Laramide Episodic Documentation in Architecture and Depofacies of Viento Formation: Consequence of La Popa Salt Weld Evolution, La Popa Basin, Northeastern Mexico*

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Abstract

The stratigraphic architecture of the Eocene Viento Formation was investigated in southwest of La Popa secondary salt-weld, adjacent to the prominent bend zone located at its midpoint. Seven stratigraphic sections, measured perpendicular to the strike of the weld, along a 4.3 km SE-NW transect document lateral erosional thinning from 880 m to zero and exhibit bedding orientations from moderately dipping (35°) distal to the weld to slightly overturned adjacent to the weld, rare, minor faults (<2 m displacement) and rare, intraformational angular unconformities (≤20°).

Viento deposits include voluminous bioturbated siltstone and sandstone containing abundant Ophiomorpha burrows and wood fragments. Depofacies consistent with deltaic deposition comprise coarsening -upward parasequences: fissile shale, ripple to plane-laminated sandstone with mud rip-up clasts, oyster bank, low angle trough cross-bedded sandstone, heterolithic mud-draped sandstone to siltstone, and conglomeratic facies. Conglomeratic facies exhibit abundant 1-15 cm large, disarticulated oysters and well-rounded, well-sorted, pebbles to cobbles composed of chert and meta-igneous clasts. Clast size and angularity both increase with increasing proximity to the weld.

Facies analysis reveals Viento deposits represent a tidally influenced, river-dominated prograding delta system. Massive input of sand continuously discharged by Viento system synchronous with episodic Laramide compression events activated beneath evaporite layer and drove evaporite diapiric rise. Extrusion of diapiric evaporates to the surfaces is demarcated by the presence of conglomerate clasts composed of exotic lithologies found incorporated within Eocene Viento deposits. These exotic clasts were incorporated into the evaporate, transported upward during diapiric rise, exhumed at seafloor, reworked, and redeposited within the Viento Formation.

Depofacies composition together with their vertical succession relationship and lateral geometry unequivocally indicates that deposition and shortening were simultaneous with salt rise.

References

Giles, K.A., and M.G., Rowan, *in press*, Concepts in halokinetic sequence deformation and stratigraphy: Journal of the Geological Society (London).

Giles, K.A., and T.F. Lawton, 1999, Attributes and evolution of an exhumed salt weld, La Popa Basin, northeastern Mexico: Geology, v. 27/4, p. 323-326.

Lawton, T.F., K.A. Giles, F.J. Vega, and C. Rosales-Dominguez, 2001, Stratigraphy and origin of the La Popa Basin, Nuevo Leon and Coahuila, Mexico, *in* C. Bartolini, R.T. Buffler, and A. Cantu-Chapa (eds.) The western Gulf of Mexico Basin: Tectonics, sedimentary basins, and petroleum systems: AAPG Memoir 75, p. 219-240.

Laramide Episodic Shortening Documentation in Architecture and Depofacies of Viento Formation: Consequence of La Popa Salt Wall Evolution, La Popa Basin, Northeastern Mexico

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April 2011, AAPG ACE, Houston, TX

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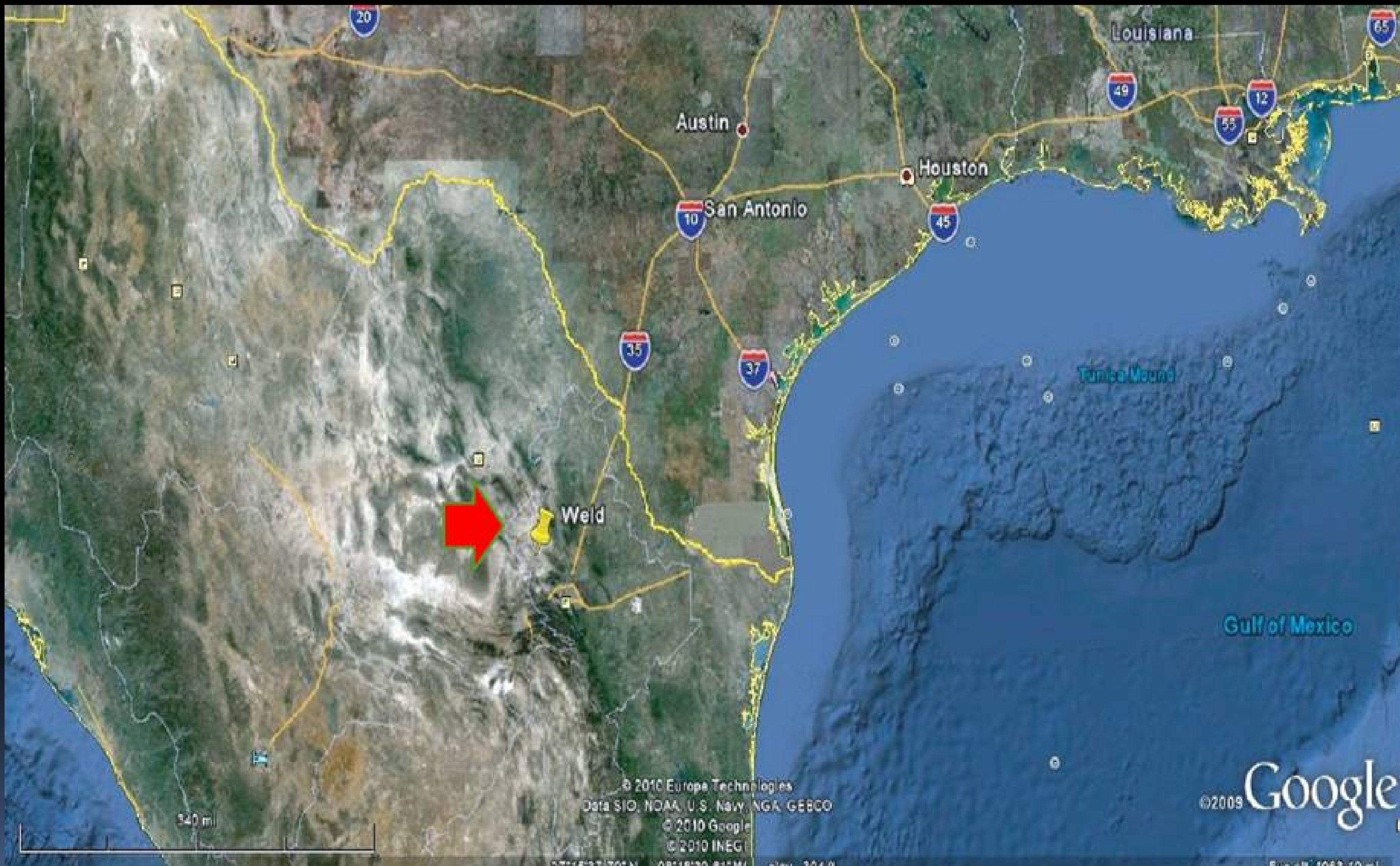
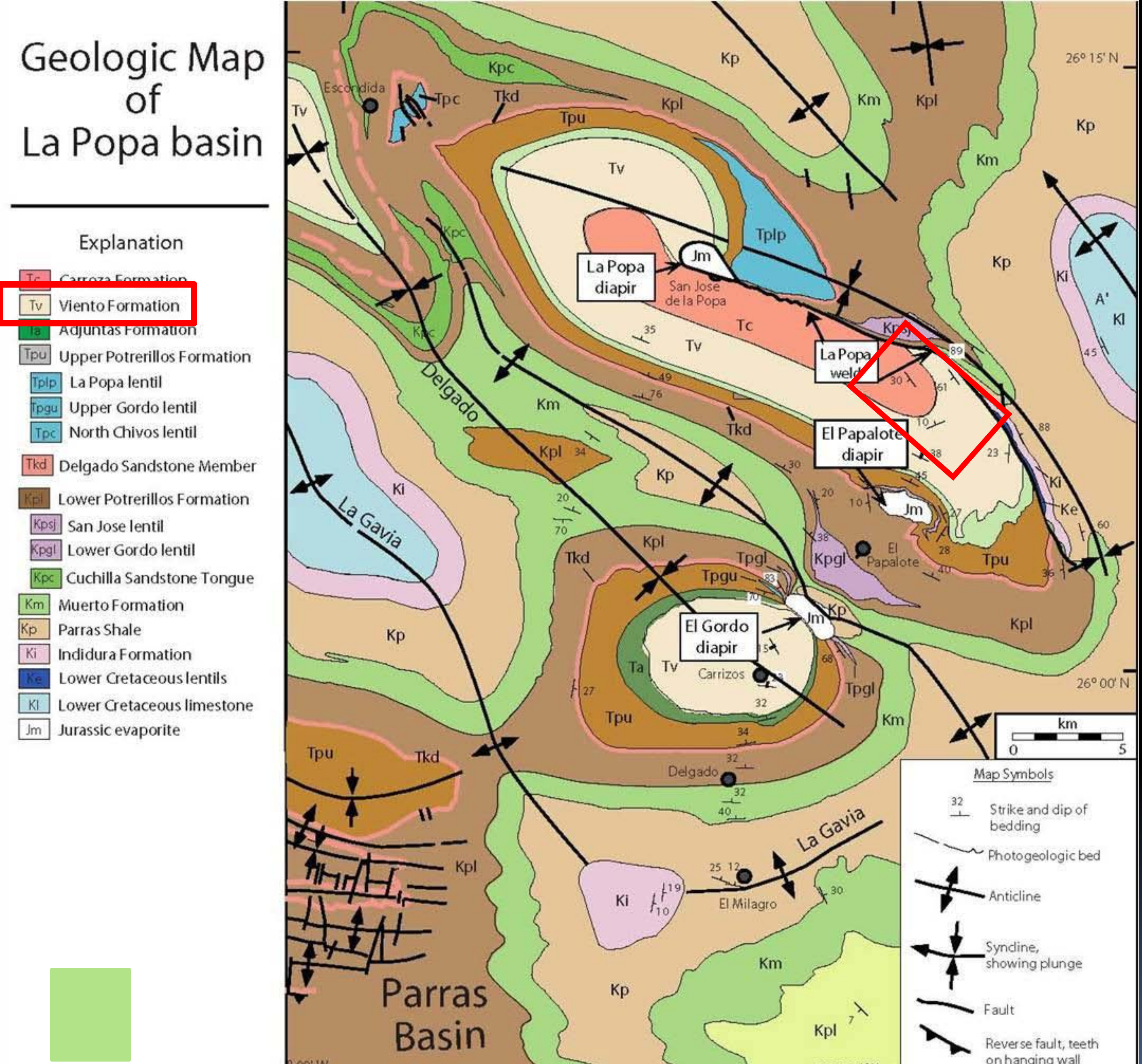
Location of the Study Area



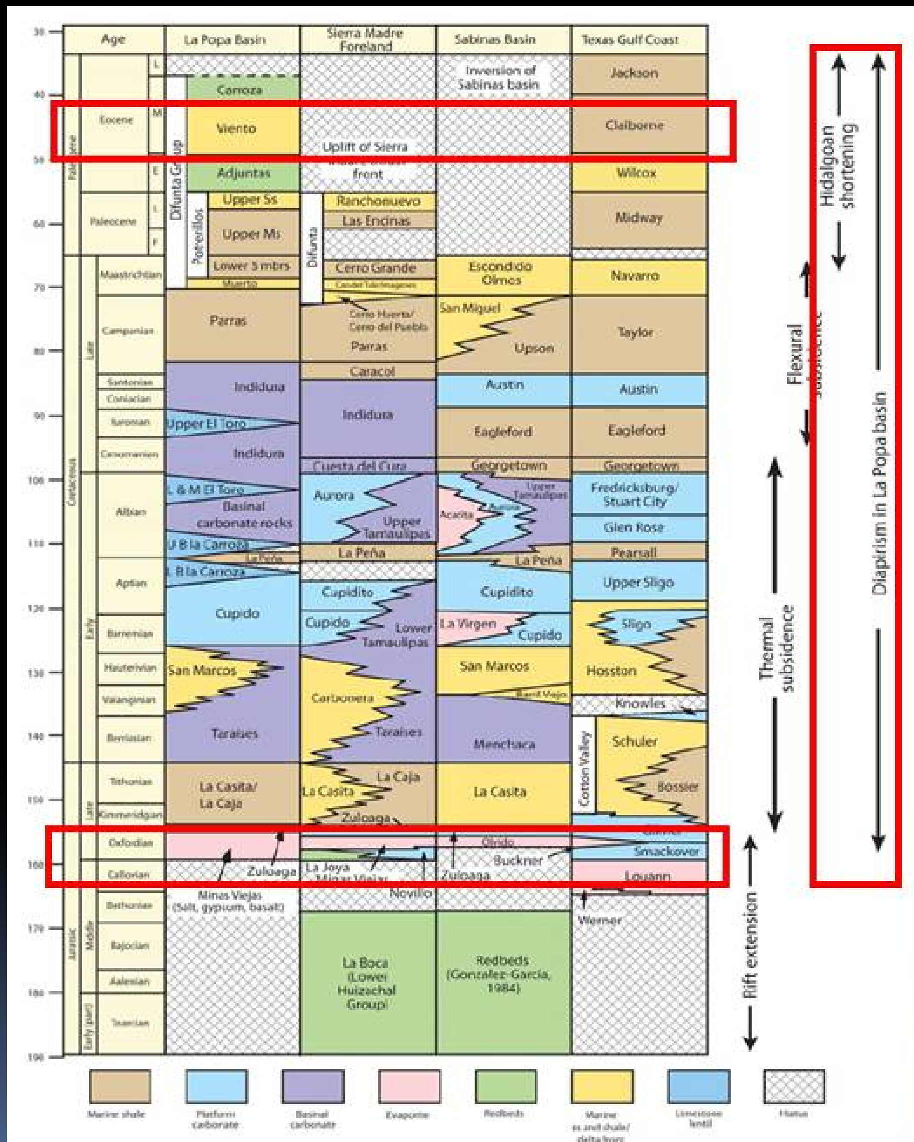
Notes by Presenter: 2This is a Google map of the location of the study area. La Popa basin is located one hour driving NW from the city of Monterrey. Tunica Mound, Sigsbee Escarpment associated with salt diapirism in GOM ~300 mile east.



Basin evolution influenced by salt tectonics

Present salt features:
El Papalote, El Gordo diapirs & La Popa weld and diapir

(Modified, from Giles & Lawton, 1999)



Chronostratigraphy of La Popa Basin & Texas Gulf Coast

Viento Formation:

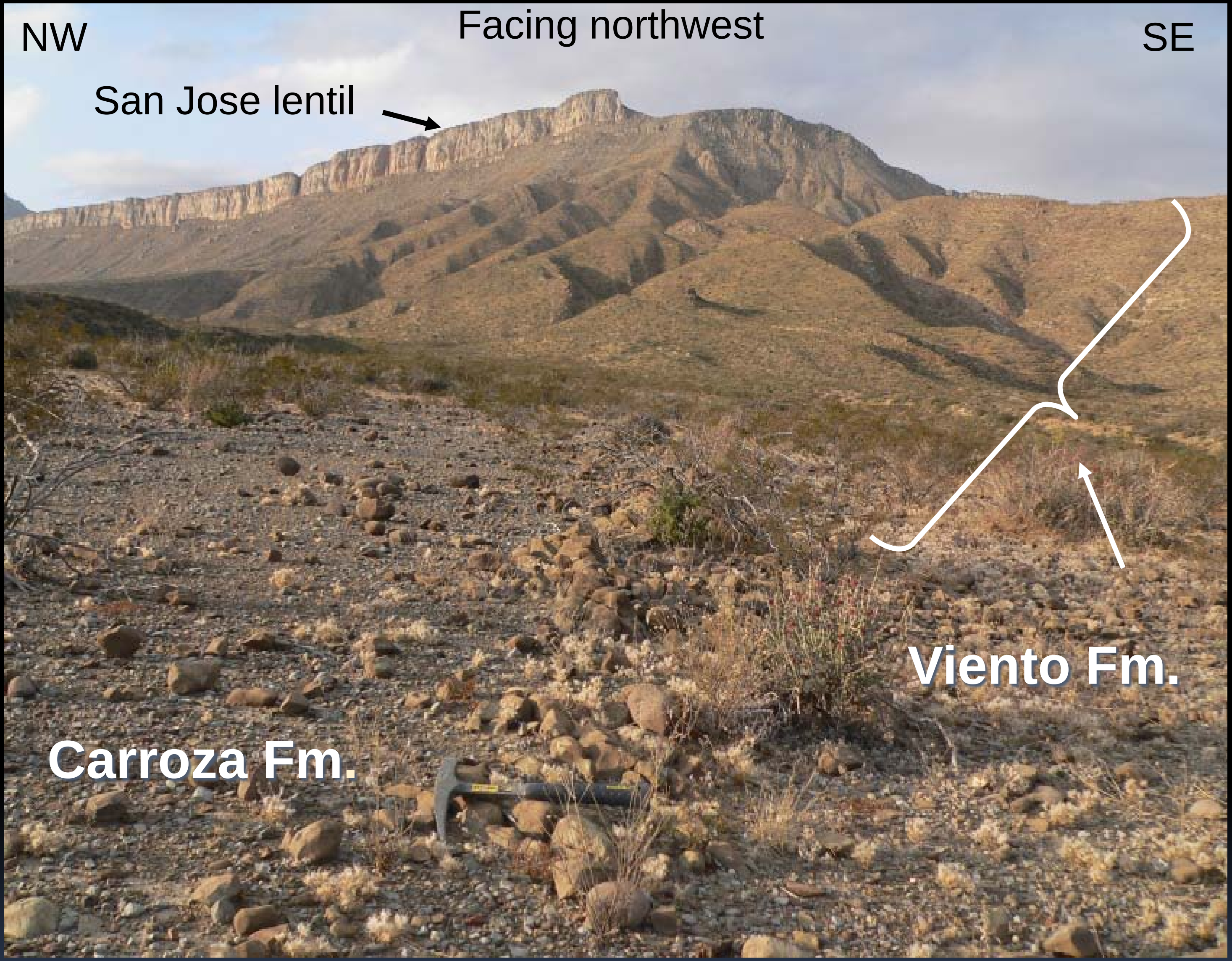
- Middle Eocene ?
- Youngest marine unit of the Difunta Group
- Overlain and underlain by terrestrial deposits
  - Carroza Fm. above
  - Adjuntas Fm. below

(From Lawton et al., 2001)

Notes by Presenter: 4In a more regional context, please note that Viento Fm. correlates with Claiborne Fm. of Texas Gulf Coast. Diapirism was on going process into La Popa from Jurassic to Paleocene. Hidalgoan shortening is the southern equivalent of Laramide orogeny, late cretaceous to Paleocene Minas Viejas, the salt source into La Popa basin, the equivalent of Louan salt in Texas Gulf Coast.

Research Questions:

1. How did salt rise of La Popa wall impact the sedimentology and depositional facies distribution of Eocene Viento Formation?
2. How do internal facies relationships and stacking patterns determine the depositional sequence stratigraphy?
3. How do structural geometries and angular unconformities of the Viento Formation determine halokinetic sequence style and determination of composite sequence boundary?



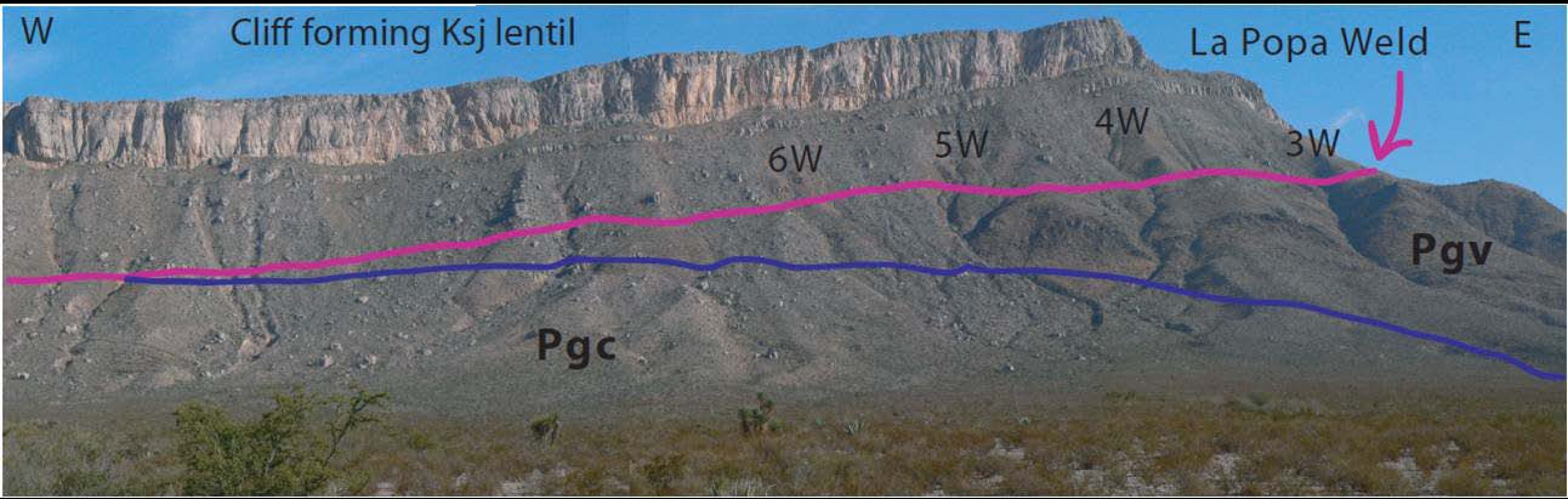
Study Area

Carroza Fm. foreground.

Viento Fm. forms prominent ridges.

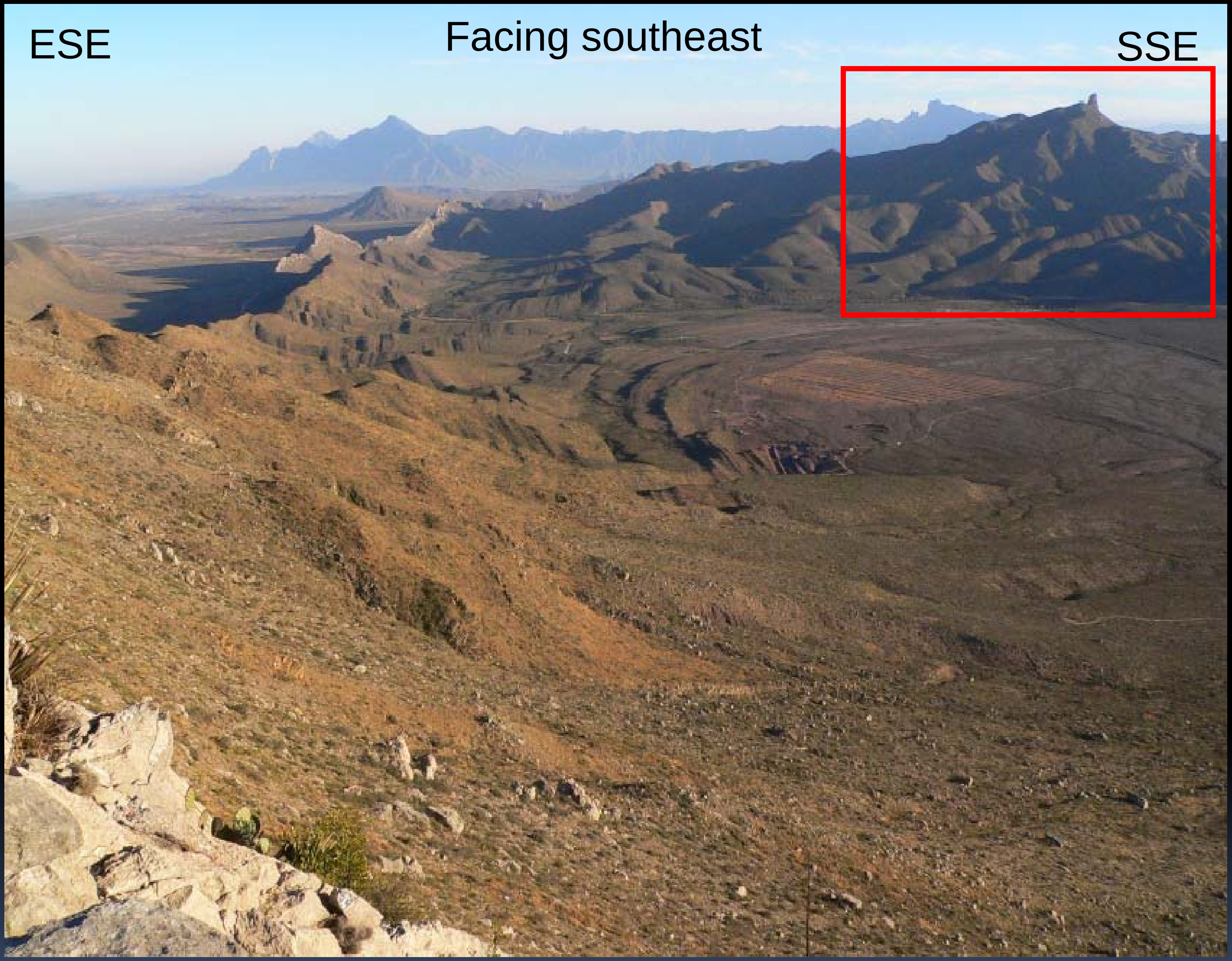
San Jose lentil forms NW skyline

Northwest Zone of the Study Area

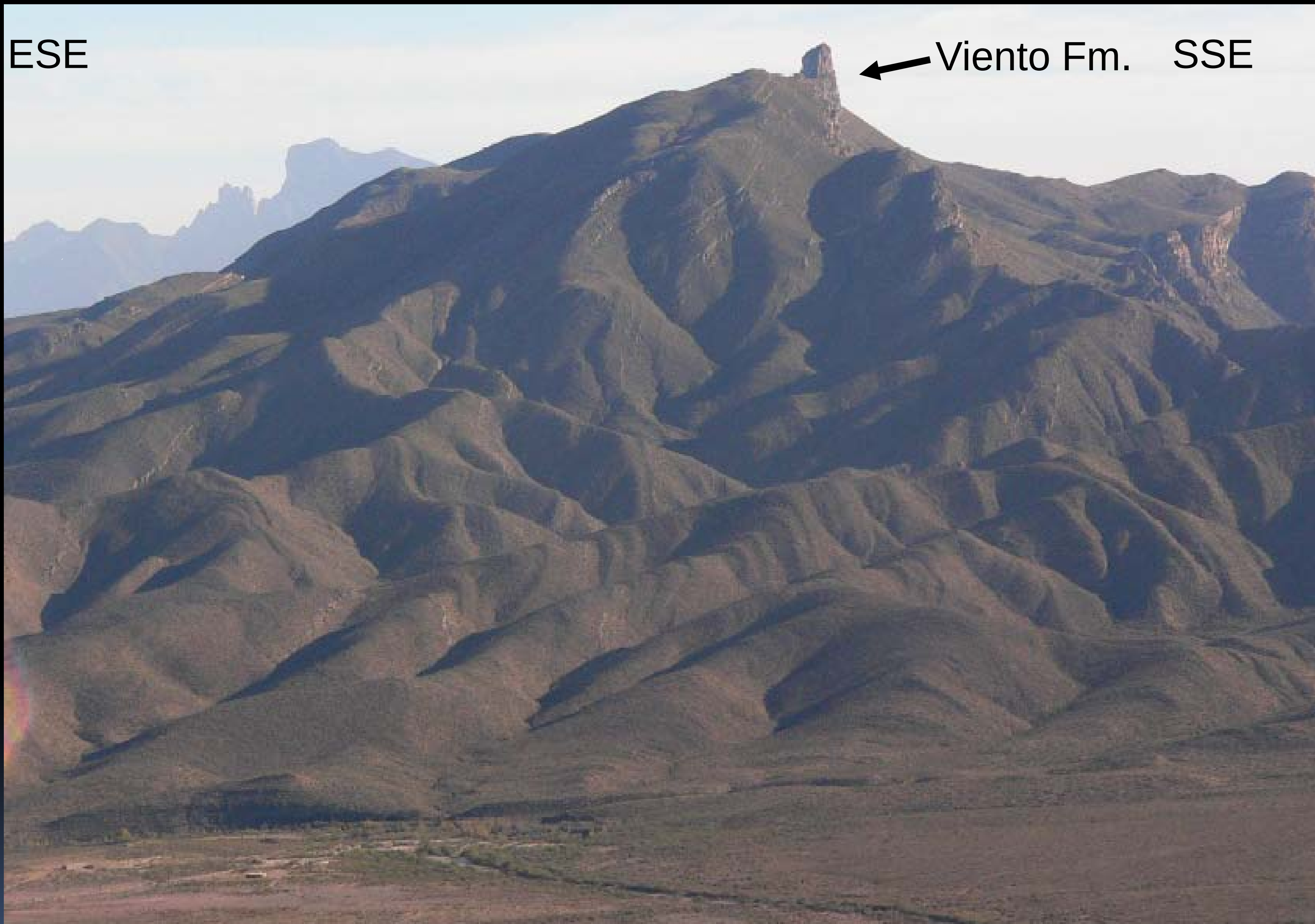


Cliff Top = ~ 1300 m elev. Valley Floor = ~ 900 m elev.

Study Area



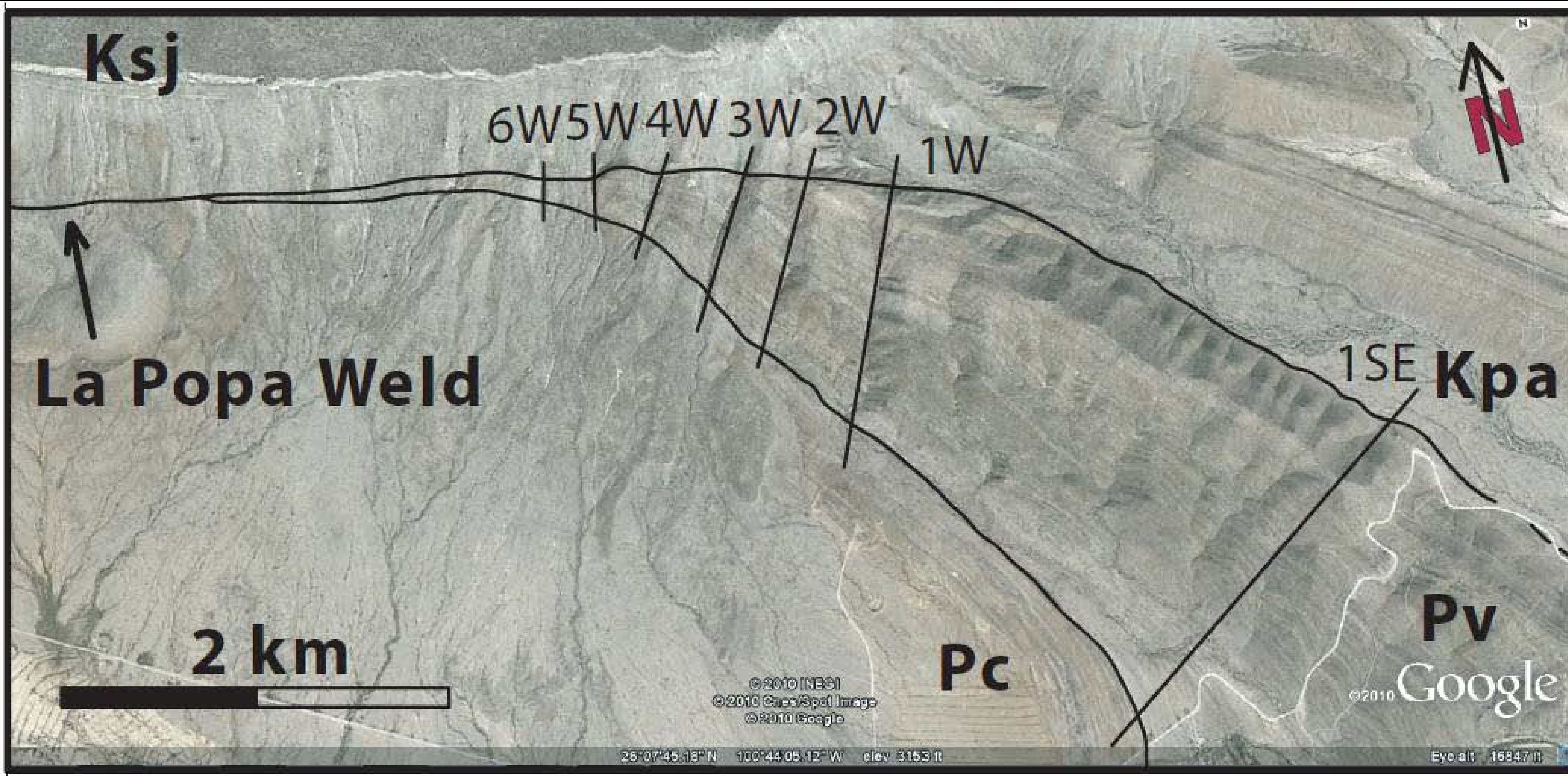
From the Weld Zone looking across the Carroza Syncline



Viento Fm. to South of Study Area at ~1500 m Elevation.

Evidence for Laramide shortening initiated in Latest Cretaceous time.

Plan View – Measured Stratigraphic Sections



Depositional Facies: Basinward to Landward

<u>Prodelta</u>– 4 Facies

Horizontal heterolithic sandstone-siltstone

Shale (gray and purple)

Limestone buildup & Oyster reef deposit (diapir roof facies)

<u>Delta front and platform</u> – 4 Facies

Bioturbated sandstone

Inclined heterolithic sandstone-siltstone

Ripple-laminated sandstone

Ball and pillow sandstone

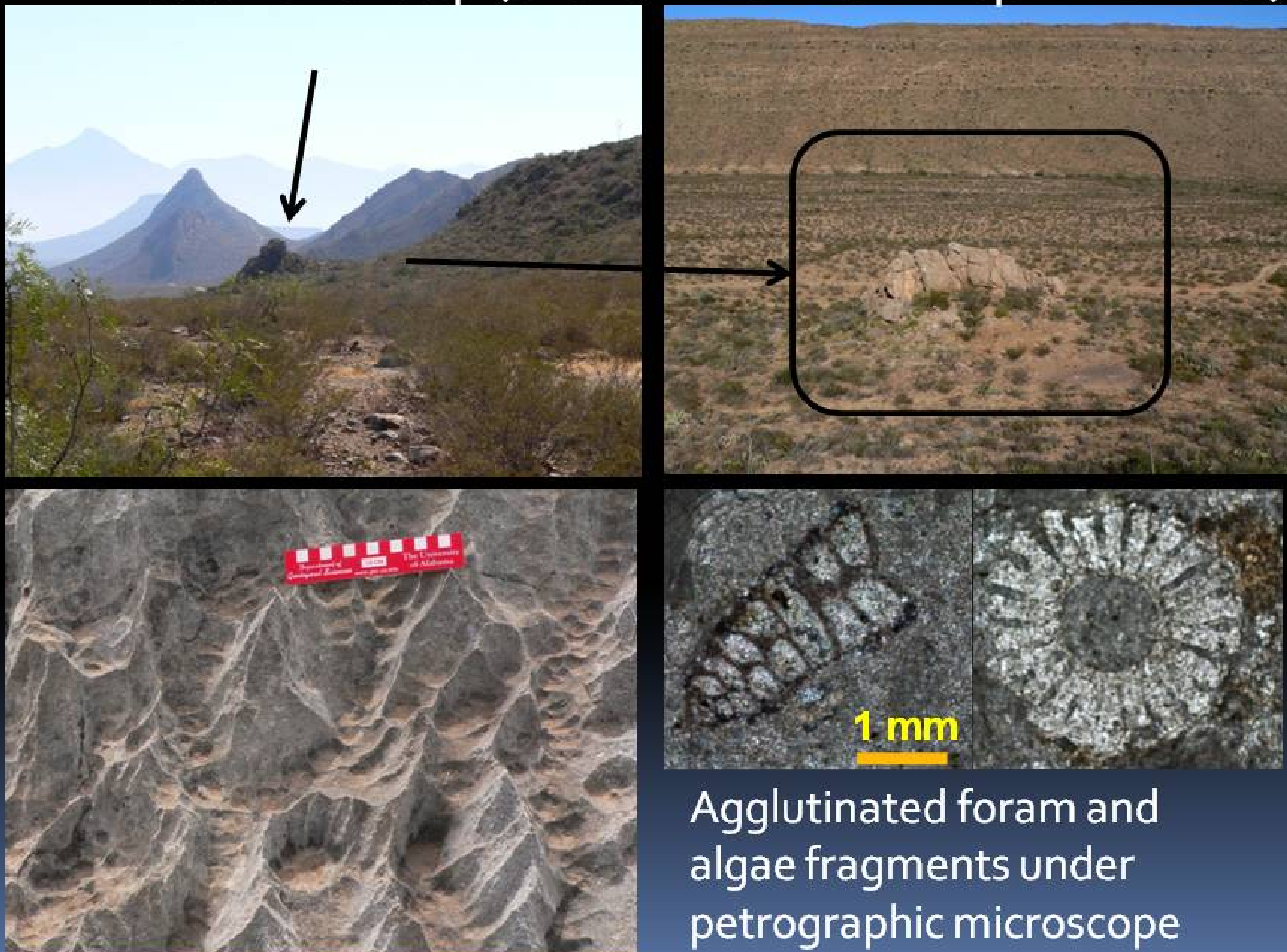
<u>Fluvial-deltaic distributary channels</u> – 9 Facies

Trough X-bedded sandstone

Conglomeratic sandstone

Pebbly sandstone

Limestone Buildup (Shallow Marine – Diapir Proximal)



Agglutinated foram and algae fragments under petrographic microscope

Notes by Presenter: 12Limestone lentil at the base of Viento Fm. adjacent to the weld. Sitting on the weld and looking south on the strike of the weld. Bed surface frontal view. Microcarst sharp weathering in limestone. Shallow, worm, high energy marine setting. Micritic mud.

Tan & Purple
Fissile Shale Facies

(Prodelta – Diapir
Proximal/Roof)

Notes by Presenter: 13Creates low topography, locally covered by vegetation or poorly exposed, beds extend +1km.

Horizontal Heterolithic Sandstone-Siltstone Facies

Oyster Reef Facies

(Shallow Marine & Prodelta)

Notes by Presenter: 14Sharp contact and parallel bedding between sandstone and siltstone successions, overall sand prone, symmetrical wavy tops. Abundant oysters, all range b/t 2-4 cm diameter, extremely endured fine sand with carbonate mud; shallow, high energy, worm waters.

Bioturbated & Ripple Laminated Sandstone Facies (Delta Front and Platform)

Notes by Presenter: 15Large, curvy, Ophiomorpha burrow formed with pellets = dwelling structures following rapid sedimentation, stressed environment, brackish water, small number & diversity of species, mouth bar to proximal delta front. Bioturbation indices between 10 and 70 %. Bottom bed, wavy ripples cast, straight crest = weak waves and bidirectional wavy ripples with mud drapes.

Trough cross-bedded
Sandstone Facies

Inclined Heterolithic
Sandstone-Siltstone
Herringbone Facies

(Delta Front & Platform)

Notes by Presenter: 16Small-scale trough X-bedded sandstone, herringbone structures small and large scale with mud drapes highlighting sedimentary structures. Depositional setting influenced by tide. Mud deposited at slack water.

Mud ripped up Clasts &
Mud Chips
Sandstone Facies

Ball & Pillow
Sandstone Facies

(Delta Front & Platform)

Notes by Presenter: 17Common subrounded to elongated mud ripped up clasts; card for scale is 15 cm long; Abundant, well-rounded, mud chips and wood fragments; grain-size chart for scale is 10 cm long; Ball and pillow structures delimited by mud intervals. Weathering spheroidal.

Wood fragments & logs, lag deposits & large-size Oyster Sandstone Facies (Fluvial –Deltaic Channels)

Notes by Presenter: 18Continental input, deltaic distributary channels. Oyster lag 15 cm thick hosted by medium-grained sandstone matrix; card for scale is 15 cm long; Imbedded, abundant, disarticulated oyster shells 10 cm Ø; rock hammer for scale is 33 cm long.

Pebbly Sandstone, Metaigneous & Limestone Clasts and Conglomeratic Sandstone Facies

(Fluvial – Deltaic Channels)

Notes by Presenter: 19Limestone clasts conglomeratic sandstone facies, exhibiting well rounded, well sorted clasts caught in a silty–to-fine, poorly sorted and bioturbated sandstone matrix. Subangular green-blue metaigneous clasts 17 cm Ø caught in endured medium well sorted sandstone; scale is 15 cm long; Sharp 20 cm thick bed of sandstone with chert pebbles well rounded to subangular; scale is 15 cm long.

Metaigneous Blocks within the Gypsum Cap Rock

Notes by Presenter: 20Superman figurine is 10 cm tall, for scale. The metaigneous clasts are smaller, well rounded in the facies away from the diapir, but increase both size and angularity proximal to the wall.

Major Flooding and Erosional events of Pebbly and Conglomeratic Sandstone Facies

Notes by Presenter: 21Major, sharp erosional contact with oyster, chert, and metaigneous clasts facies that overlay fine, well sorted, mud-draped, trough cross-bedded sandstone; card for scale in cm to the left; (f) Erosional contact with chert pebbly facies that overlay silty, bioturbated sandstone facies; divisions on Jacob staff are 10 cm long.

Facies Associations:

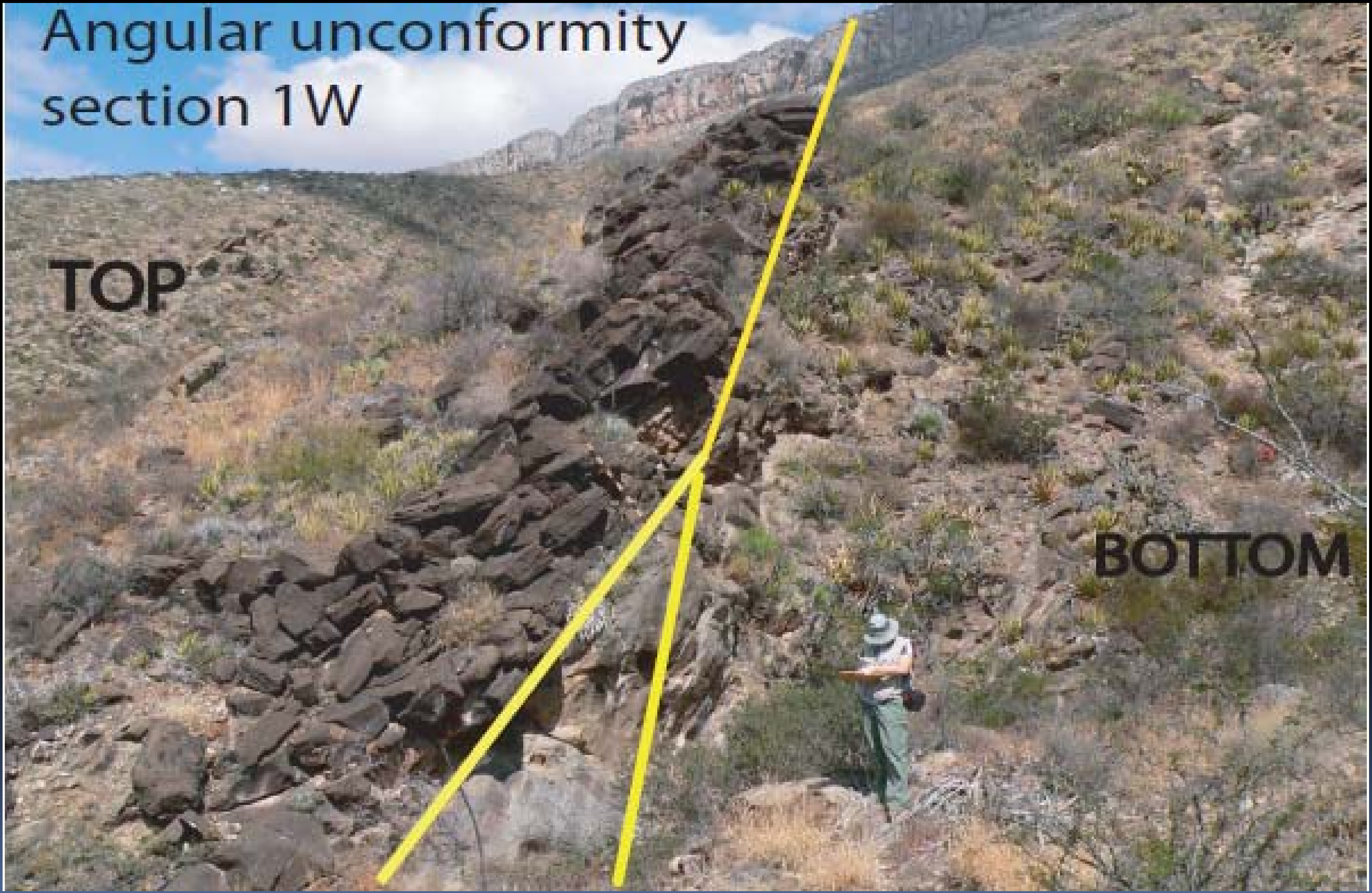
1) Prodelta with diapir roof carbonate buildups
2) Proximal to distal delta front and platform
3) Fluvial-deltaic distributary channels

Overall Shallowing Upward to form a
Regressive System

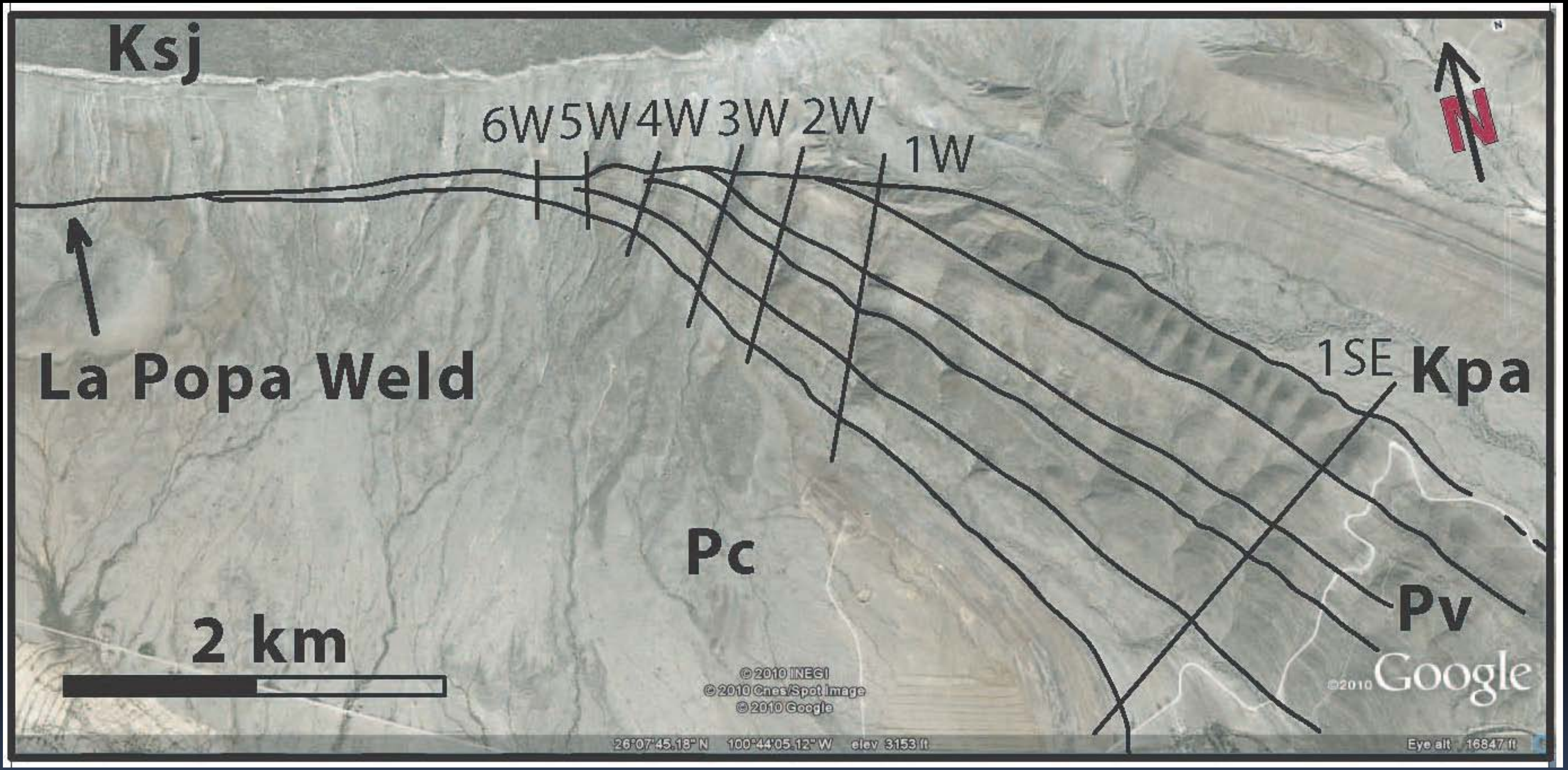
Vertically Dipping to Upturned Beds Near Diapir

Notes by Presenter: 23Note the sharp base of the ridge-forming sandstone bed overlaying a shale unit ~ 2 m thick.

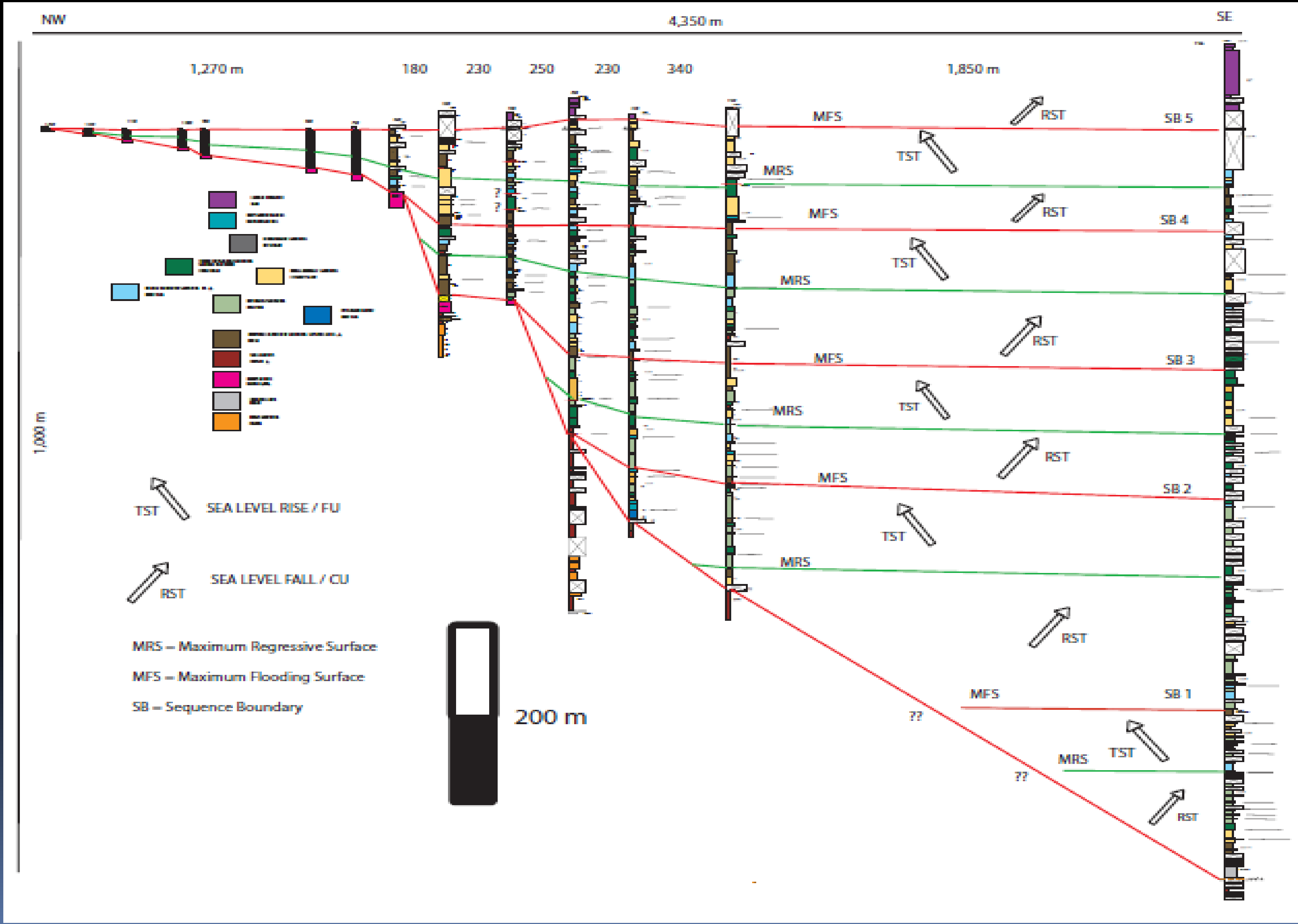
~15 Angular Unconformity



Plan View – Correlation of Measured Stratigraphic Sections (in total over 3,500 m log)



Fence Diagram showing Shallowing Upward Facies Distribution

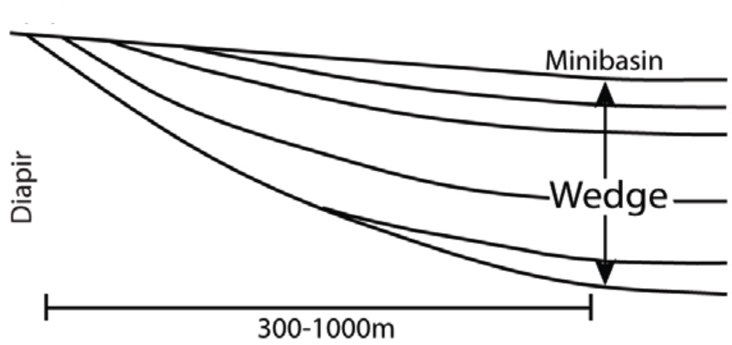


Interpretation of Halokinetic Sequence Stratigraphy

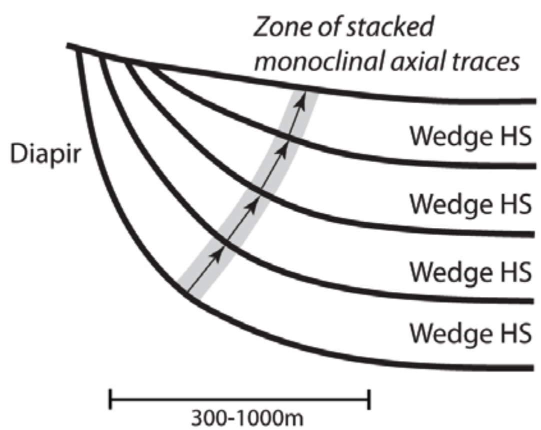
Based on the models from *Giles and Rowan, 2011*

The 3 facies associations *wedge* toward the diapir to form a *Tapered Composite Halokinetic Sequence*

Sediment Accumulation Rate > Salt Rise Rate



- Drape folding 300-1000m from diapir.
- <30 degree angular unconformities.
- Broad zone of gradational facies changes.



- Convergent base and top boundaries.
- Broad zone of thinning toward diapir.
- Axial trace of monocline progressively inclined from diapir.

Stratigraphic Architecture Conclusions

1. Overall, lateral decrease in thickness from ~ 900 m to pinch out over ~ 5 km distance form a series of 5 wedges, each wedge ~ 150 m tick

2. Wedges forming angular truncations of ~15° becomes conformable within tens of meters

3. Beds flatten in basin but are overturned near salt wall

Halokinetic Sequence Stratigraphy Conclusions

1. Metaigneous clasts at top of sequence indicate slow, continuous salt rise due of sediment load
2. Metaigneous clasts through out the sequence indicate episodic salt rise due to compression events
3. Increase in local third order net sediment accumulation rates relative to salt rise rates formed a Tapered Composite Halokinetic Sequence

Depositional Environment Conclusions

1. Facies include Prodelta, Proximal and Distal
   Delta Front and Platform, and Terrestrial deposits and indicate that deposition and salt rise were coeval

1. Deposited in a Tidally Influenced Delta System

2. Overall shallows upward to form a Regressive System

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