Interactions Between Rift Tectonism and Sedimentation, Cretaceous Chihuahua Trough*

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Abstract

Syn-depositional faults and oblique-to-basin-margin rotation have both influenced sedimentation in the Aptian and Albian strata Of the Chihuahua trough. Regionally, the trough fill increases from 120 m at the margin of the formation to over 3 km in the trough interior. This thickening is abrupt and occurs over 30 km. Depositional environments range from medial alluvial fans through distal shelves and represent a transgression as tectonism waned and eustatic sea level rose. Four formations were deposited during the waning stages of this Jurassic to Cretaceous extensional basin. Three observed syn-depositional faults die out in the Finlay formation, but have increased displacement in underlying sediments. Two of the faults are antithetic and dip toward the basin margin, whereas one is synthetic. Eustatically influenced stratigraphy, including both parasequences and sequence boundaries cross the faults and are offset with little apparent thickening or thinning. Rotation causes most of the thickening within the study area. One easily correlated formation, bounded above and below by transgressive surfaces, thickens from 375 m on the northern side to 437 m on the southern side. Rotation of the lower part of the formation results in a 7-degree dip when the structural dip of the top of the formation is flattened. Most of this thickening occurs in shelf mudstones, which are rotated and truncated sequence boundaries and then buried by coastal and fluvial sandstones. For example, the thickness of one shale bed varies from 18 m on the side to 70 m within 2 km.

INTERACTIONS BETWEEN RIFT TECTONISM AND SEDIMENTATION, CRETACEOUS CHIHUAHUA TROUGH.

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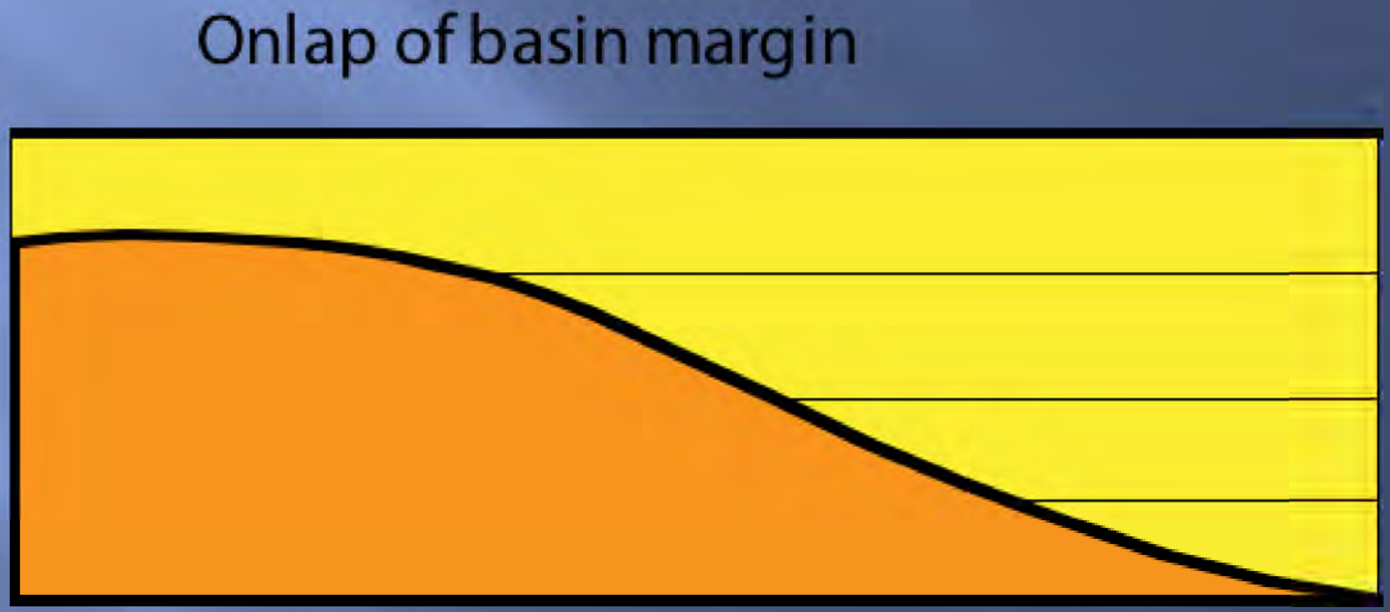
Questions

- In a superb exposure with strata thickening into a extensional basin system

1. How are changes in thickness accommodated?
2. Control by Tectonic elements?
3. Eustacy -- Sequence Stratigraphy?
4. Stratigraphic influence?

There are several different Geometries that can accommodate thickening. Rotation preserves most beds at the basin margin. Onlap only exposes upper



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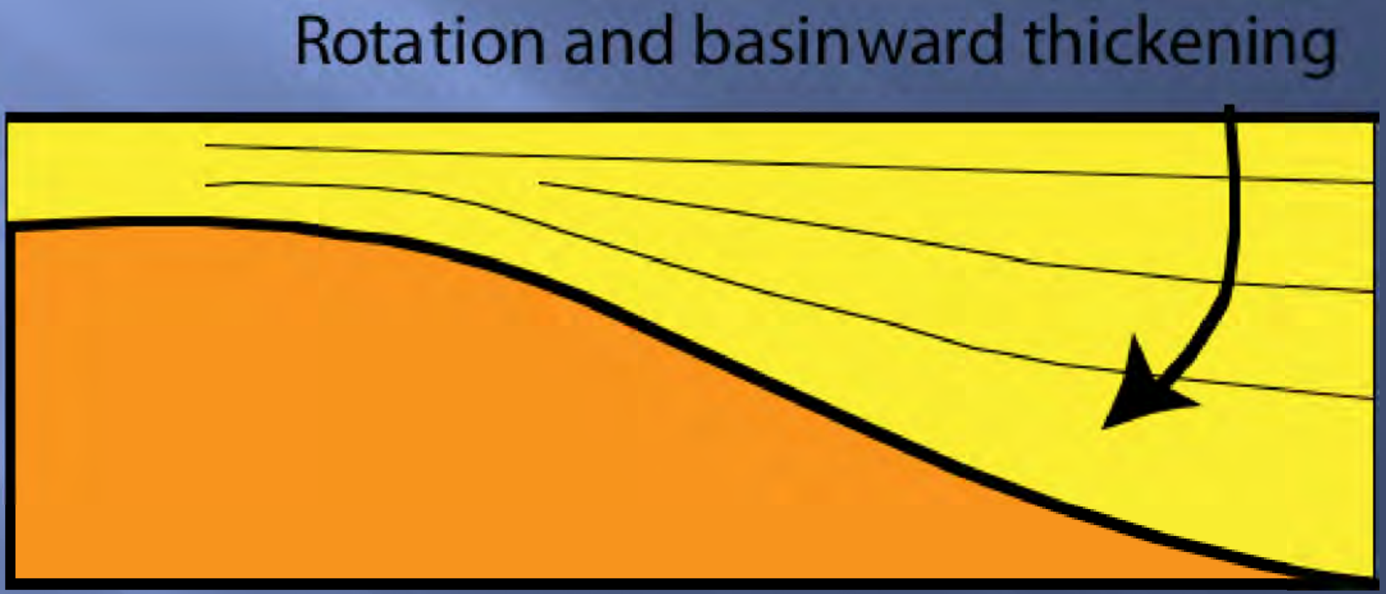

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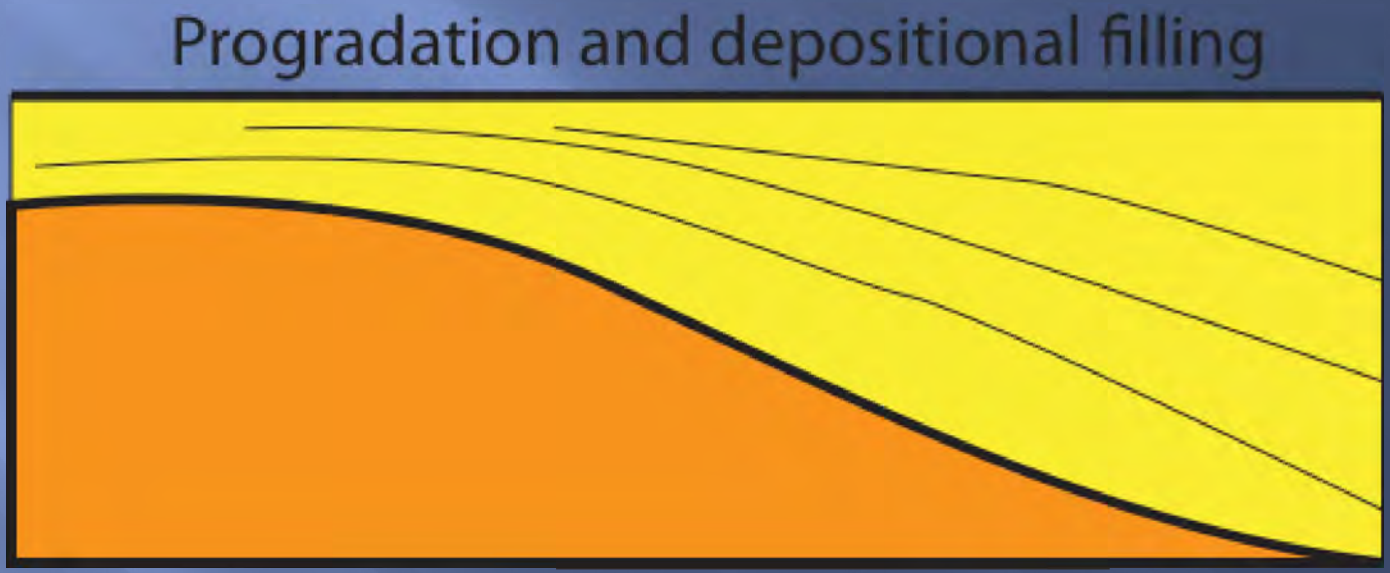

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Any of the above combined with Faulting

The study area is in the Indio Mountains of West Texas, located along the border, halfway between El Paso and Big Bend

During the Jurassic and Cretaceous, the study area lay along the north flank of a narrow sea that extended for over 1,000 km from the Gulf of Mexico to SE Arizona. The portion of the sea including the Indio Mountains is known as the Chihuahua Trough.

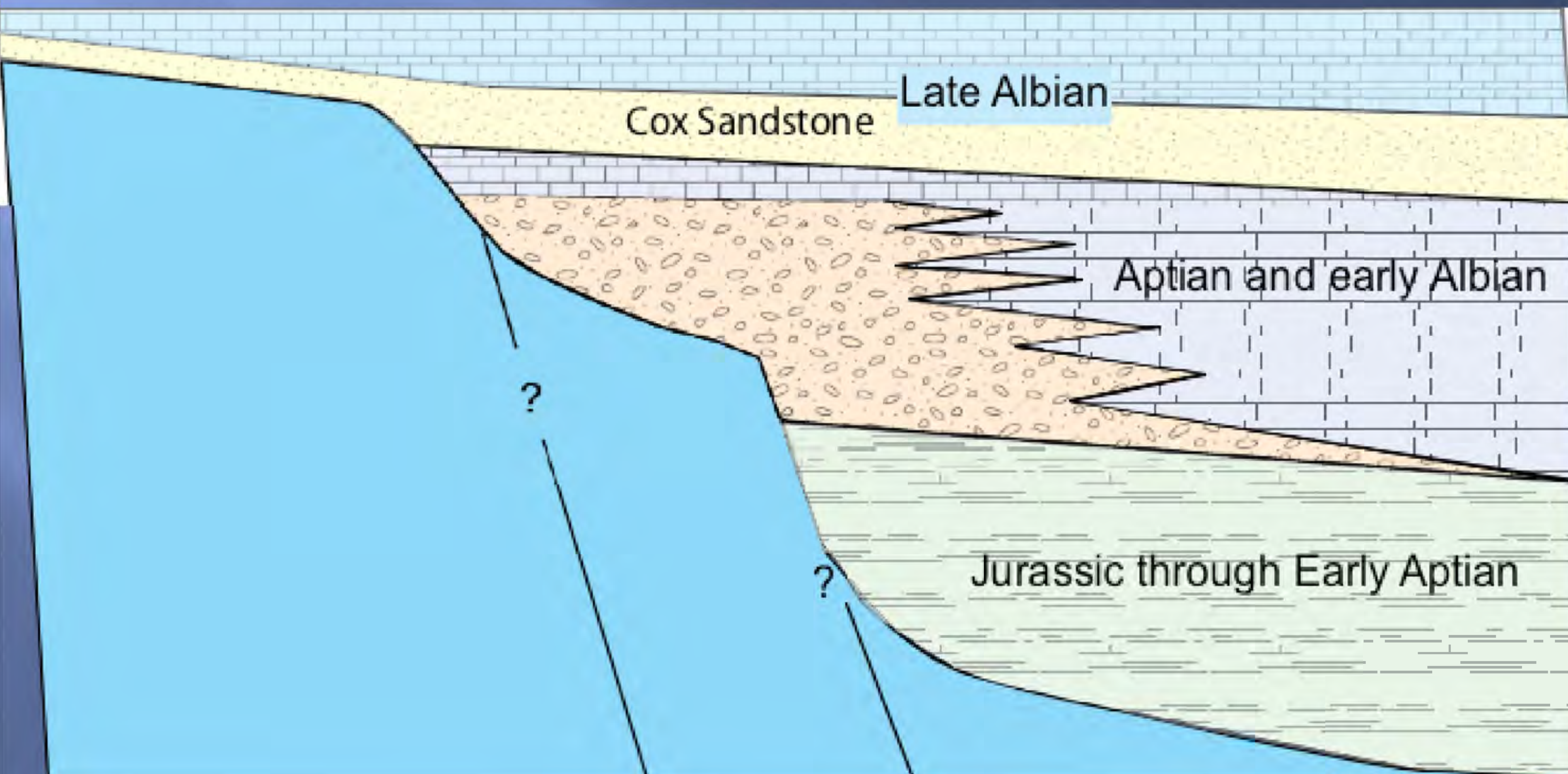
Chihuahua Trough

- Rifting from Middle Jurassic to Early Late Cretaceous (End of Cenomanian)
- 5 km of Cretaceous strata in deepest basins.
- Jurassic Evaporites
- Early Cretaceous Conglomerates and coarse Sandstones
- Late Cretaceous fluvial and shallow marine.

Tectonic Events

- Late Cretaceous Rifting and Strike Slip Faulting? (Chihuahua Trough)
- Inversion during Laramide thrust Faulting on salt decollement
- Late Tertiary Extension exposed Cretaceous rift fill along ranges oblique to basin margin

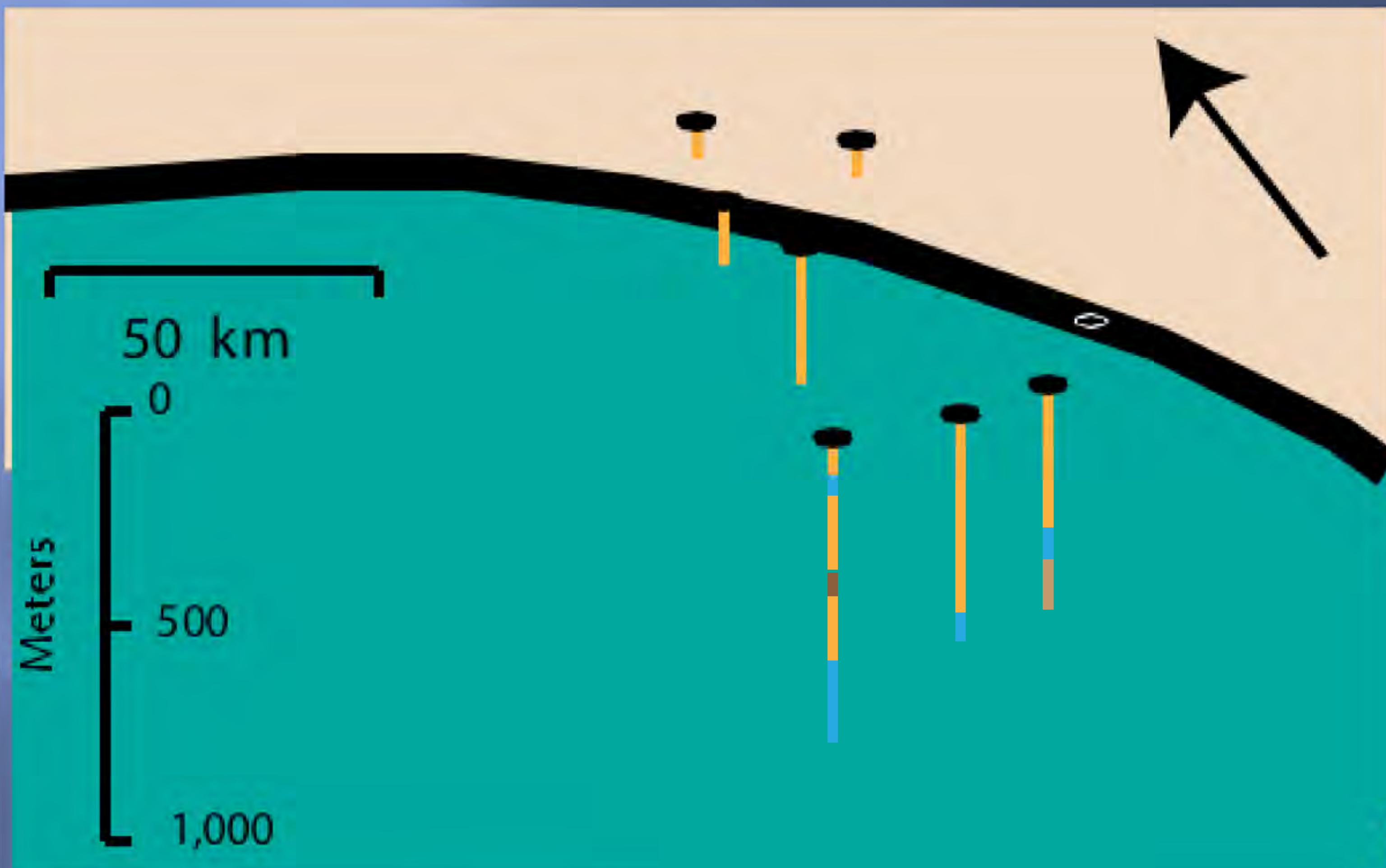
Cretaceous Stratigraphy				
			Chihuahua Trough Events	
Upper/Late	**Maastrichtian**	**70.6 - 65.5**		
	Campanian	**83.5 - 70.6**		
	Santonian	**85.8 - 83.5**		
	Coniacian	**89.3 - 85.8**		
	Turonian	**93.5 - 89.3**		
	Cenomanian	**99.6 - 93.5**		
Lower/Early	**Albian**	**112.0 - 99.6**	Subsidence and broadening of basin	Transgression and expansion of basin, followed by renewed erosion on flanks and deposition of
	Aptian	**125.0 - 112.0**	Tectonism (Extensional) Deposition in Basin Center	Expansion of Deposition Terrestrial conglomerates and sandstones prograde into basin
	Barremian	**130.0 - 125.0**		
	Hauterivian	**136.4 - 130.0**		Marine clastics and limestones
	Valanginian	**140.2 - 136.4**		


Late Albian
Cox Sandstone
Aptian and early Albian
?
?
Jurassic through Early Aptian

The Cox Sandstone

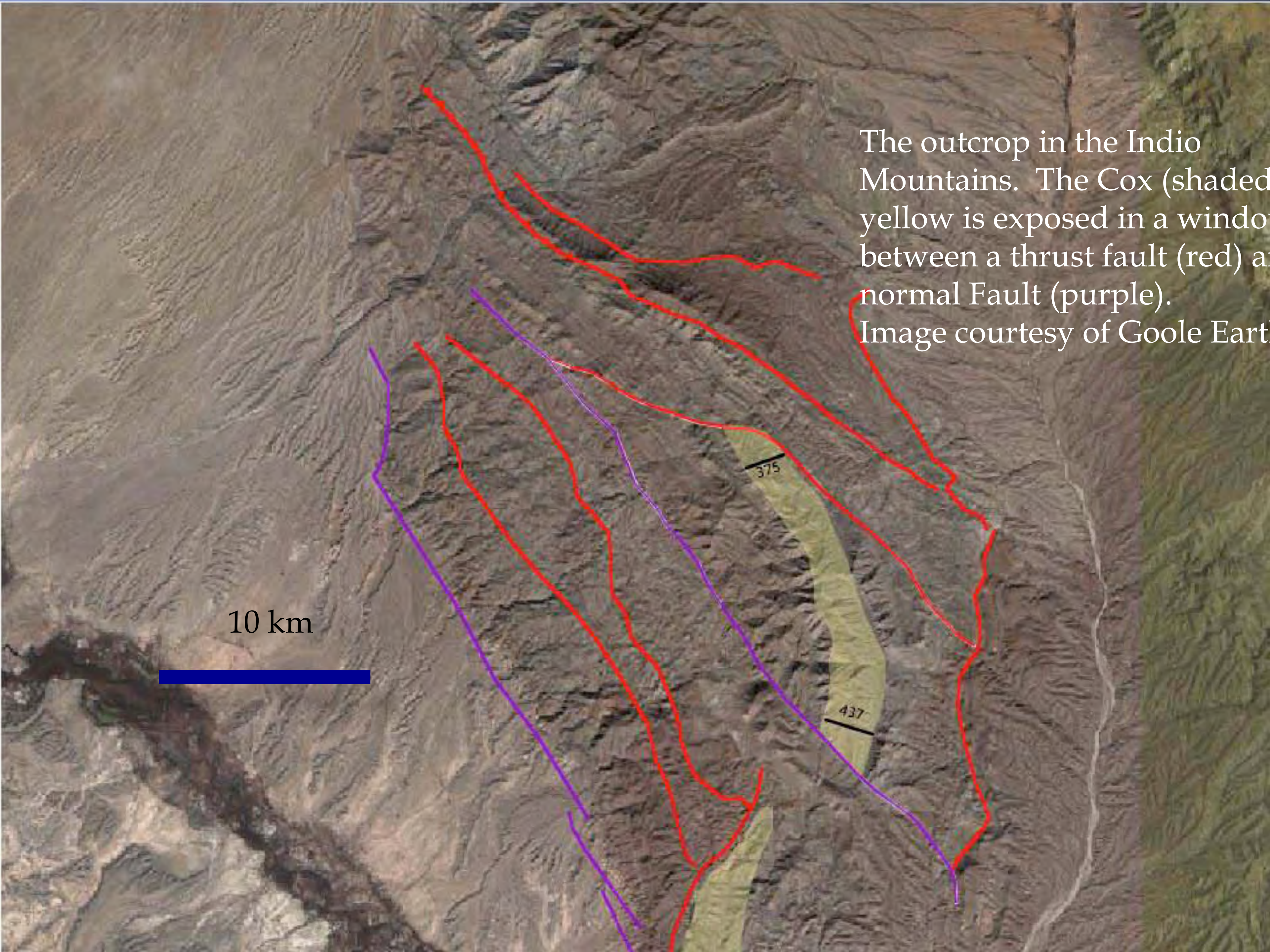
- Albian, deposited near end of active rifting
- Overlaps basin margin, but thickens into rift
- Overlying Finley formation is similar
- Highstand coastal sandstone
  - Abundant petrified wood.
  - Thin marine limestones, particularly near base and in upper third. Intertonguing contact with the overlying Finlay LS.

Cox ss increases from 60 m outside of basin to 600 m in interior



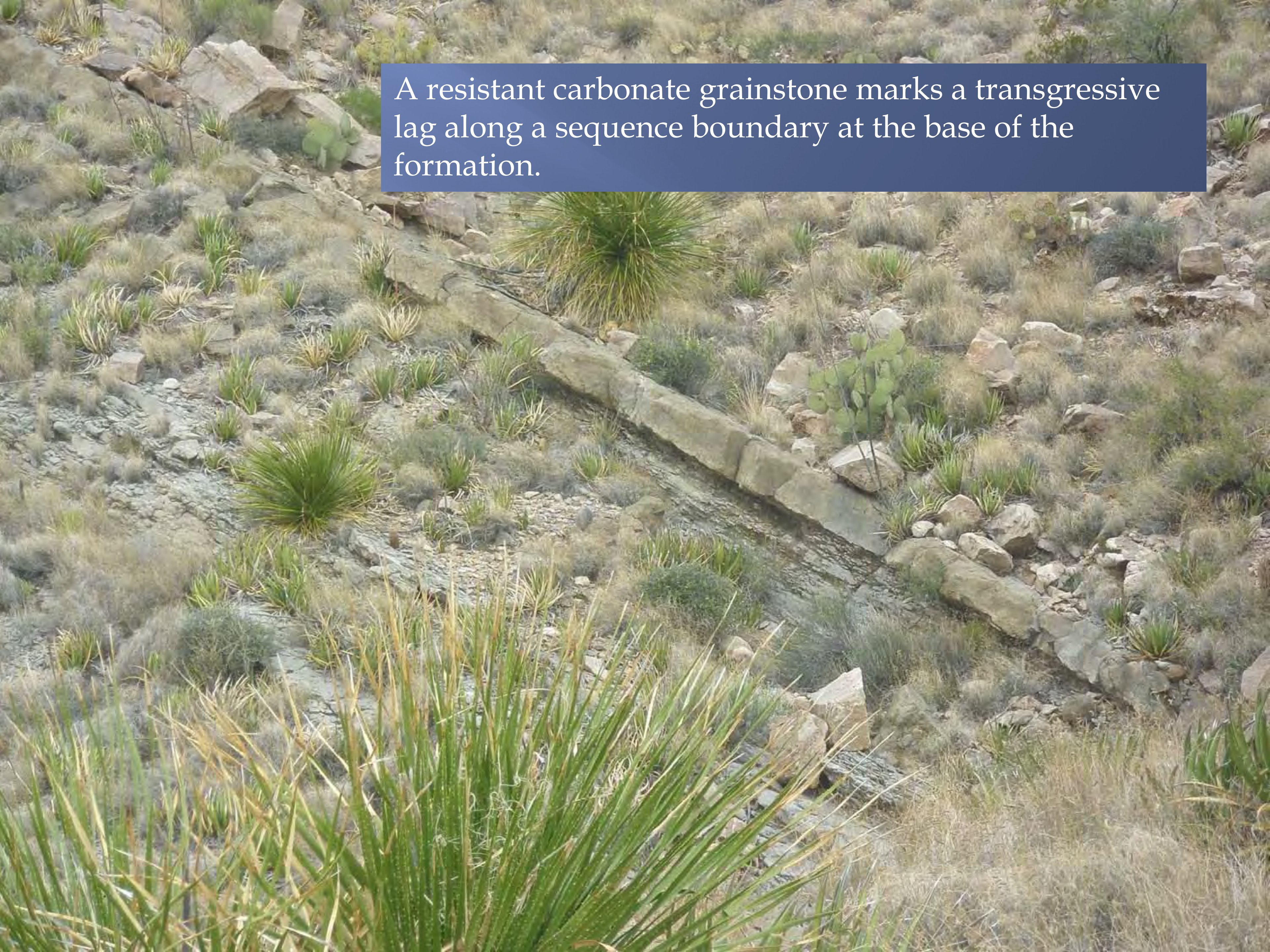
The Outcrop

- Disadvantages.
  - Largely two dimensional, oblique to basin margin
- Advantages
  - Relatively continuous outcrop, excellent exposure
  - Well expressed parasequences aid in correlation and interpretation.
  - Sequence stratigraphy is consistent and interpretable



The outcrop in the Indio Mountains. The Cox (shaded yellow is exposed in a windo between a thrust fault (red) a normal Fault (purple).
Image courtesy of Goole Eart

Highstand not visible


A resistant carbonate grainstone marks a transgressive lag along a sequence boundary at the base of the formation.

Sequence Stratigraphy

- Base is local angular unconformity with transgressive lag at top
- Three sequences of marine to fluvial Transgressive Systems Tracts overlain by Fluvial highstand Systems Tracts

Uppermost Highstand not shown

Transgressive Tract Environments

- Carbonate Shelf with fossiliferous LS (rare)
- Inner shelf mudstones, rippled and HCS sandstones
- Shoreface Sandstones, HCS and rippled
- Fluvial Channel Sandstones
- Floodplain Mudstones and Sandstones.

Thin ripple cross-stratified beds in a thin marine mudstone

Wave and current ripple cross-stratified sandstone


Hummocky X strata

Trough cross-stratified and laminated shoreface sandstone

Transgressive channels form narrow sandbodies

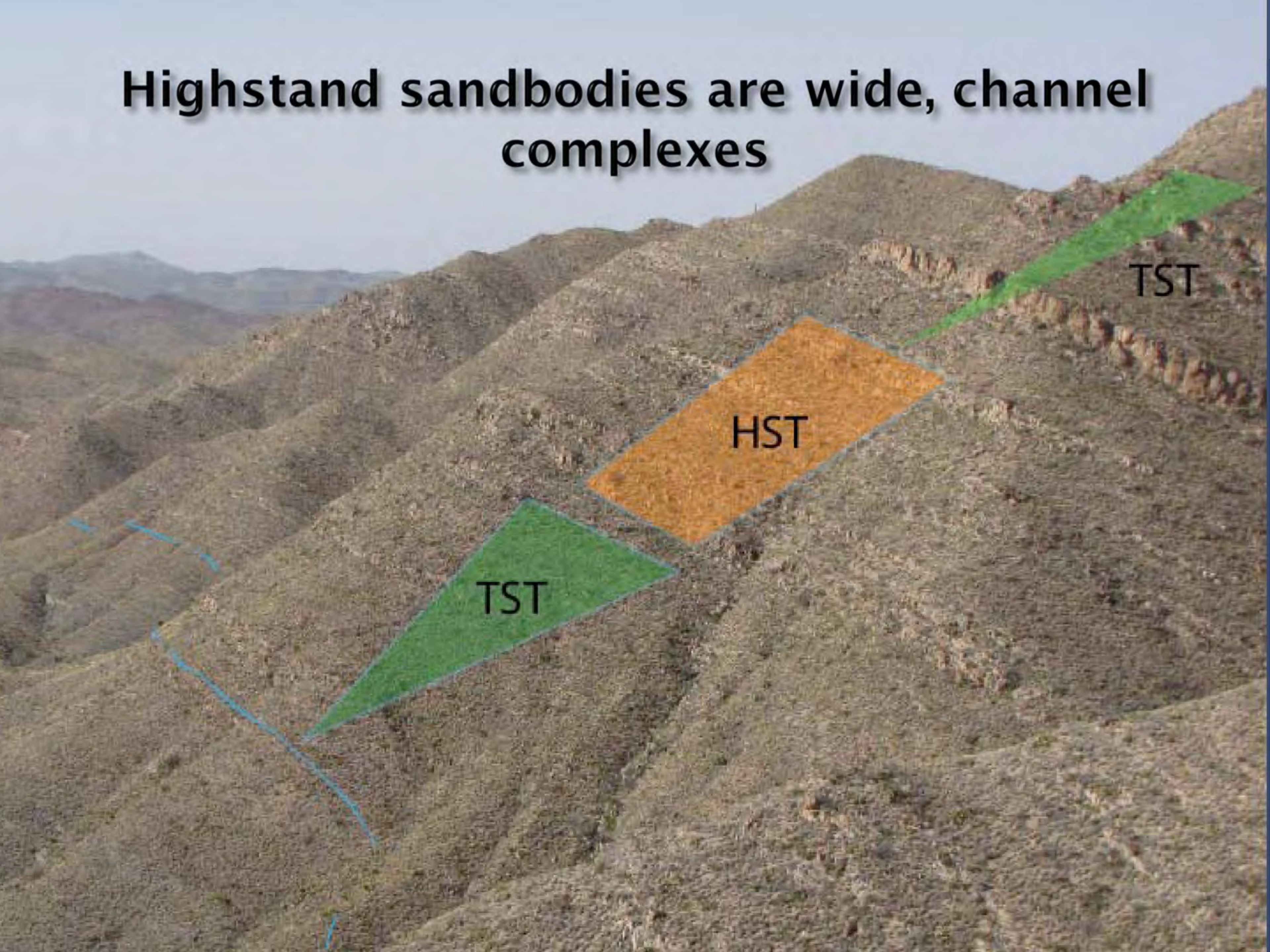
Floodplain mudstones and sandstones

Highstand Systems Tract Environments

- Shoreface Sandstones
- Fluvial Channel Sandstones (channel complexes)
- Floodplain Mudstones

Floodplain mudstone with a crevasse splay sandstone.

Highstand sandbodies are wide, channel complexes



Large Planar tabular cross strata in a channel sandstone

Sediment Dispersal

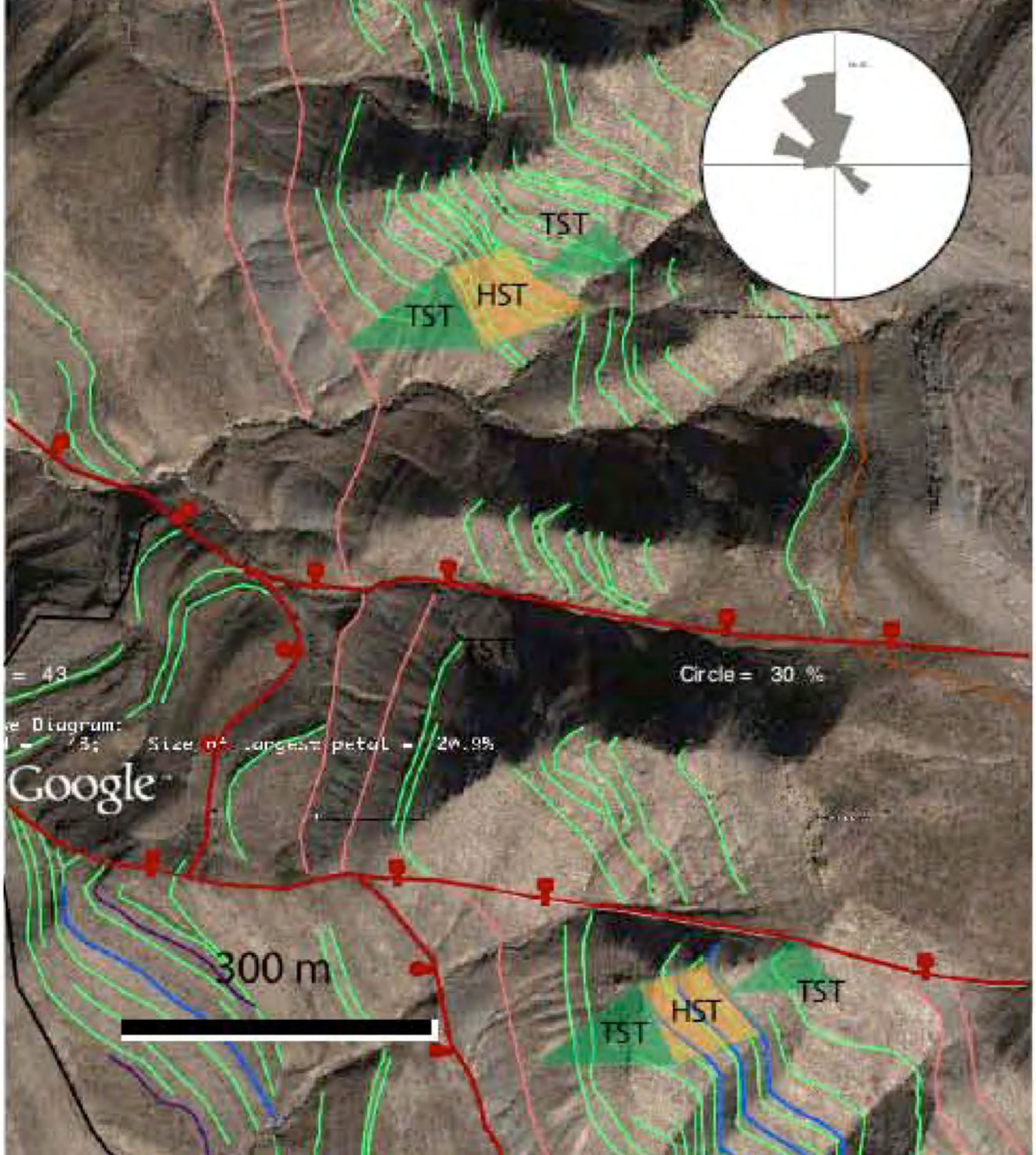
- Complex orientations, due to Meandering systems
- Trough axes primarily to NW, sub-parallel to syntectonic faults and basin margin.
- No known source, basin more complex

SO WHAT ACCOMMODATES THE EXPANSION OF STRATA INTO THE BASIN?

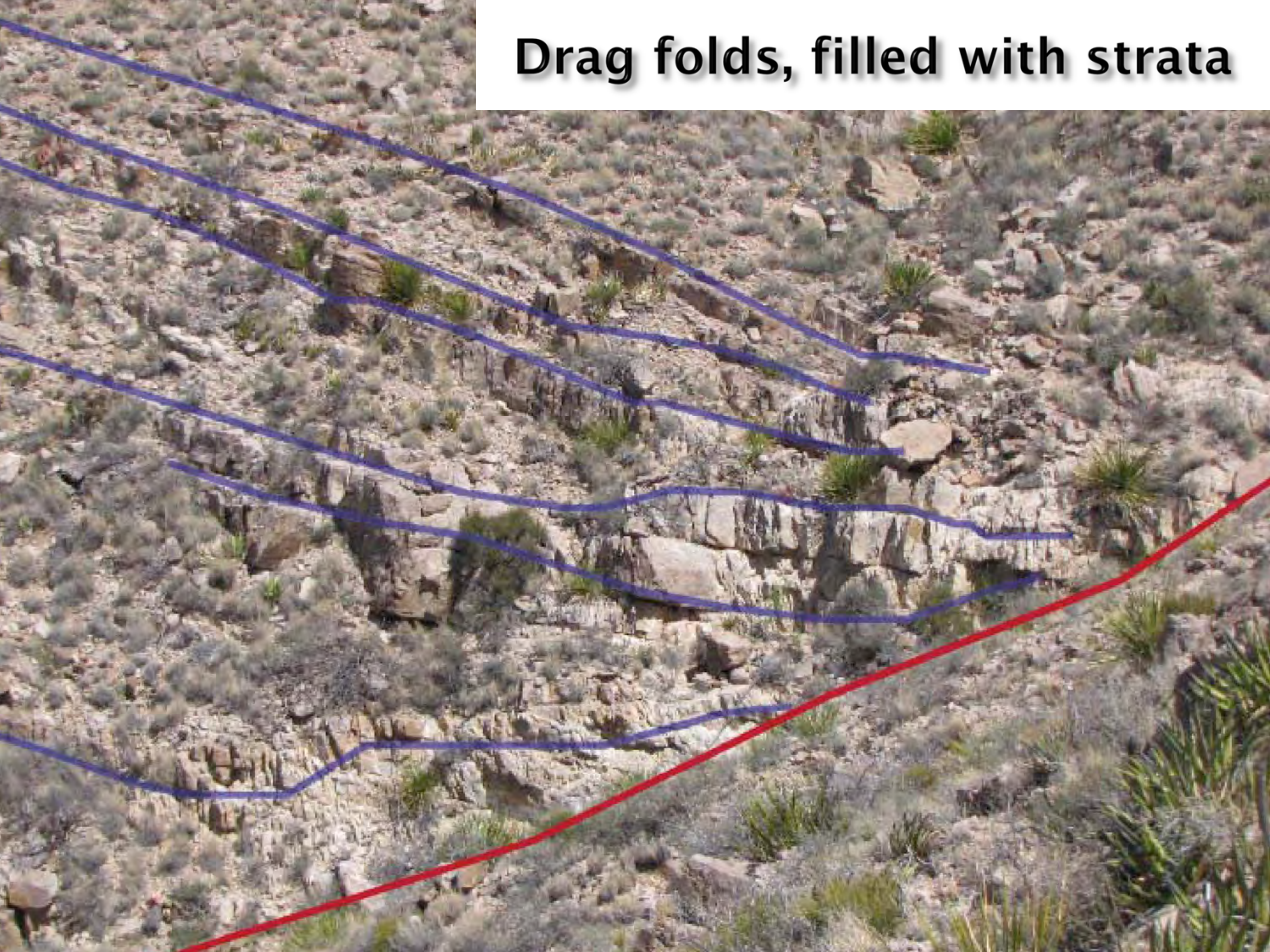
Thickening is associated with Syntectonic Faults

- Down to West (Oblique Synthetic) (350 degrees)
- Down to North (Oblique Antithetic) N70
  - Present day dips 65-72 degrees
  - Rotation to horizontal gives 7 degree tilt of footwall (upthrown) block that is onlapped at base

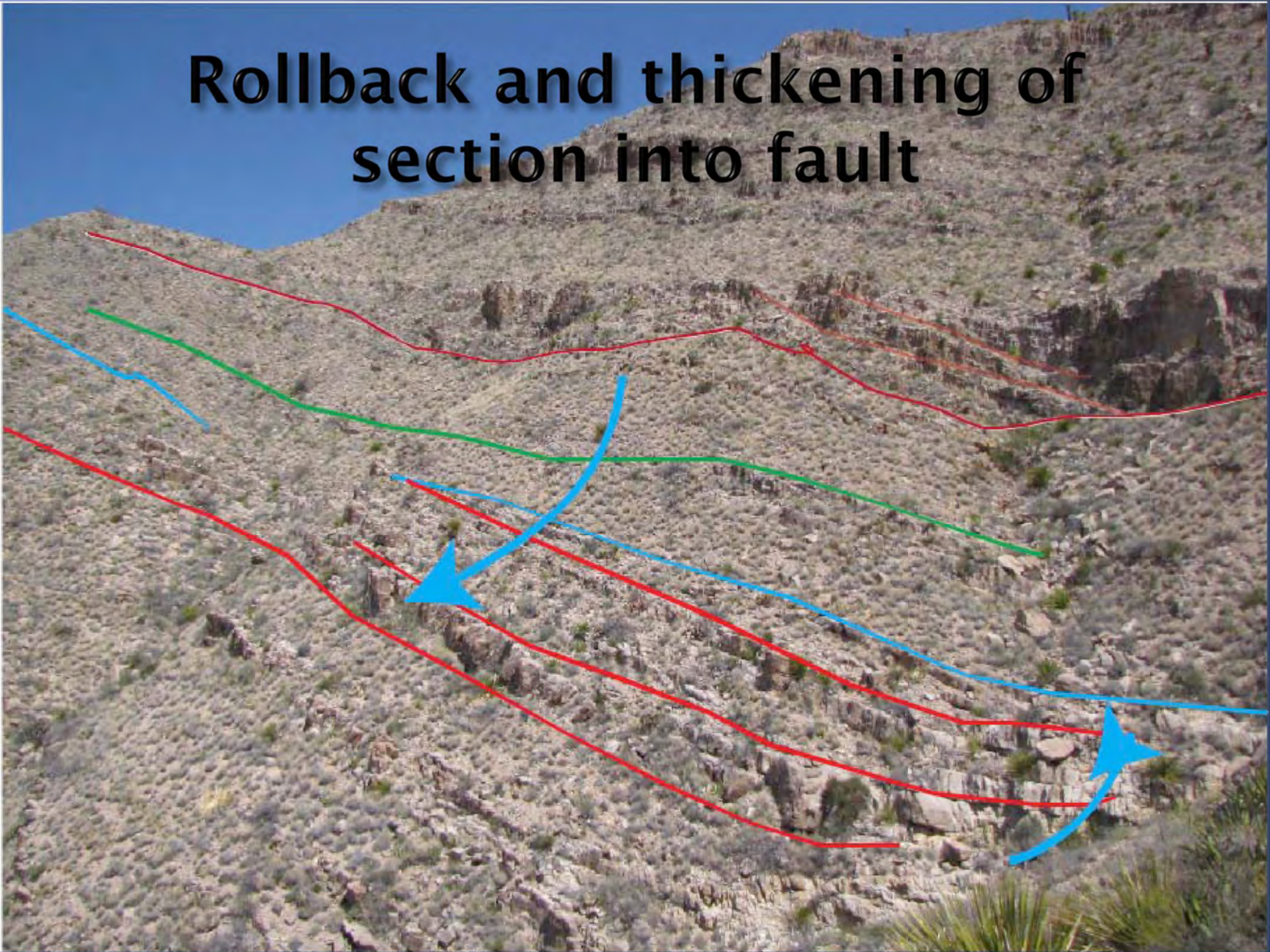

50 km
Basin Margin
Footwall
Rotation

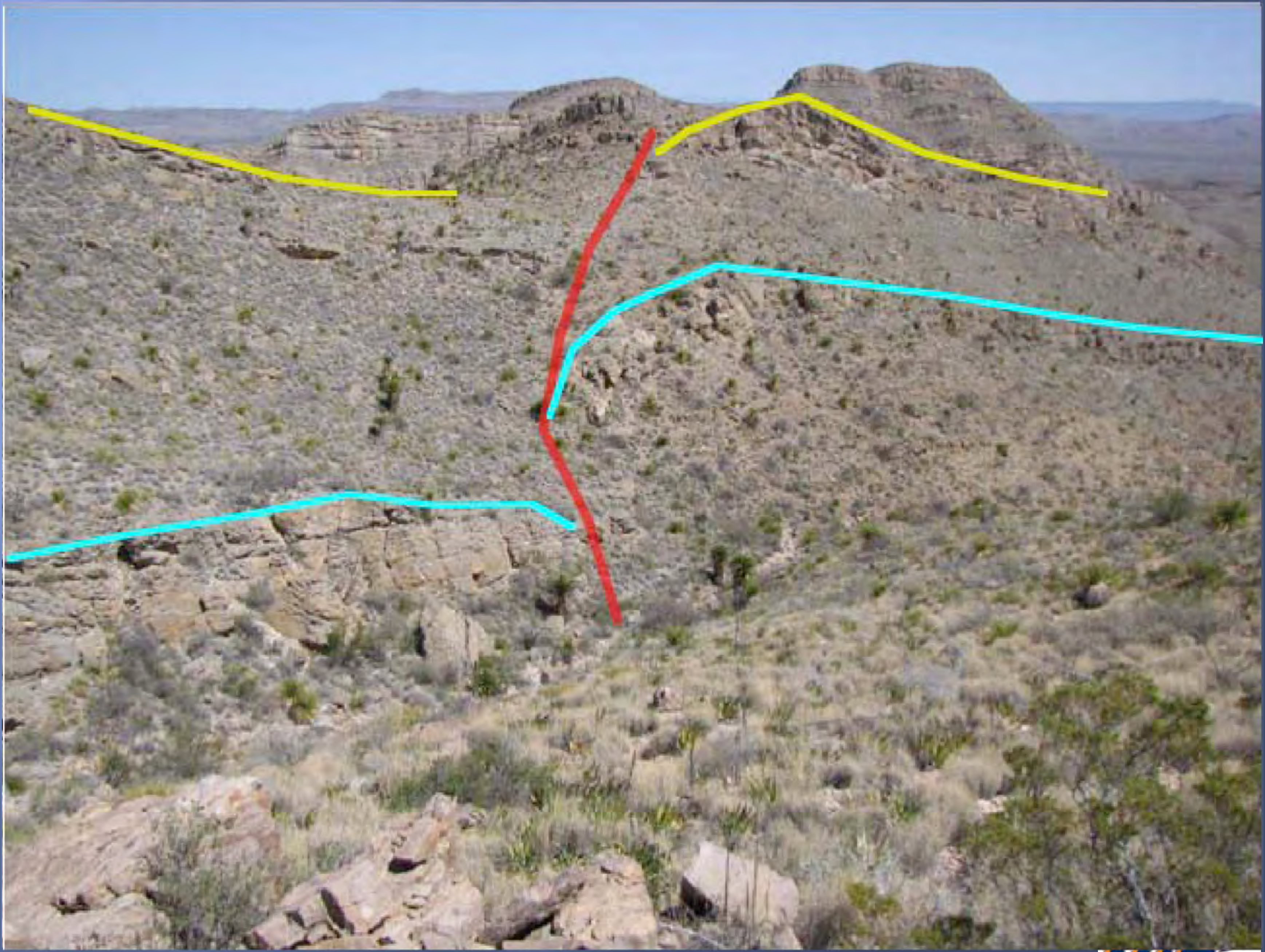

TST
HST
TST
Circle = 30 %
300 m
TST
HST
TST

Drag folds, filled with strata



Rollback and thickening of section into fault

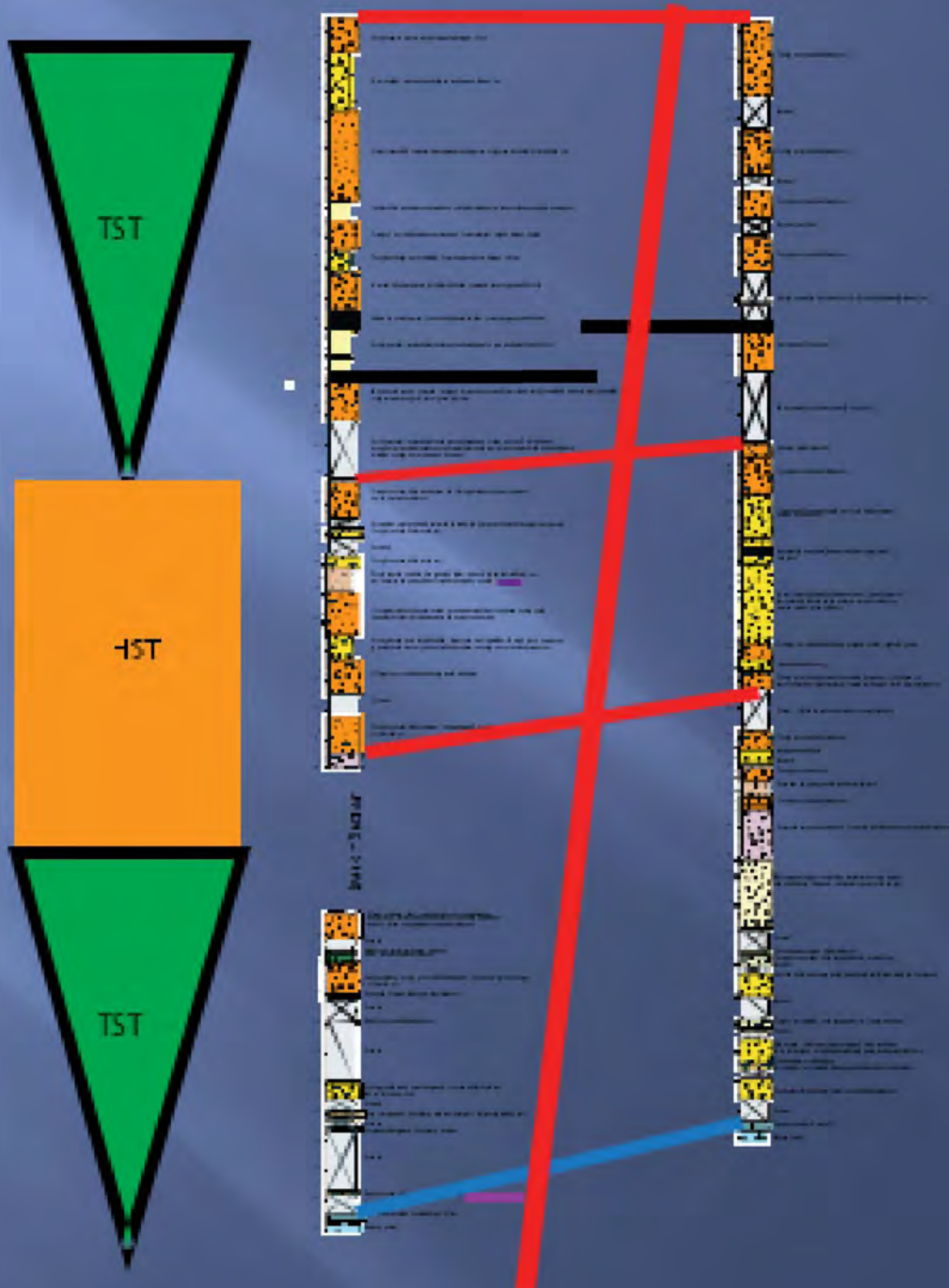




Growth across fault

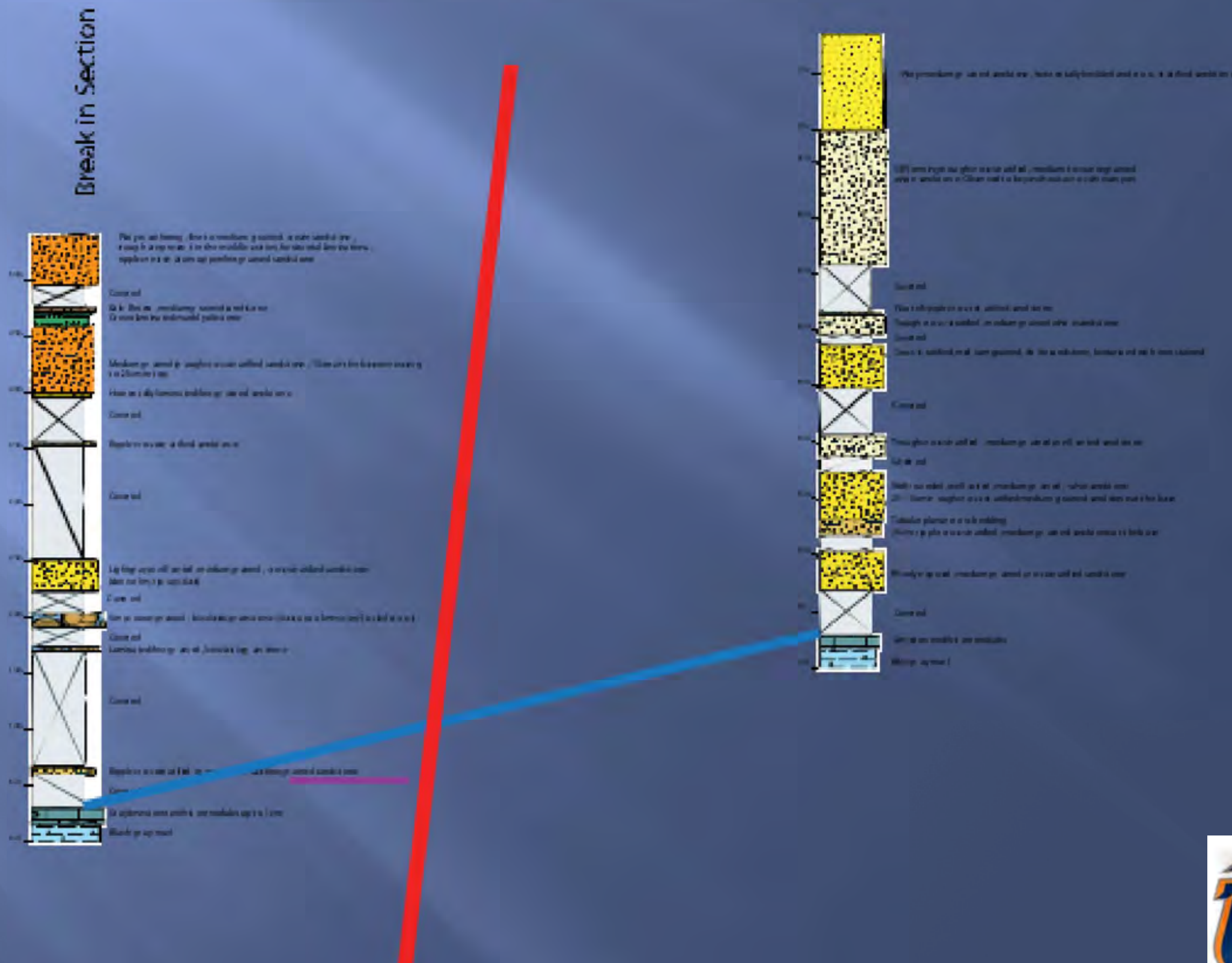
- 54 m of offset at base of Cox SS
- 23 m at top of Cox ss

Section hung on marker bed in middle Cox 240 m



Transgressive Systems Tract

- Fluvial Channel fills
- Shoreface and Innder Shelf Sands
- Nonmarine Shales
- Outer Shelf Muds

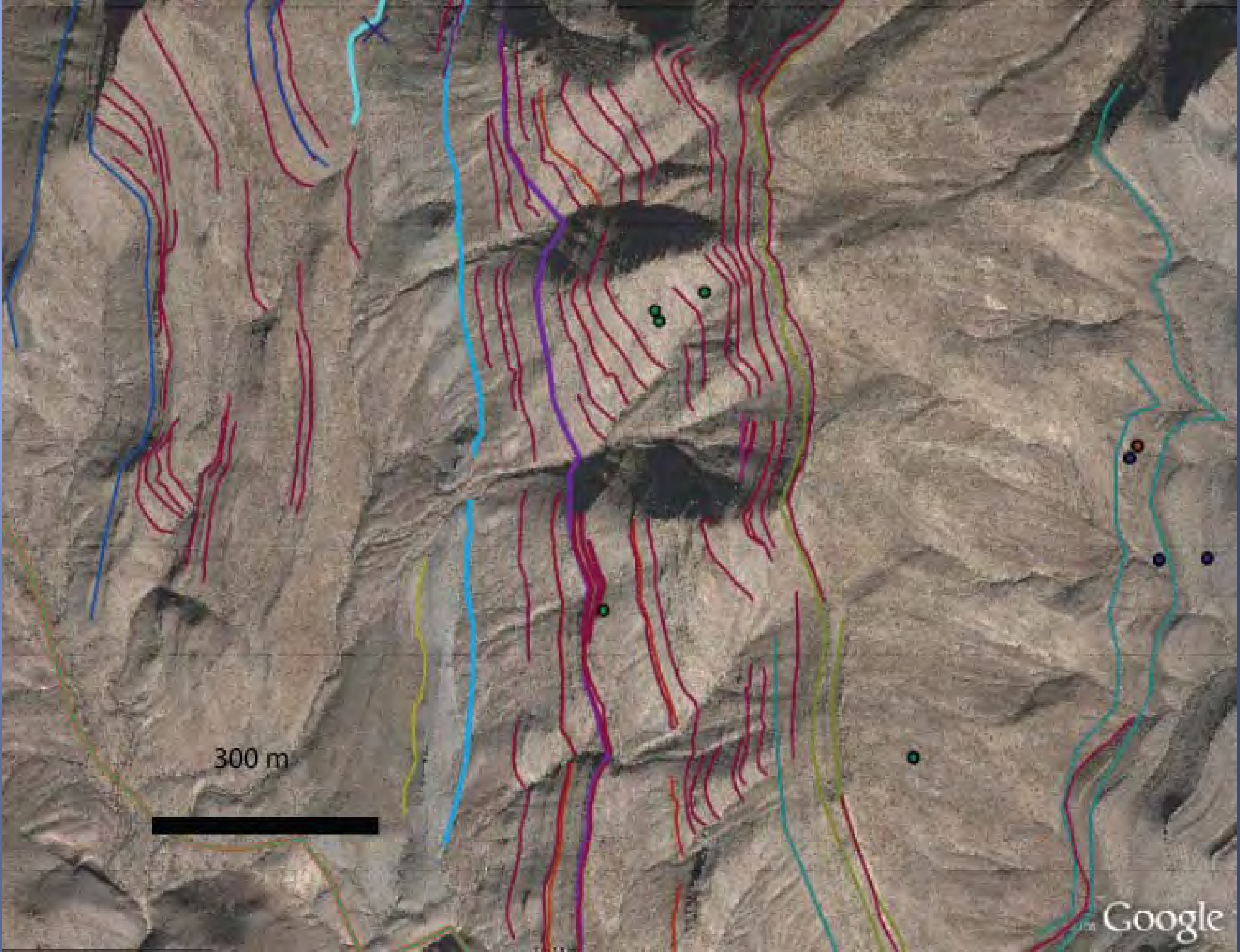


Highstand Systems Tract

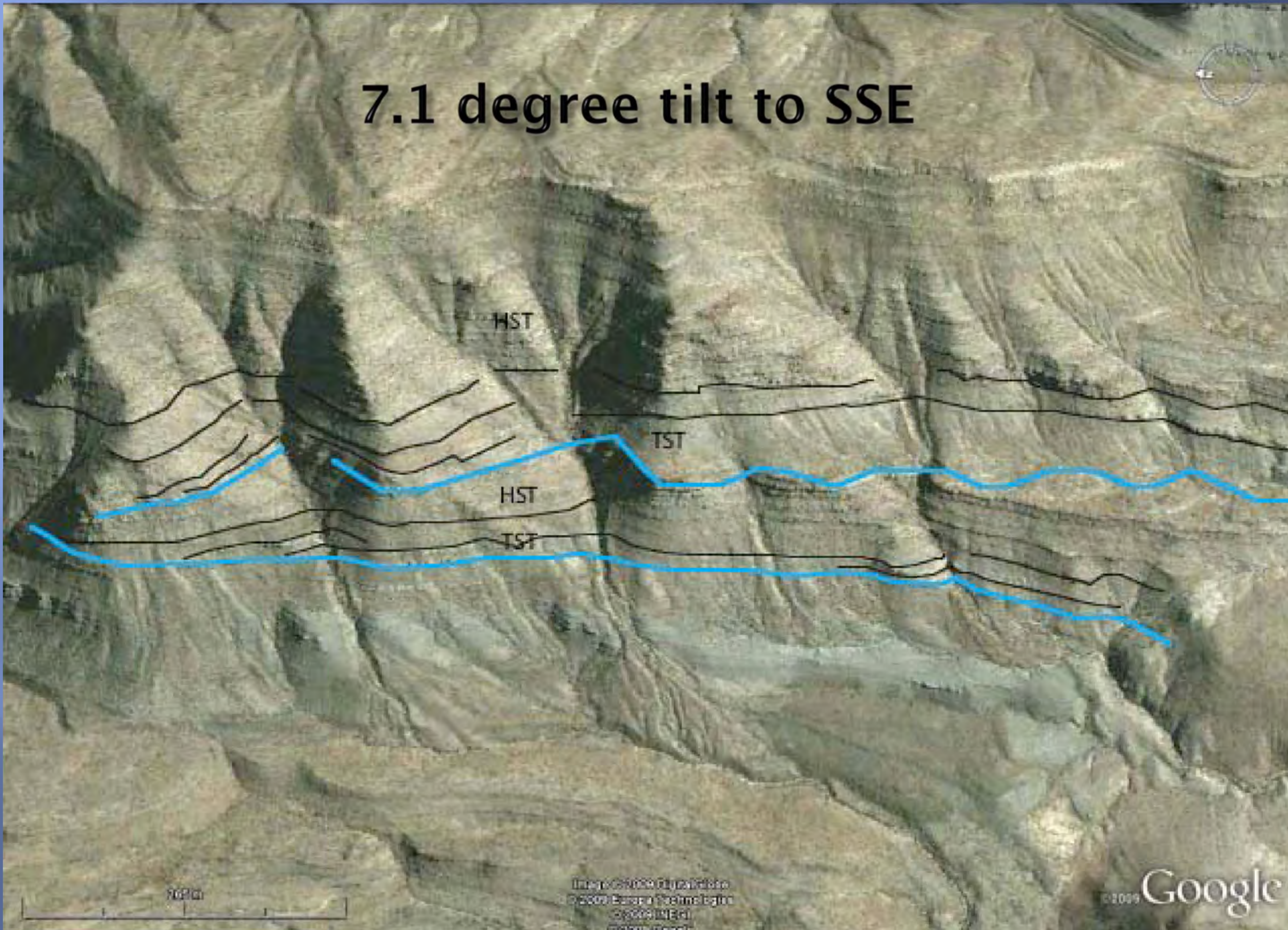
- Fluvial Channel fills
- Shoreface and Innder Shelf Sands
- Nonmarine Shales
- Outer Shelf Muds

Growth thickening across faults

- Highstand tracts do not change thickness.
- Fault offset is accommodated in different thickness of transgressive tracts. 23 m in basal and unconformity, 7 m in second


300 m
Google

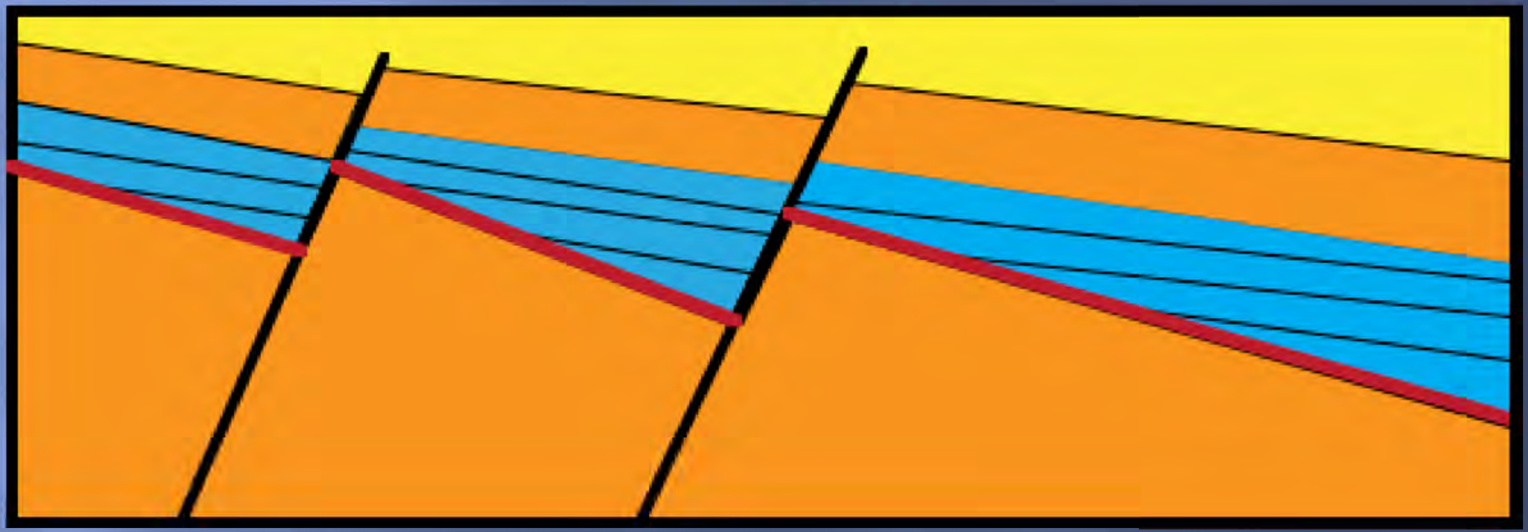
7.1 degree tilt to SSE



Expansion of section

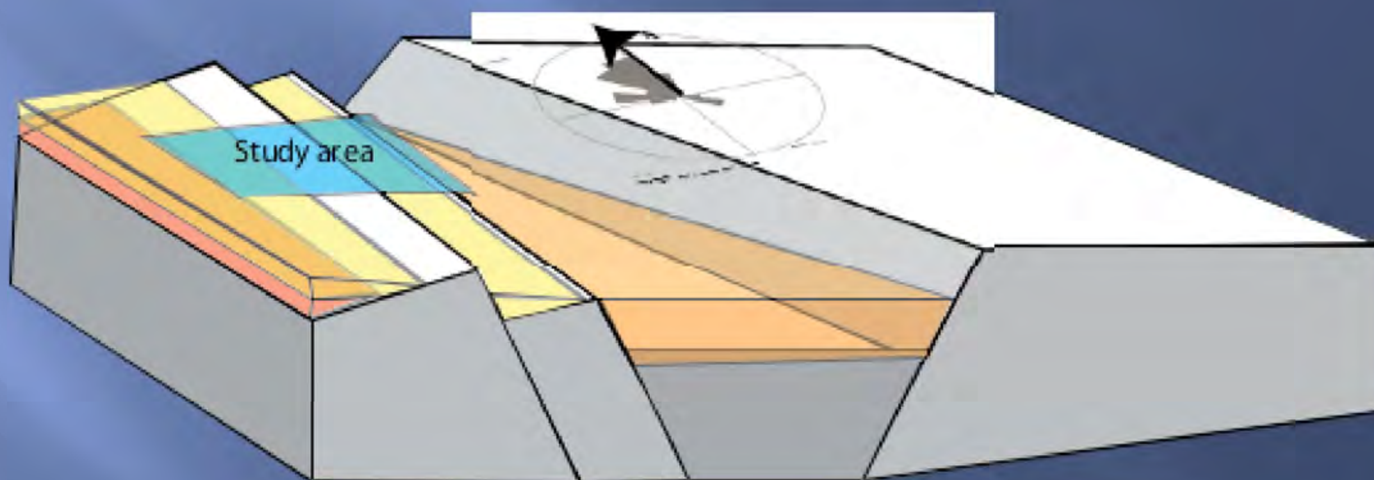
- The greatest expansion of section occurs through
  - Onlap onto sequence boundaries.
  - Expansion of Transgressive Systems Tract shales as underlying strata are rotated.

Final model

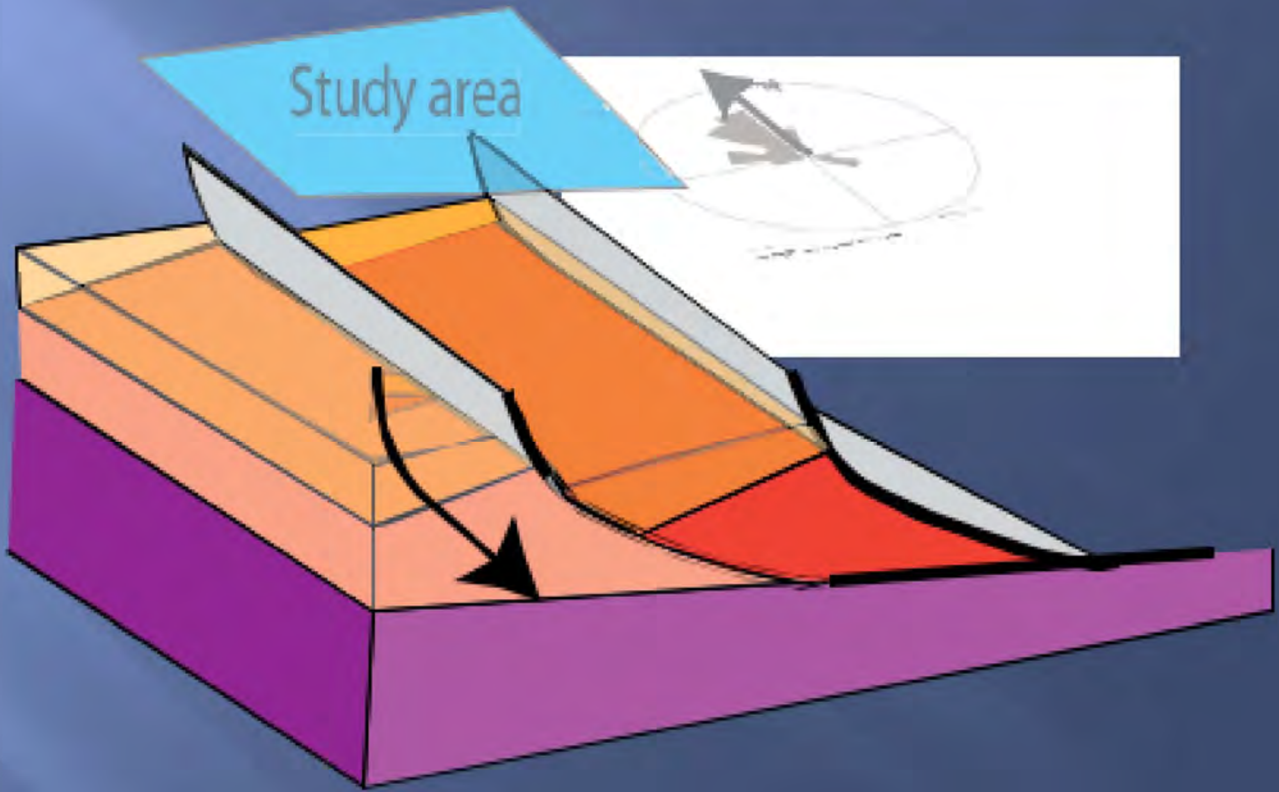


Section Expansion accommodated by onlap of sequence boundaries .
Transgressive systems tract beds are rotated and thicken basinward

Model with Antithetic Faults



Salt influenced Tectonism



Summary

- Expansion is accommodated by onlap of Sequence Boundaries and expansion of Transgressive Systems Tract Shelf Shales.

- Sequence stratigraphy is key, both onlap and bed expansion models apply

- Antithetic fault geometries fit either a complex basin structure, or salt tectonism.