Attributes of Carbonate Platforms Associated With Passive Salt Diapirism*

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Abstract

Older concepts of carbonate deposition around passive salt diapir highs envision atoll-like geometries with interior hypersaline lagoons that experienced frequent subaerial exposure events and extensive meteoric diagenesis. Recent detailed depositional and diagenetic facies analysis of outcropping diapir-related carbonate platforms suggest atolls and extensive subaerial exposure are an exception rather than the rule. Outcropping salt diapir-related carbonate platforms in strata of Neoproterozoic-Cambrian, South Australia; Cretaceous-Paleogene, Mexico; and Cretaceous, Spain, are stratigraphically contained within both hook and wedge-type halokinetic sequences (HS); however, their depositional facies distribution and structural geometry varies between the two types. Platforms within hook-HS are typically isolated, thinner, and less areally extensive than in wedge-HS. Halokinetic drape folds are very steep, near 90 degrees, and tight (folding extends >150m from diapir). Hook-HS contain basal debris flow facies with clasts of both diapir-roof and diapir–derived detritus and fauna tolerant of moderate fluctuations in salinity. The overlying normal marine boundstones/grainstones display steep depositional gradients away from the diapir, windward-leeward facies relationships, but lack interior lagoon facies. Locally, boundstones may be highly fractured with extensive early marine fracture-filling cements. The high-energy carbonate facies are overlain by deeper water shale or carbonate mudstone platform-drowning facies. In contrast, wedge-HS are typically downdip from highly productive regional carbonate platform systems and contain thicker, more widespread, lower gradient boundstone and grainstone facies than hook-HS. Halokinetic drape folding is low-angle (<20 degrees) and forms broad, open folds (folding extends up to 1.5km from the diapir). Basal debrites and halokinetic-induced fracturing are absent. In both types of halokinetic sequences, carbonate production on the diapir-related platform progressively decreases due to relative sea-level rise so that local sediment accumulation rate versus diapir rise rate decreases, resulting in increased topographic relief over the diapir and subsequent diapir roof erosion forming a local angular unconformity (HS boundary). The carbonate facies lack evidence of hypersaline conditions, dolomitization, extensive meteoric diagenesis or exposure, and are not associated with caprock formation.

Reference Cited

Bosence, D.W.J., 2005**,** A genetic classification of carbonate platforms based on basinal and tectonic settings in the Cenozoic: Sedimentary Geology, v. 175, p. 49-72.

Giles, K.A., and M.G. Rowan, 2012, Concepts in halokinetic sequence deformation and stratigraphy, *in* G.I. Alsop, S.G. Archer, A.J. Hartley, N.T. Grant, and R. Hodgkinson, eds., Salt-tectonics, sediments and propsectivity: Geological Society Special Publications, v. 363/1, p. 7-31.

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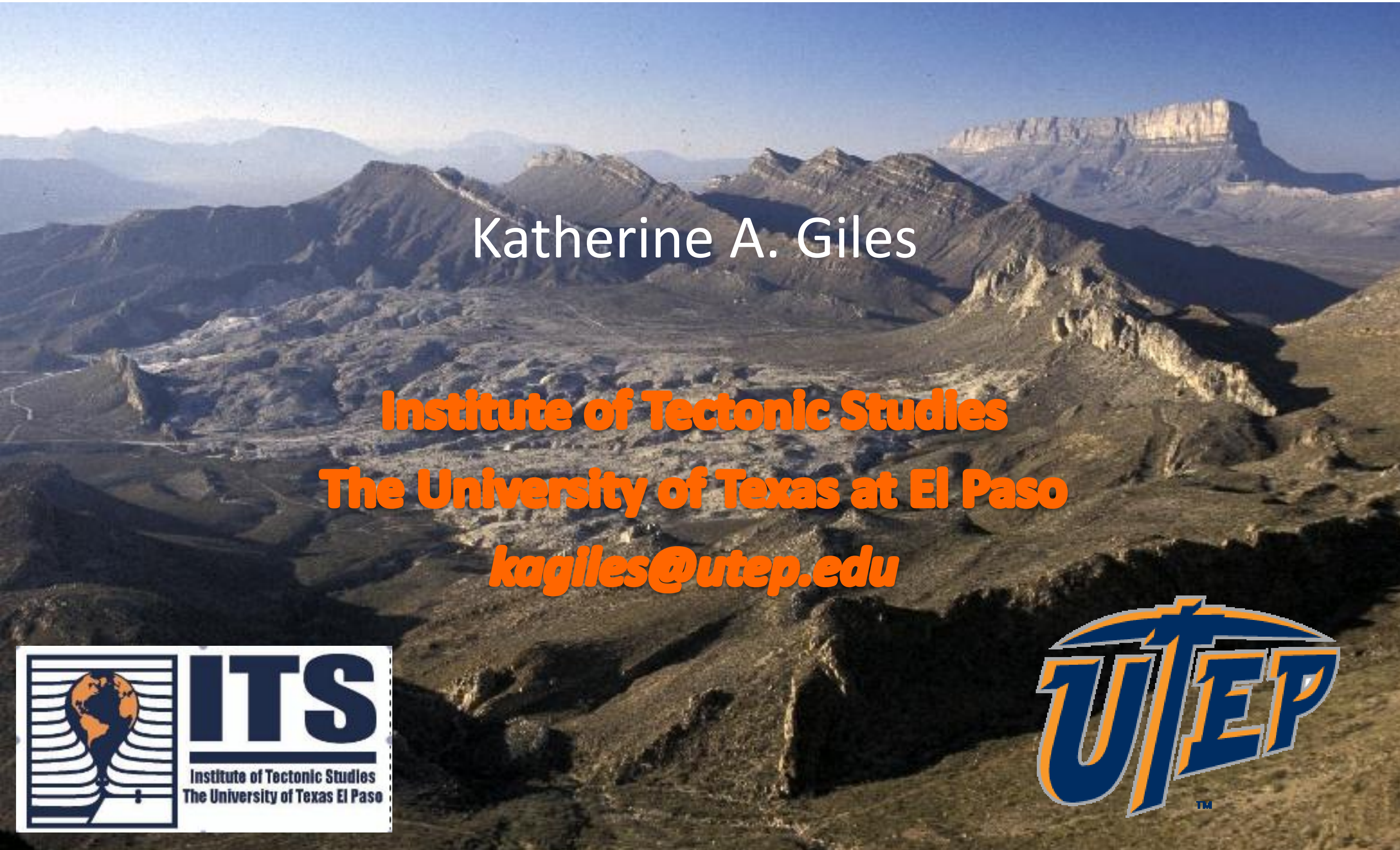

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Analysis of Outcropping Carbonate Platforms from 3 Different Salt Basins

Cretaceous: Basque-Cantabrian Basin, Northern Spain

Neoproterozoic -Cambrian: South Australia

Cretaceous – Paleogene: La Popa Basin NE Mexico

4 Main Points

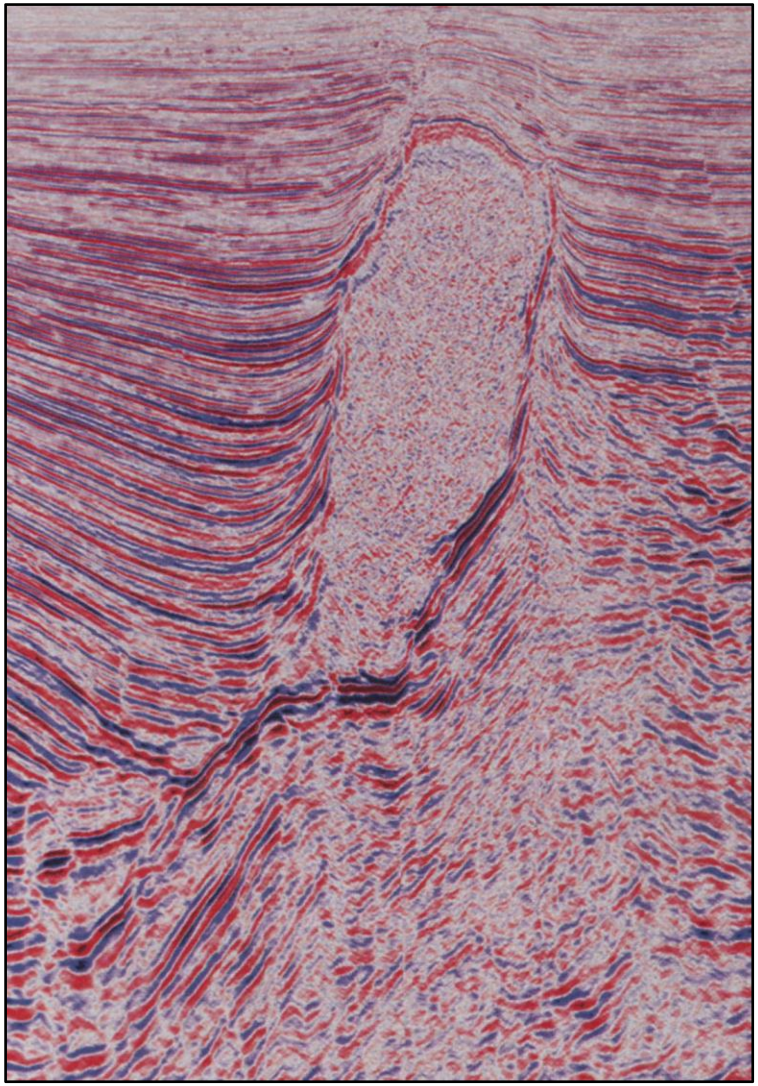
① Recognition of passive diapirism

② Atoll-like facies model not substantiated

③ Major CO_3 buildup associated with diapir inflation during TST

④ Thick platform assemblages lack evidence of extensive subaerial exposure, meteoric diagenesis or caprock formation

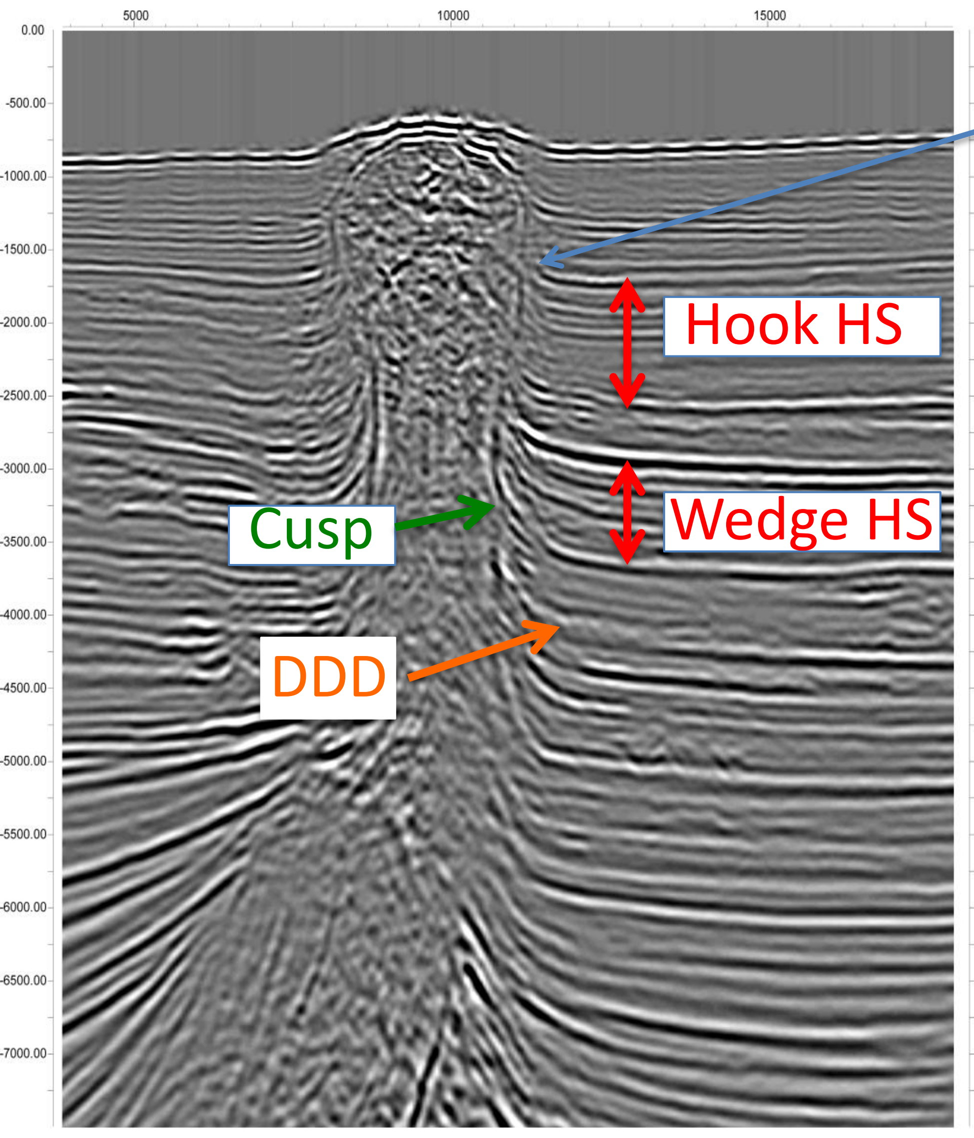
Is there Evidence for Syndepositional Passive Salt Diapirism?



Super Important for Risking Salt Plays

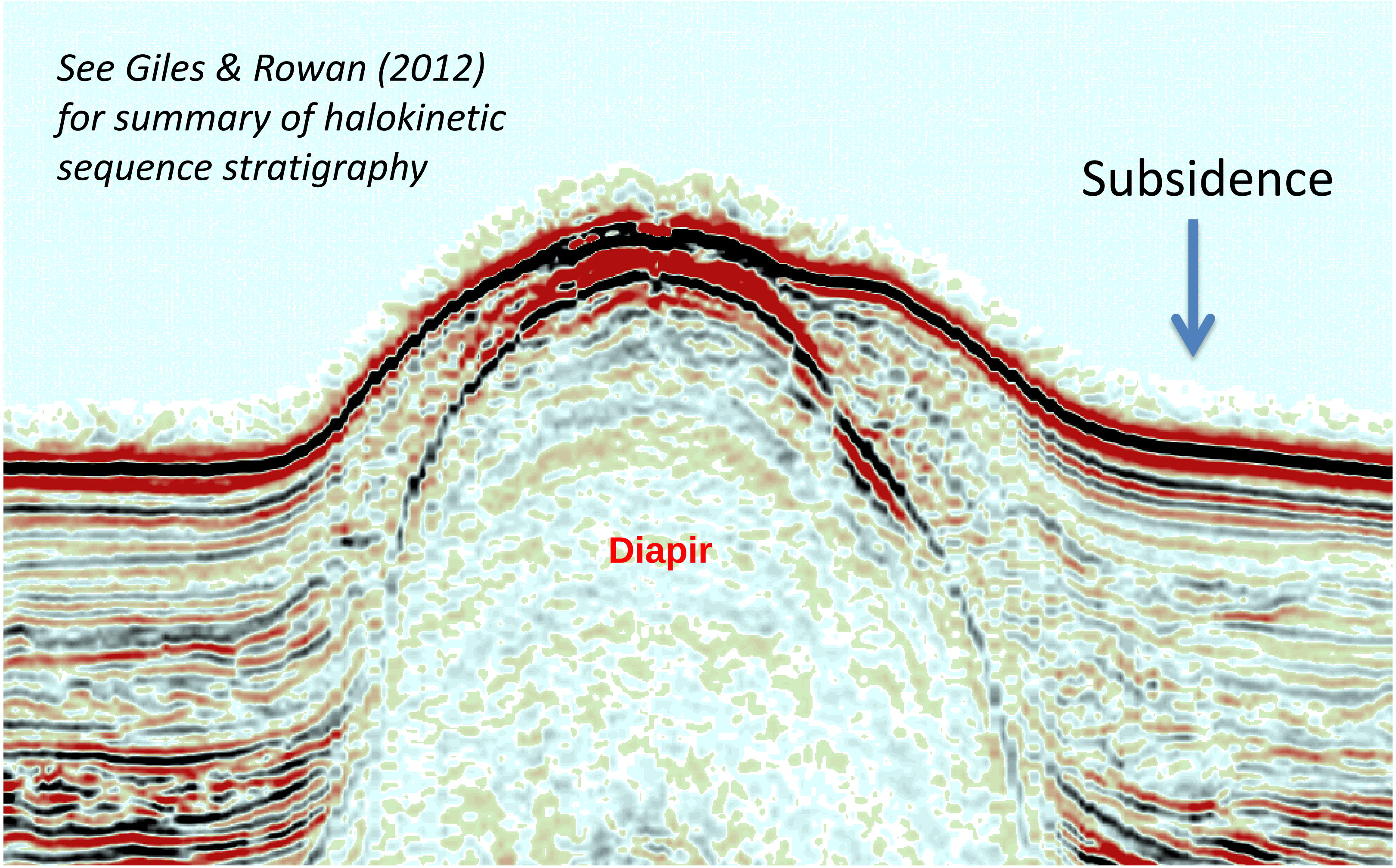
- Structural style and integrity of traps
- Reservoir facies, geometry and continuity
- Seal geometry and integrity
- Hydrocarbon charging

Recognition of Syndepositional Passive Diapirism

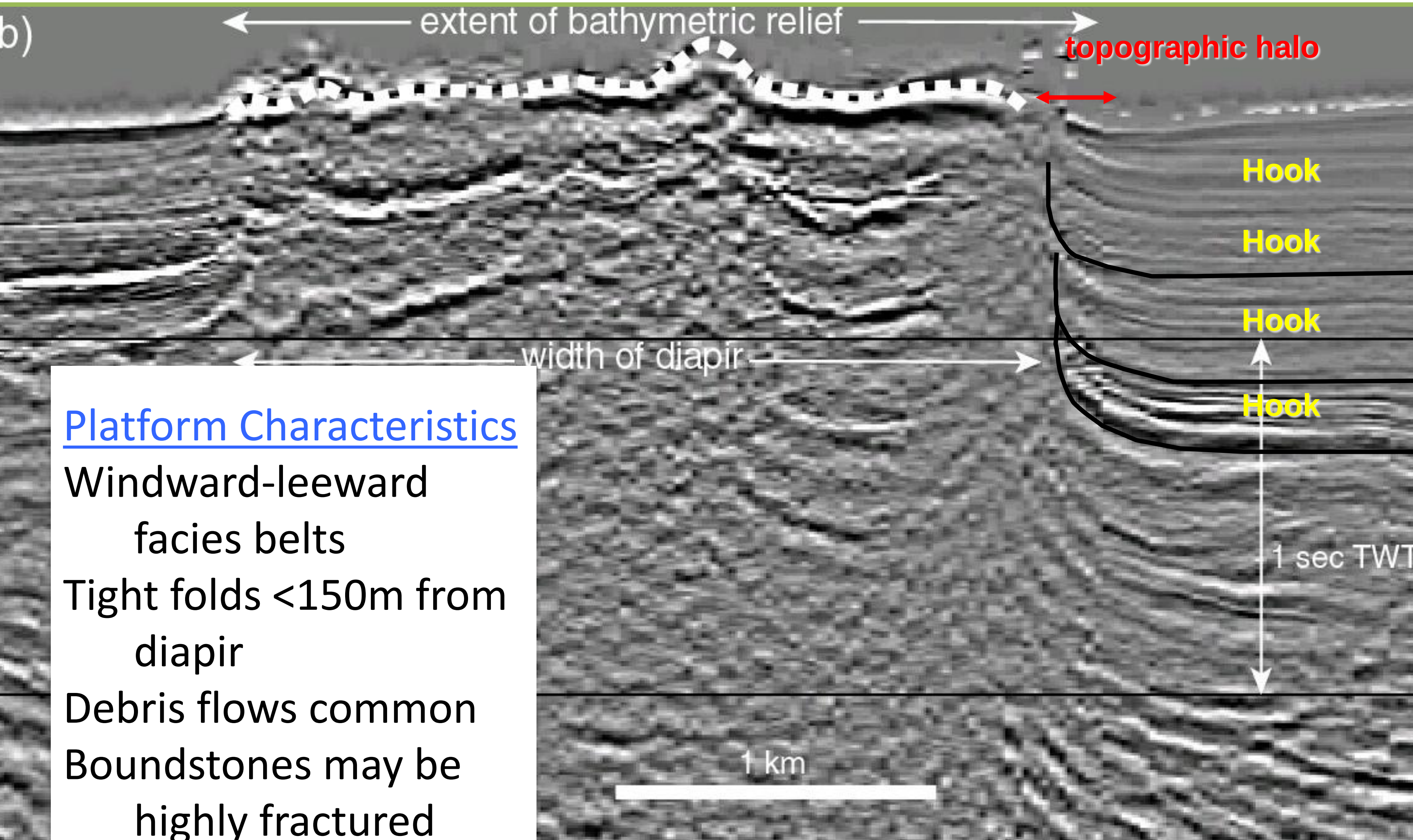


- Drape Folds: Thinned and upturned strata on margins of diapirs or welds
- Halokinetic Sequences (HS)
  - Hook HS /Tabular CHS
  - Wedge HS /Tapered CHS
- Salt Cusps
- Diapir-Derived Detritus (DDD): deposited in adjacent strata

Halokinetic Drape Fold



Thin Roof Forms Hook Halokinetic Sequences and Tabular Composite Halokinetic Sequence



Platform Characteristics

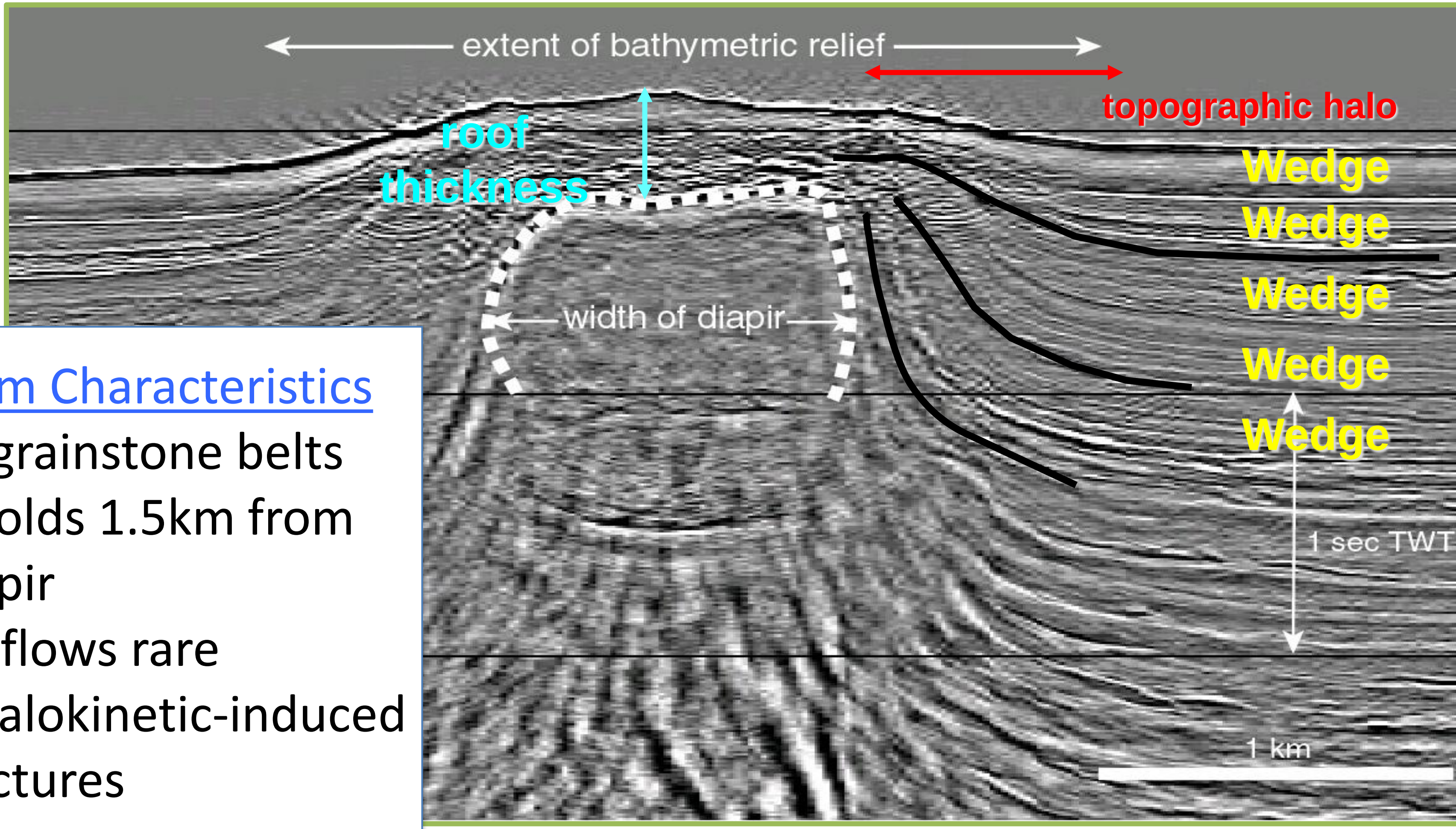
Windward-leeward facies belts

Tight folds <150m from diapir

Debris flows common

Boundstones may be highly fractured

Thick Roof Forms Wedge Halokinetic Sequences and Tapered Composite Halokinetic Sequence



Platform Characteristics

Broad grainstone belts

Open folds 1.5km from diapir

Debris flows rare

Little halokinetic-induced fractures

Controls on Diapir Roof Thickness

<u>Diapir Rise Rate</u>

- Overburden load on autochthonous level
- Shortening

<u>Sed. Accumulation Rate</u>

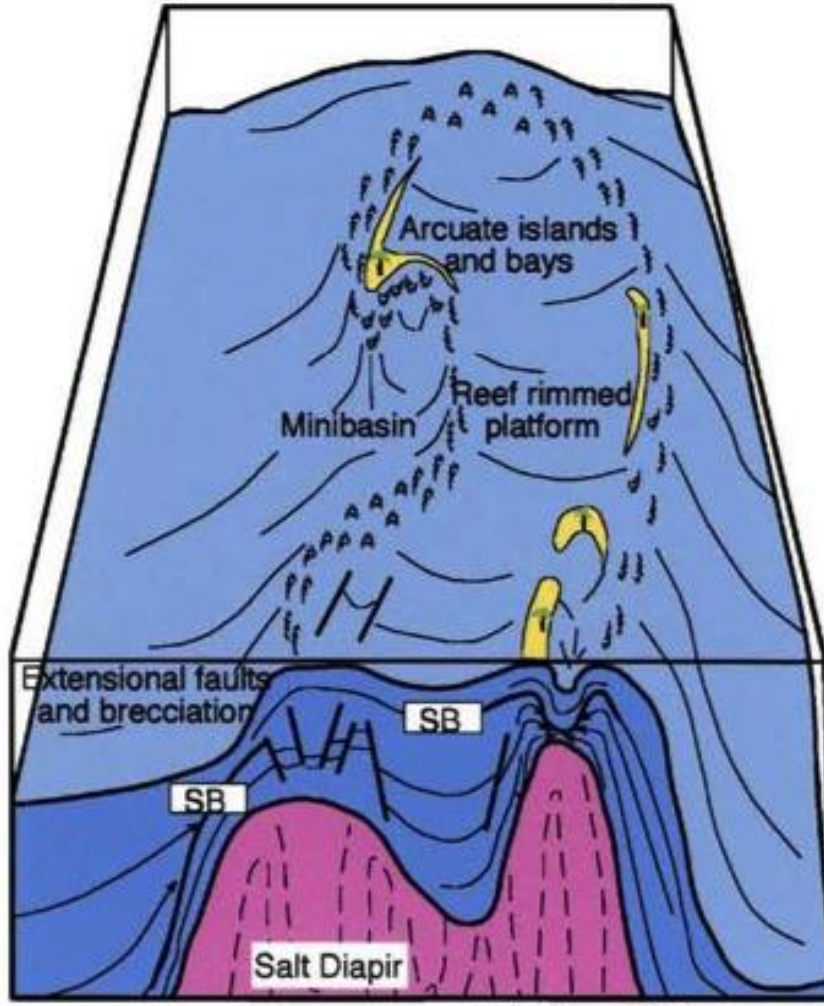
- Flux of sediment to site from regional & local sources
  - sea-level change
  - tectonics
  - climate

Hook HS
Tabular-CHS
Thin Roof **=** **Diapir rise rate** **>** **Sediment accumulation rate**

Wedge HS
Tapered-CHS
Thick Roof **=** **Diapir rise rate** **<** **Sediment accumulation rate**

Atoll-like Facies Model Not the Norm

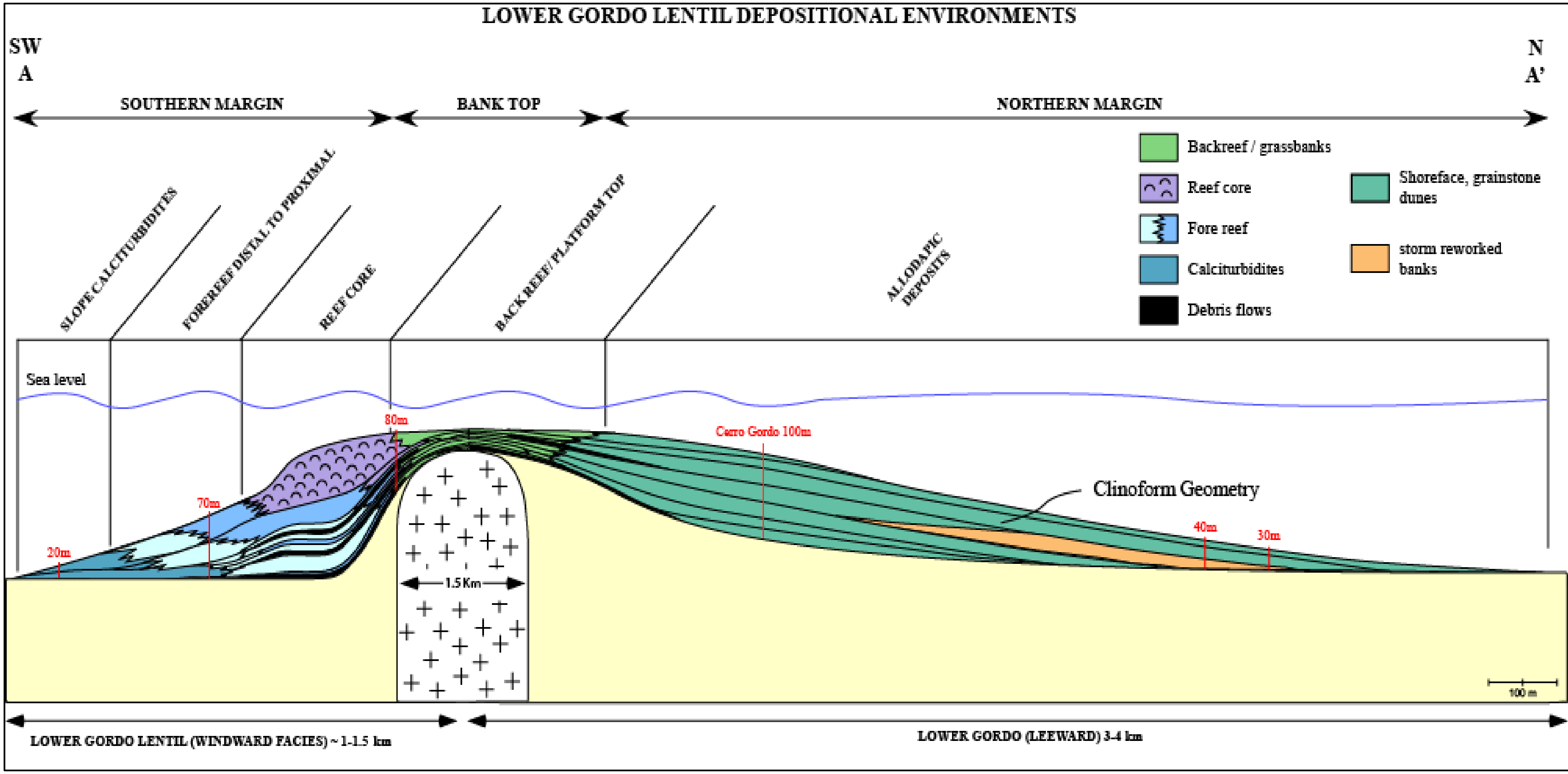
- Rimming reefal facies
- Interior hypersaline lagoon
- Onlapped depositional SB
- Extensional faulting & brecciation
- Static substrate



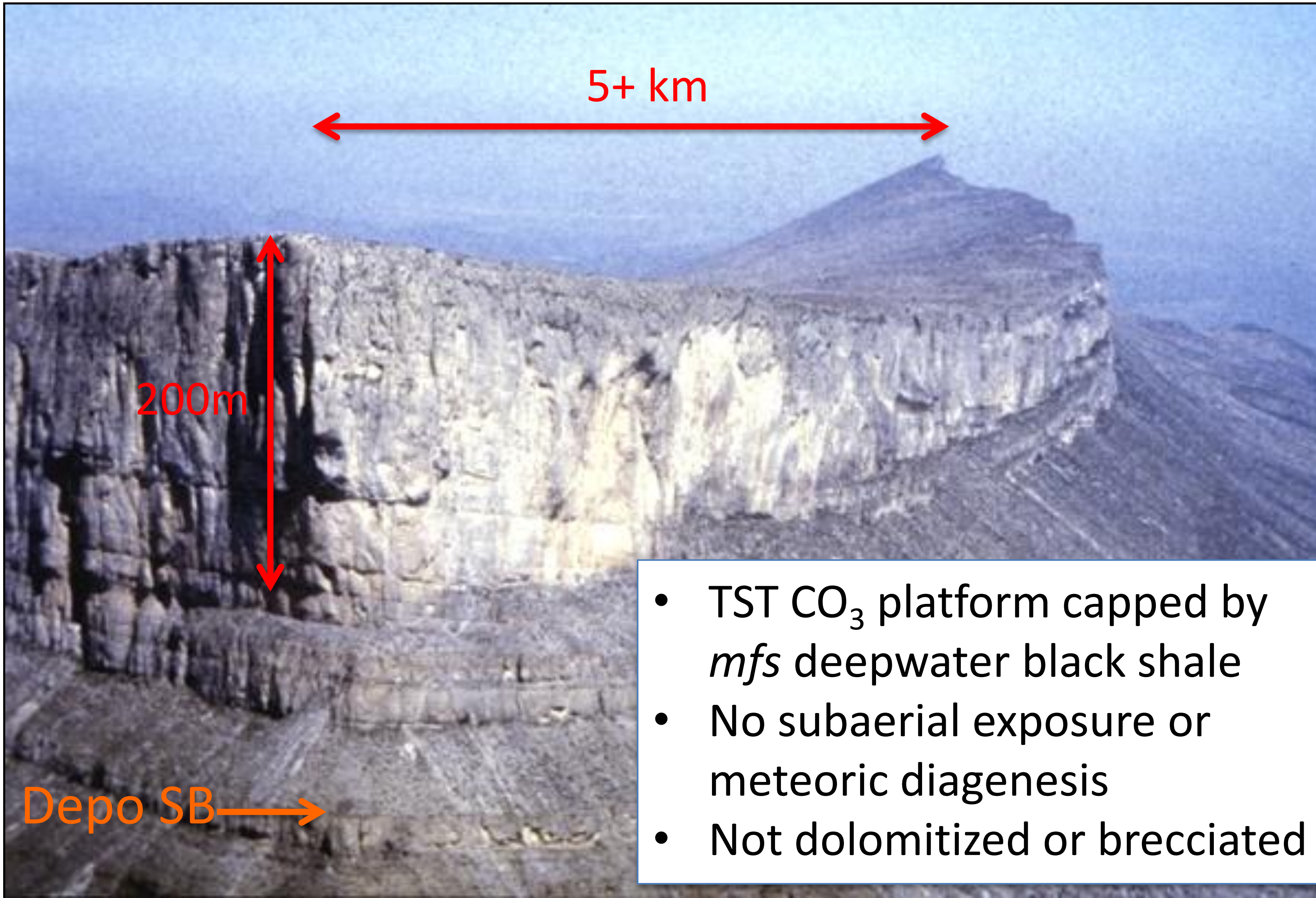
Bosence, D., 2005, Sedimentary Geology 175, p. 49-72.

Hook HS, Cretaceous- Paleogene Carbonate Platforms El Gordo Diapir, La Popa Basin

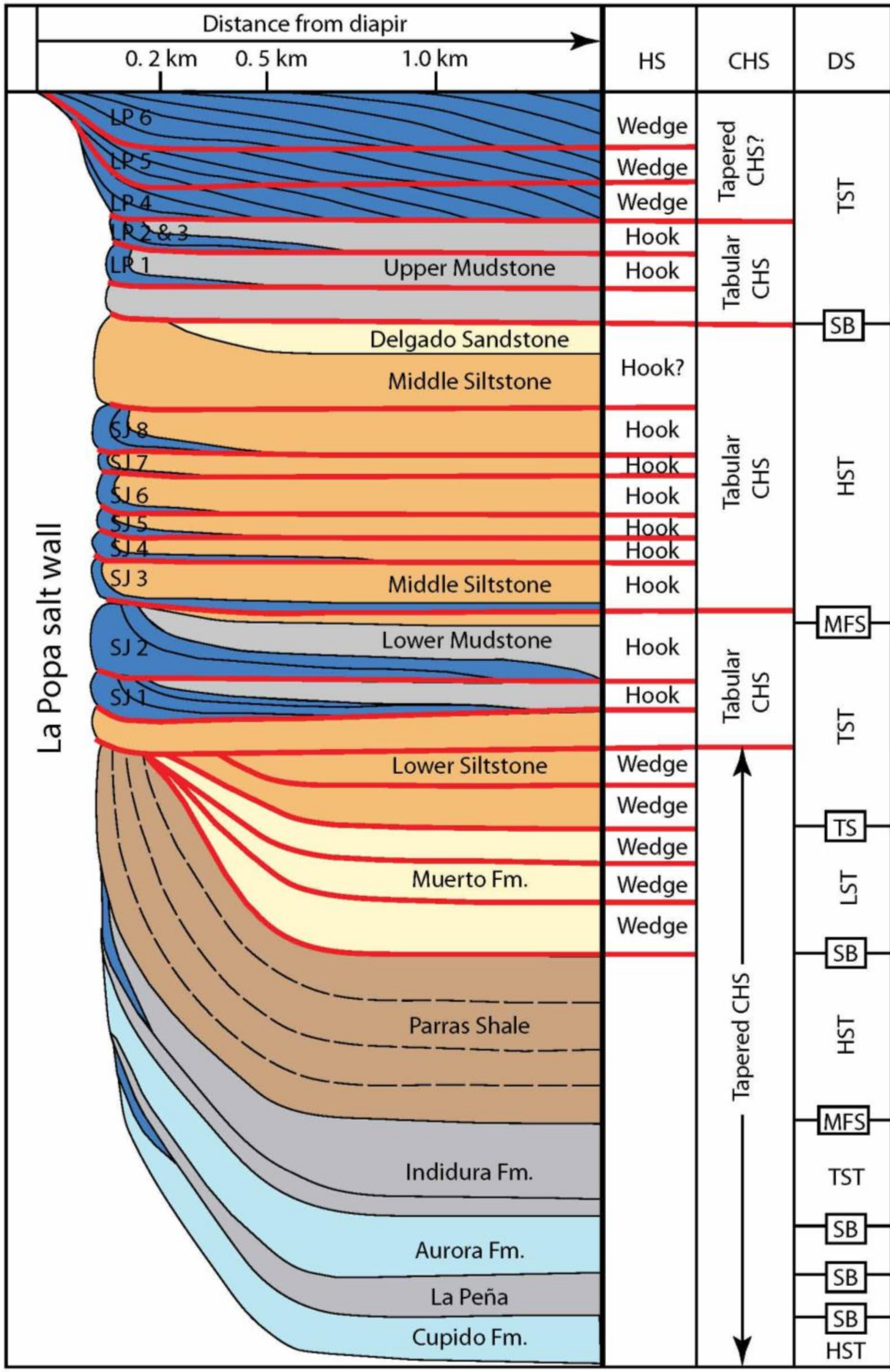
Windward Heterozoan Reefs & Leeward Red Algal/Echinoid Grainstone, La Popa Basin



Tapered CHS Leeward Grainstone Margin La Popa Salt Weld, La Popa Basin



- TST CO_3 platform capped by *mfs* deepwater black shale
- No subaerial exposure or meteoric diagenesis
- Not dolomitized or brecciated

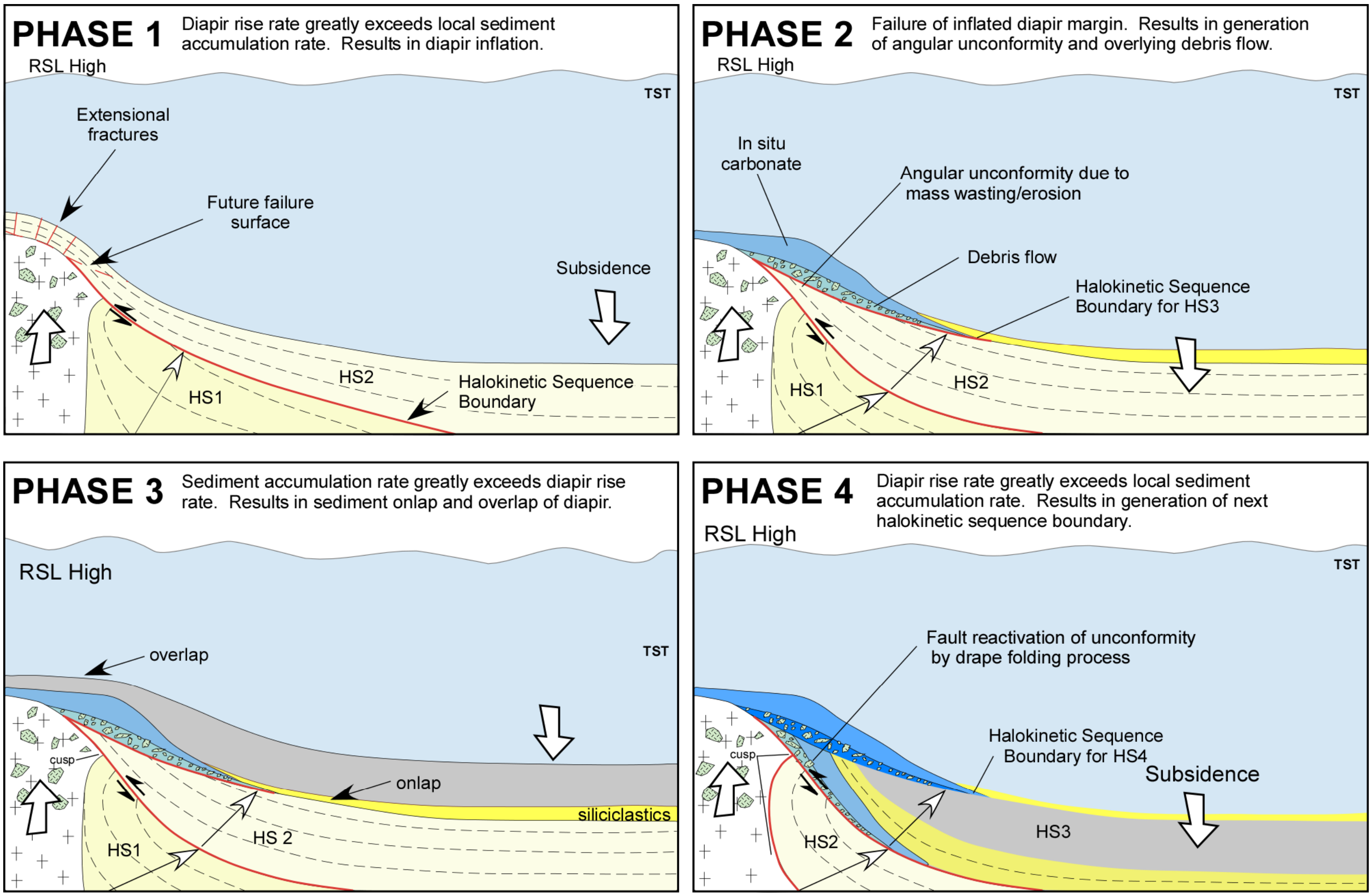


TST CO_3 Buildup

TST CO_3 Buildup

Periods of Major CO_3 Buildup during TST

Why High CO_3 Production During TST?



Summary Main Points

① Recognition of passive diapirism

② Atoll-like facies model not the norm

③ Major CO_3 buildup associated with diapir inflation during TST

④ Lack evidence of extensive subaerial exposure, meteoric diagenesis or caprock formation

Concluding Remarks

- Carbonate platform attributes (facies, geometry, HS stacking pattern) on passive diapirs primarily *locally* controlled
- Attributes can *vary widely from diapir to diapir*
- Local platform can *deviate widely from regional trends*.
- *Halokinetic Sequence Stratigraphy* more useful than depositional sequence stratigraphy in predicting attributes of carbonate platforms developed on salt diapirs
- *Recognition of passive diapirism* is paramount to developing successful exploration strategies in salt basins