

Stratigraphic Architecture of Isolated Carbonate Platforms: A Case Study from the Mid-Cretaceous El Doctor Platform, Central Mexico*

Abdulah Eljalafi¹

Search and Discovery Article #30626 (2019)**

Posted September 9, 2019

*Adapted from presentation given at AAPG 2019 Annual Convention & Exhibition, San Antonio, Texas, May 19-22, 2019

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Abstract

The mid-Cretaceous (Albian-Cenomanian) El Doctor platform of central Mexico is one of a series of isolated platforms that record the final phase of shallow water carbonate deposition in the Western Gulf of Mexico. Vertical exposures of >400m provide insight into the complex facies relationships between shallow water shelfal carbonates and their marginal slope deposits. The distribution of shelf (El Abra Fm.) to basin (Cuesta del Cura Fm.) facies of the El Doctor platform suggest development of a progradational steep-walled platform that supported a rudist-dominated reef margin and associated grainy slope (Tamabra Fm.). This field-based study explores an outcrop analog for reservoirs associated with isolated carbonate platforms and their slope deposits (such as the Poza Rica field) to provide detailed lithologic characterization within platform environments. We interpret three dominant facies associations (FA) in the 730m of measured section and >300 samples collected: Platform Interior (**FA1**) deposits extend the length of the platform (~45km long and ~15km wide) and include miliolid wackestones, algal boundstones, and burrowed-skeletal packstones. Upward shallowing tidal cycles are characteristic of FA1. Platform Margin (**FA2**) deposits extend from a dominantly high energy shelf crest to the edge of the platform at the reef wall. FA2 is characterized by oo-pisolitic packstones-grainstones with fenestral porosity. Further offshore intertidal to subtidal deposits are dominated by coated grains consisting of skeletal debris (requiniids, caprinids, corals, chondrodontid clams). Skeletal content increases towards the shelf margin in the reef flat forming skeletal rudstones. A bound reef wall has not yet been identified in the field and could be attributed to the highly erosive tectonically modified nature of the platform margin, evident in the grainy nature of the fore-reef and slope deposits. Platform Slope (FA3) deposits consist of thin-bedded mudstones and packstones cut by megachannels up to 50m thick by 300m. The vertical transition from lower slope to fore-reef facies suggest a dominantly progradational system during the Albian-Cenomanian, a time when shallow water platforms reached their maximum extent around the GOM. The volume of grainy material on the slope attests to the amount of shedding from the shelfal deposits during a highstand period. The shelf to basin profile investigated here provides an important analog for reservoir scale characterization of platform margin and slope deposits that comprise significant oil and gas fields in Mexico (eg. Tuxpan, Cordoba, Campeche-Yu-catan platforms). The scale of vertical exposure at El Doctor provides a unique opportunity to study the characteristics and facies relationships of a Cretaceous shallow water carbonate platform and associated slope and basinal deposits.

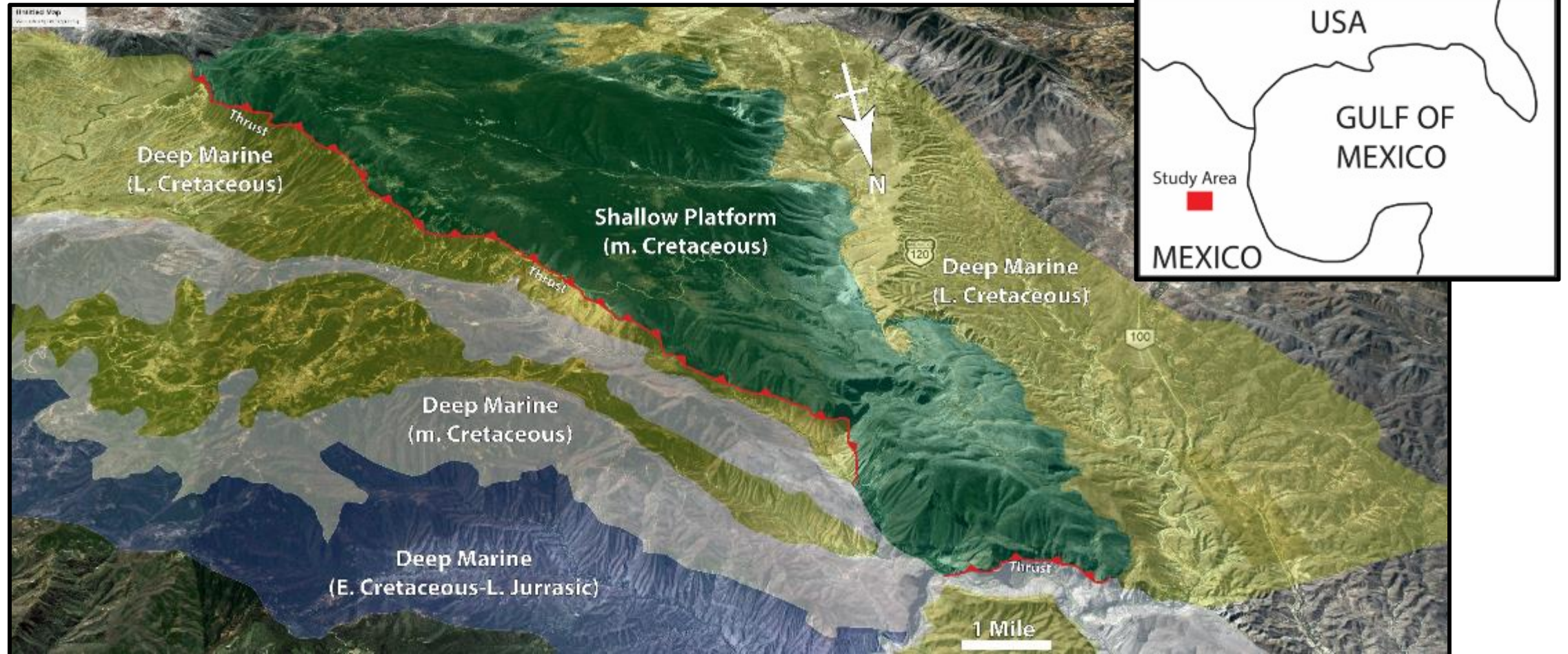
Selected References

Enos, P., 1977, Holocene sediment accumulations of the south Florida shelf margin: in Quaternary Sedimentation in South Florida, Enos, P., and R.D. Perkins, (eds), Geological Society of America, Memoir 147, p. 1-130.

Janson, X., C. Kerans, R. Loucks, M.A. Marhx, C. Reyes, and F. Murguia, 2011, Seismic architecture of a Lower Cretaceous platform-to-slope system, Santa Agueda and Poza Rica fields, Mexico: AAPG Bulletin, v. 95/1, p. 105–146. doi: <https://doi.org/10.1306/06301009107>

Phelps, R.M., C. Kerans, R.G. Loucks, R.W. Scott, B.P. Da Gama, J. Jeremiah, and D. Hull, 2014, Oceanographic and eustatic control of carbonate platform evolution and sequence stratigraphy on the Cretaceous (Valanginian-Campanian) passive margin, northern Gulf of Mexico: Sedimentology, v. 61, p. 461–496.

STRATIGRAPHIC ARCHITECTURE OF ISOLATED CARBONATE PLATFORMS: A CASE STUDY FROM THE MID-CRETACEOUS EL DOCTOR PLATFORM, CENTRAL MEXICO



Acknowledgements:



**Charles
Kerans**

**Paul
Enos**

**Fernando
Nunez**

**Abdulah
Eljalafi**



Acknowledgements:



Manolo



Mario



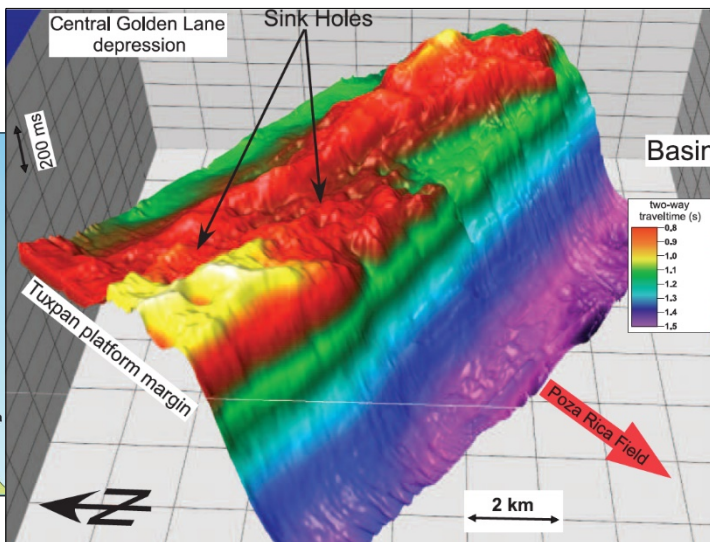
Introduction



Project Motivation



(Janson et al., 2011)



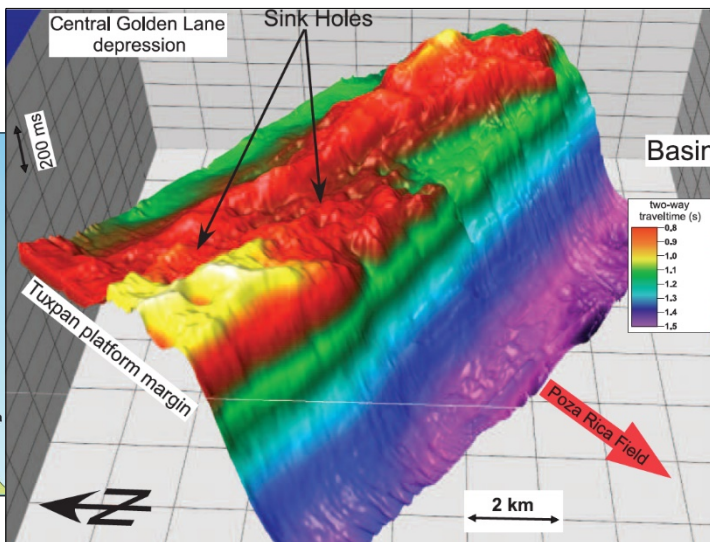
Introduction



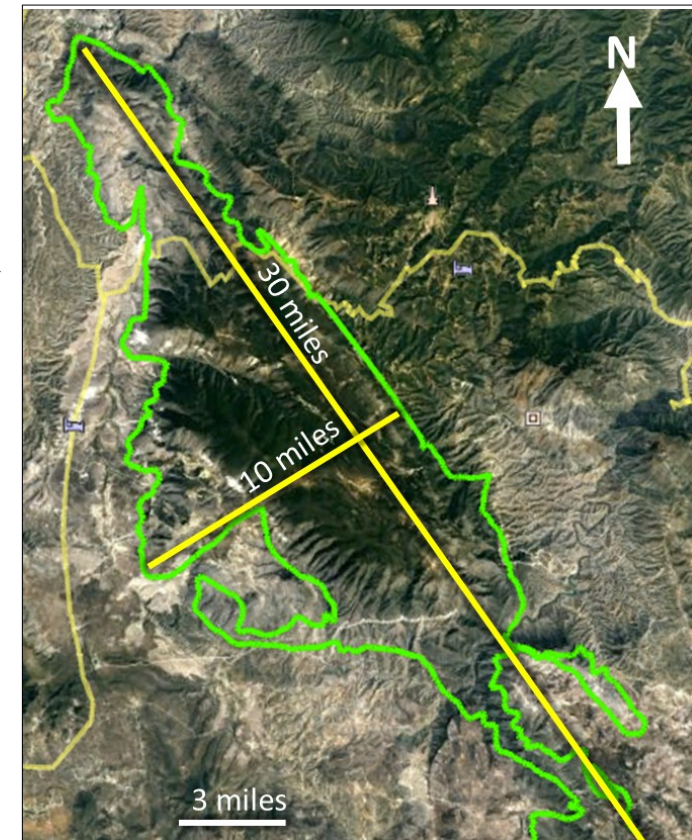
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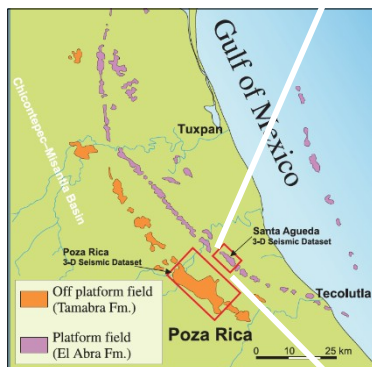
Field Area and Methods



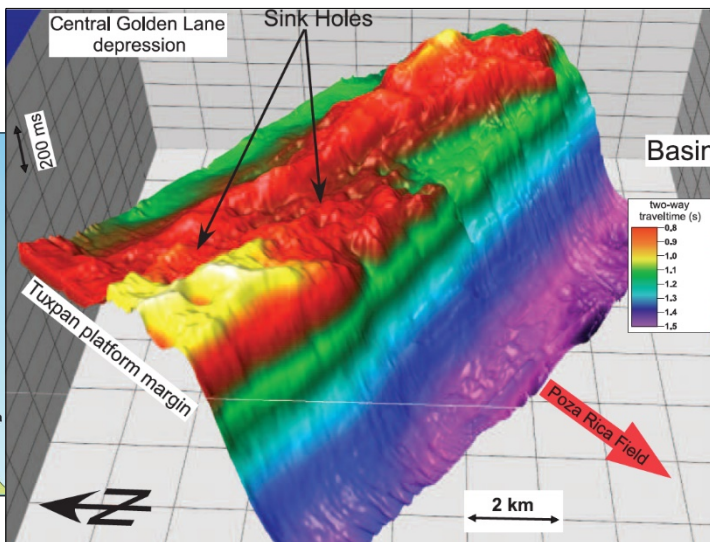
Introduction



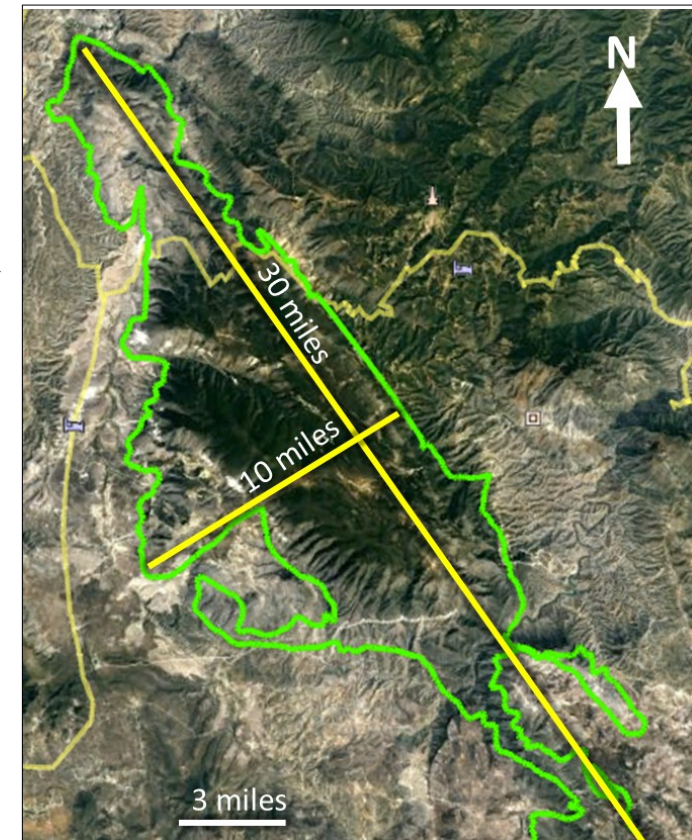
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Field Area and Methods



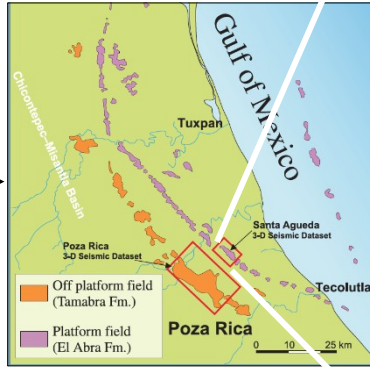
Facies Analysis



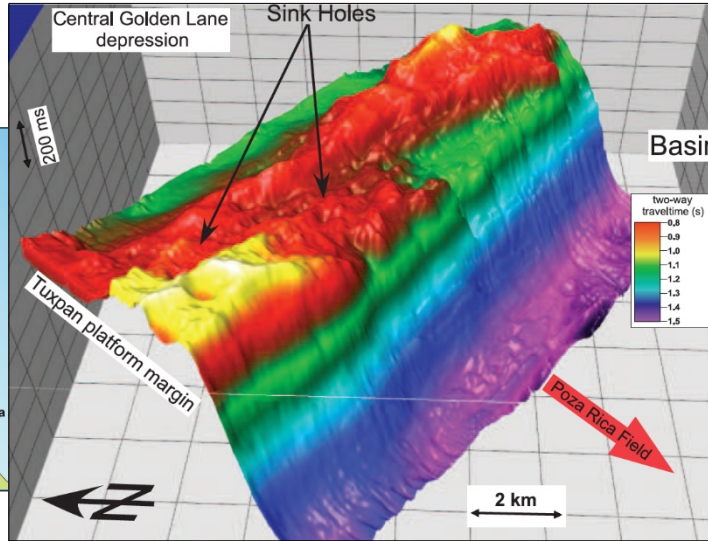
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Project Motivation



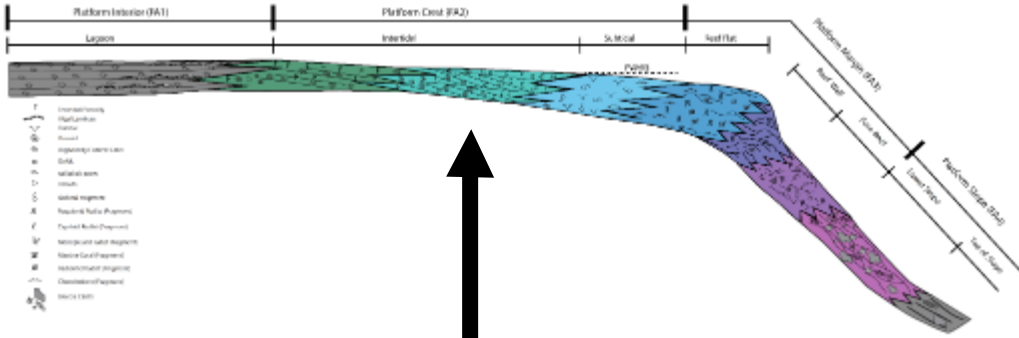
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Field Area and Methods



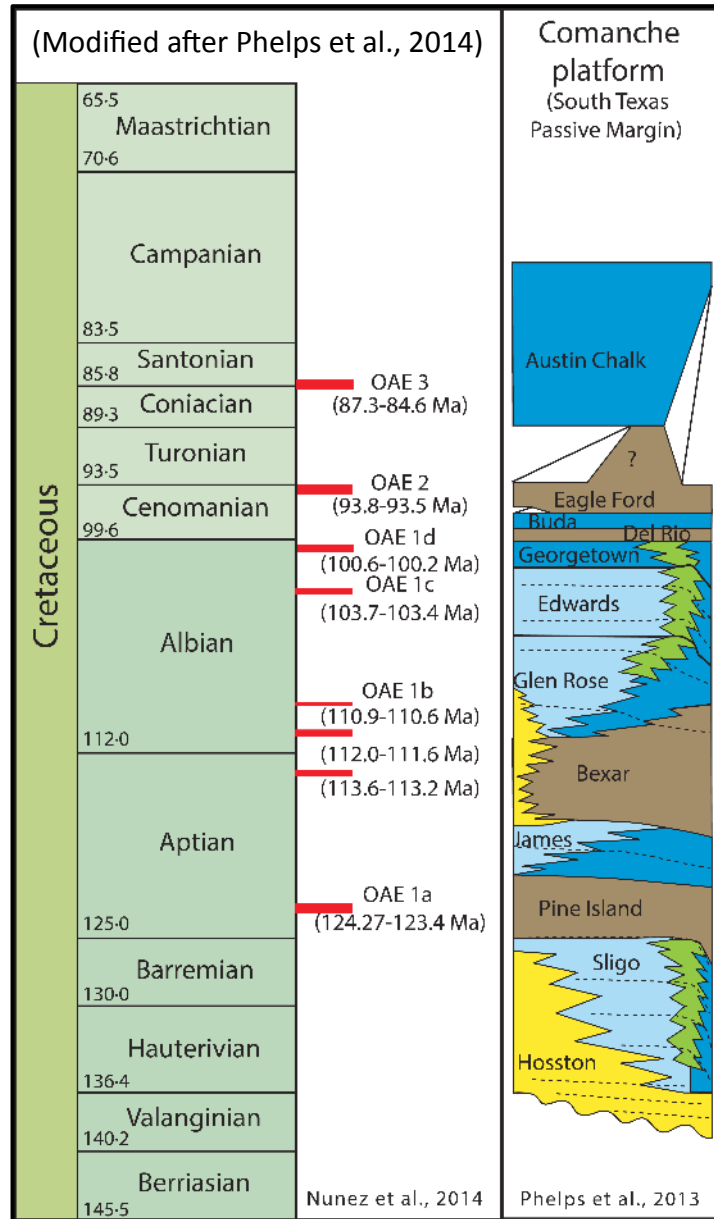
Preliminary Results



Facies Analysis

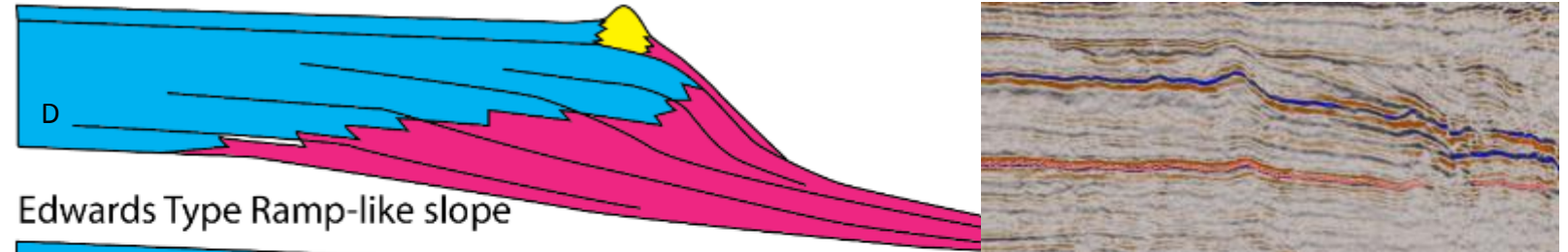


Project Motivation: Platform Response to OAEs

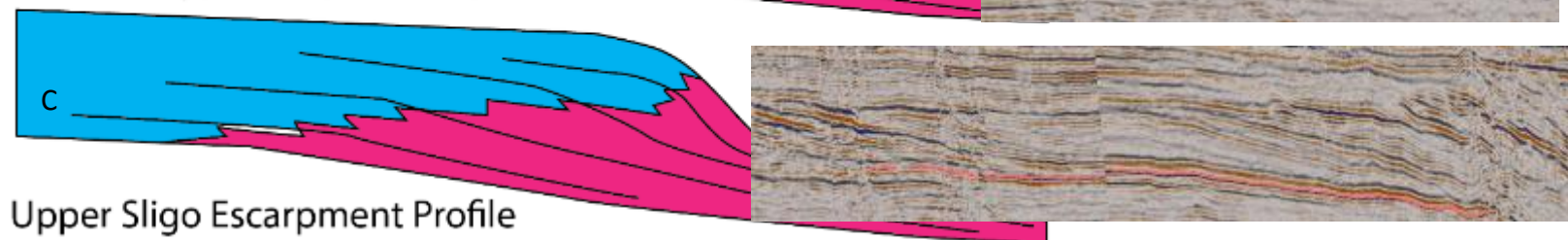


Sligo-Glen Rose/Edwards Margin Types

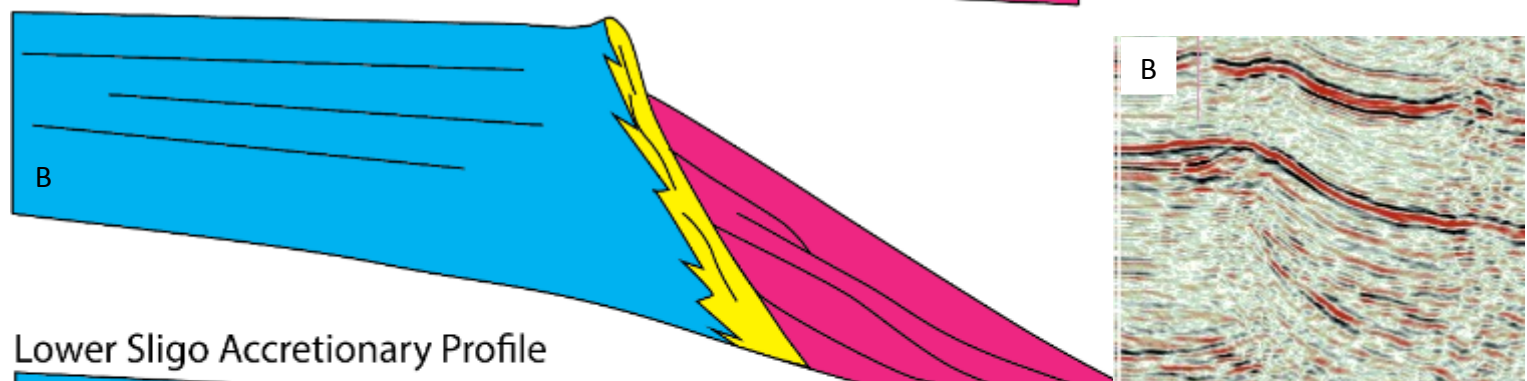
Latest Edwards (Grgtwn) Backstepped Rim



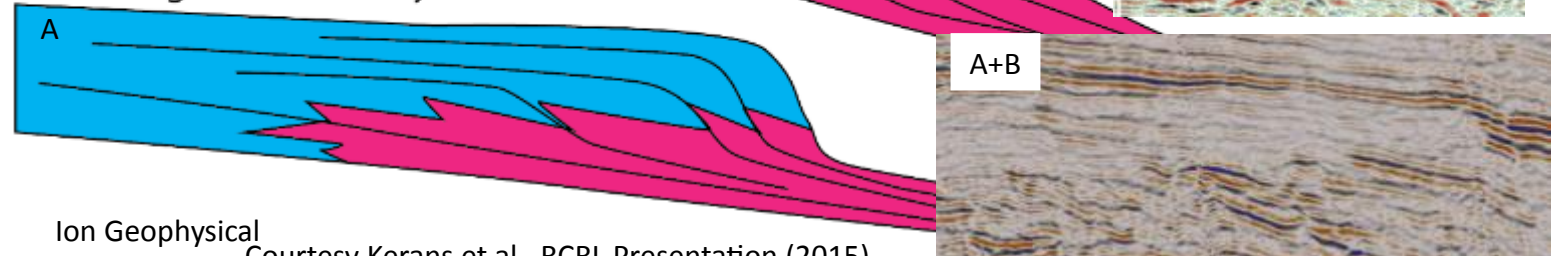
Edwards Type Ramp-like slope



Upper Sligo Escarpment Profile



Lower Sligo Accretionary Profile



Ion Geophysical

Courtesy Kerans et al., RCRL Presentation (2015)

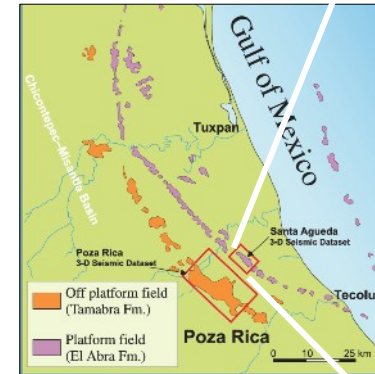
Research Objectives



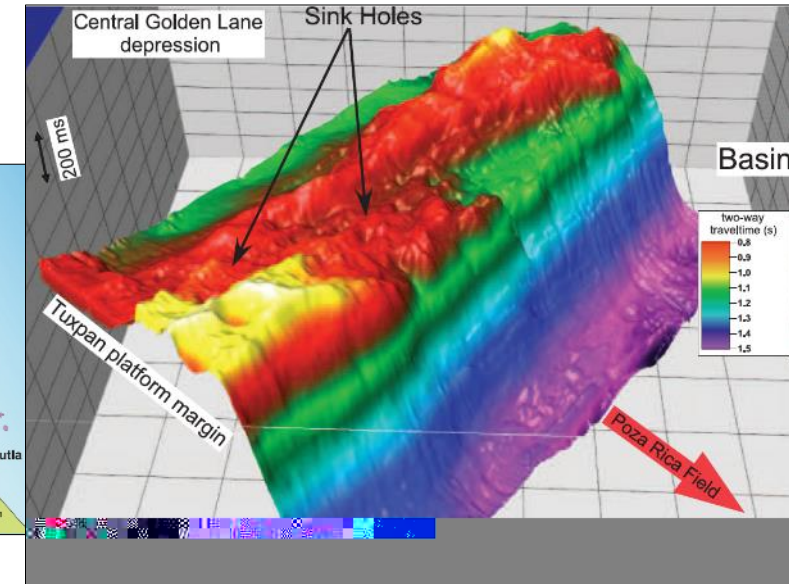
- ☐ Shelf to basin profile characterization for Mid-Cretaceous isolated platforms in Mexico
 - ☐ Strike and dip variability at El Doctor platform exposures
 - ☐ Comparison to:
 - ☐ VSLP
 - ☐ Tuxpan
 - ☐ Comanche Shelf

El Doctor Platform (This Study)

Tuxpan Platform



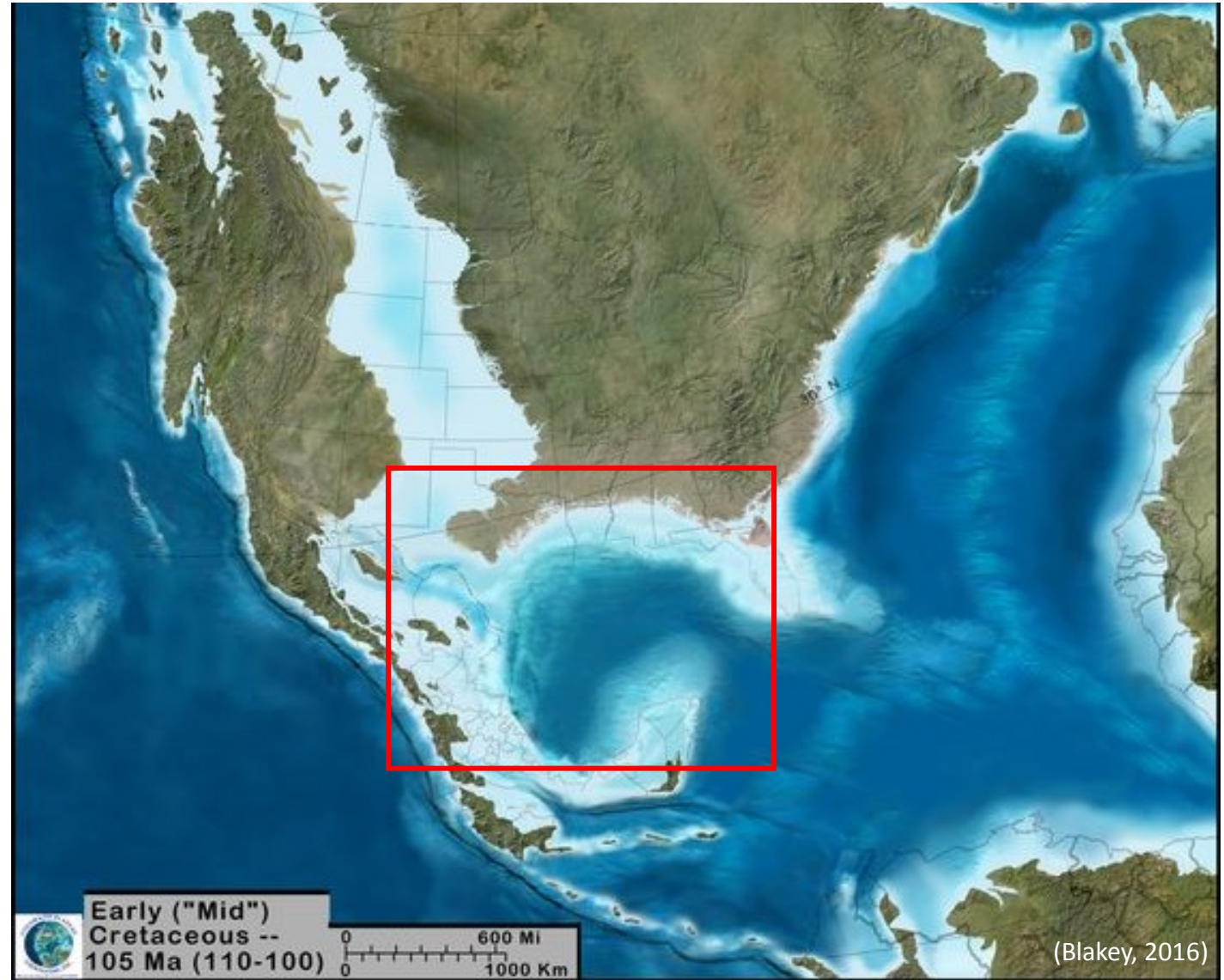
(Janson et al., 2011)



Study Area - Paleogeography

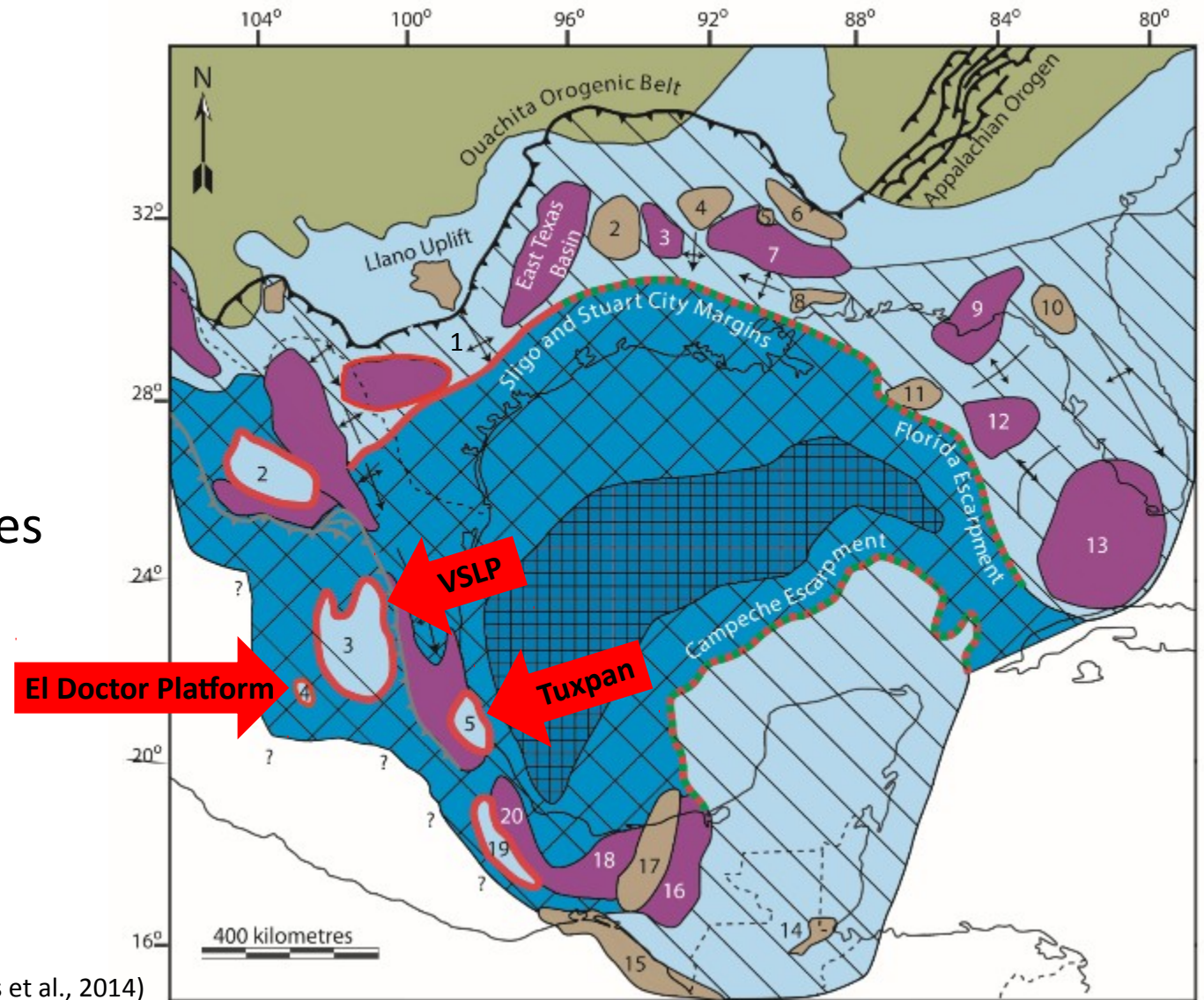
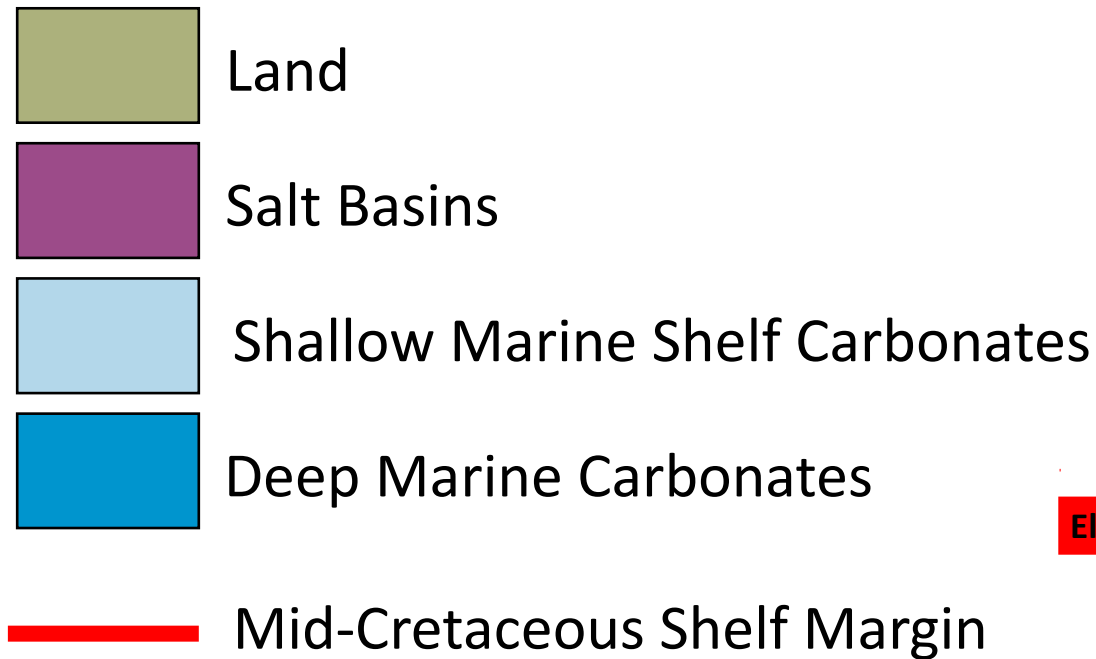


PERIOD	EPOCH	AGE	PICKS (Ma)
CRETACEOUS	LATE	MAASTRICHTIAN	66.0
			72.1
		CAMPANIAN	
			83.6
		SANTONIAN	86.3
		CONIACIAN	89.8
		TURONIAN	93.9
		CENOMANIAN	100
	EARLY	ALBIAN	113
			113
		APTIAN	
			126
		BARREMIAN	131
		HAUTERIVIAN	134
		VALANGINIAN	139
		BERRIASIAN	145



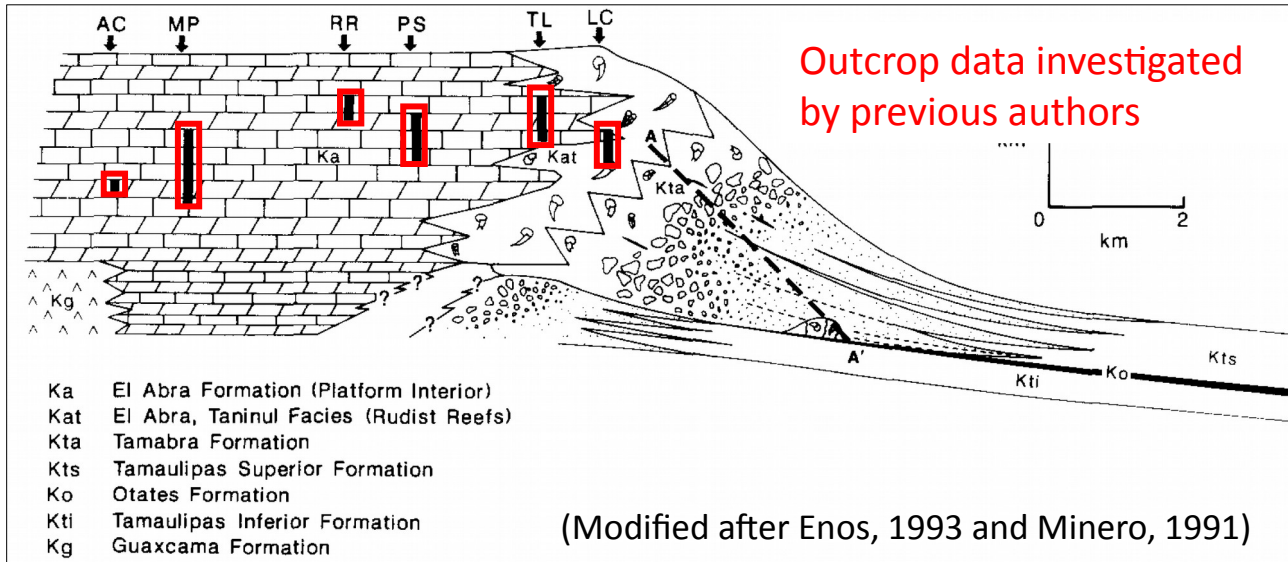
(Blakey, 2016)

Study Area - Paleogeography



(After Phelps et al., 2014)

Isolated Platform Depositional Models



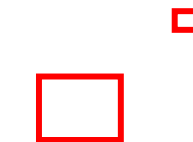
Outcrop Based Models – VSLP

- ☐ Lack full spectrum of platform environments
- ☐ No stratigraphic correlation base
- ☐ Discontinuous quarry cuts
- ☐ Discontinuous outcrops with heavy vegetation cover
- ☐ No appreciation of true platform scale

Subsurface Based Models – Tuxpan

- ☐ Very limited “rock data”
- ☐ Data availability concentrated mainly in distal slope (Tamabra Fm.)
- ☐ Scarce wells in platform top environments
- ☐ Heavy Karstification in platform top

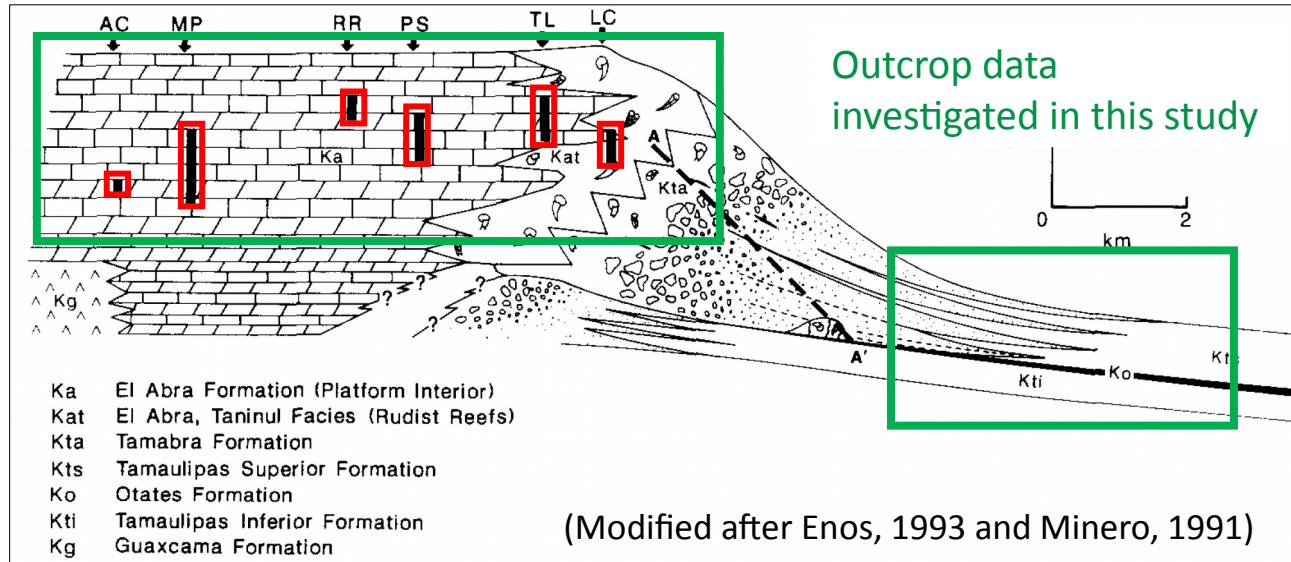
(Modified after Enos, 1993)



Subsurface data investigated by previous authors

(Enos, 1977)

Isolated Platform Depositional Models



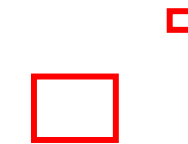
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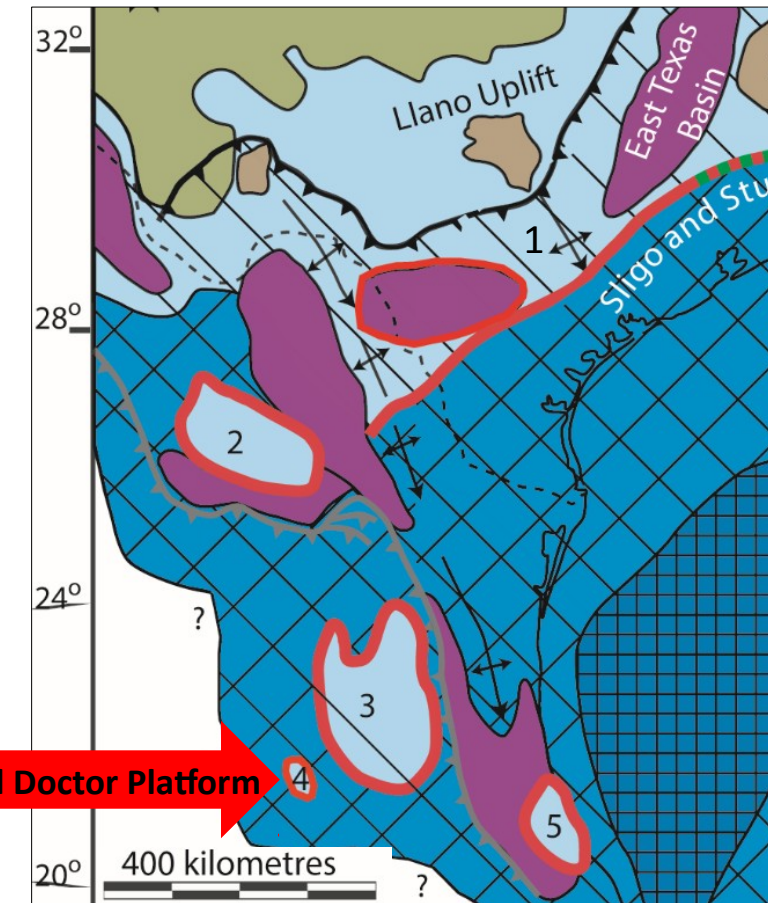
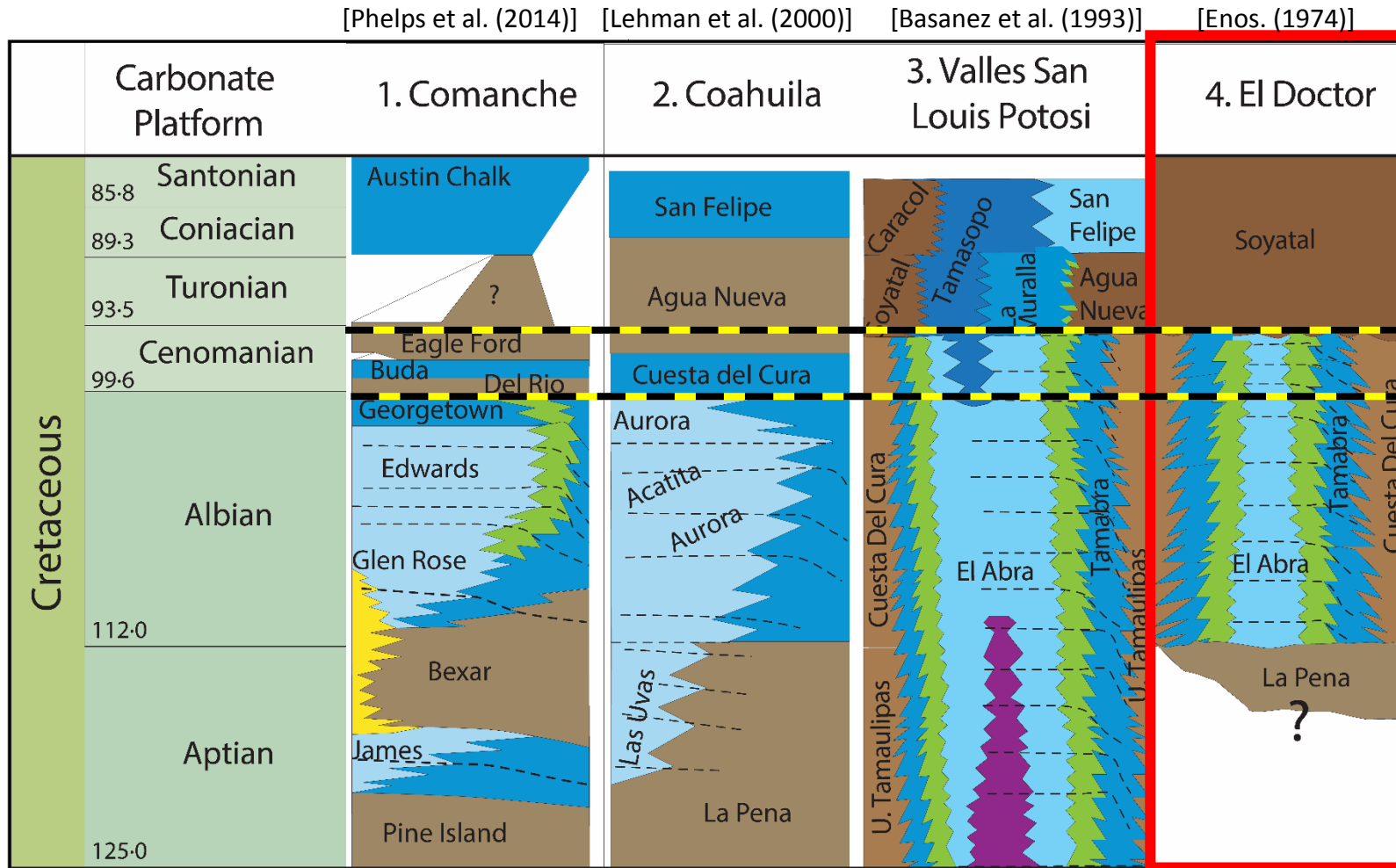
(Modified after Enos, 1993)



Subsurface data investigated by
previous authors

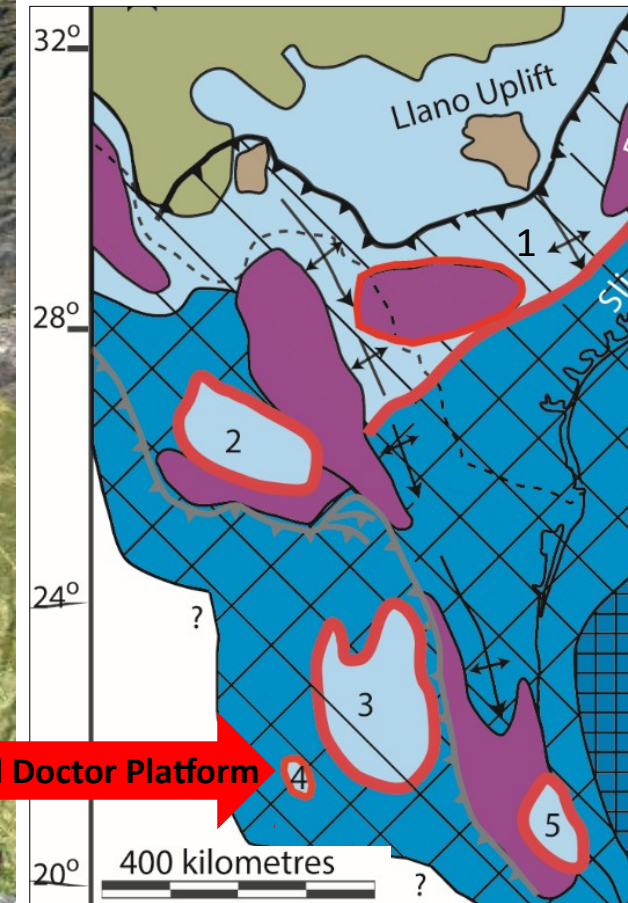
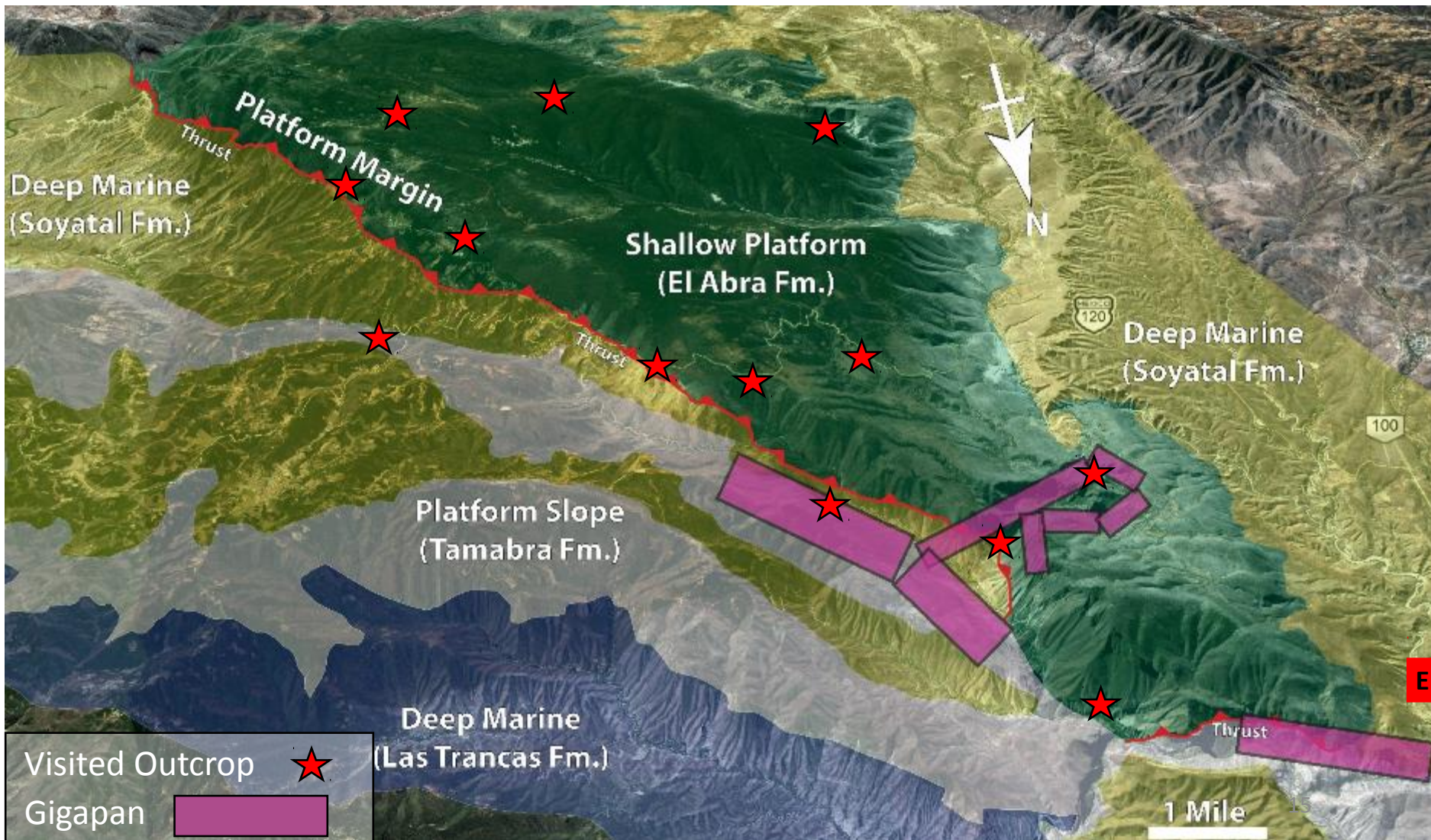
(Enos, 1977)

Study Area - Stratigraphy



(After Phelps et al., 2014)

Study Area – Outcrop Distribution

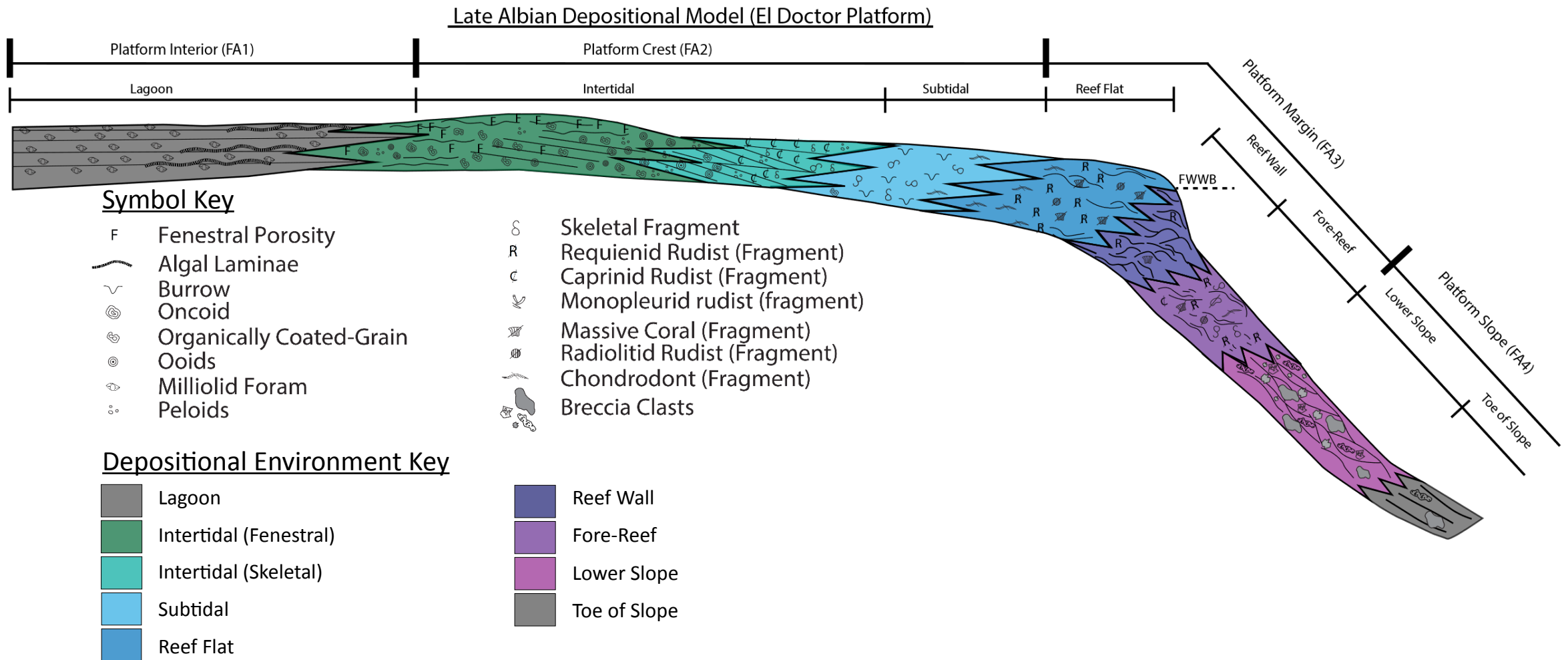


(After Phelps et al., 2014)

Results – Shelf to Basin Facies Distribution



Significant variations along shelf margin -> influence on platform interior deposits



Results – Shelf to Basin Facies Distribution



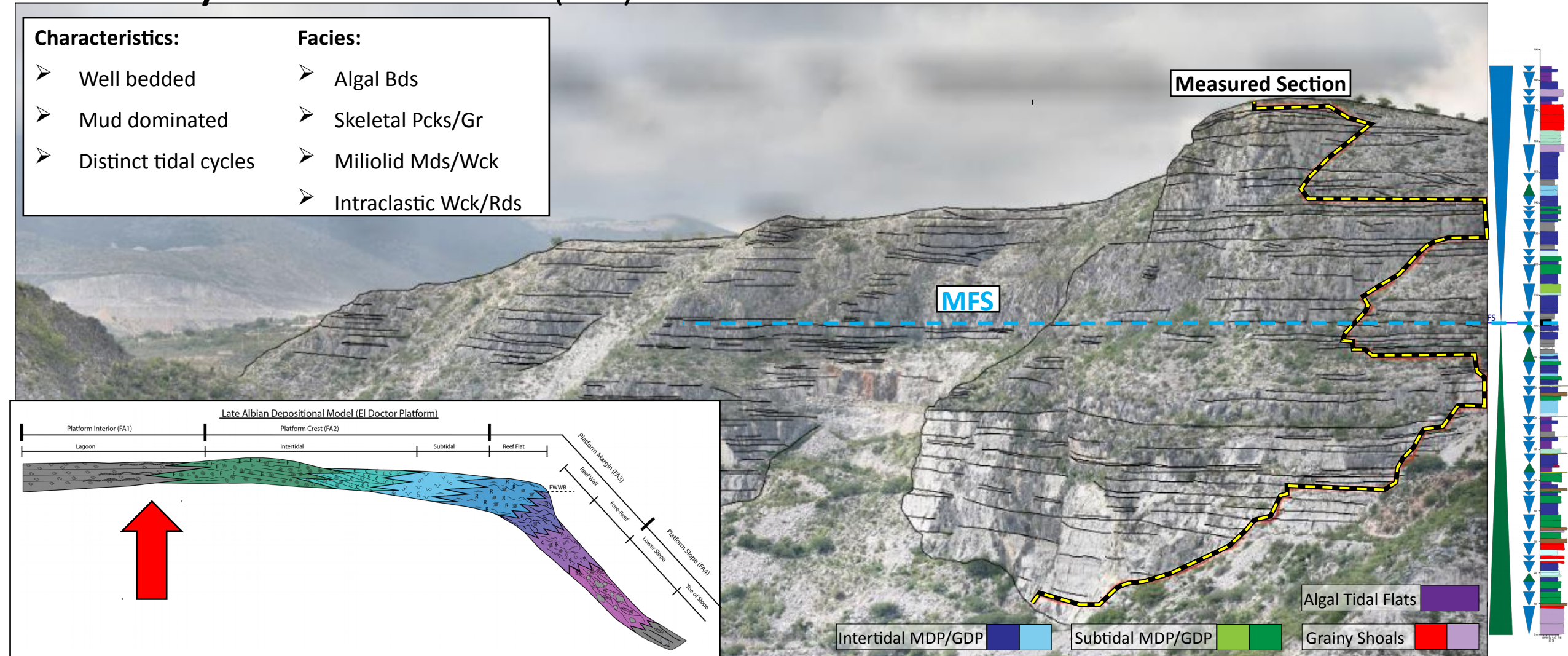
Facies Analysis- Platform Interior (FA1)- Intertidal to Shallow Subtidal

Characteristics:

- Well bedded
- Mud dominated
- Distinct tidal cycles

Facies:

- Algal Bds
- Skeletal Pcks/Gr
- Miliolid Mds/Wck
- Intraclastic Wck/Rds



Motivation

Background

Problem Statement

Study 1

Study 2

Study 3

Timeline

Results – Shelf to Basin Facies Distribution



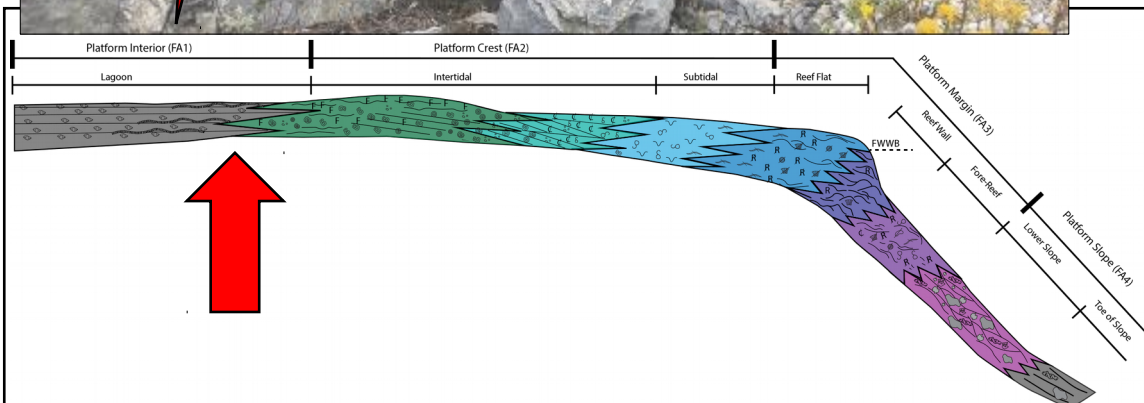
Facies Analysis- Platform Interior (FA1)- Intertidal to Shallow Subtidal

Algal Boundstone- cycle top



Burrowed Wck/Pck- cycle base

Gastropod/rudist Pcks/Flts- mid cycle



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Results – Shelf to Basin Facies Distribution



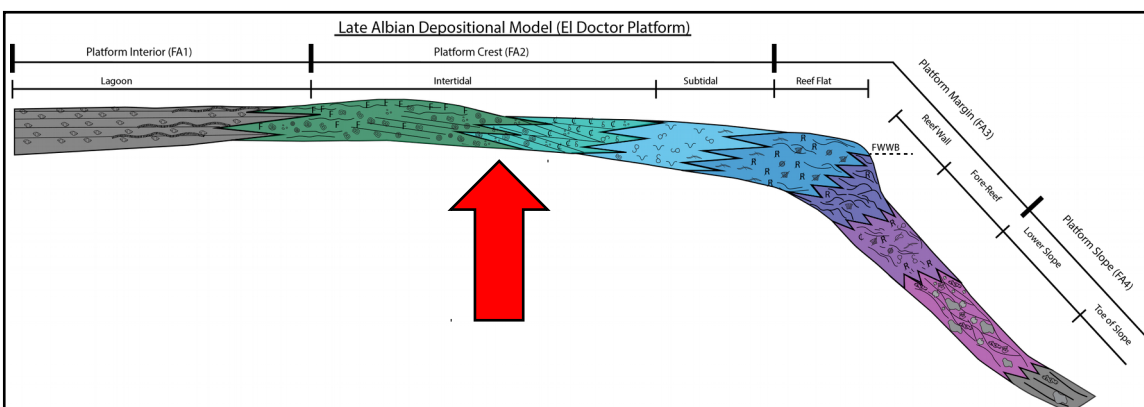
Facies Analysis- Platform Crest (FA2)- Supratidal to Intertidal (Foreshore)

Characteristics:

- Highly amalgamated
- Indistinct bedding
- High energy
- Aggradational

Facies:

- Fenestral Pcks/Gr
- Coated Skeletal Pcks/Gr
- Ooid-Pisolite Gr
- Intraclastic Gr/Rds



Motivation

Background

Problem Statement

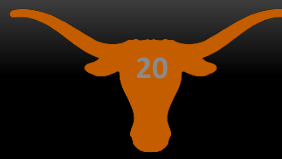
Study 1

Study 2

Study 3

Timeline

Results – Shelf to Basin Facies Distribution



Facies Analysis- Platform Crest (FA2)- Supratidal to Intertidal (Foreshore)

Tepee Structures

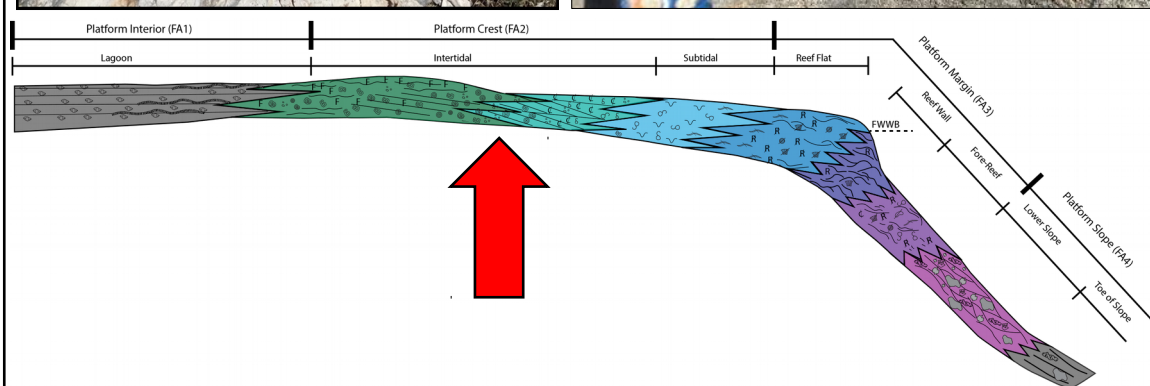


Coated Grain-Skeletal Gr Shoals



Facies:

- Fenestral Pcks/Gr
- Coated Skeletal Pcks/Gr
- Ooid-Pisolite Gr
- Intraclastic Gr/Rds



Motivation

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Study 2

Study 3

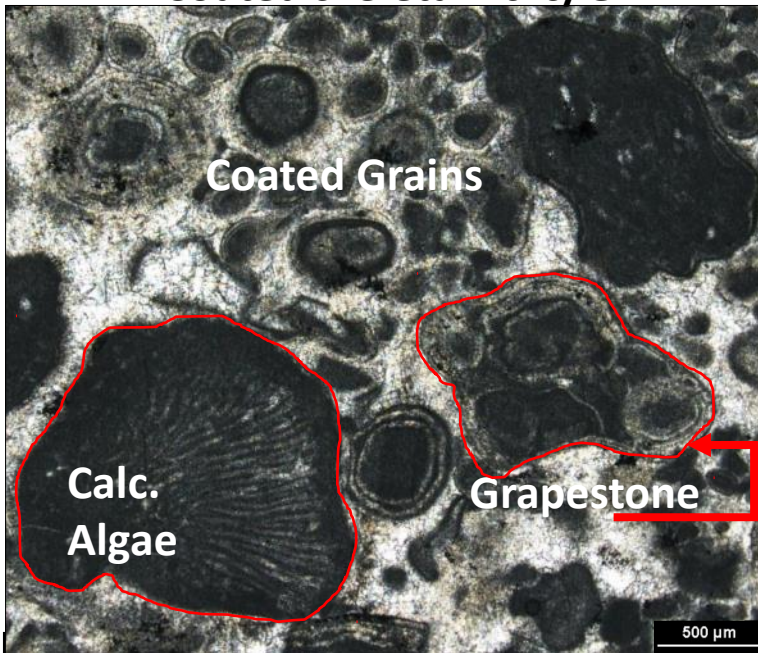
Timeline

Results – Shelf to Basin Facies Distribution



Facies Analysis- Platform Crest (FA2)- Supratidal to Intertidal (Foreshore)

Coated skeletal Pcks/Gr

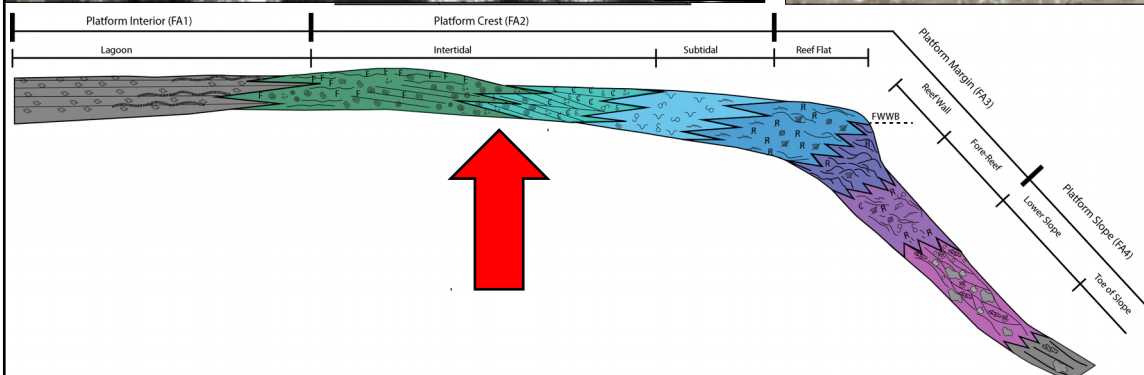


Fenestral Pck/Gr



Facies:

- Fenestral Pcks/Gr
- Coated Skeletal Pcks/Gr
- Ooid-Pisolite Gr
- Intraclastic Gr/Rds



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Study 3

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Results – Shelf to Basin Facies Distribution



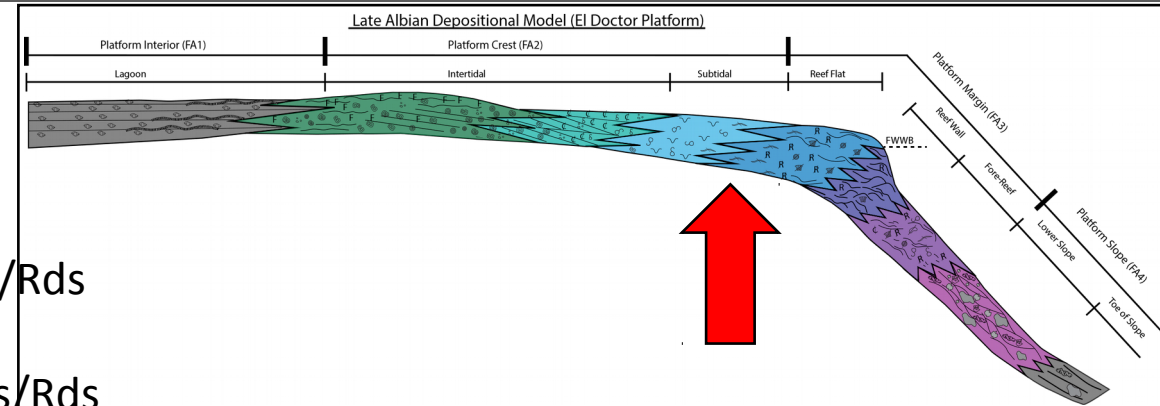
Facies Analysis- Platform Margin (FA3)

Characteristics:

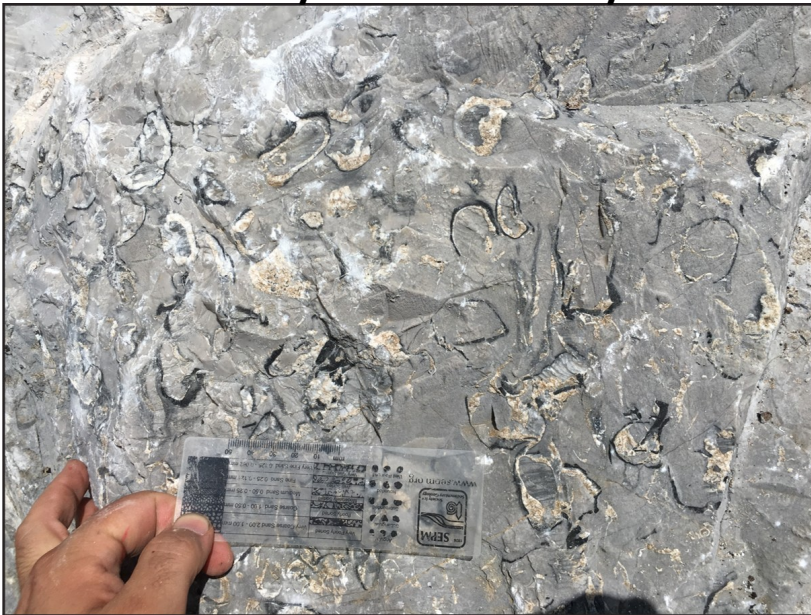
- Poorly bedded, amalgamated
- Fining up trends (gravity flows)
- Very skeletal (rudist dominated)

Facies:

- Caprinid Gr/Rds
- Tucasid/Radiolitid Pcks/Gr/Rds
- Skeletal Pcks/Rds
- Chondrodontid/rudist Pcks/Rds



Toucasid/Radiolitid Wks/Pcks



Chondrodont Pcks/Flts



Caprinid/Caprotinid Gr/Rds



Results – Shelf to Basin Facies Distribution



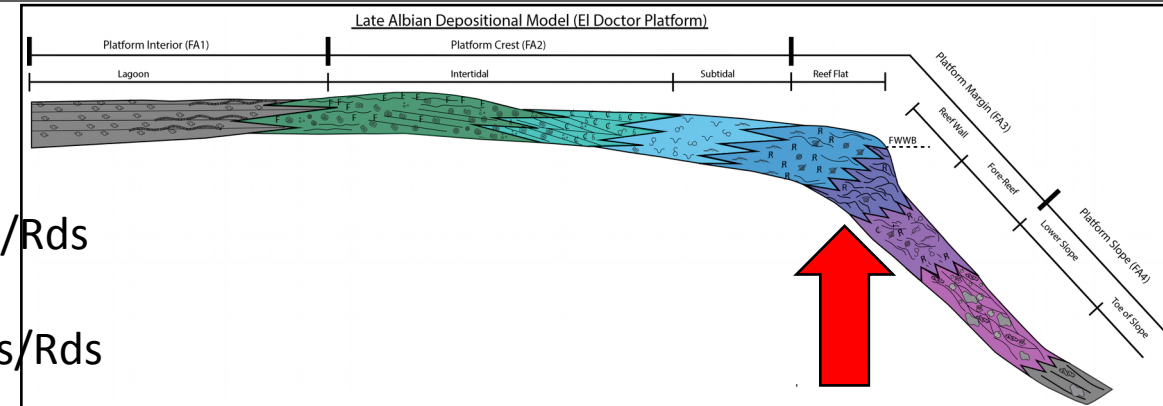
Facies Analysis- Platform Margin (FA3)

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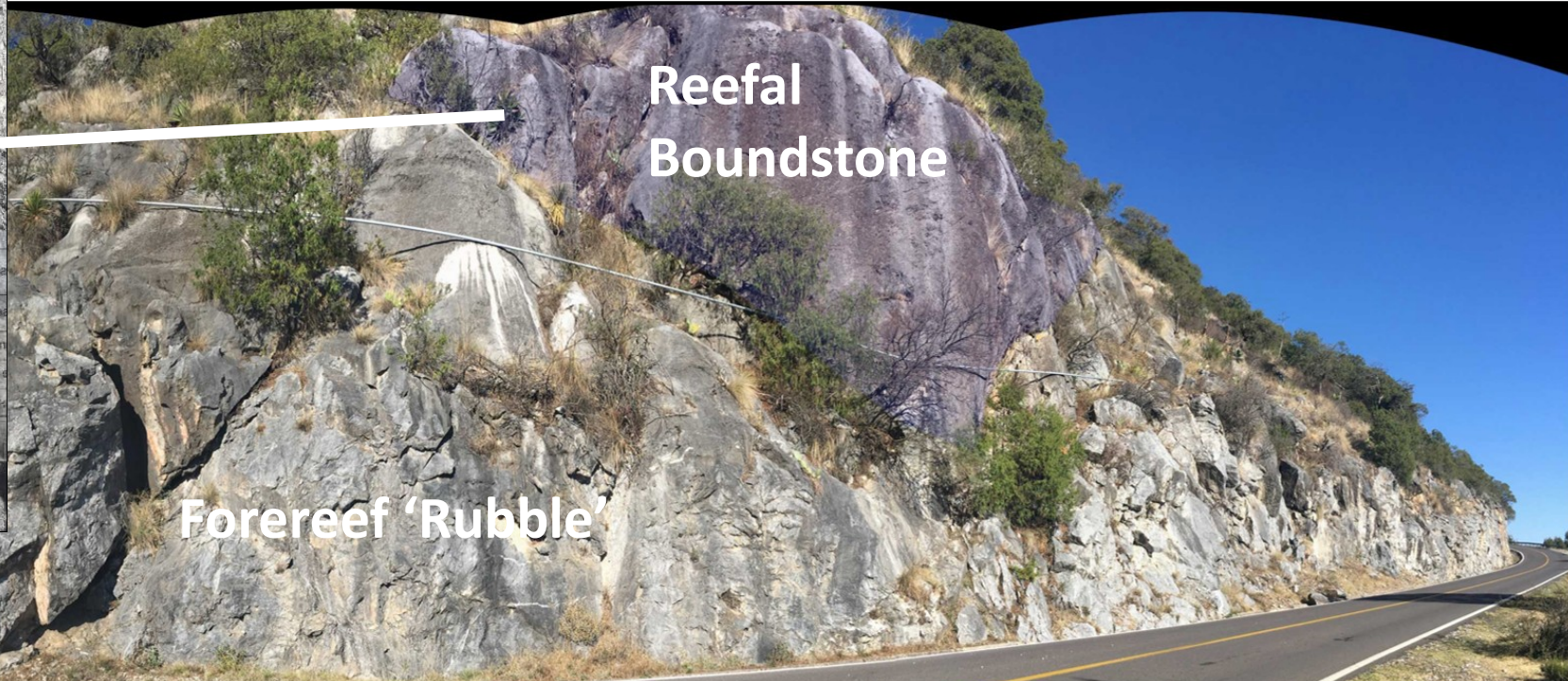


Coralgal Boundstone

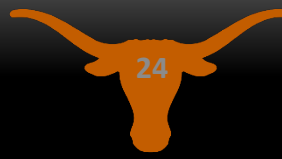


Reefal Boundstone

Forereef 'Rubble'



Results – Shelf to Basin Facies Distribution



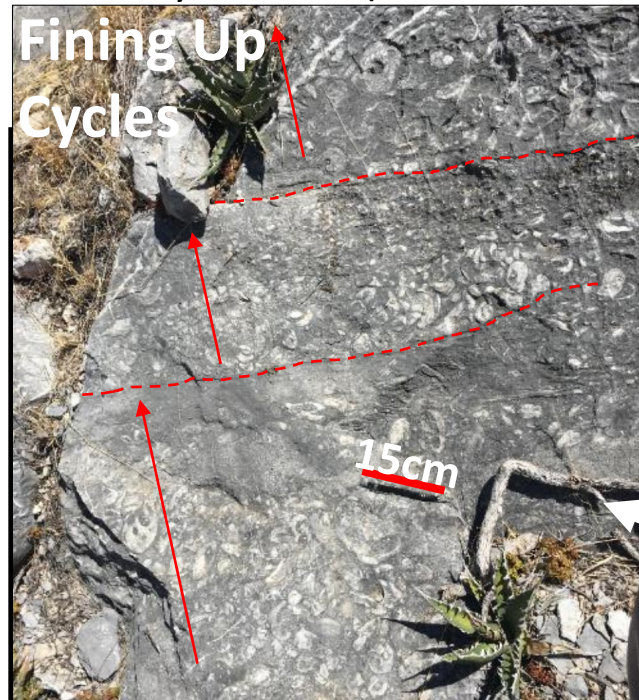
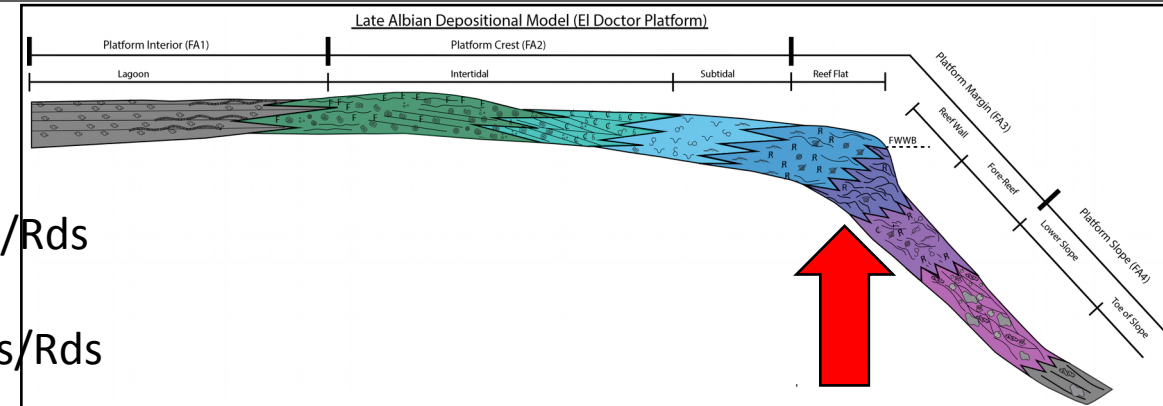
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Results – Shelf to Basin Facies Distribution



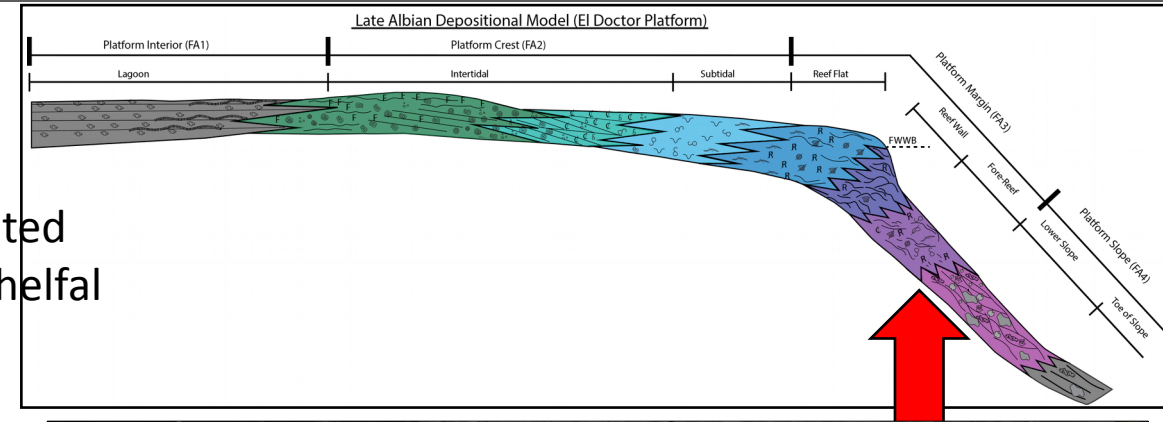
Facies Analysis- Platform Slope (FA4)

Characteristics:

- Well bedded, current ripples, fine laminations, overlie breccia
- Small fining upward packages (Bouma) -> deep water turbidites

Breccia Characteristics:

- Poorly bedded, amalgamated
- Breccia blocks consist of shelfal material



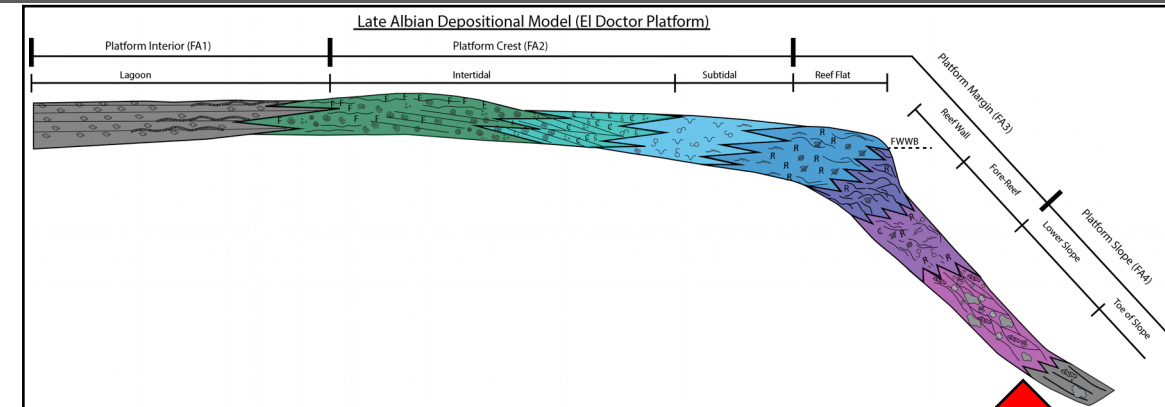
Results – Shelf to Basin Facies Distribution



Facies Analysis- Platform Slope (FA4)

Characteristics:

- Channelized morphology
- Amalgamated channel backfill
- Surrounded by pelagic mudstones



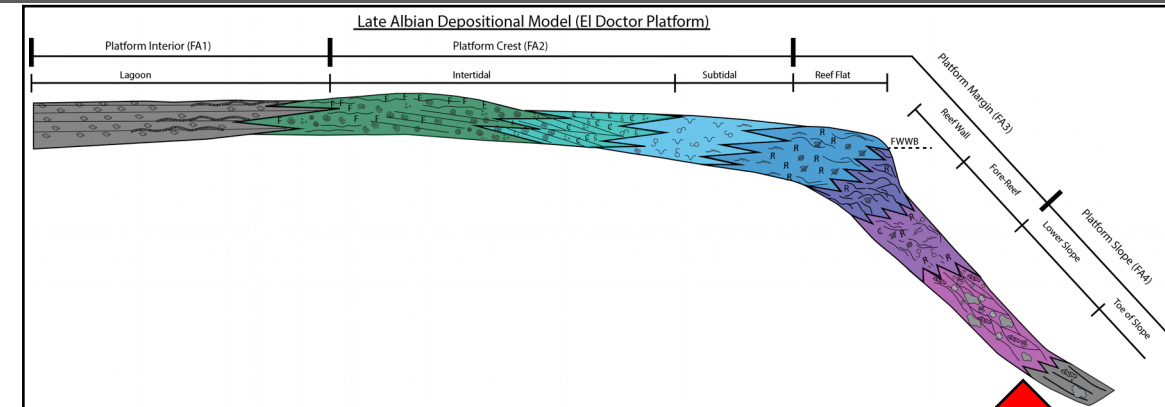
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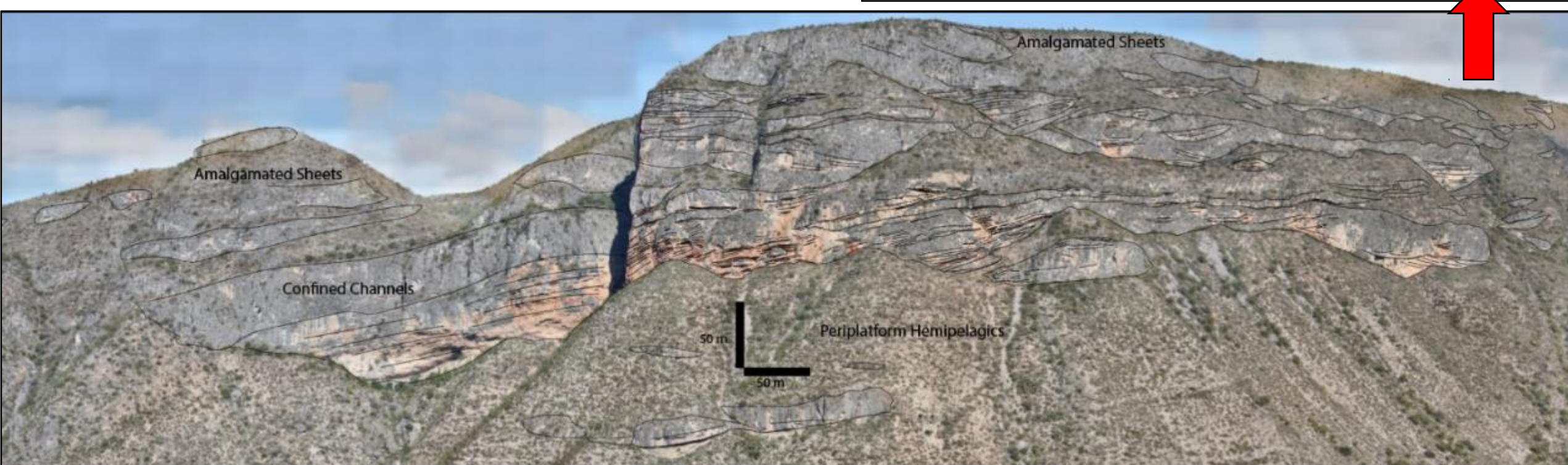
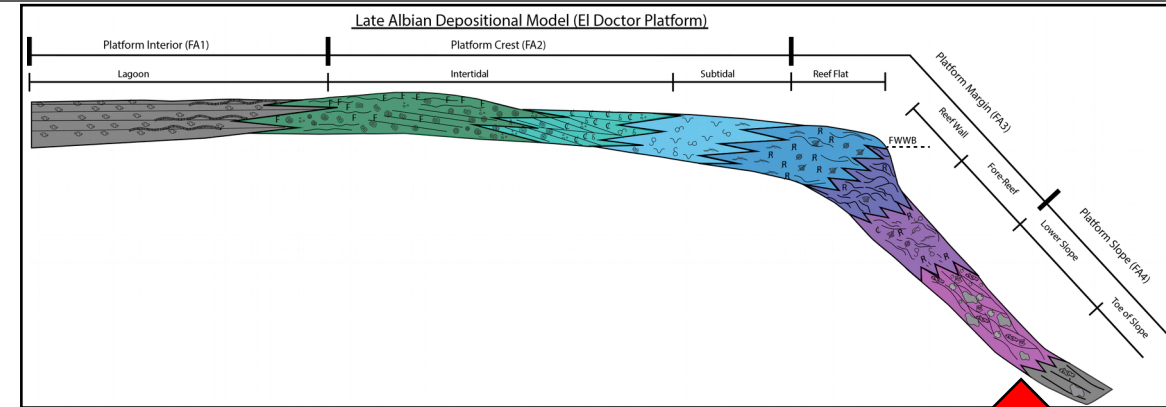
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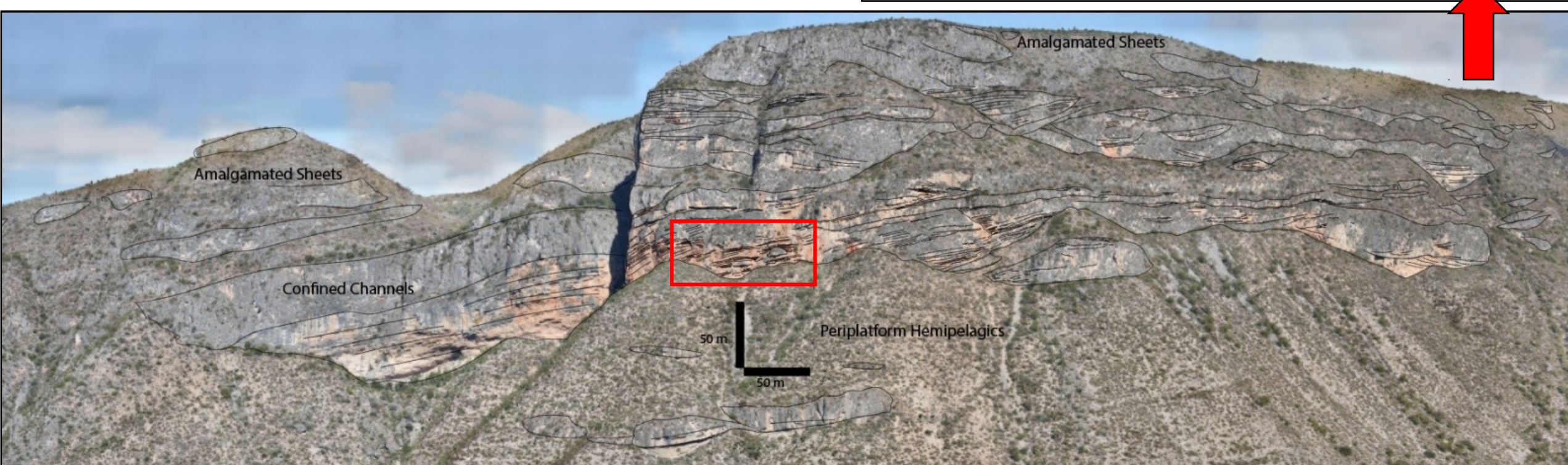
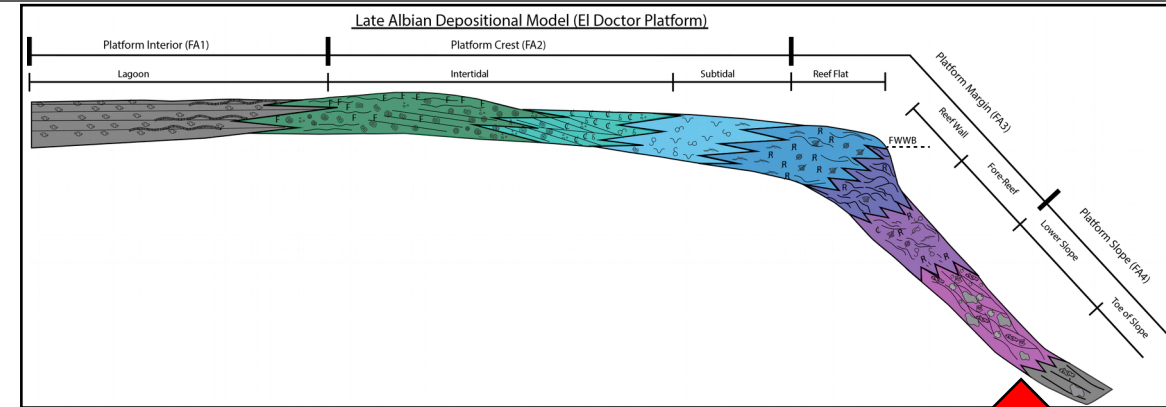
Results – Shelf to Basin Facies Distribution



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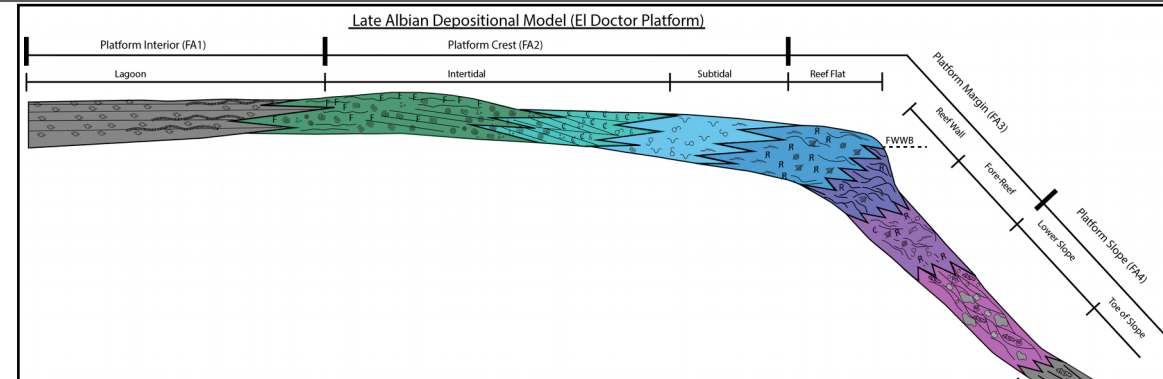
Results – Shelf to Basin Facies Distribution



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- Surrounded by pelagic mudstones



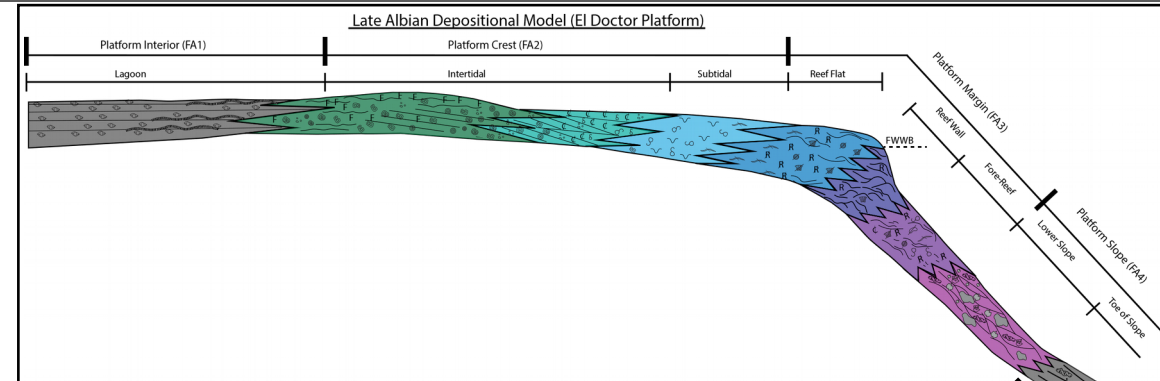
Results – Shelf to Basin Facies Distribution



Facies Analysis- Platform Slope (FA4)

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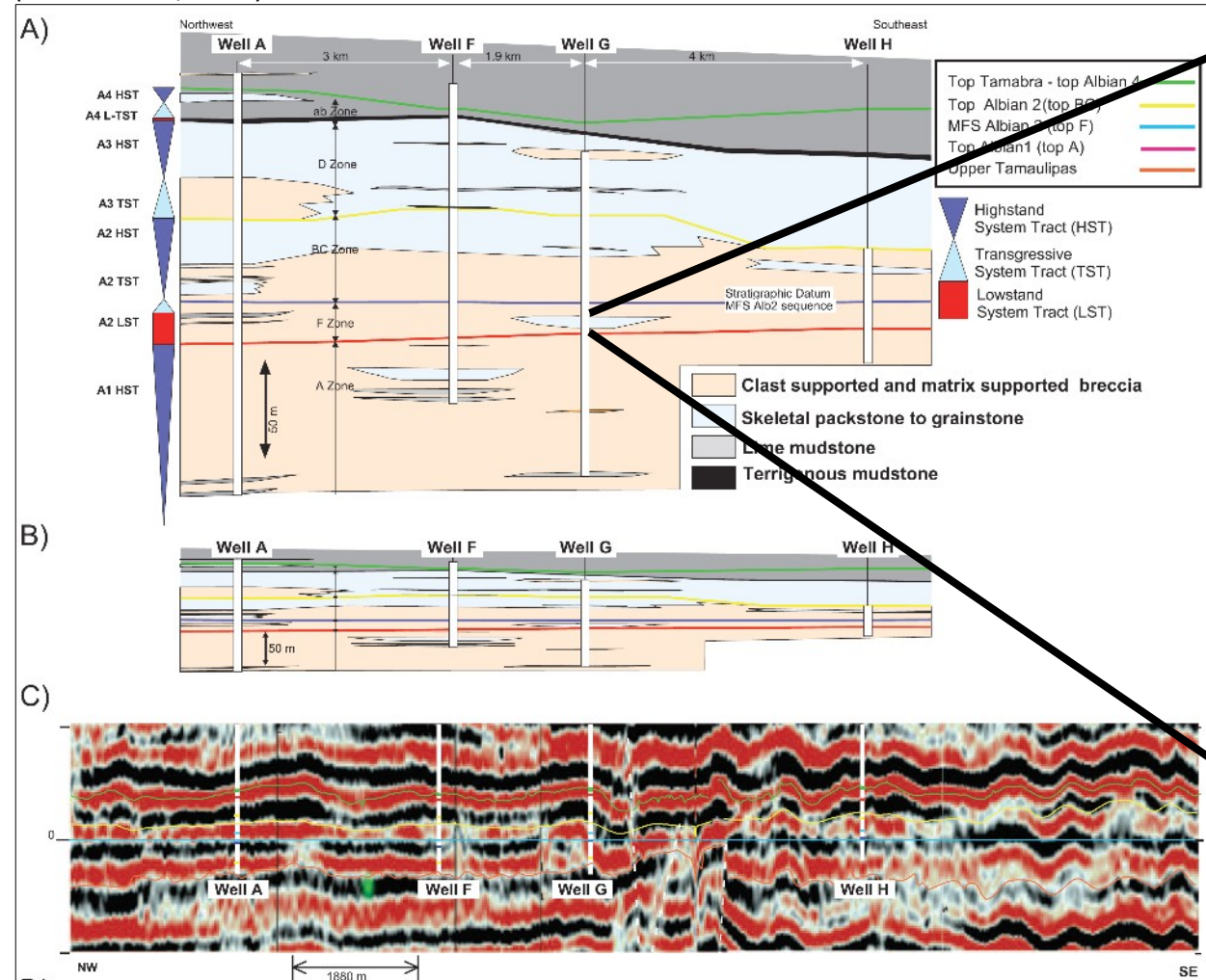
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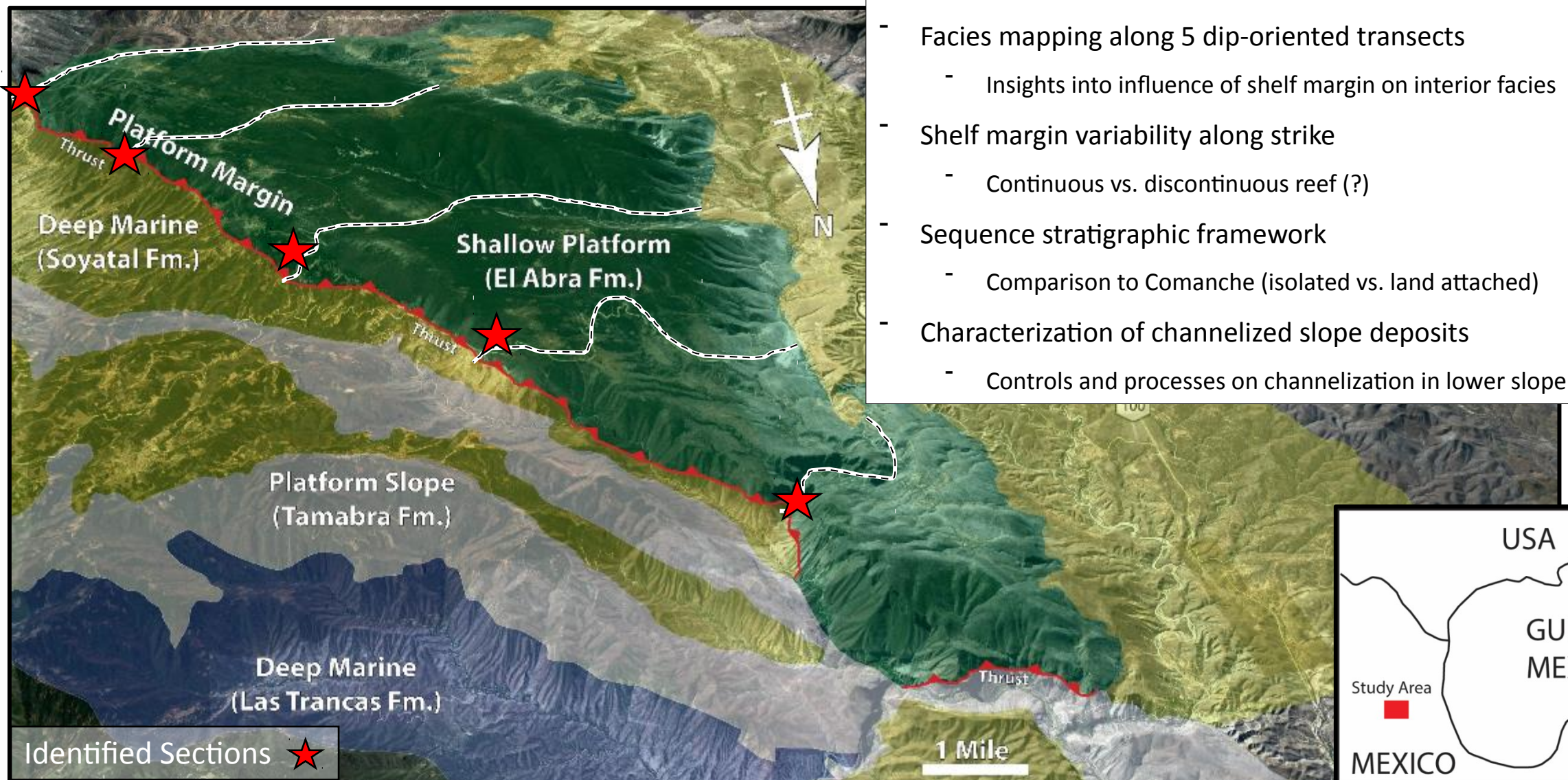
Results – Shelf to Basin Facies Distribution

Analogue to subsurface debris aprons around the Tuxpan platform in east-central Mexico

(Janson et al., 2011)



Future Work- 3-D Platform Architecture



Motivation

Background

Problem Statement

Study 1

Study 2

Study 3

Timeline

Thank You

