Shelf Physiography and Accommodation as Controls on Permian Grainstone Bodies*

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Abstract

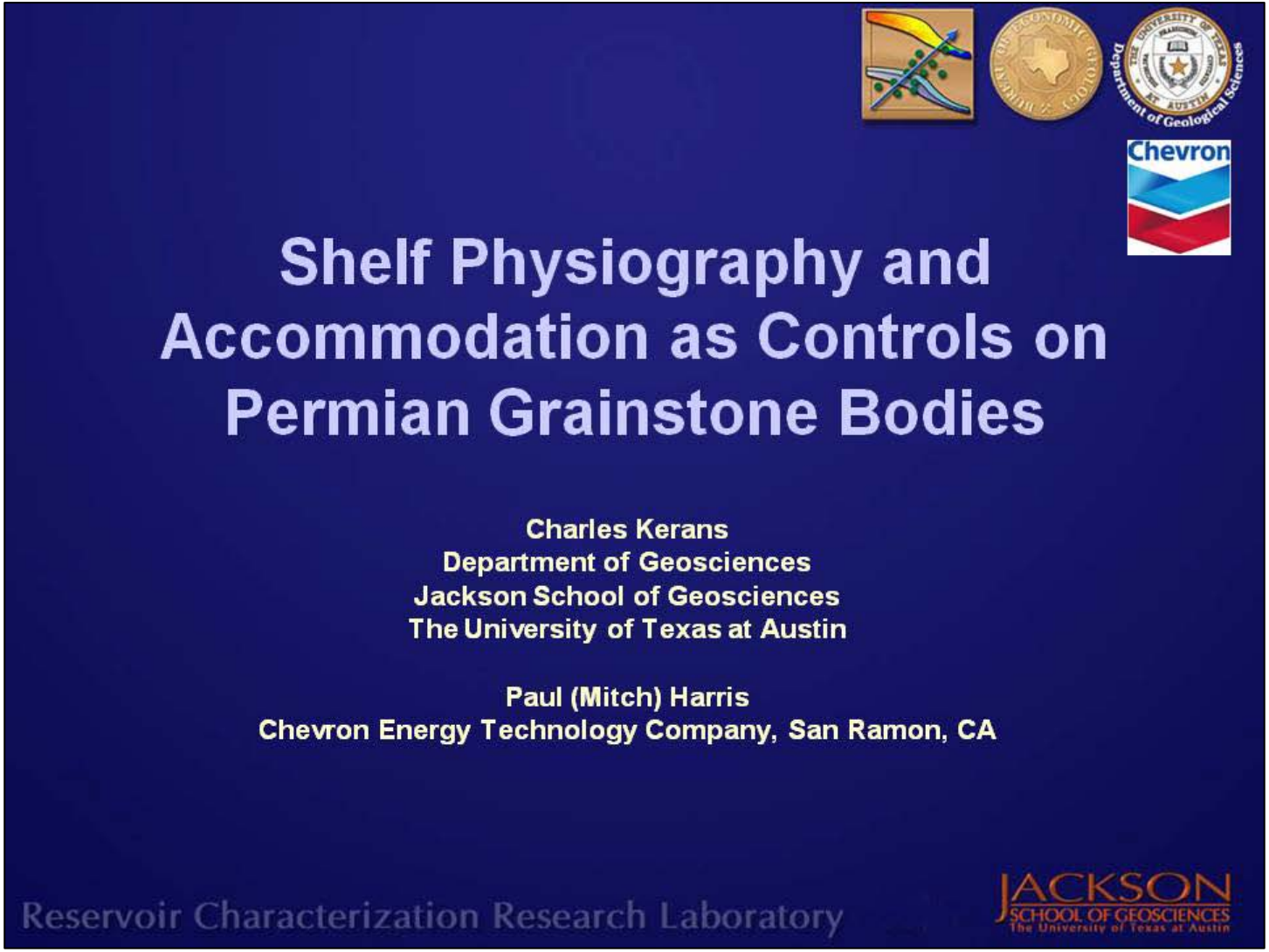
Outcrops of Permian carbonates in the Guadalupe Mountains, Permian Basin, provide an ideal laboratory for examining the impact of shelf physiography and sequence-scale accommodation on carbonate grainstone bodies. Key variables effecting grainstone development are oceanographic parameters (wind and tidal current regimes, ocean water chemistry) and the physiography of the shelf, along with the accommodation setting of the platform which controls the style of preservation in the stratigraphic record. As the ~2 km thick shelf-to-basin exposure defining the western margin of the outcrops maintains a constant orientation and stable basin/climatic setting, it is possible to focus on variation in grainstone development with respect to shelf physiography and systems-tract facies partitioning across twenty-eight high-frequency sequences (HFS) and over 100 cycles. Grainstone bodies within the San Andres (G1-9HFS), Grayburg (G10-12HFS), Queen (G13-14HFS), upper Yates (G24-26HFS), and Tansill (G27-28HFS) shelf strata are available for analysis at the cycle-scale.

San Andres (G1-4) ramps display ramp-crest strike-parallel grainstone bars with low (2-10m) relief, dip-widths of 0.1-2 km, average bedform size of 0.2 m, and fine-medium-grained fusulinid-ooid composition. Grayburg transitional ramp-rim profiles, with their steeper, higher-relief/energy margins, contain both wave- and tide-dominated sand-bodies with dip dimension (0.5-5 km), bedform size up to 2 m, and are medium-coarse grained mixed intraclastic-oolitic deposits. Queen-Tansill reef-rimmed profiles have 0.1-0.5 km dip-width wave-dominated grainstone elements set up by the focused wave impact 0.5 km or less from the abrupt shelf edge. Early-lithified vadose-tepee-modified storm berms stabilize this profile and set up a dramatic grain-size distribution from back-barrier lagoonal stromatolitic mudstones through the shoal complex and seaward to outer shelf packstones in less than 1 km.

Sequence-scale accommodation variations control the vertical and lateral stacking of grainstones, impacting connectivity of facies elements. Dramatic variations in stacking are observed from ramp systems where TST tide-dominated grainstones contrast with seaward-prograding wave-dominated HST foreshore-upper shoreface sheet sands. Steep-rimmed systems where bathymetry limits progradation are dominated by vertical stacking of grainstone bodies.

Reference

Barnaby, R.J. and W.B. Ward, 2007, Outcrop analog for mixed siliciclastic-carbonate ramp reservoirs; stratigraphic hierarchy, facies architecture and geologic heterogeneity: Grayburg Formation: Journal of Sedimentary Research, v. 1, p. 34-58.



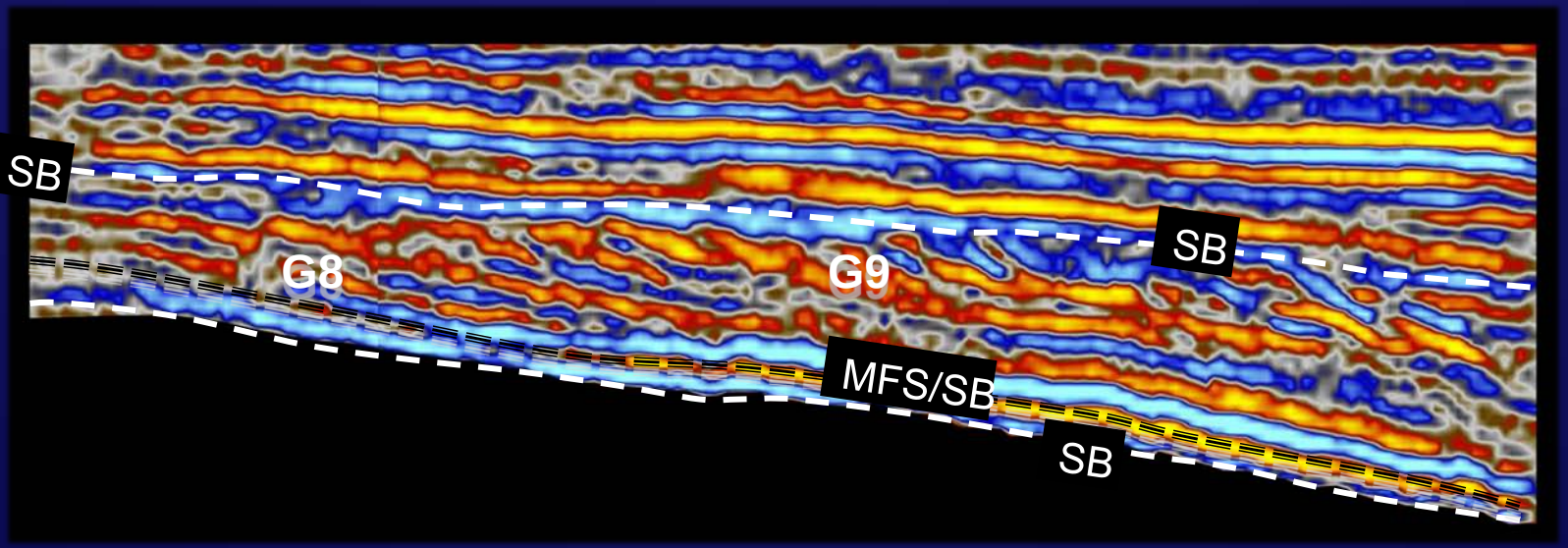
Notes by Presenter: This talk will provide important generalizations concerning carbonate reservoir geology and sequence stratigraphy that are considered fundamental predictive attributes useful when exploring for or developing resources in these complex systems.

Outline

- Goals
- Review – Controls on Grainstone Geobody Dimensions
- Data/Setting
- San Andres Ramp System
- Grayburg Transitional Ramp-Rim System
- Queen TRR to Rimmed Shelf
- Yates Rimmed Shelf
- Comparison of Features
- Conclusions

Goals

- Synthesize Permian grainstone dimensional data
- Consider processes that control grainstone development/preservation
- Identify proxies for estimating grainstone dimensions from standard subsurface data, core, seismic



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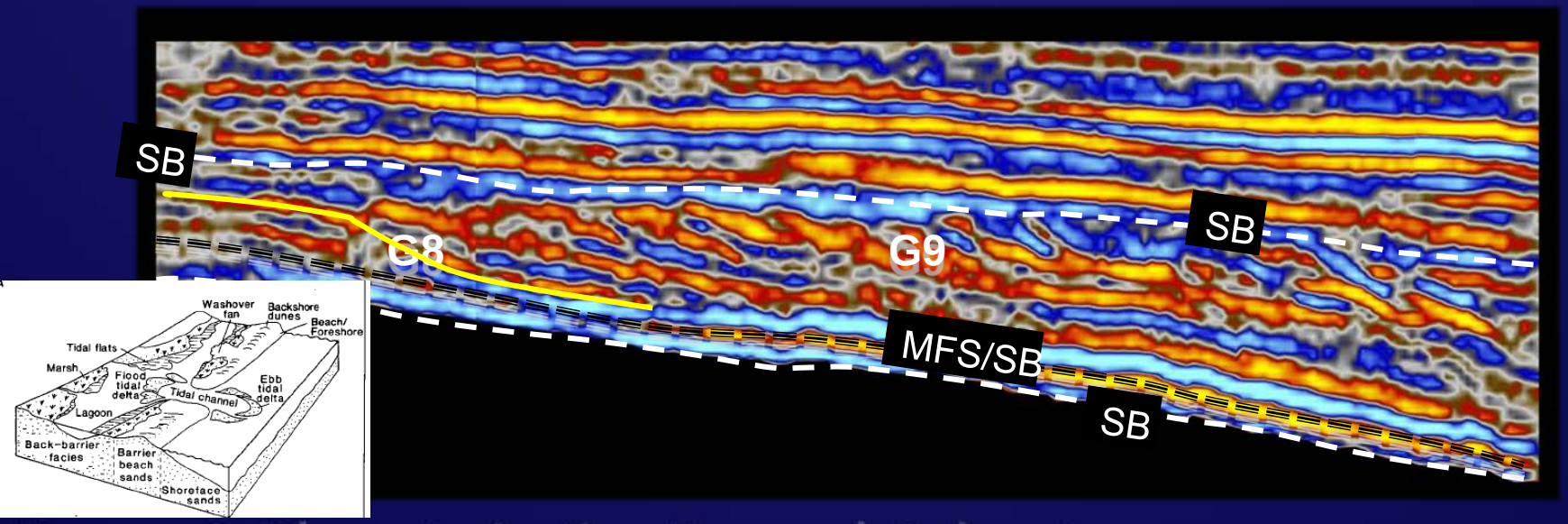

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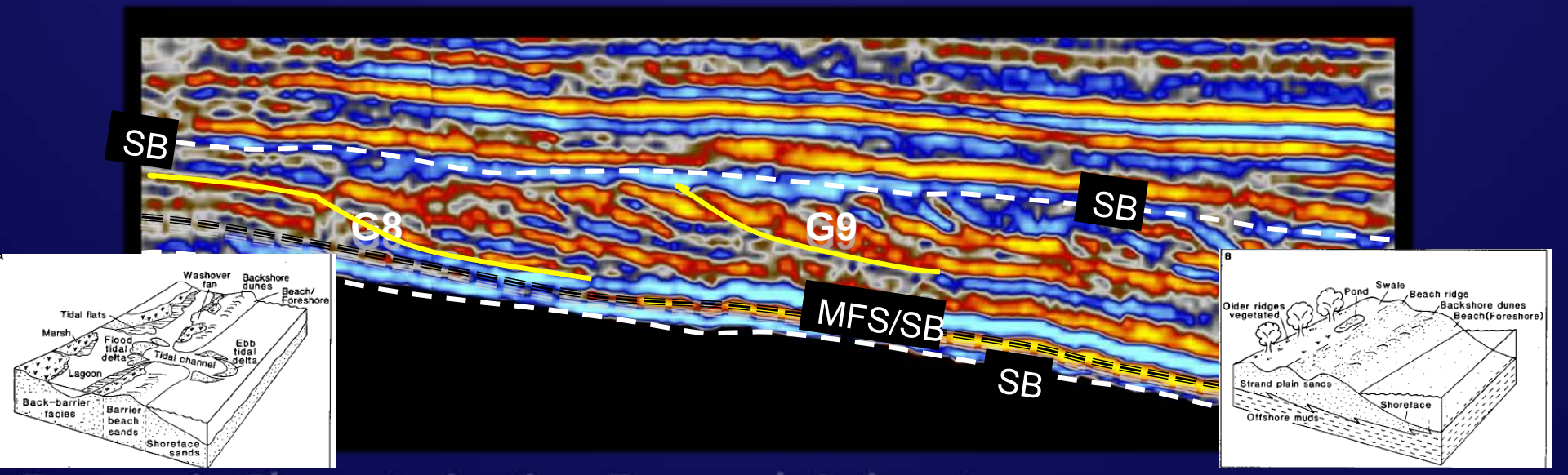

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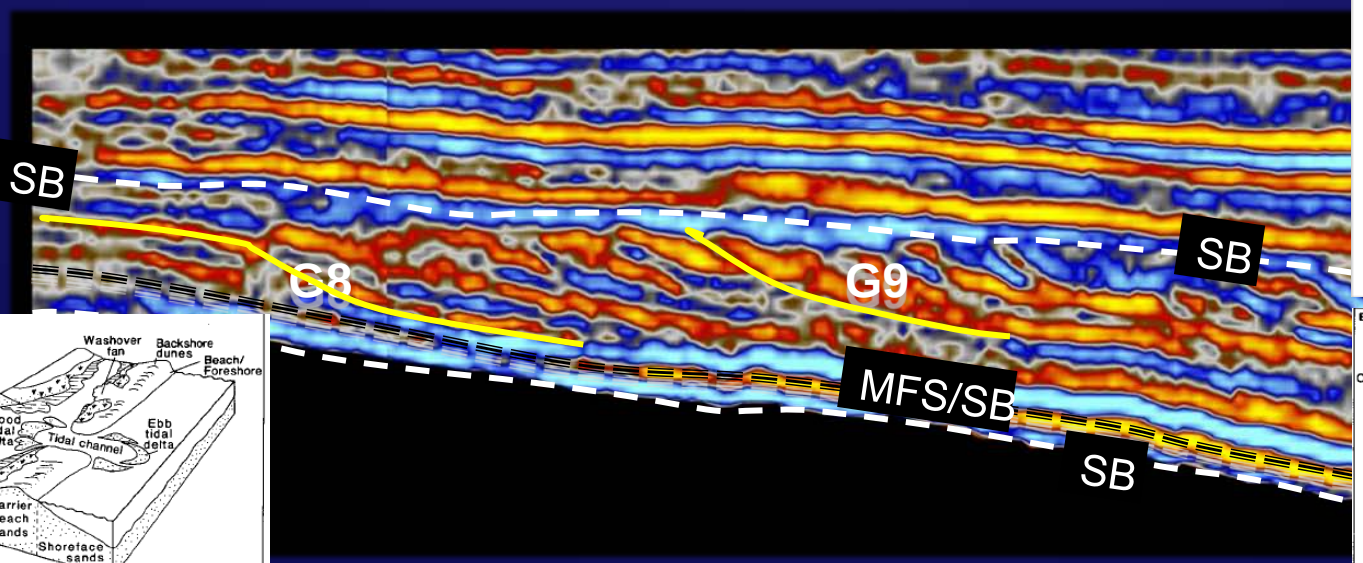

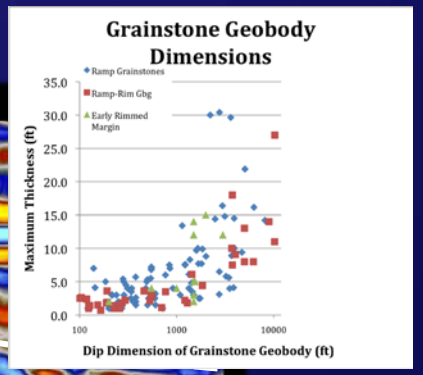

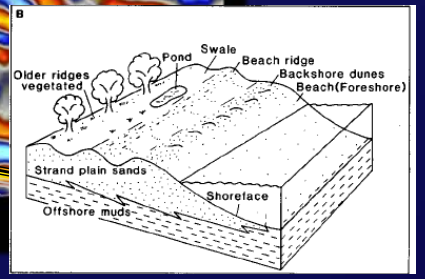

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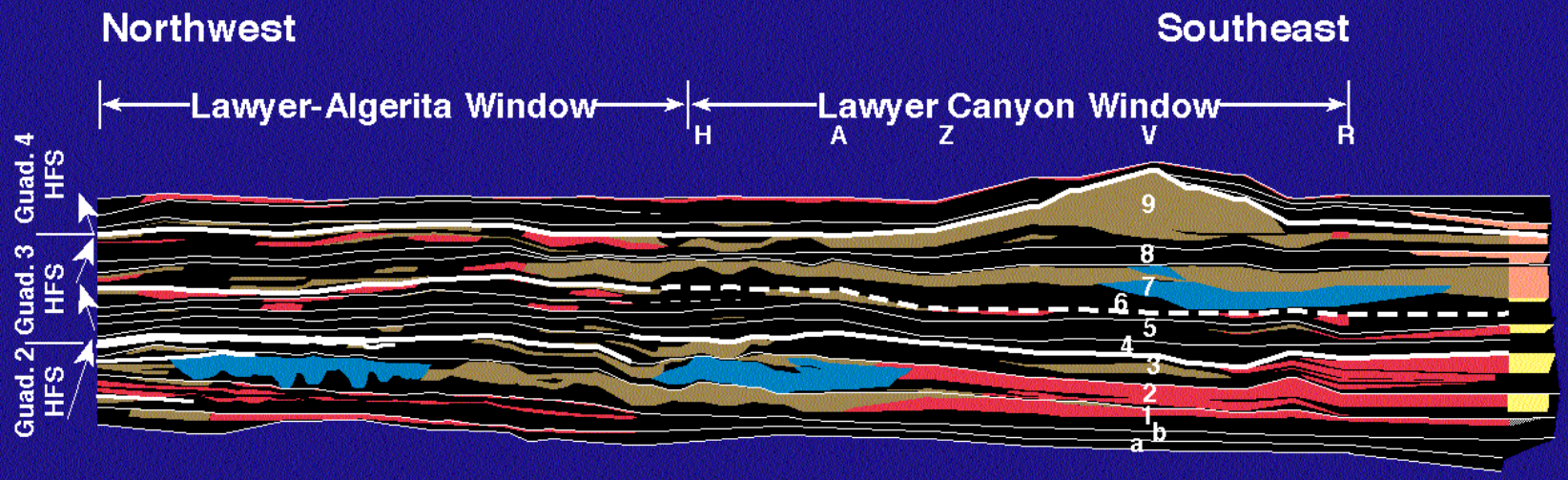
Controls 1 – Accommodation and Facies Proportions/Preservation

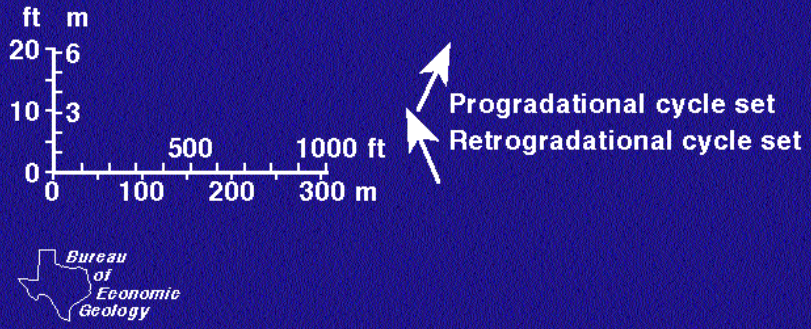


Trough crossbedded ooid-peloid grainstone

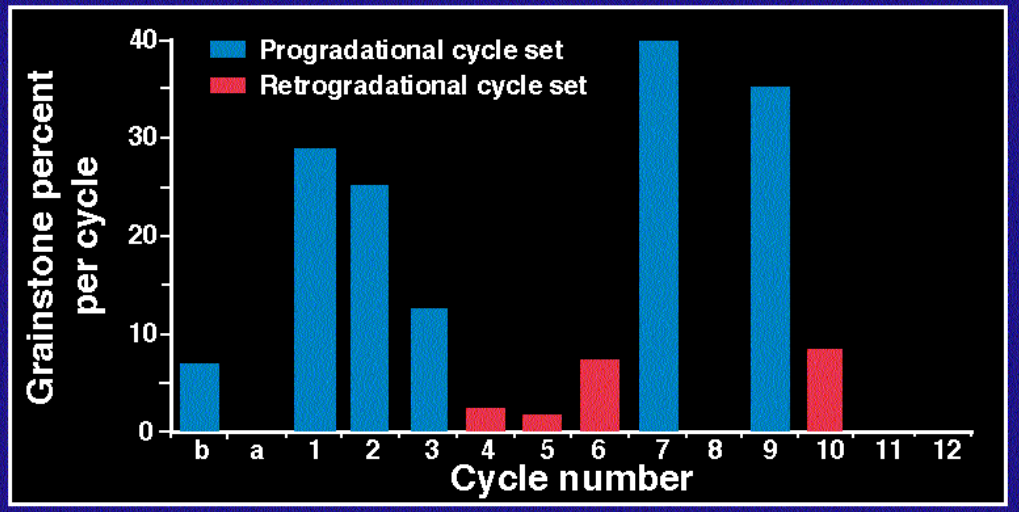
Accretion-bedded grainstone/packstone

Sheet-laminated ooid-peloid grain-dominated packstone and packstone

1 Cycle number



Bureau of Economic Geology



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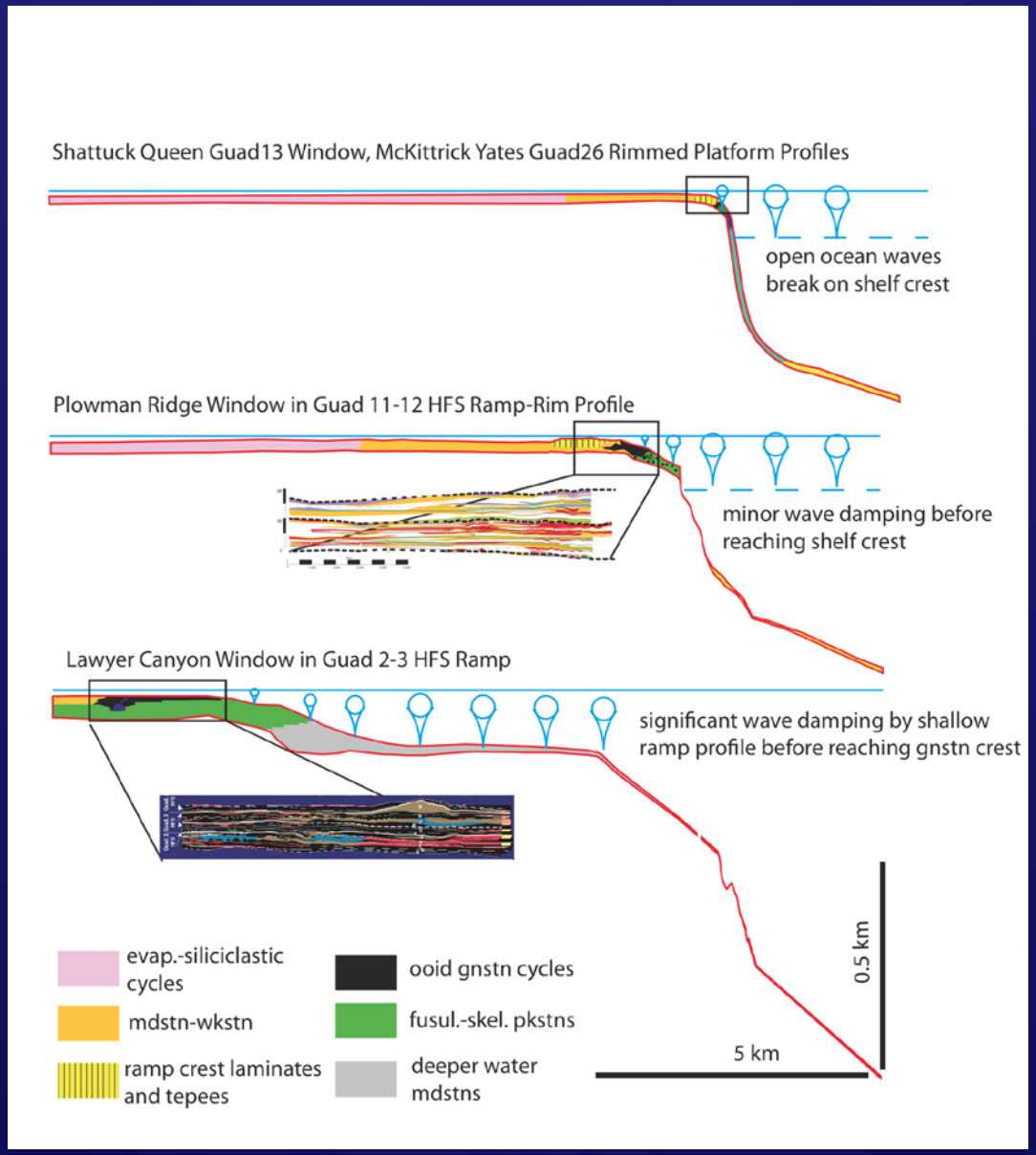
Controls 2 - Variation in Shelf Profile



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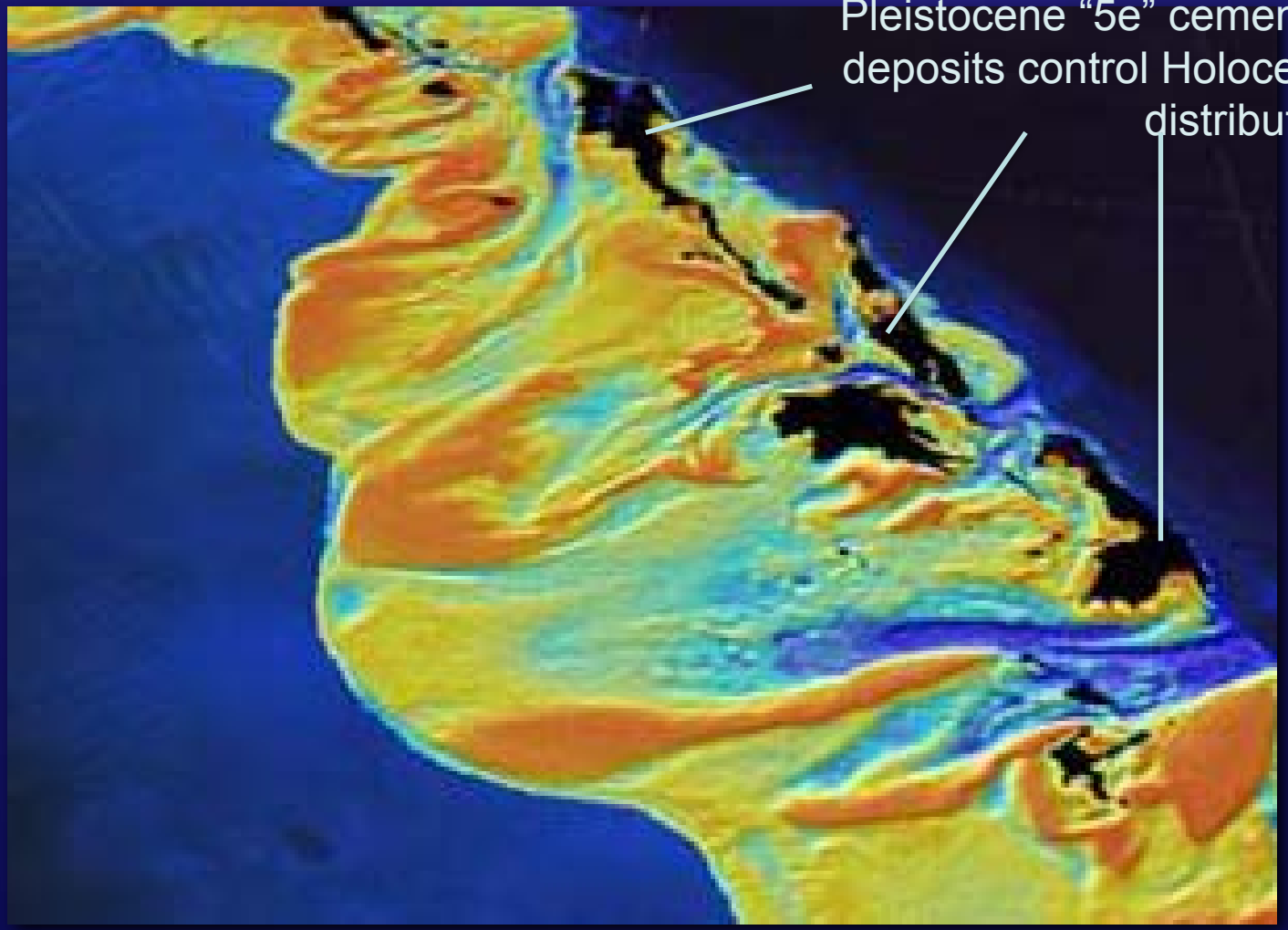
Controls 3 – Cycle-Scale Diagenesis controlling Depositional Architecture



Pleistocene “5e” cemented highstand deposits control Holocene grainstone distribution, Exumas

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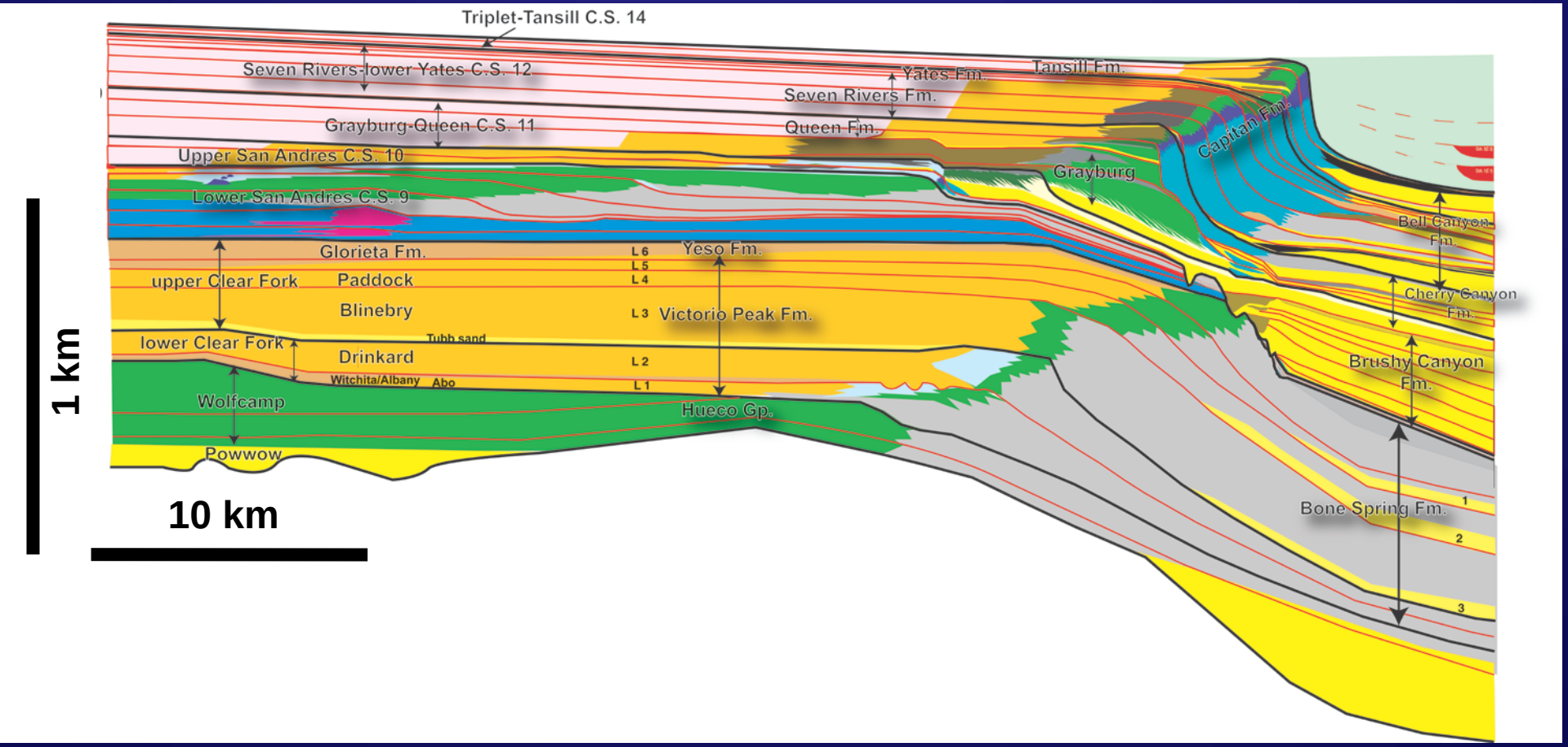
Wolfcampian-Guadalupian Sequence Framework, Guadalupe Mts.

N S



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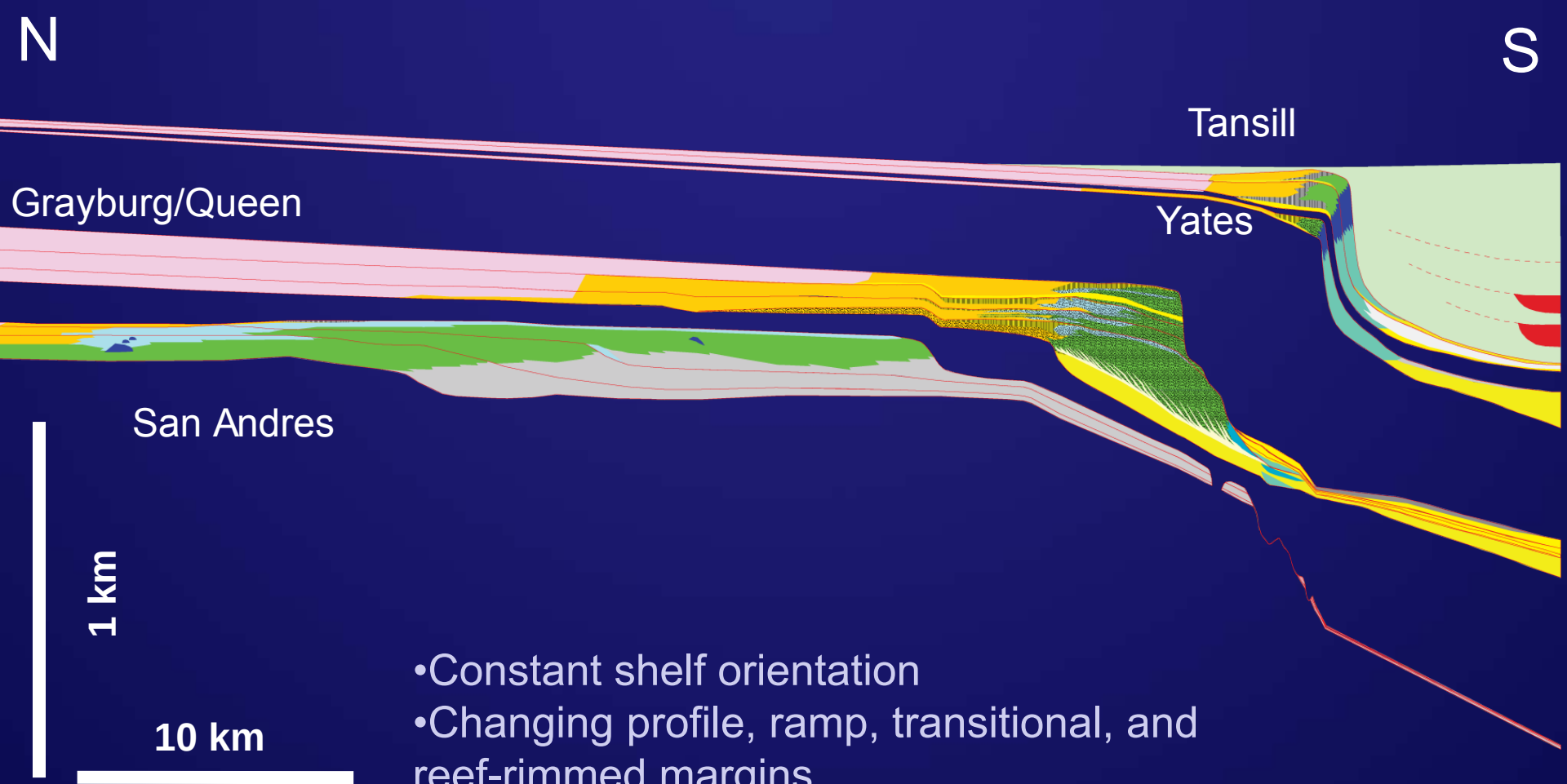
Sequence Setting and Depositional Profile of Data Sets



- Constant shelf orientation
- Changing profile, ramp, transitional, and reef-rimmed margins

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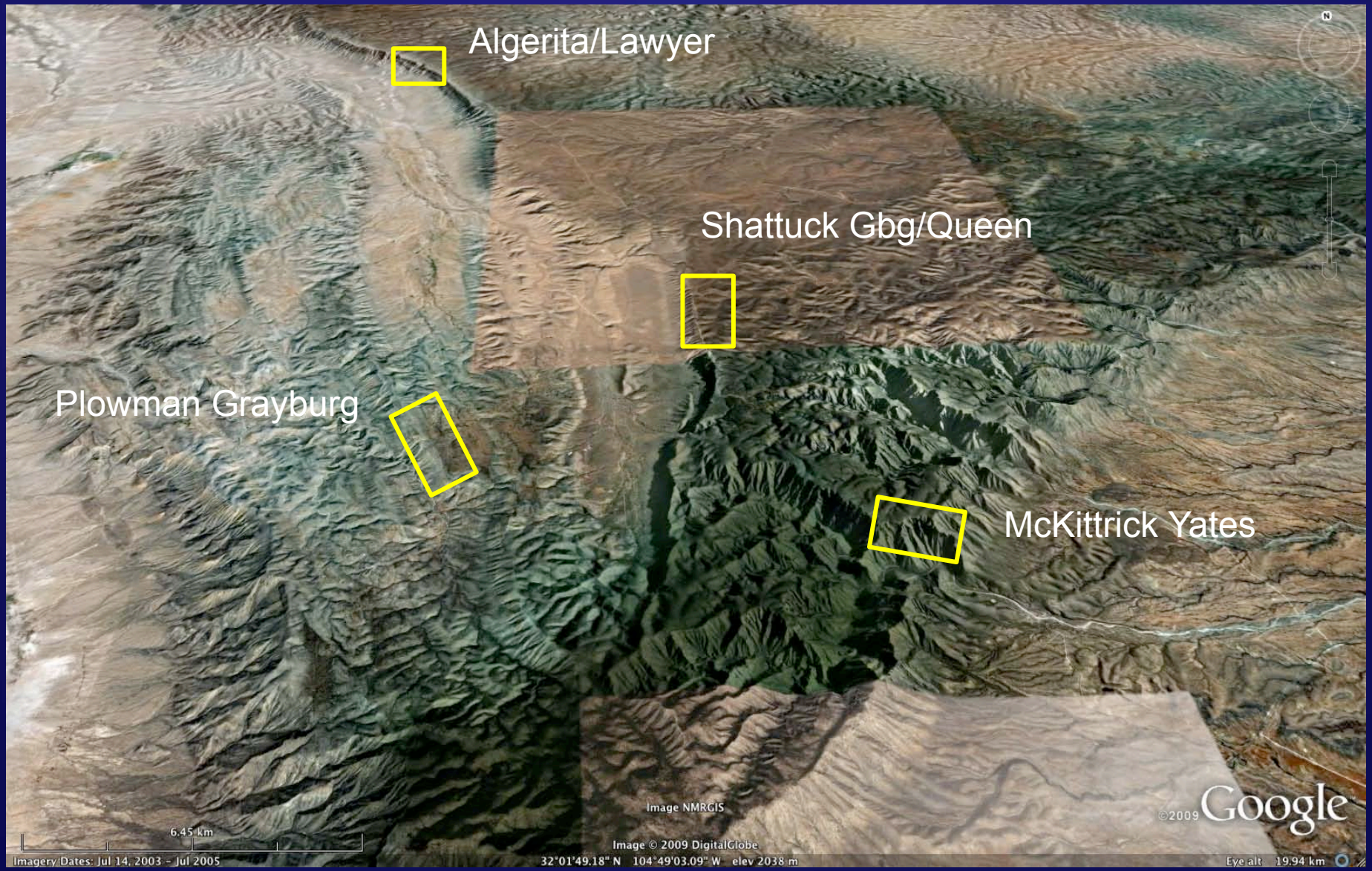
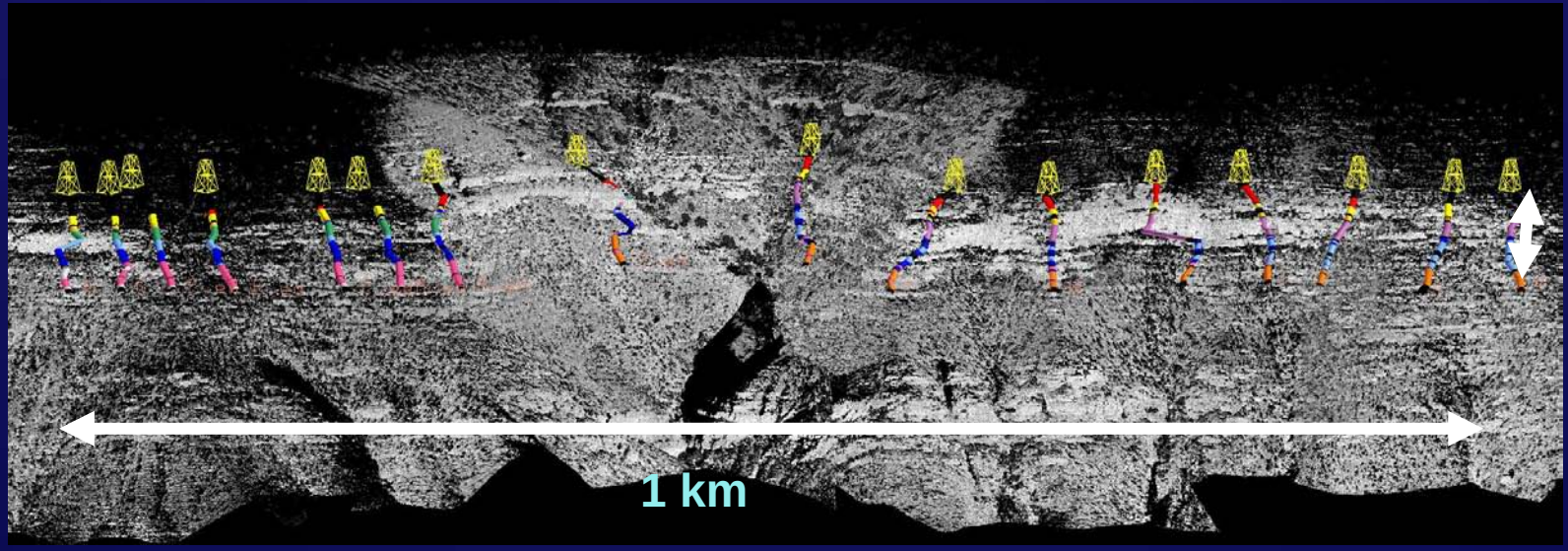
Distribution of Grainstone Windows



Grainstone Geobody Data

- Grainstone geobodies restricted to cross-bedded or current-laminated facies as seen in outcrop
- Geobody outline captured through combination of mapping and section-measuring
- Data recorded as 2D dip length vs. maximum thickness…..limited understanding of strike variability, map pattern



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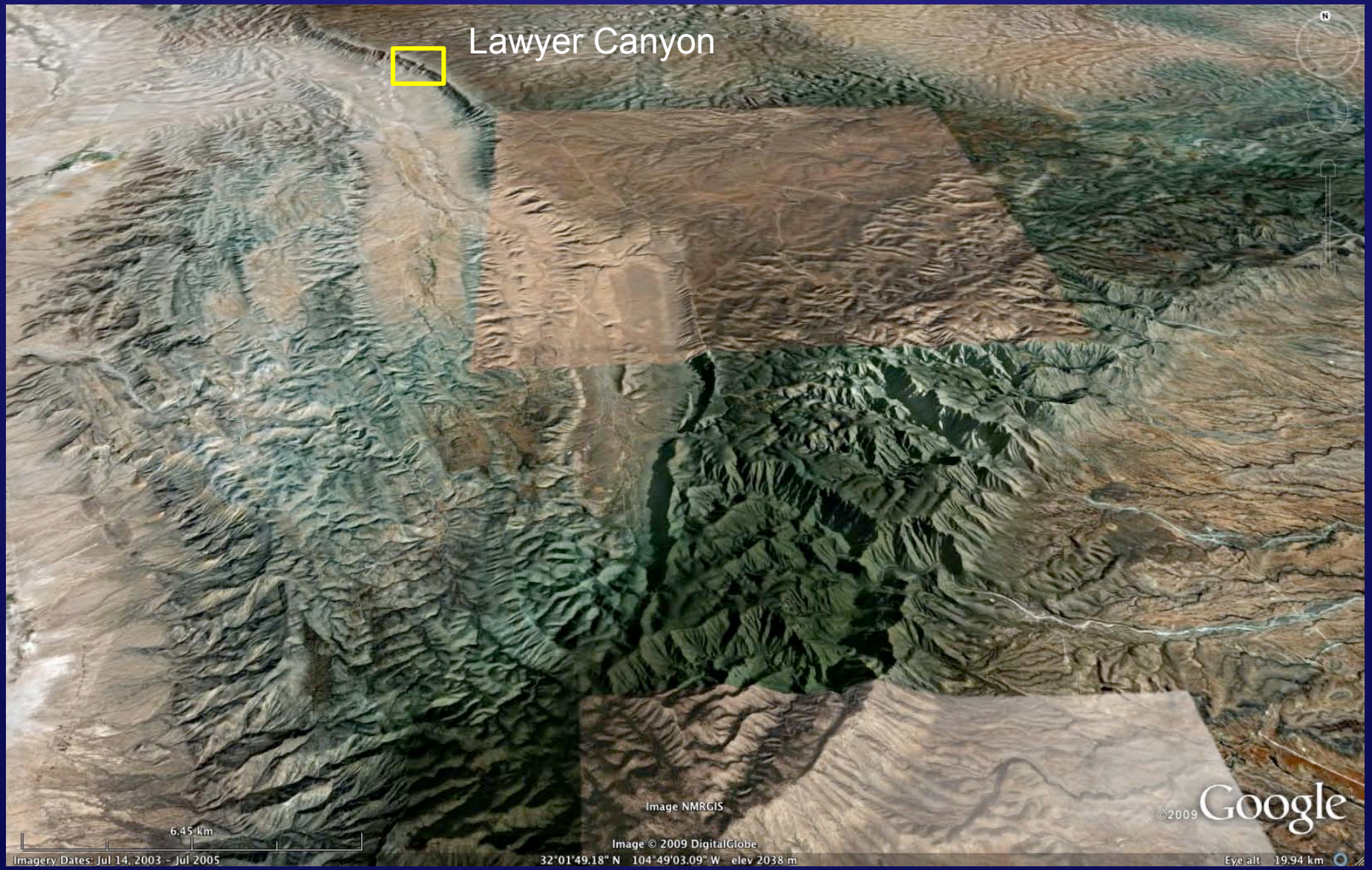
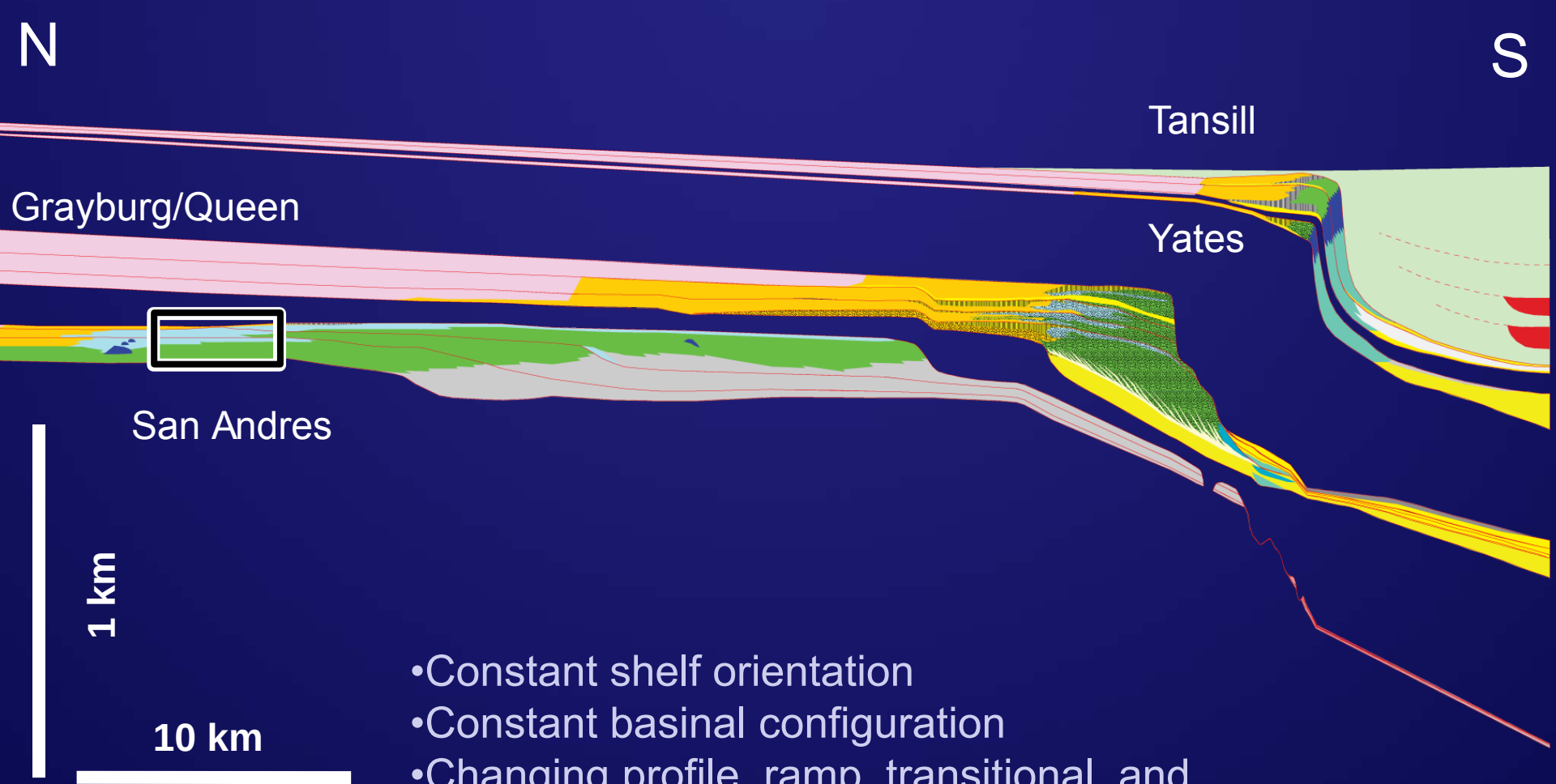
San Andres Lawyer Canyon



San Andres Lawyer Canyon – Low Angle Ramp



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- Constant basinal configuration
- Changing profile, ramp, transitional, and reef-rimmed margins

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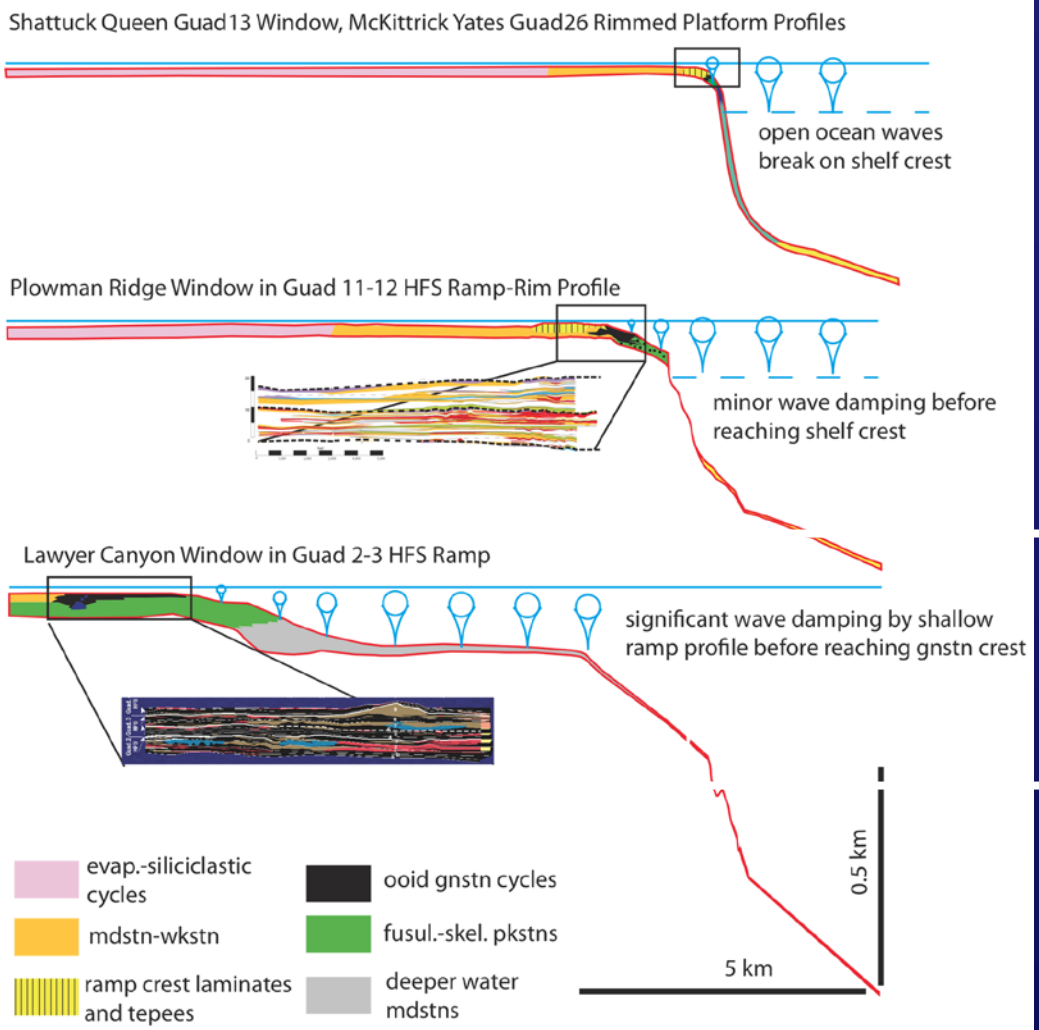
Variation in Shelf Profile



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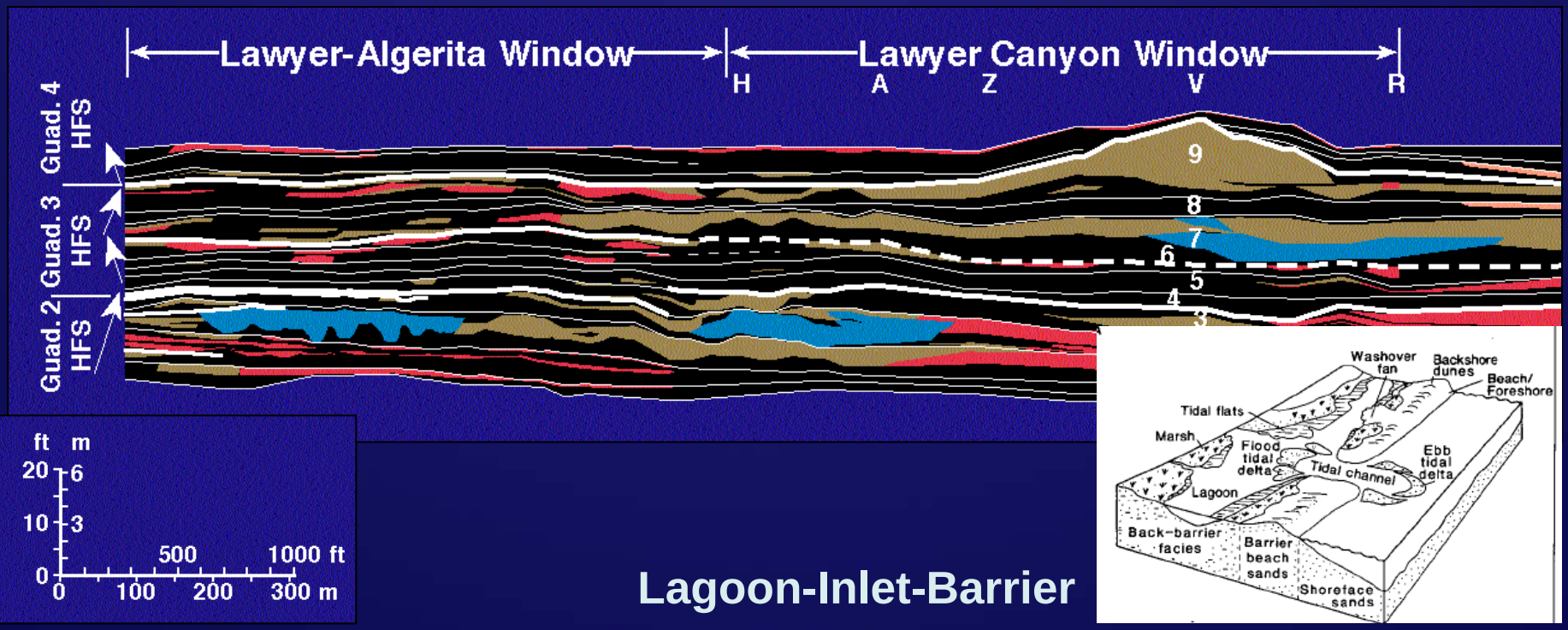
San Andres Lawyer Canyon with LIB Low P/A system

N

S



Lagoon-Inlet-Barrier

Reservoir Characterization Research Laboratory

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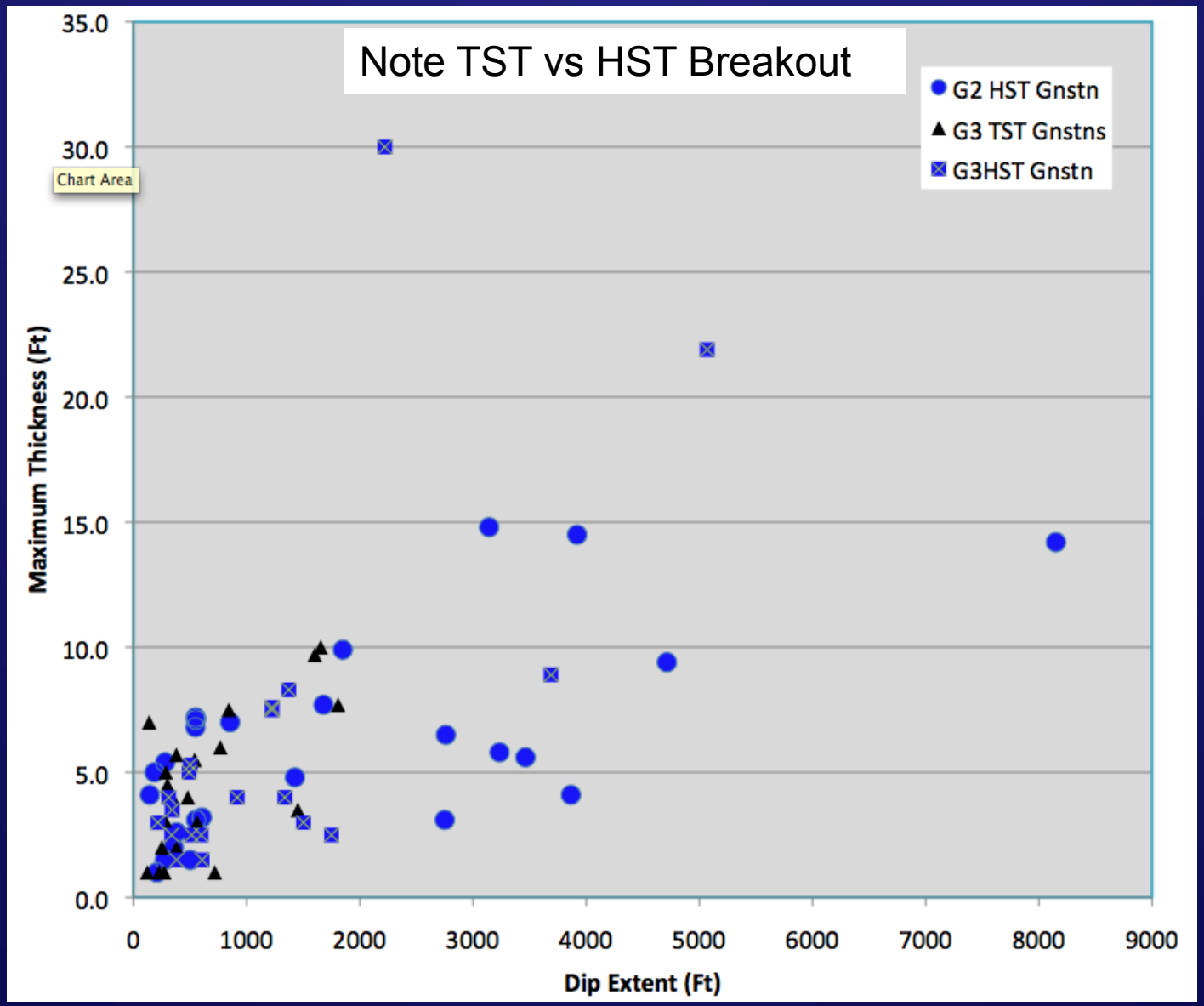
San Andres Grainstone Dimensions



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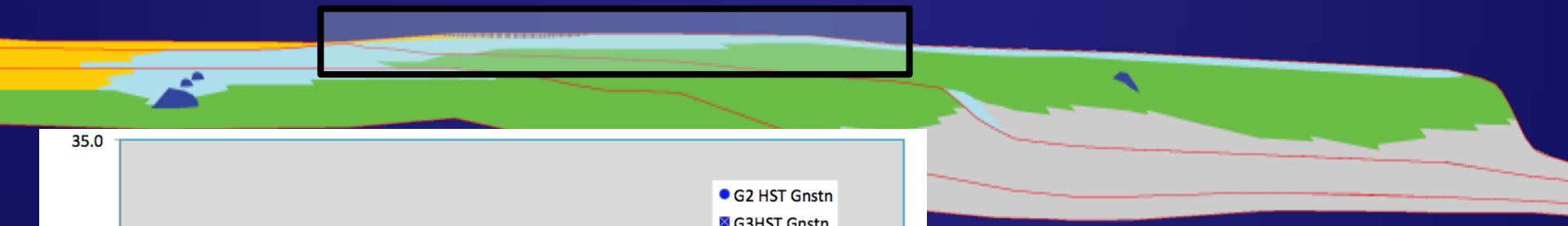
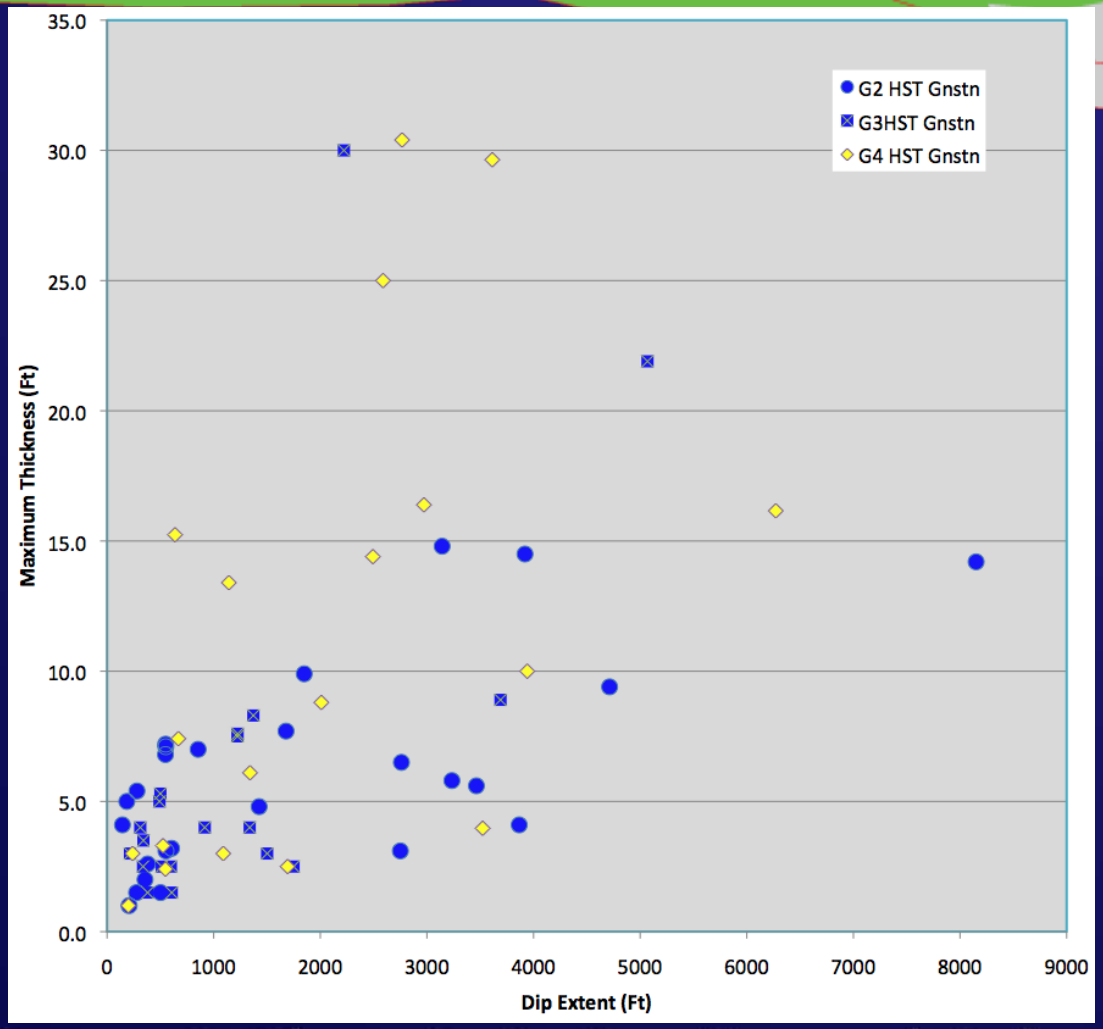
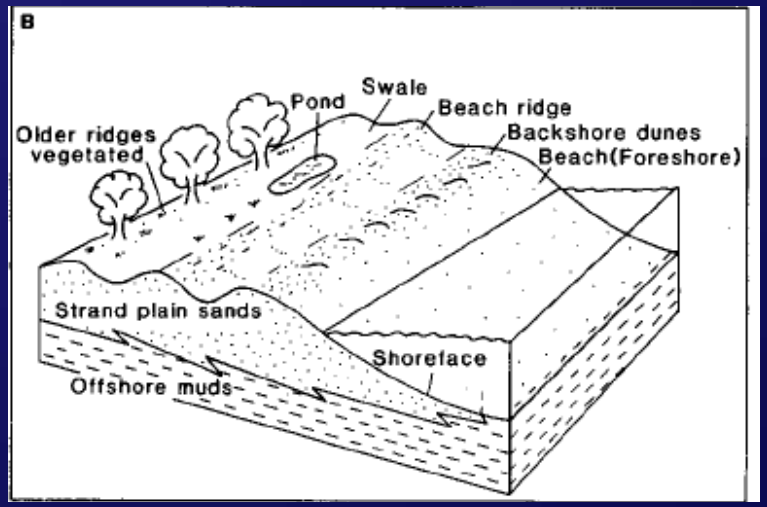
San Andres Lawyer Canyon, Foreshore-Shoreface systems with Hi P/A





Foreshore-Shoreface



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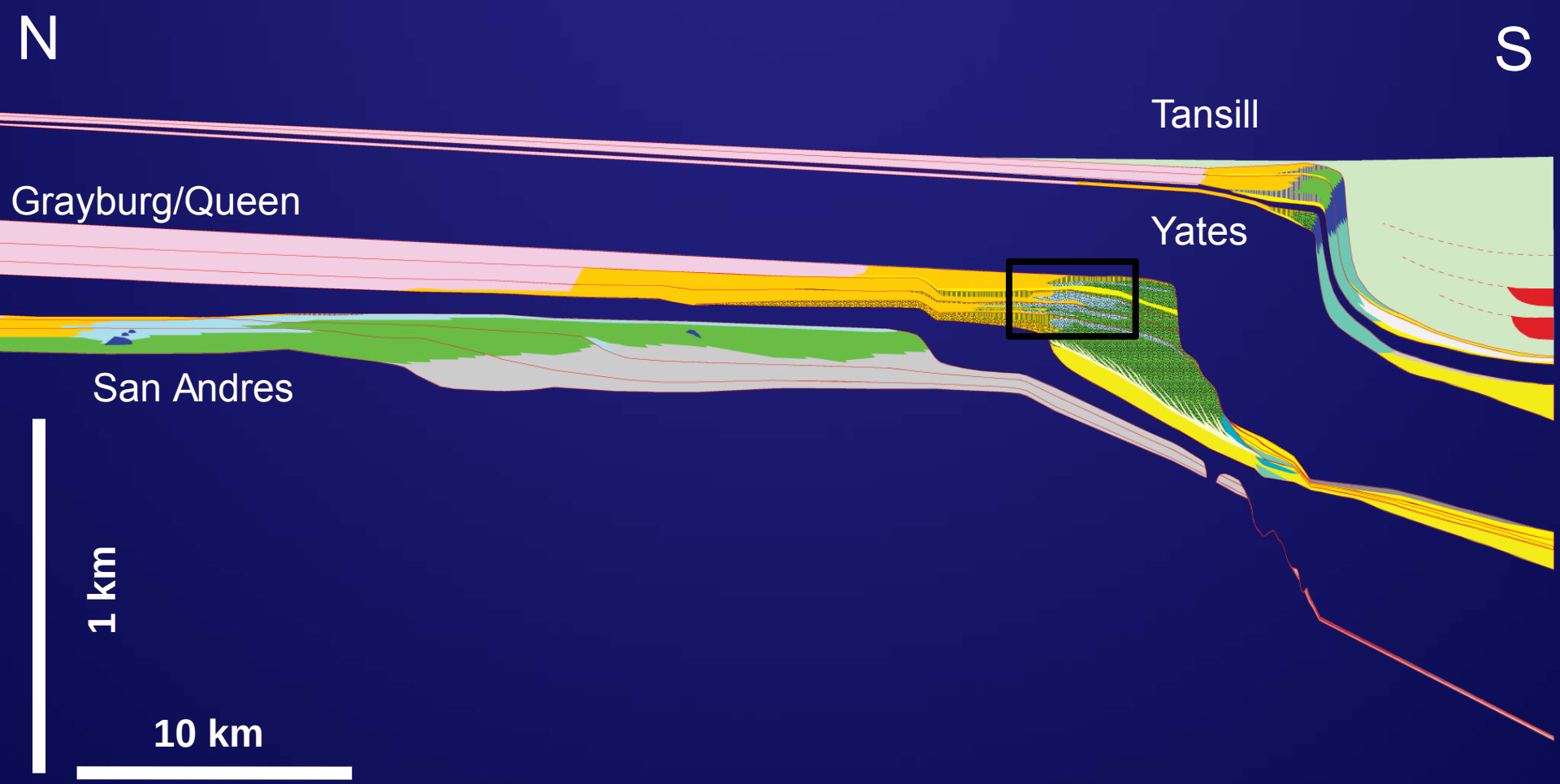
Grayburg – Plowman Ridge

Grayburg Plowman: Transitional Ramp-Rim Profile



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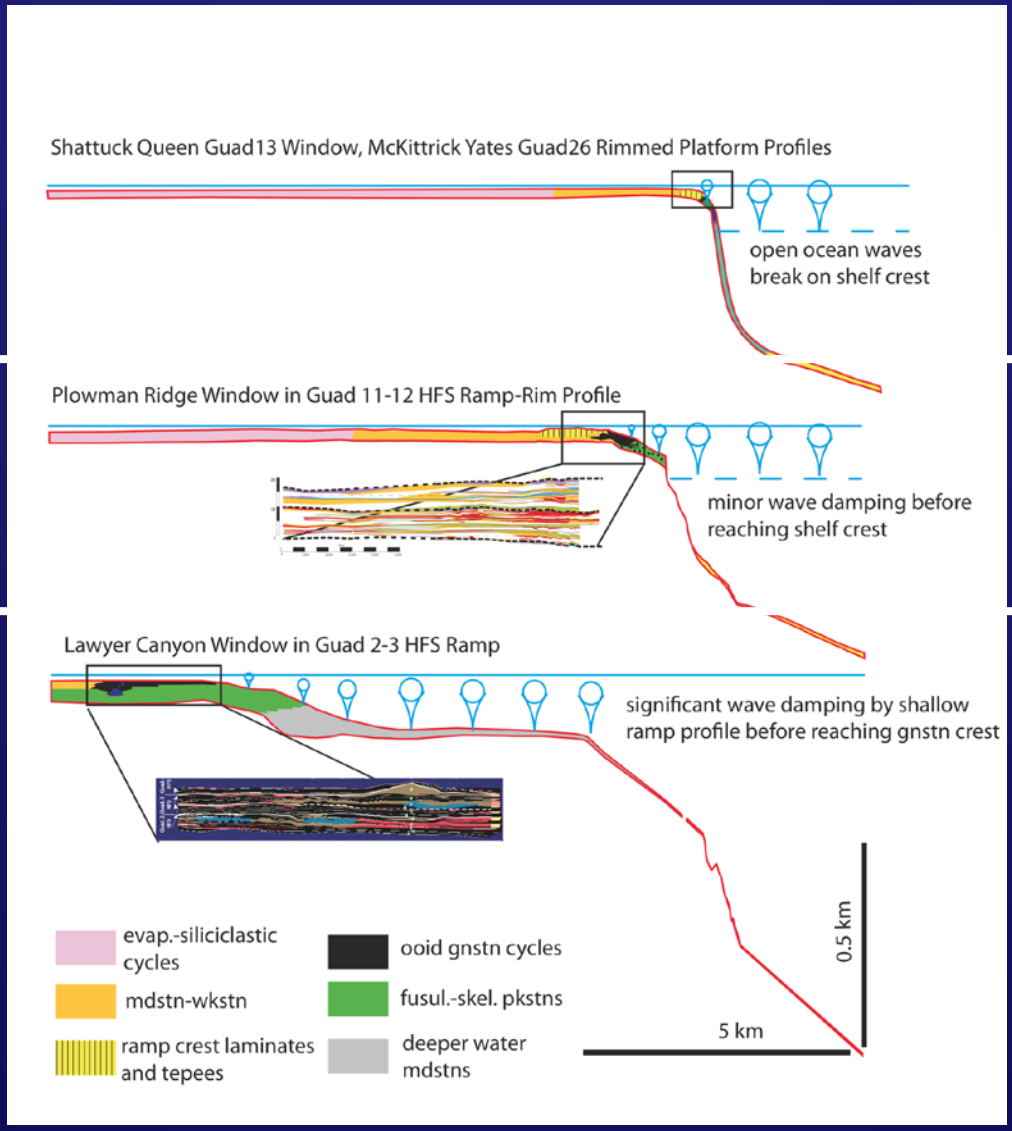
Variation in Shelf Profile



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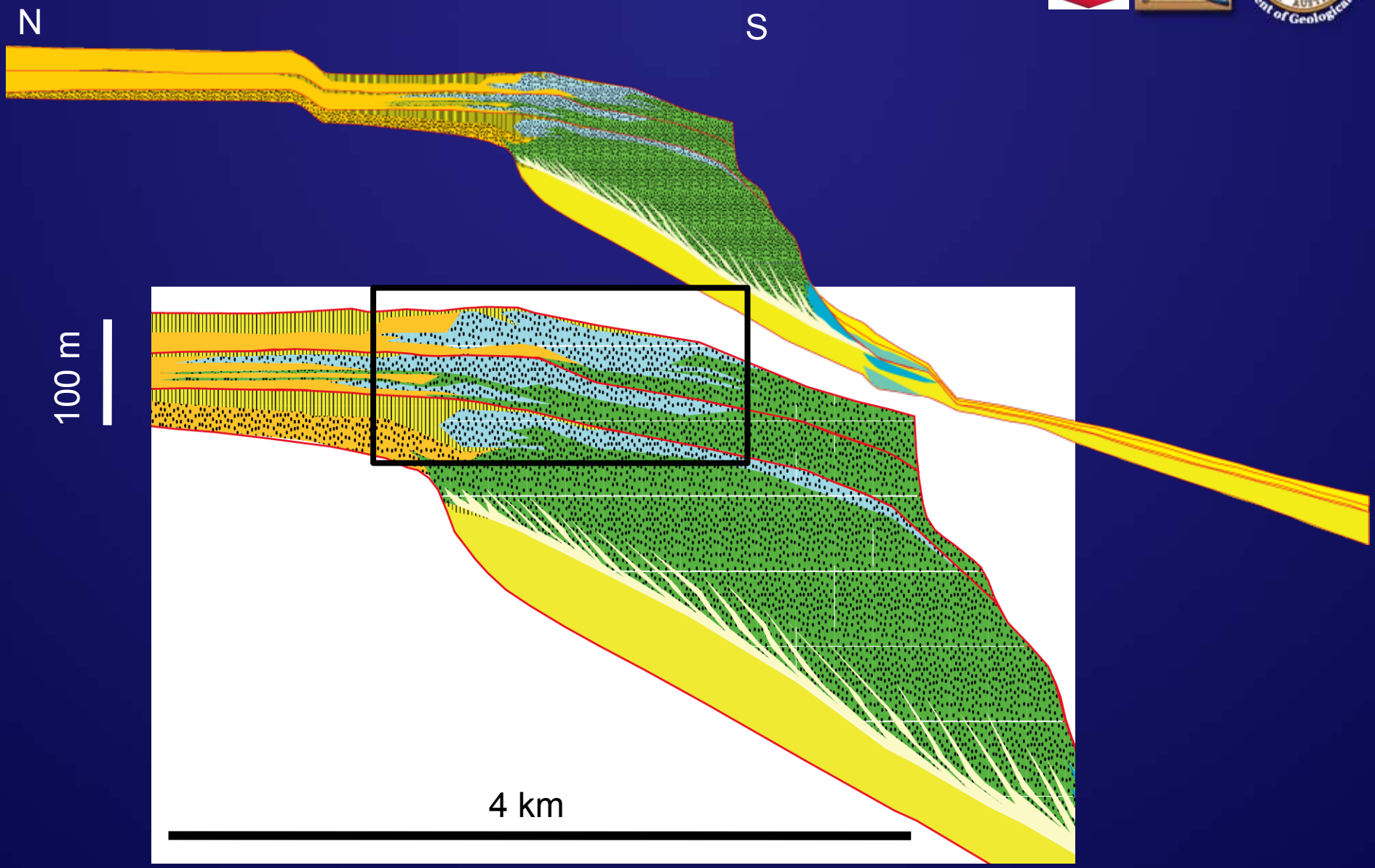
Grayburg –Plowman Ridge



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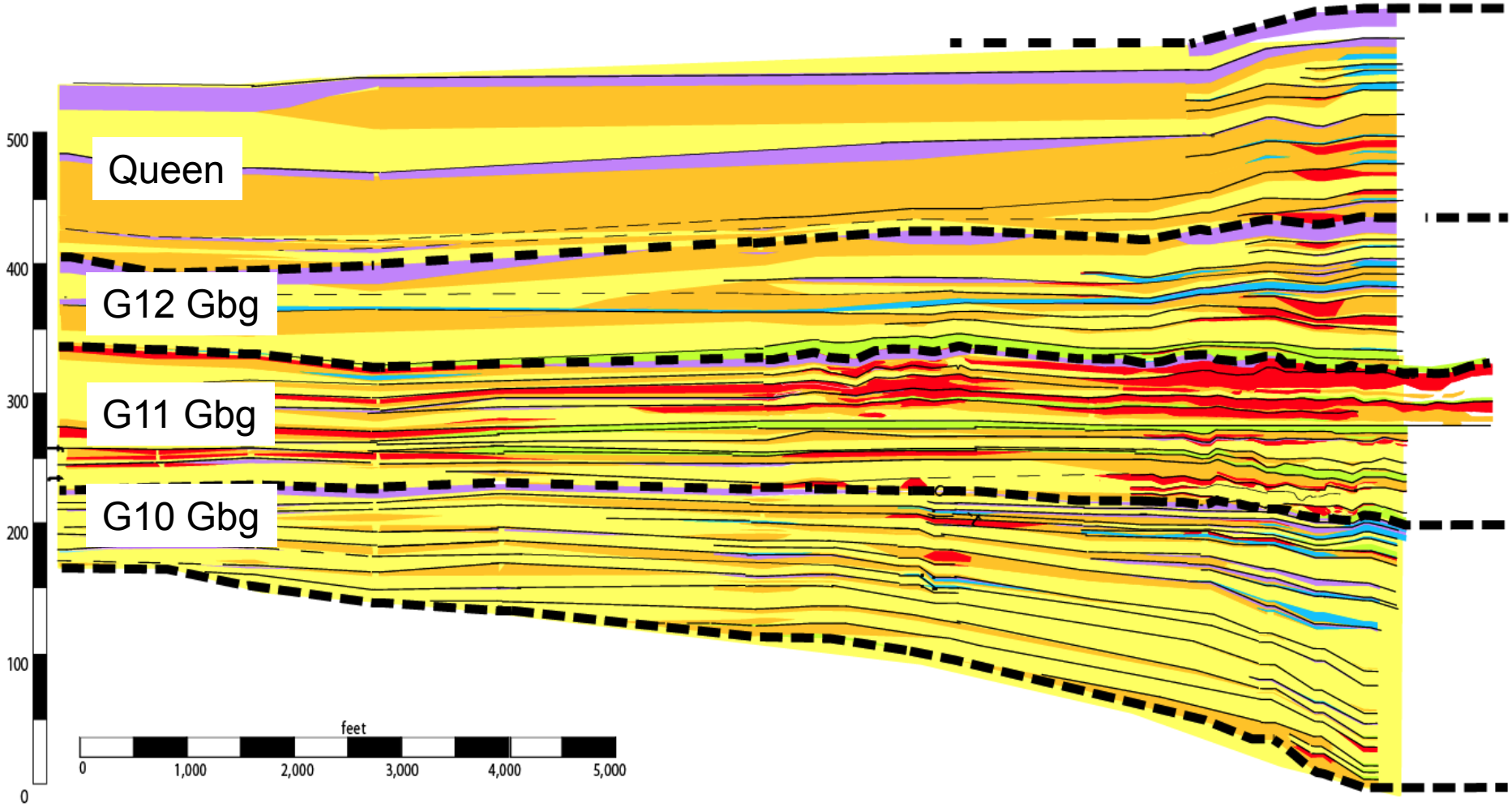
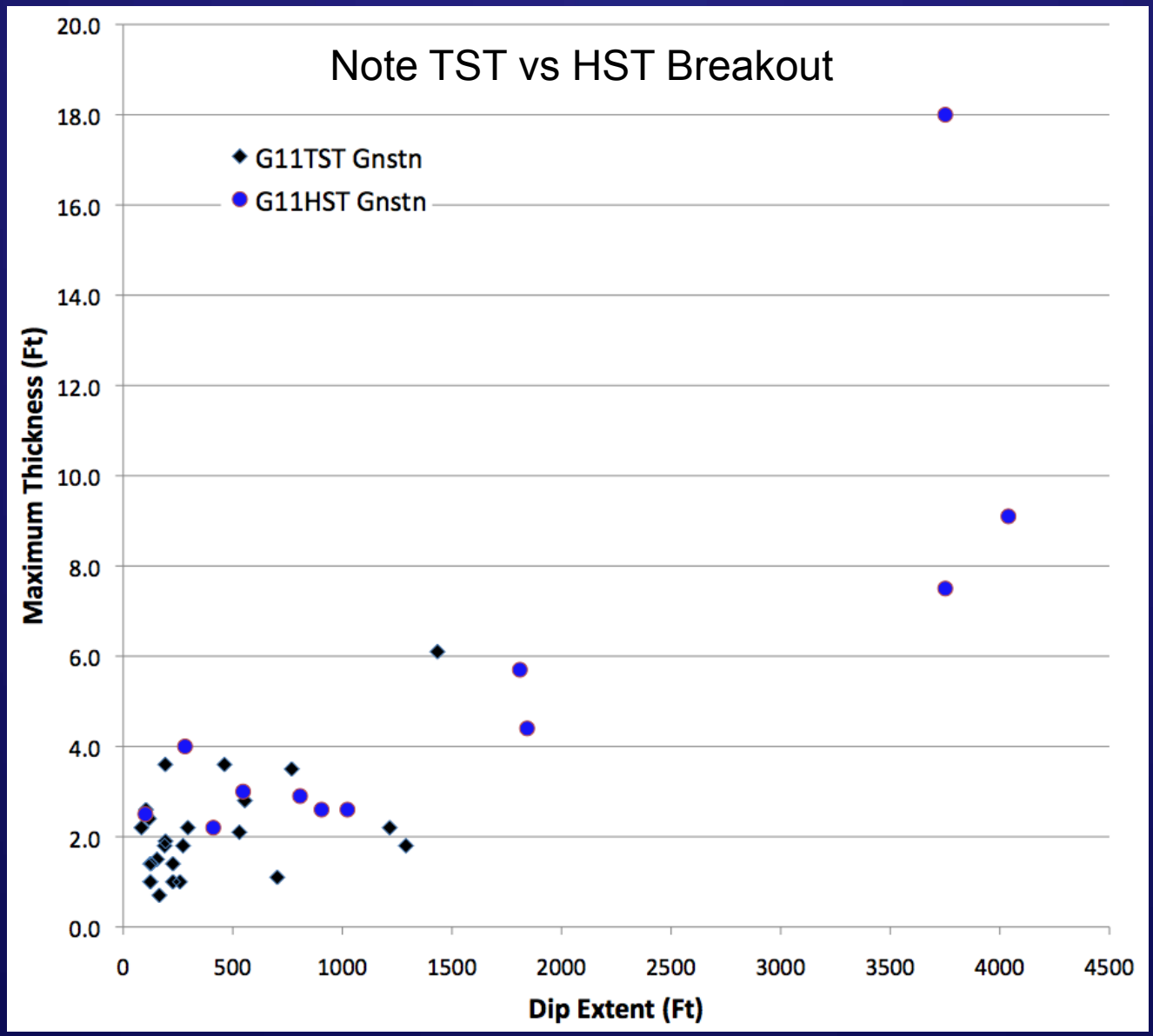
Plowman Ridge Grayburg

Barnaby and Ward (2007)



Dimensional Data, Plowman Ridge



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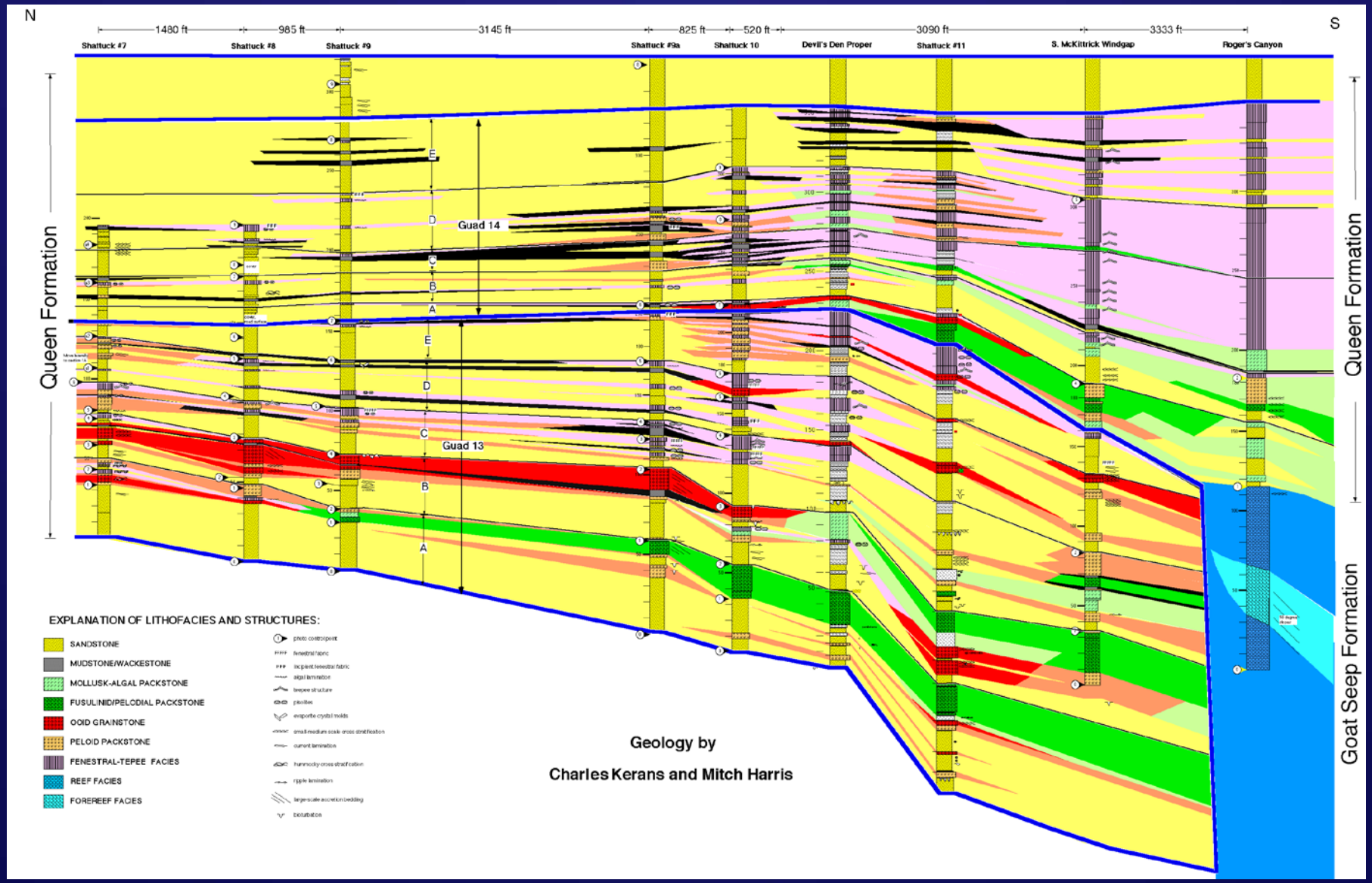
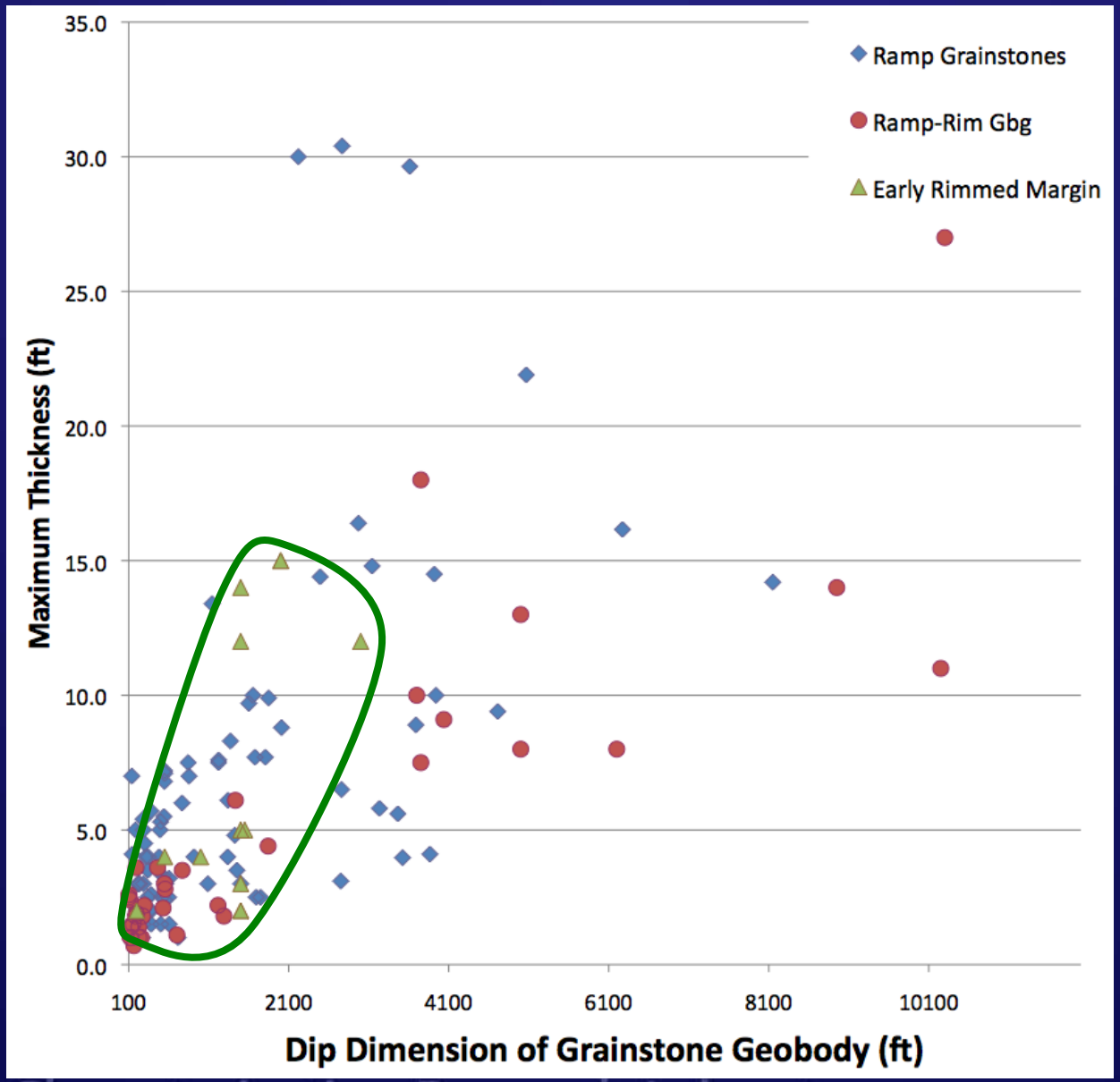
Shattuck Wall - Queen

Shattuck Queen – Early Rimmed



Queen Grainstone Geobodies



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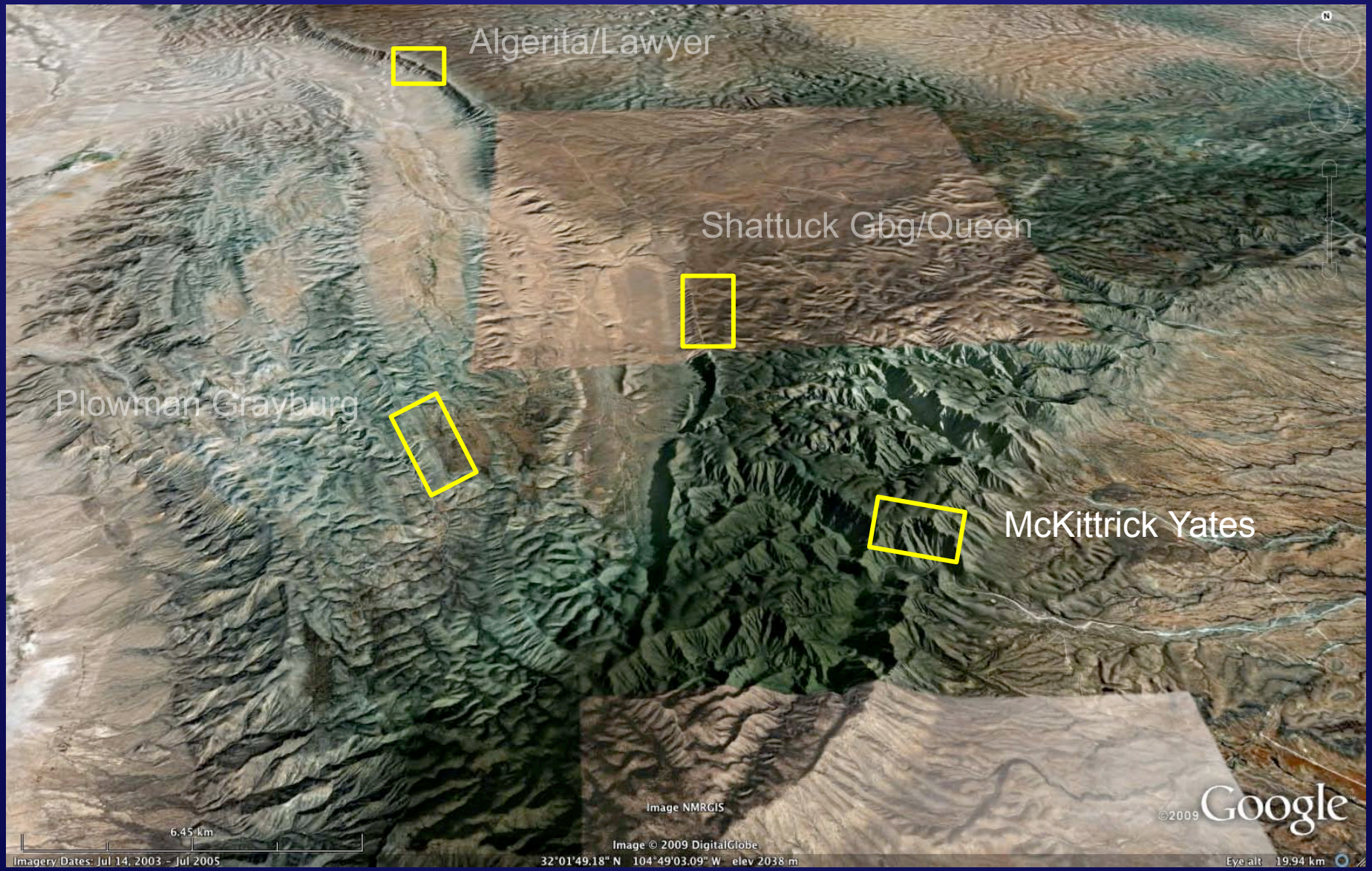

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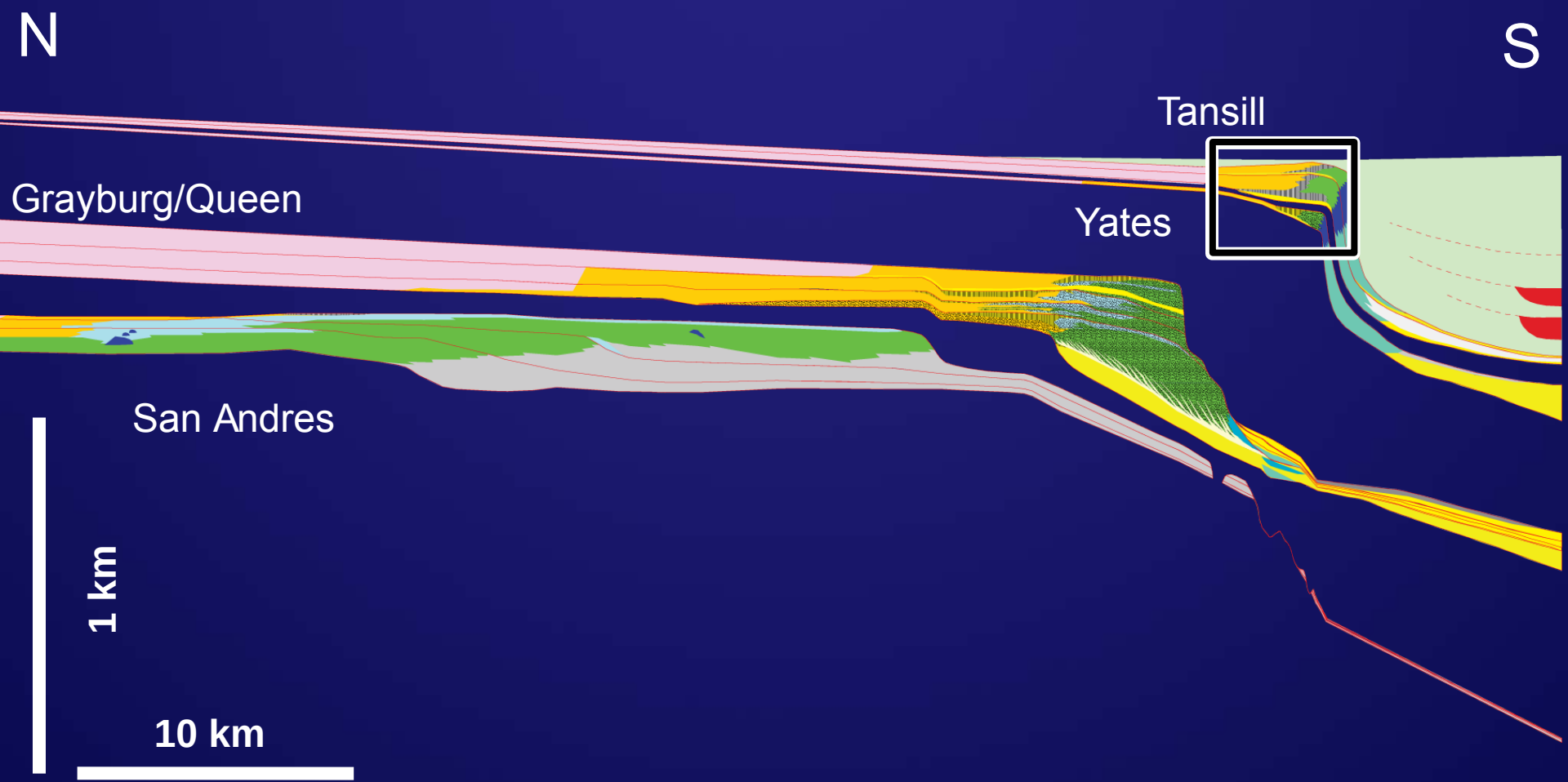
McKittrick Yates



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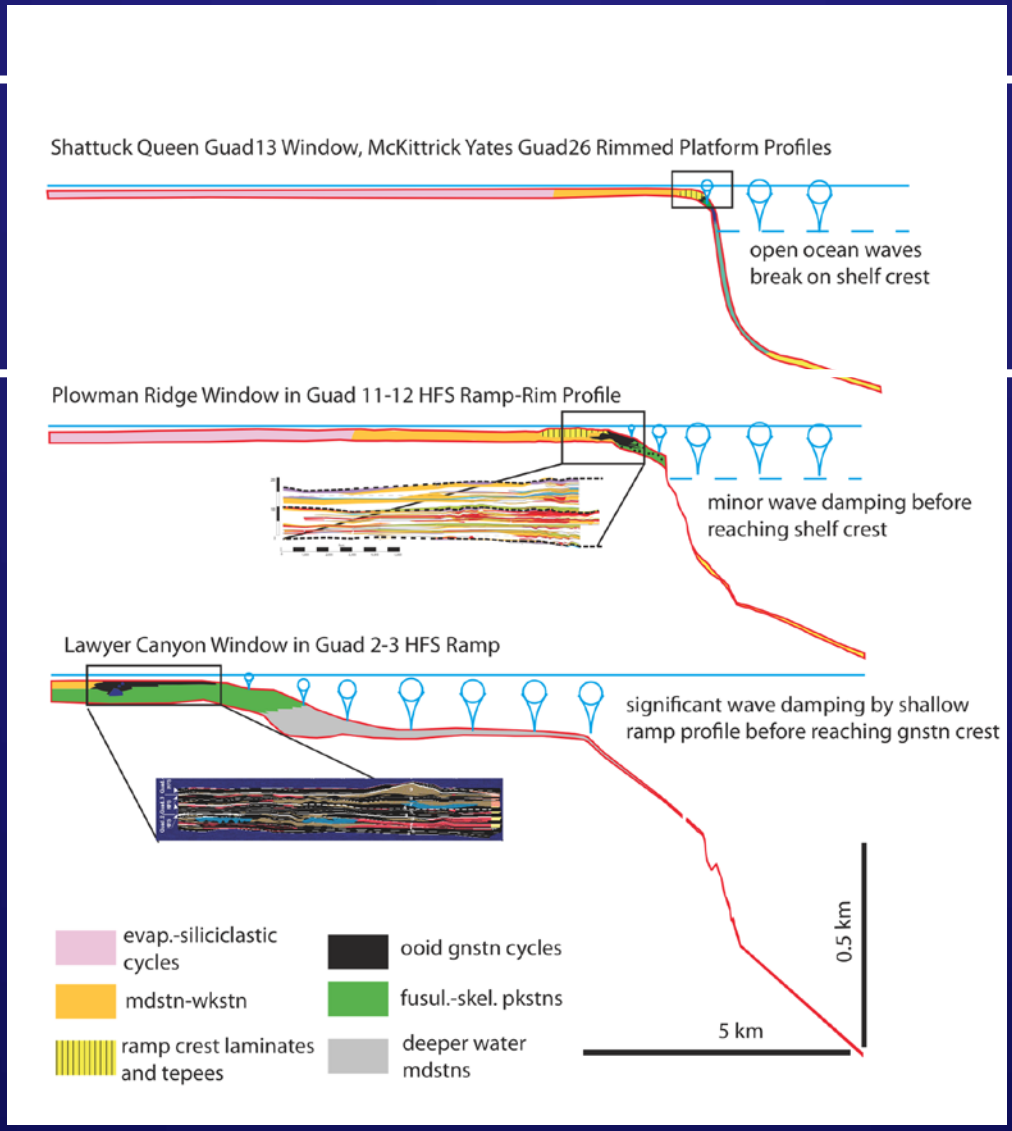

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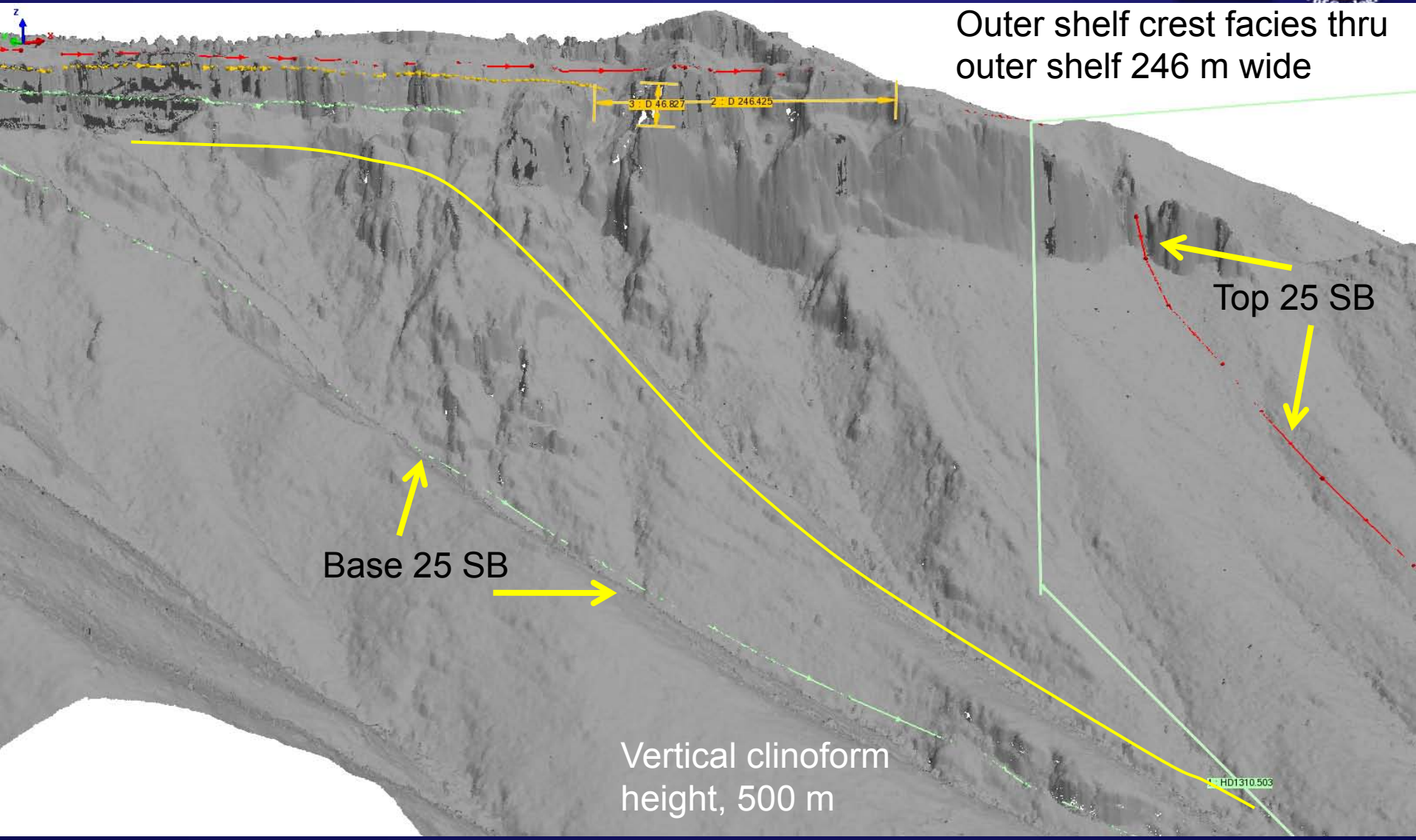
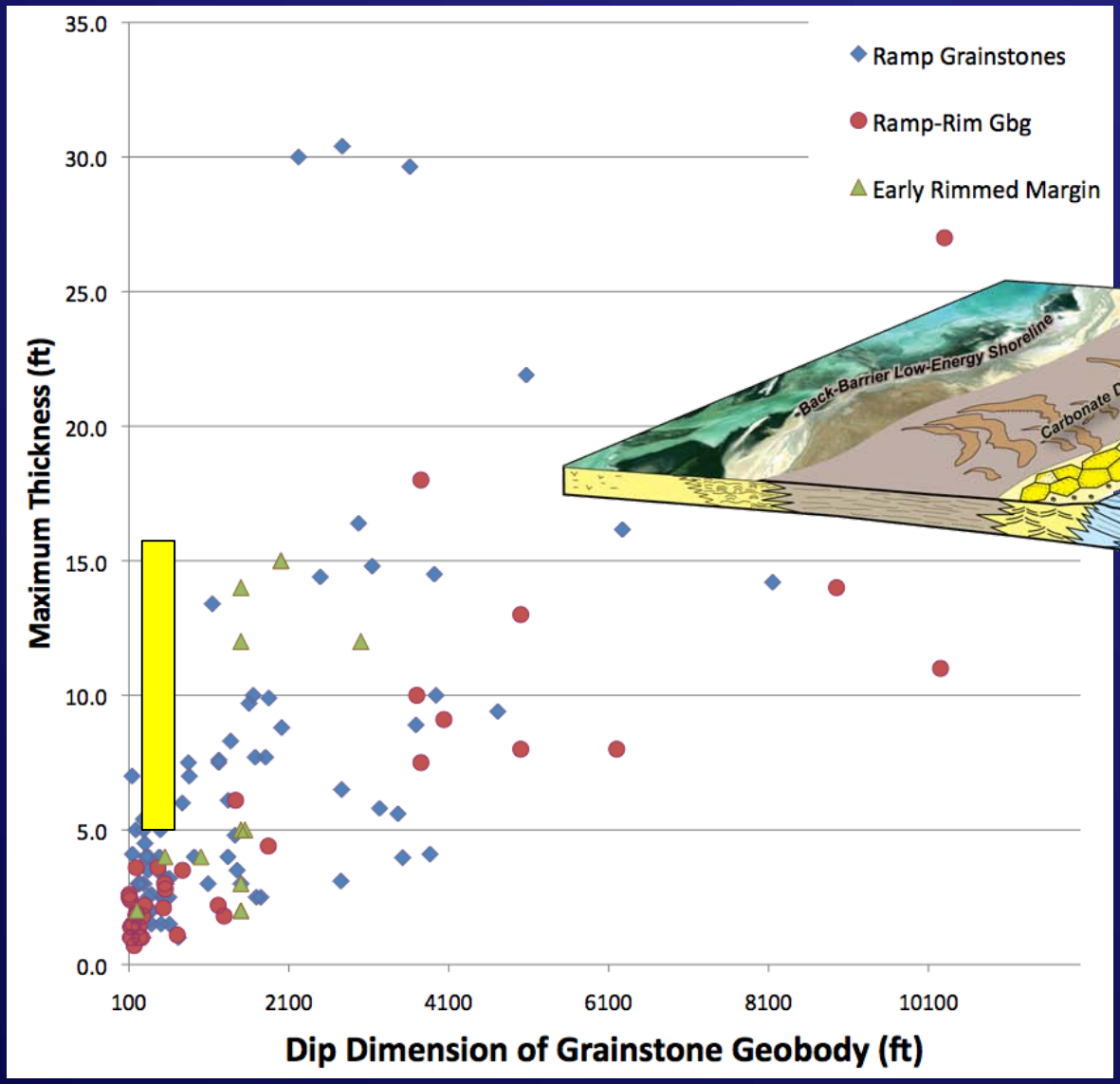
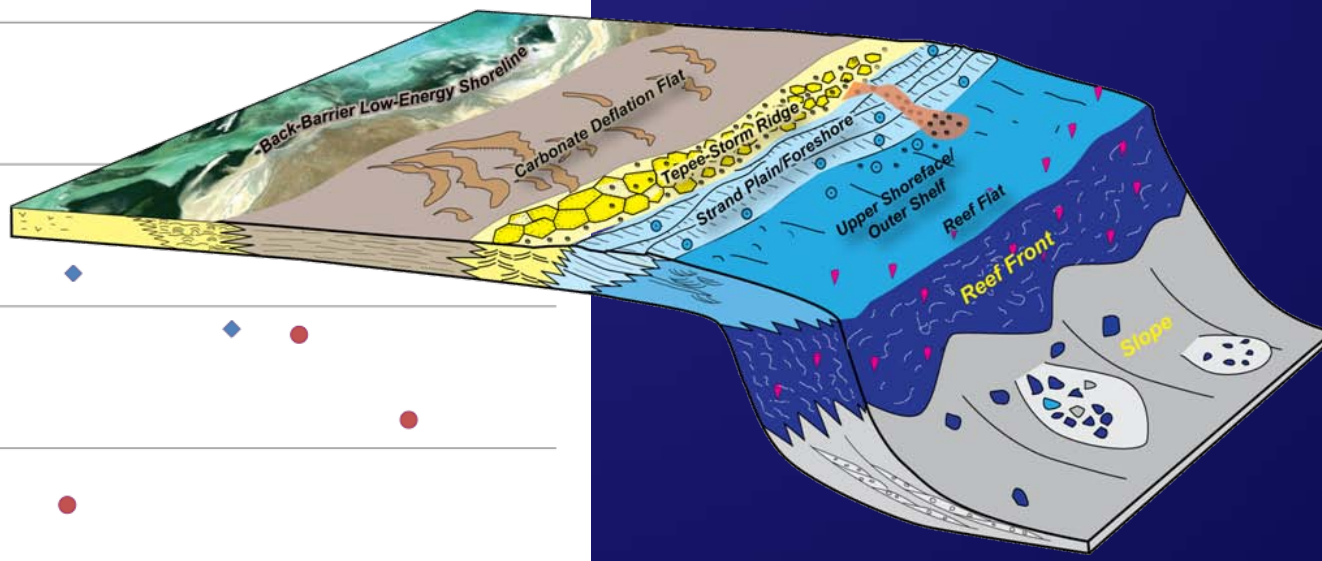
Yates Storm-Ridge Setting



Yates Storm-Ridge Related Foreshore Grainstones





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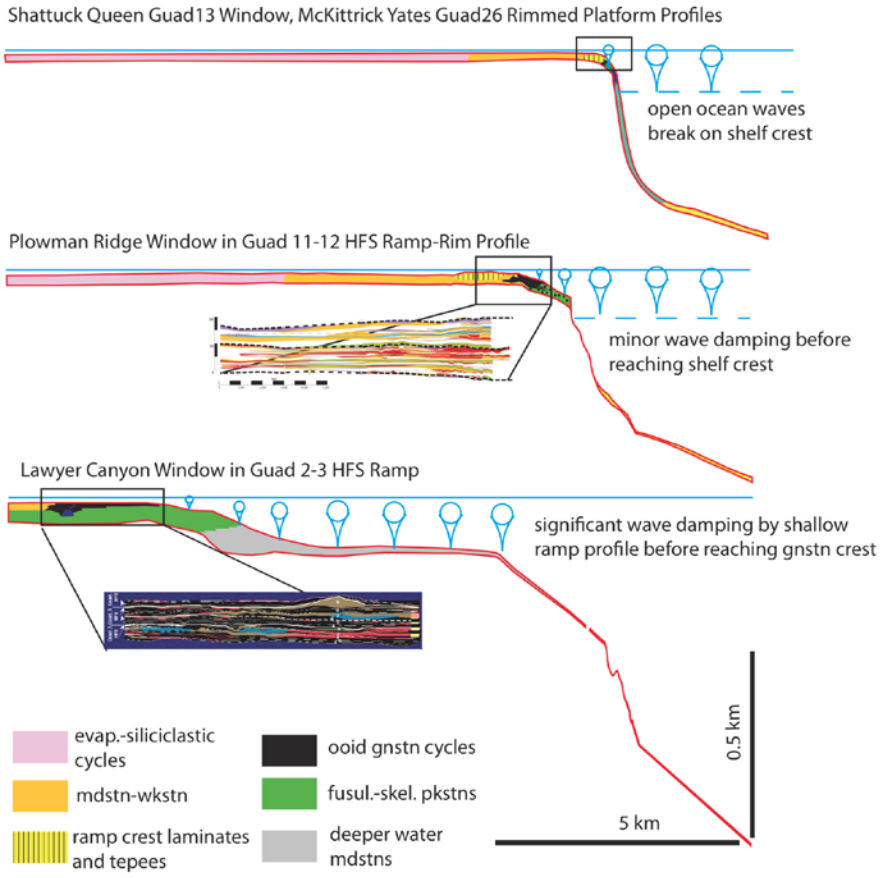
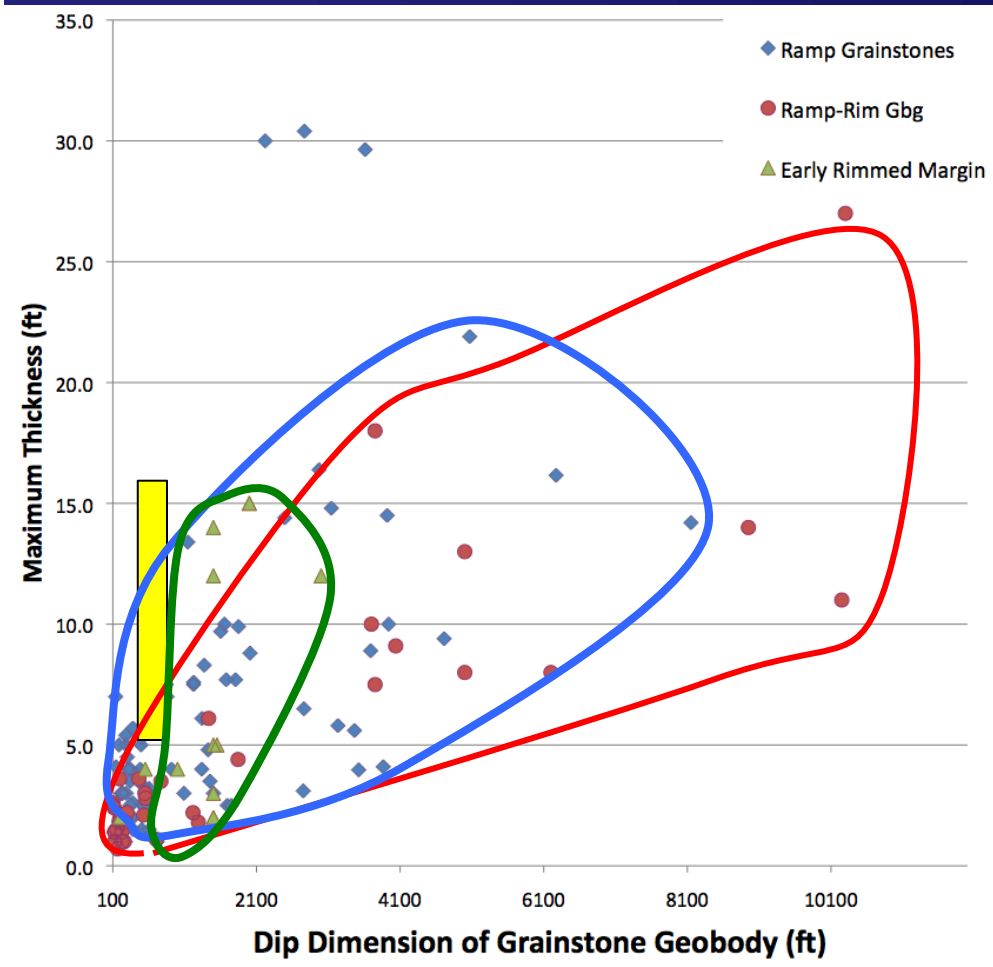
Controls on Grainstones – Shelf Profile





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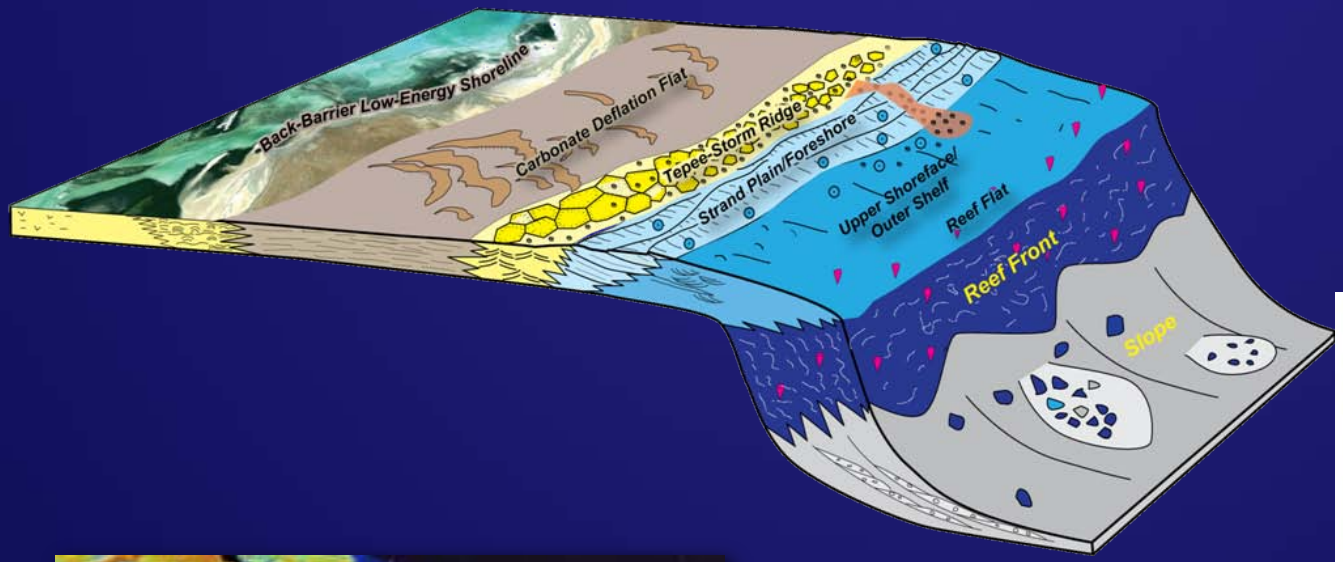
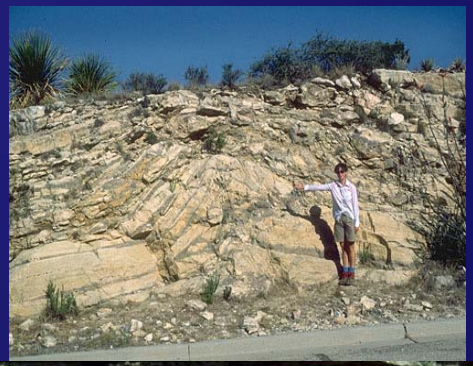
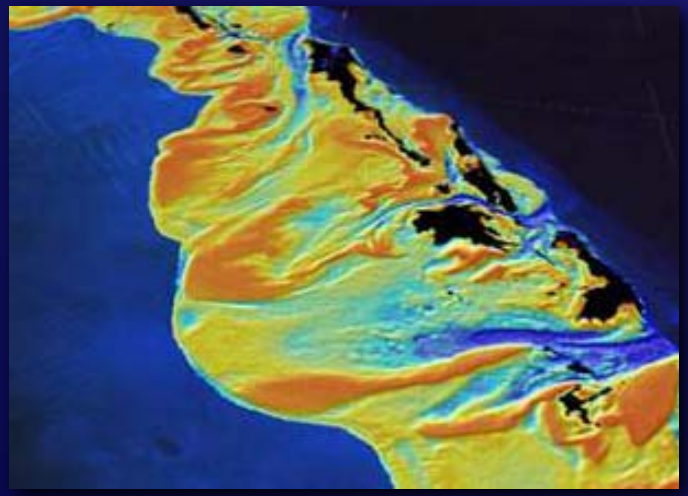
Cycle-scale Diagenetic Modification of Depositional Profile

Early-cemented storm ridge constrains grainstone dimension in Yates Margin







Early-cemented Pleistocene Islands control ooid tidal delta lobe distribution

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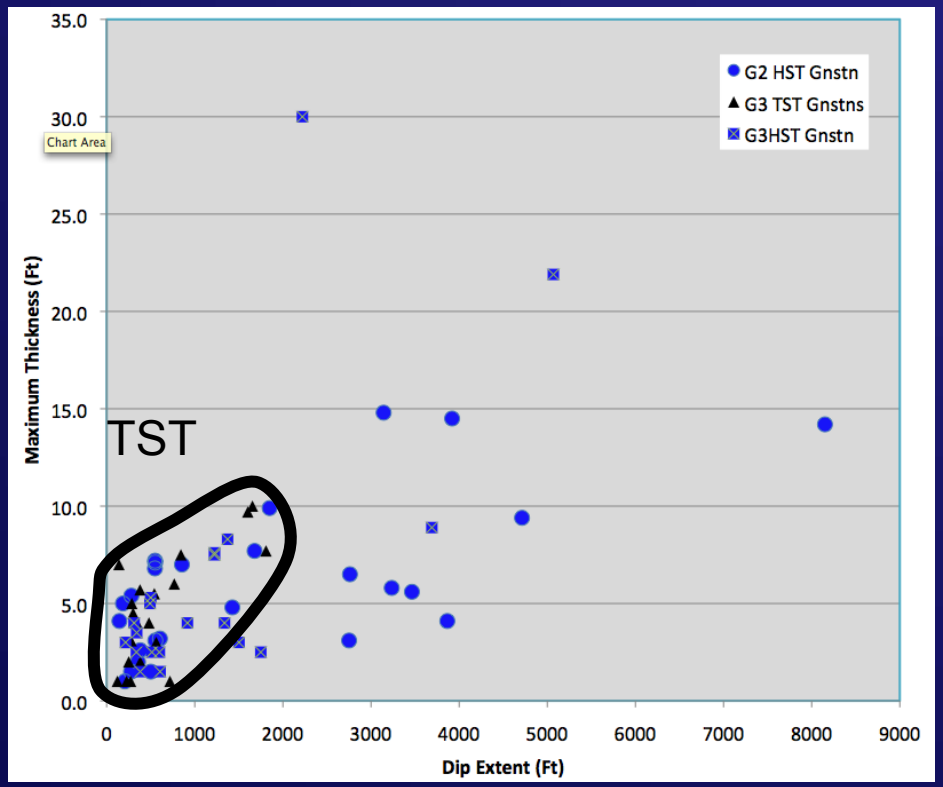
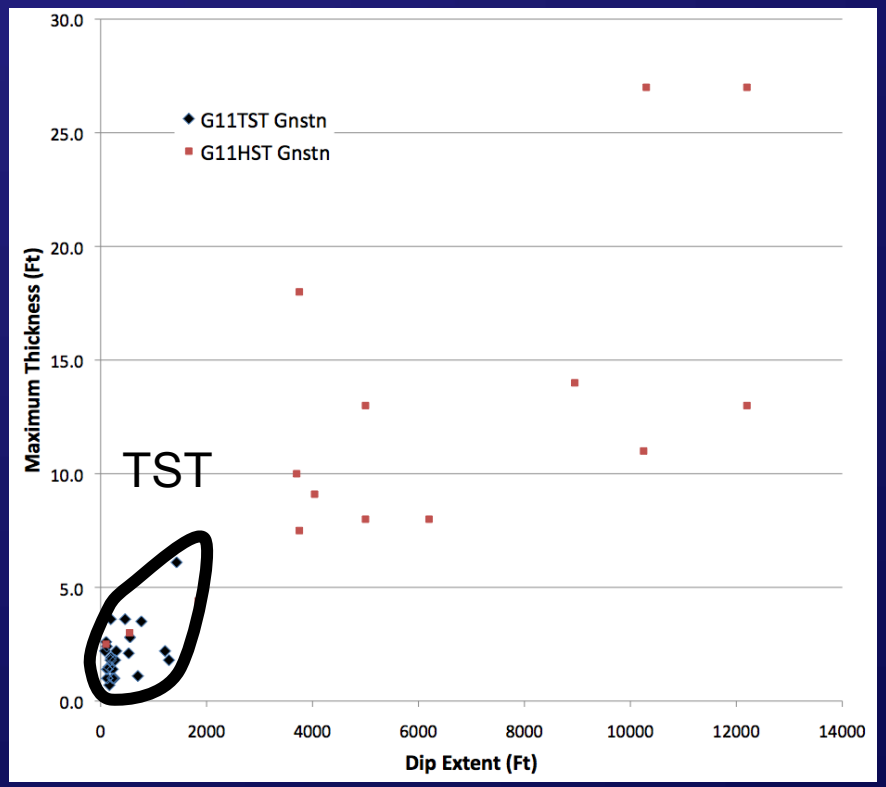
Accommodation Control on Grainstones

- **Sequence-scale accommodation control has clear impact on grainstone dimensions, as well as abundance**





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Conclusions

- Grainstone dimensions vary over 2 orders of magnitude in response to evolving depositional profile and linked diagenesis
- Key factors controlling dimensions include
    - Systems-tract-linked accommodation
    - Ramp to rim evolution and distribution of wave energy
    - Diagenetic modification of depositional profile