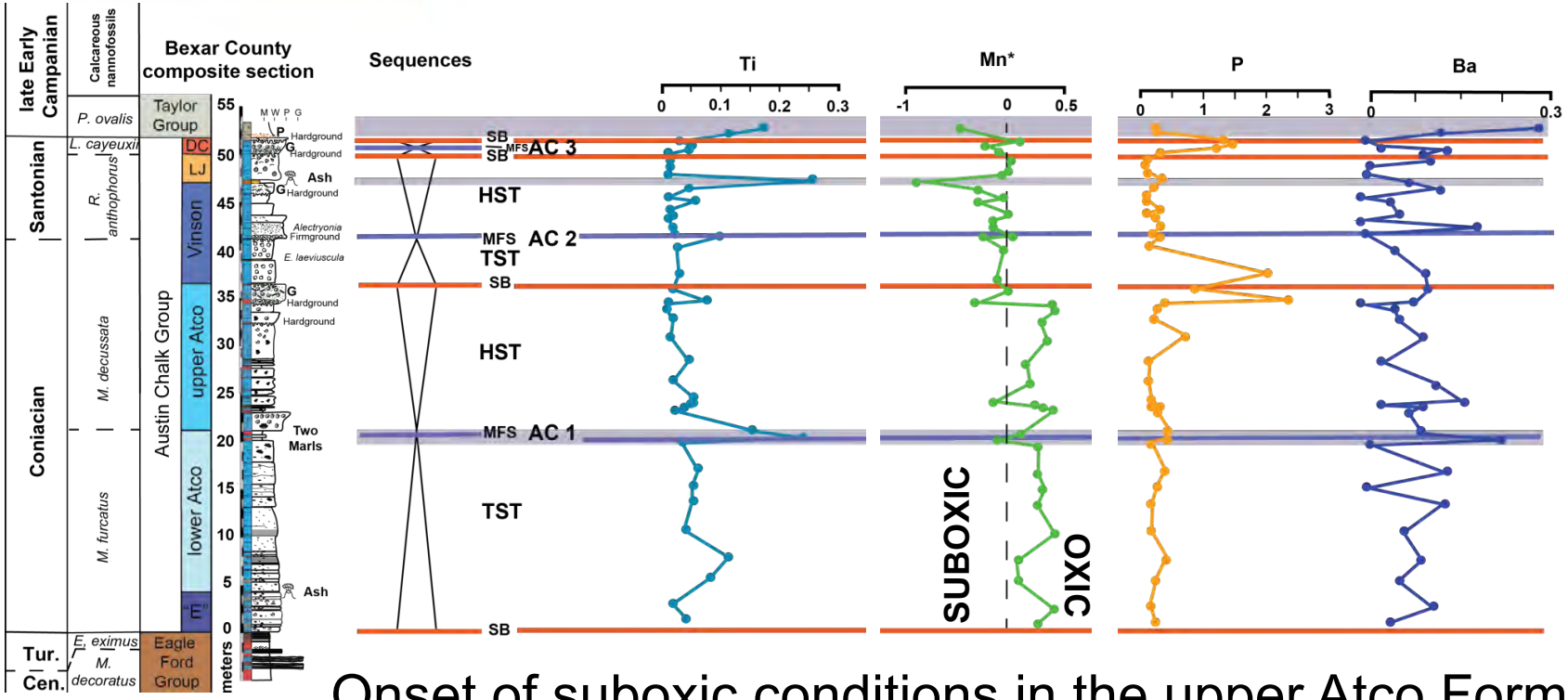
l. EF

Nomenclature of Ewing (2013)



Other forcing mechanisms?

XRF geochemical data



Onset of suboxic conditions in the upper Atco Formation associated with enhanced nutrient supply

Conclusions

Two main phases of condensation and/or omission: near the Coniacian – Santonian boundary and at the Austin Chalk – Taylor Groups boundary

Local and regional variations in thickness related to tectonically-enhanced subsidence

Paleoenvironmental change (nutrient, oxygenation) in the late Coniacian – Santonian: trigger for facies changes?