Controls on Seismic-Scale Reservoir Architecture of Mixed Carbonate-Siliciclastic Platform Margins: Example from the Triassic Yangtze Platform, South China*

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Abstract

Comparative analysis of platform evolution recorded in three continuous, two-dimensional, platform-to-basin transects of the Triassic Yangtze carbonate shelf, south China, indicates that laterally-variable tectonic subsidence, local faulting, and rate of basinal clastic deposition at the toe of slope controlled the evolution, large-scale architecture, and geometry of the platform margin and slope. Lateral and temporal changes in these three parameters and their various combinations during the Middle and early Late Triassic were responsible for the remarkable along-strike variability in the observed platform architecture. Aggradation and progradation patterns were controlled by local tectonic subsidence. Margin backsteps and retreats resulted from local faulting. Different slope geometries and margin types were controlled by degree and timing of basinal siliciclastic influx. Eustasy, in contrast, had very little influence on platform morphology and large-scale architecture.

Evolution, architecture, and time of drowning of several isolated platforms to the south, in the adjacent Nanpanjiang foreland basin, reflect the south-to-north onset of rapid subsidence and basin fill.

The evolution and large-scale architecture of carbonate platforms in south China represent an important analog for understanding, quantifying, and predicting lateral variability in seismic-scale characteristics of carbonate reservoir systems. The evaluation of controls on carbonate-platform evolution suggests that, given subsidence history and basinal siliciclastic dispersal pattern, the basin-wide, seismic-scale evolution of carbonate accumulations is predictable. Resulting models can be used to help exploration of carbonate reservoirs in frontier or under-explored basins.

Selected References

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Schlager, W. (editor), 2005, Carbonate Sedimentology and Sequence Stratigraphy: SEPM, Tulsa, Oklahoma, 200 p.

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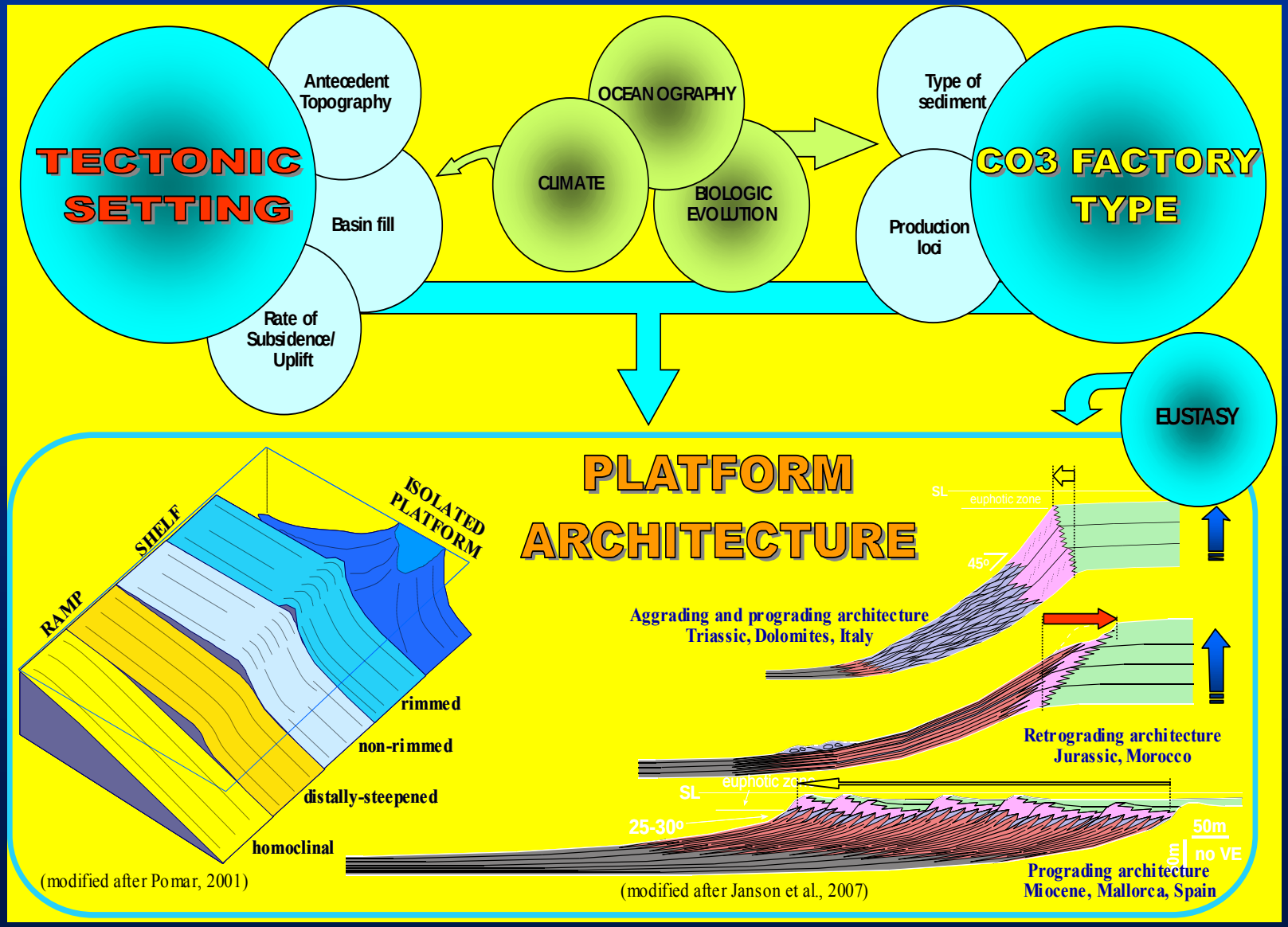
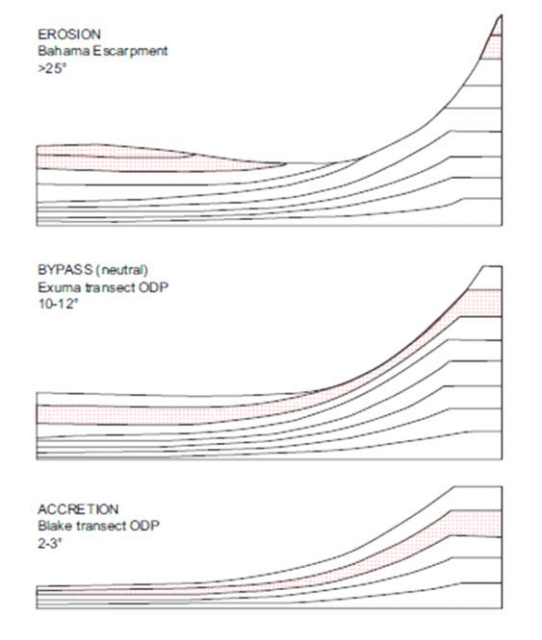
Controls on carbonate platform architecture

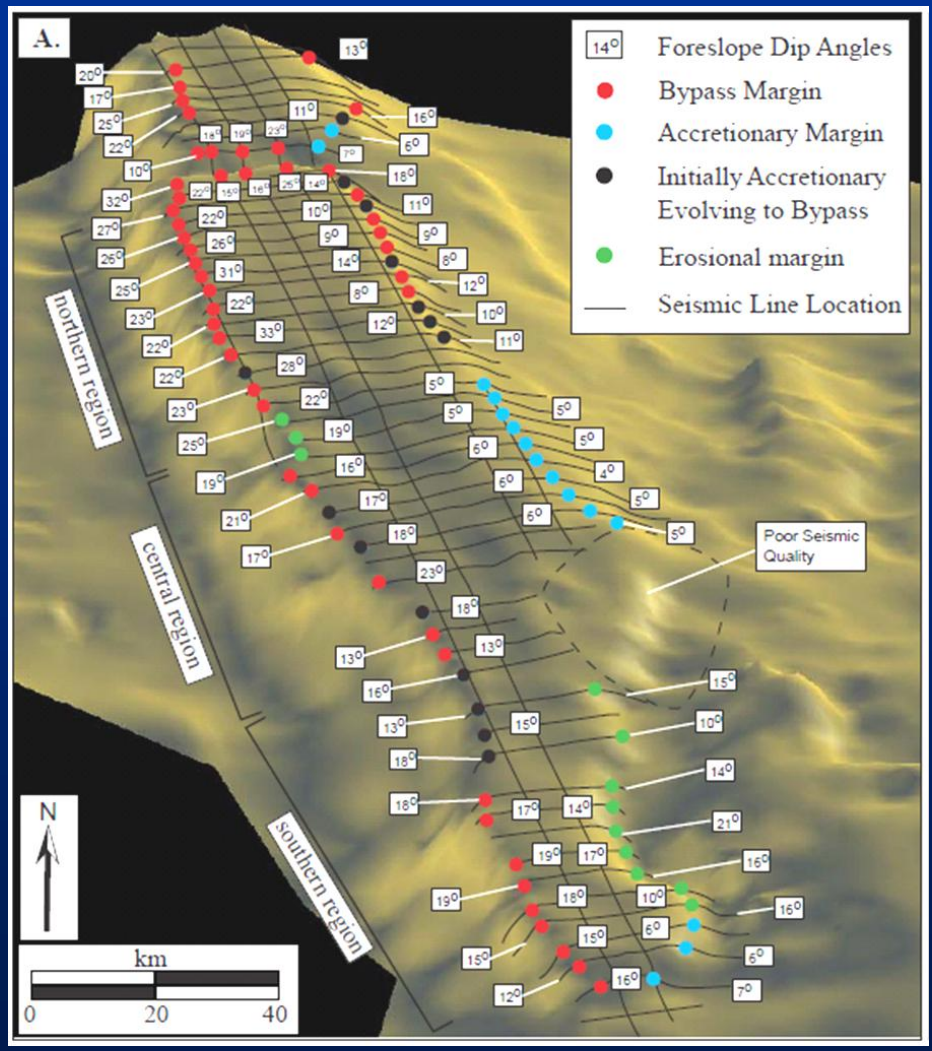


- **Lateral and vertical variation in platform architecture and margin type is common**



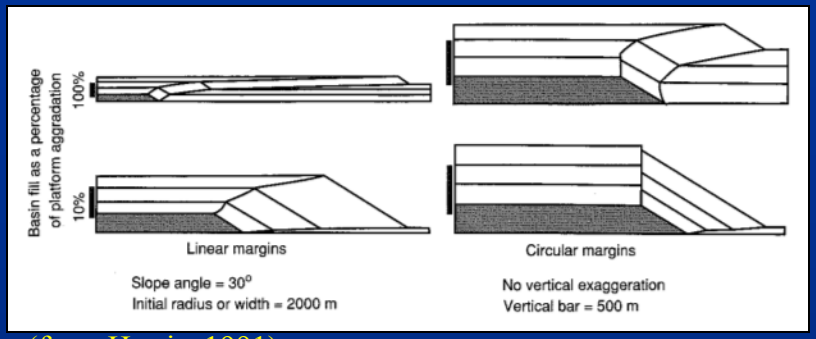
(from Schlager, 2005)

- **How predictable are large-scale geometries & margin types of carbonate systems? And their variation in time and space?**



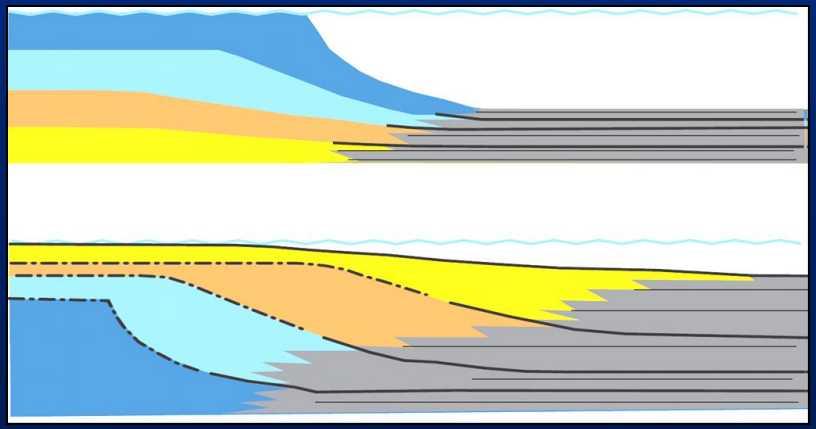
Miocene isolated platform, offshore Vietnam (from Owen, 2001)

•Can we predict and quantify platform margin geometries from 2D lines?

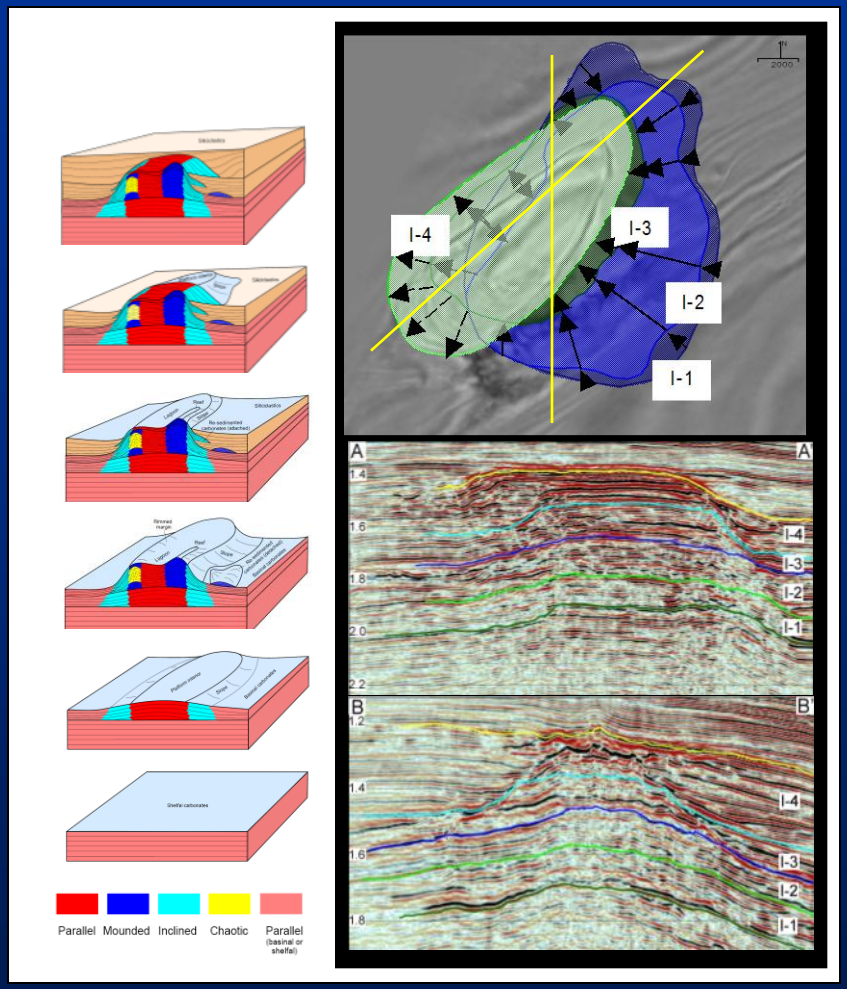


(from Harris, 1991)

Extent of buildup progradation depends directly on the rate of basinal deposition



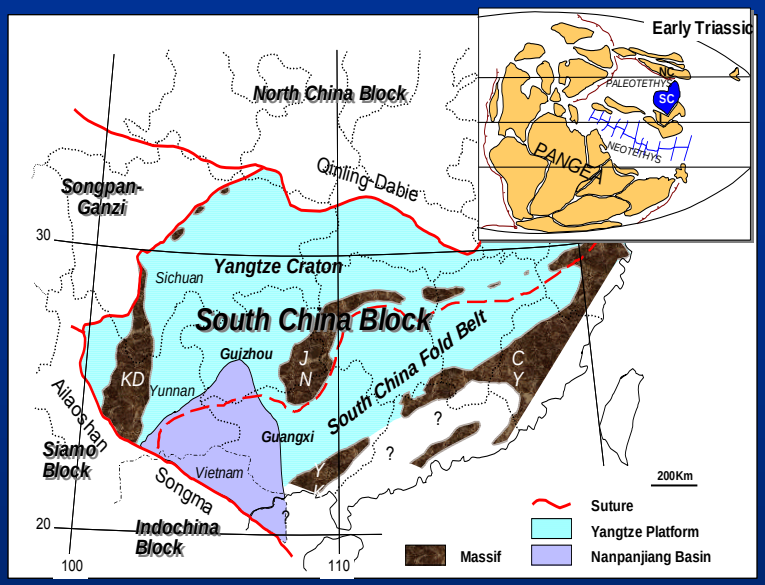
(modified after Schlager, 2005)

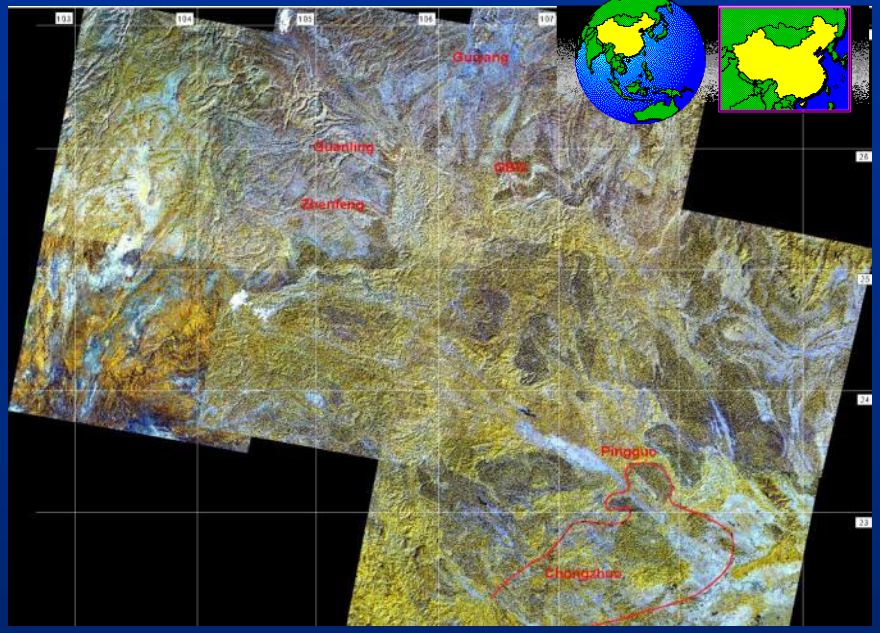


•What controls these geometries and architectures?

•What is the impact of basinal clastics in mixed systems?

Geologic Setting





CARBONATE DEPOSITION STARTED IN THE LATE PRECAMBRIAN

DEVONIAN: RIFTING

PERMIAN: RENEWED EXTENSION

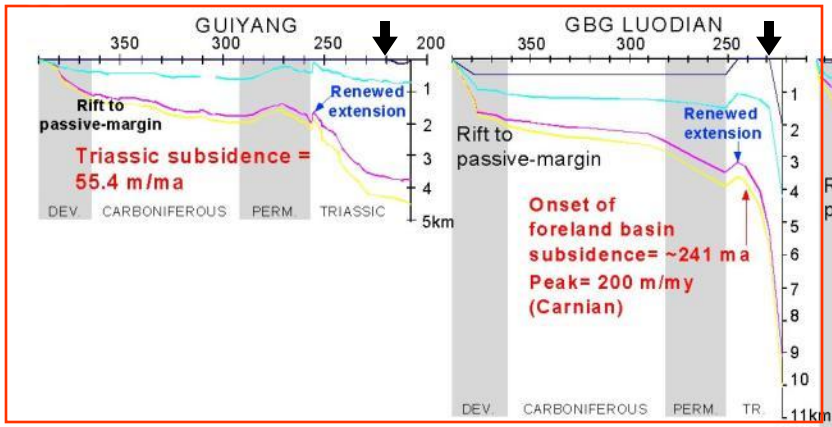
TRIASSIC: FORELAND BASIN

Triassic Yangtze Platform margin exceptionally exposed in SW Guizhou Province

Several isolated platforms in adjacent Nanpanjiang Basin – Guizhou & Guangxi Provinces

SUBSIDENCE ANALYSIS

A



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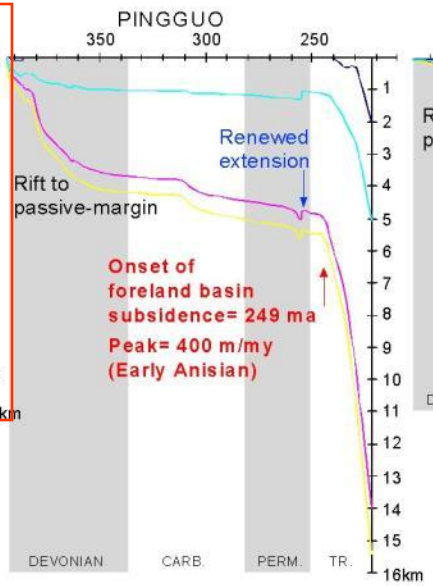
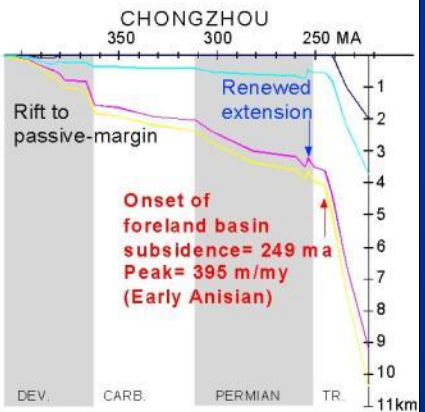
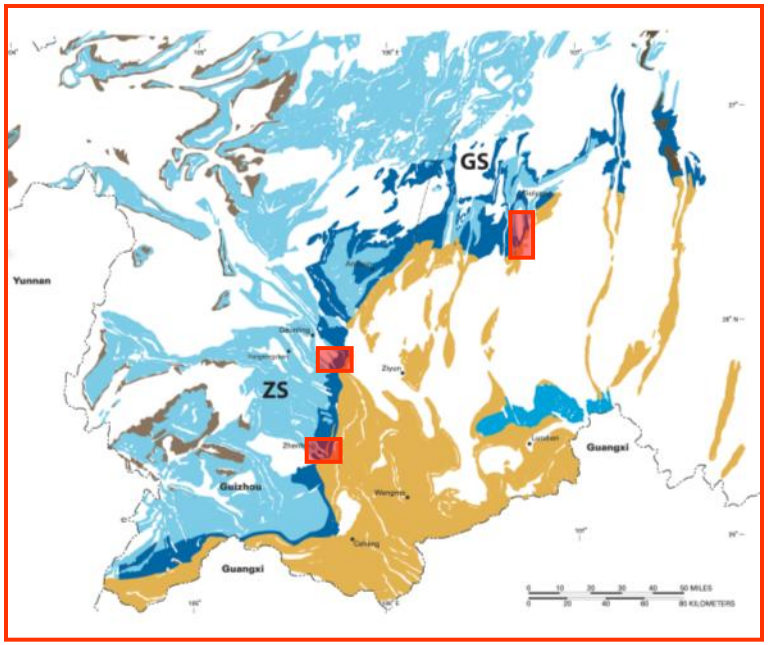
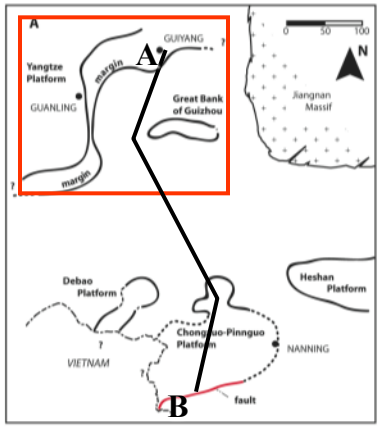


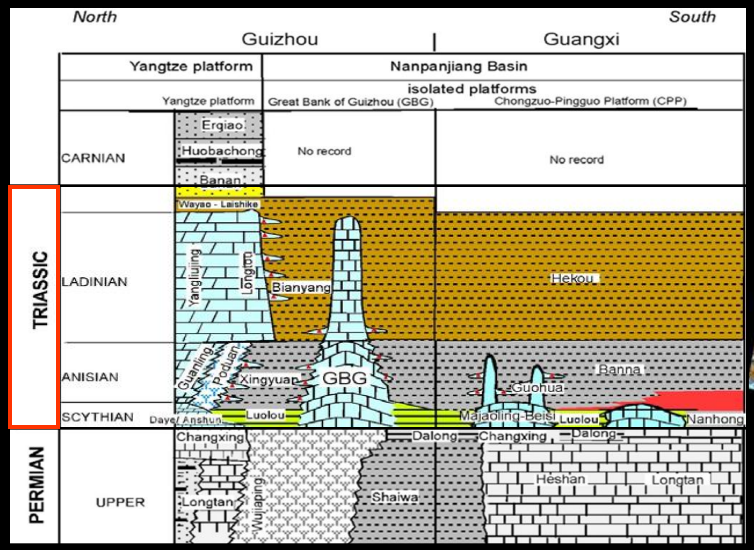


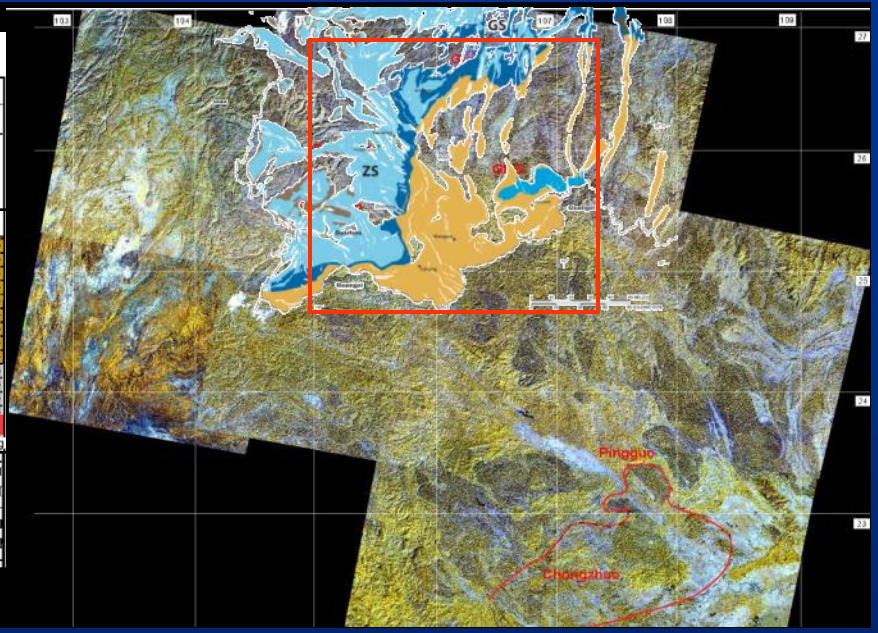




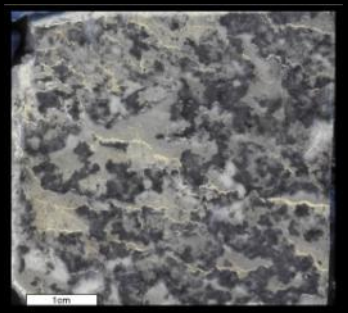
South to North onset of rapid subsidence in foreland basin setting

Stratigraphy

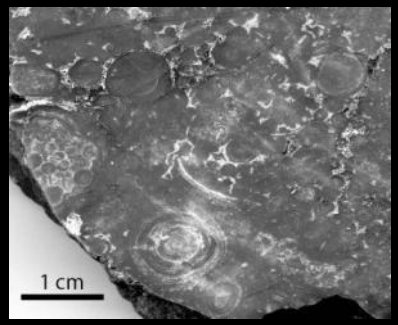




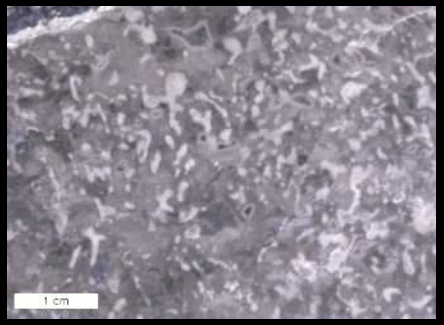
P/T: calcimicrobial mounds & biostromes



Early Triassic: giant ooids

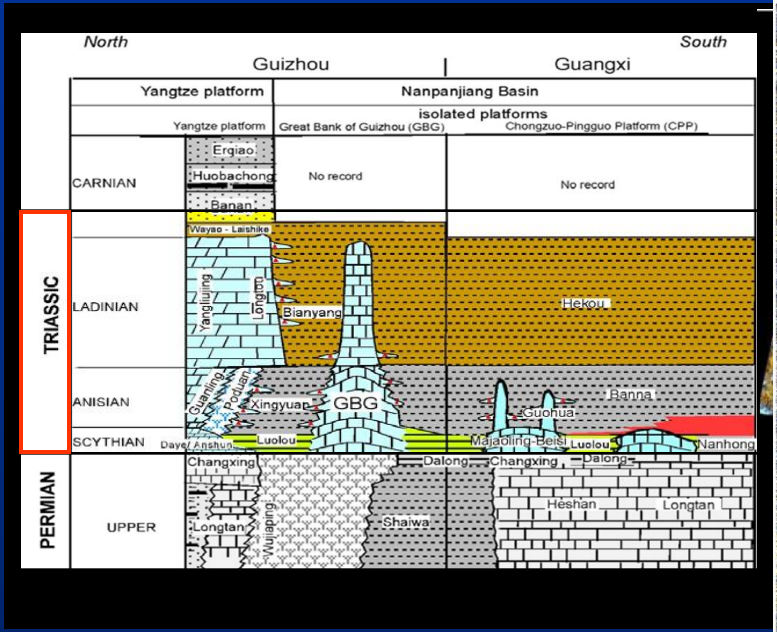


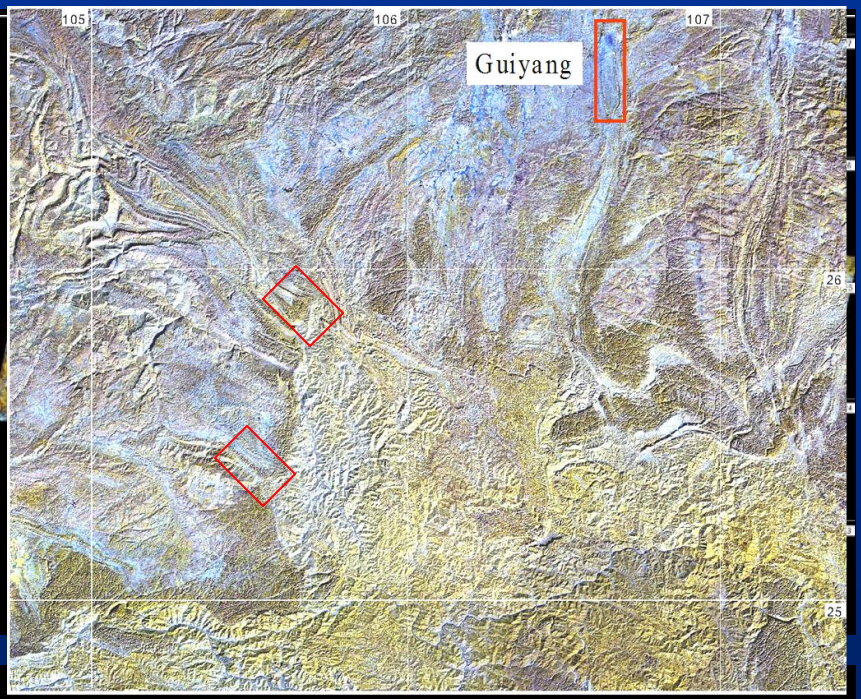
Anisian: *Tubyphytes* reefs



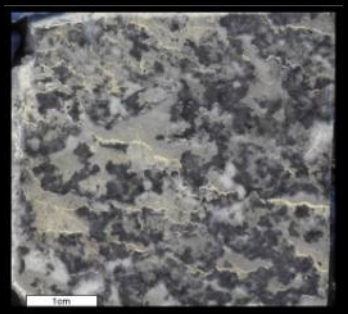
Ladinian-Carnian: Coral, algal, spongae, cement reefs

Stratigraphy

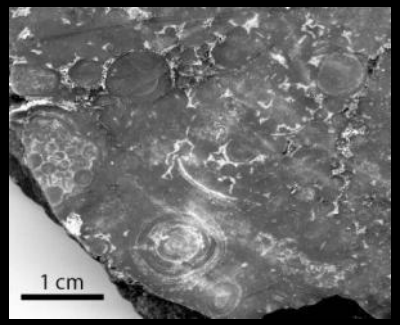




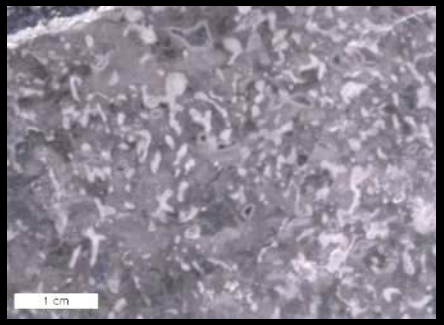
P/T: calcimicrobial mounds & biostromes



Early Triassic: giant ooids

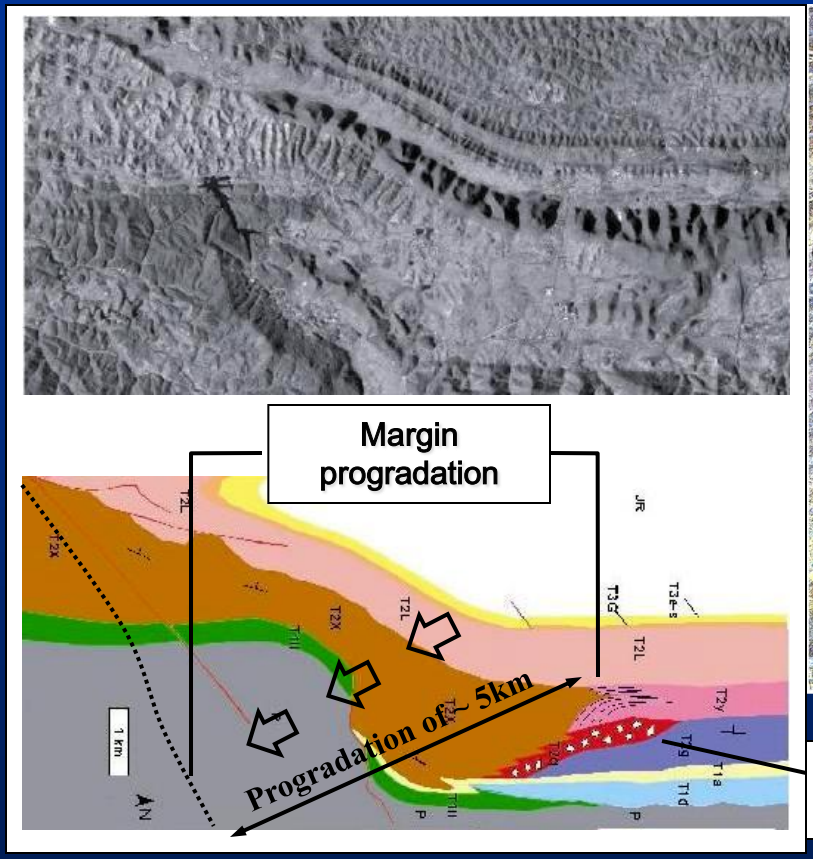


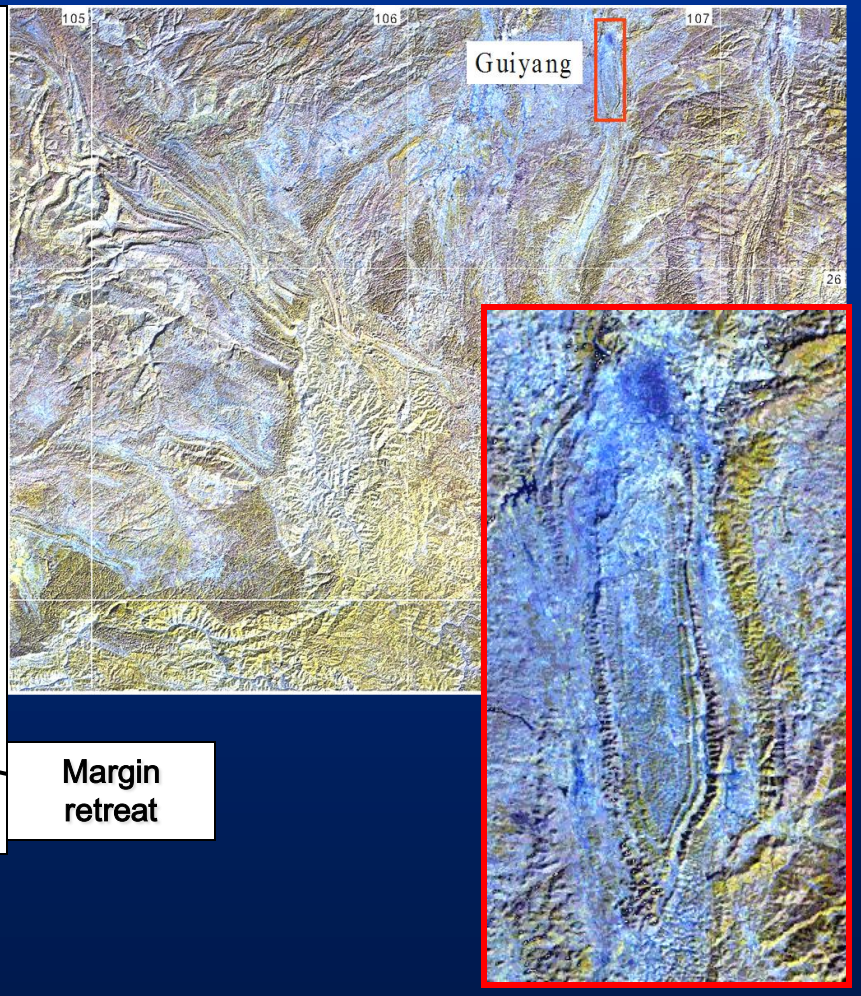
Anisian: *Tubyphytes* reefs



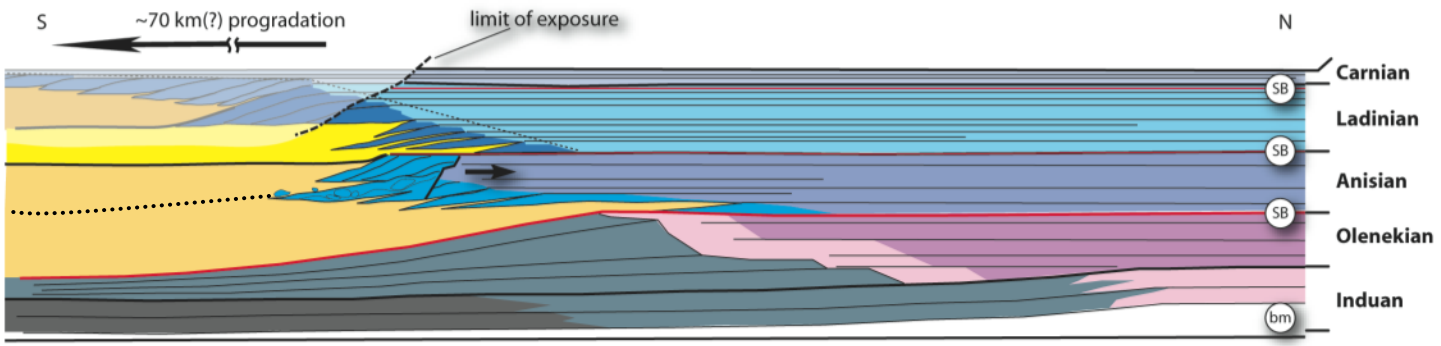
Ladinian-Carnian: Coral, algal, spongae, cement reefs

Platform Margin Architecture - Guiyang Margin





Architecture of Guiyang Margin



Induan (early Early Triassic): ramp morphology; low rate of basin fill

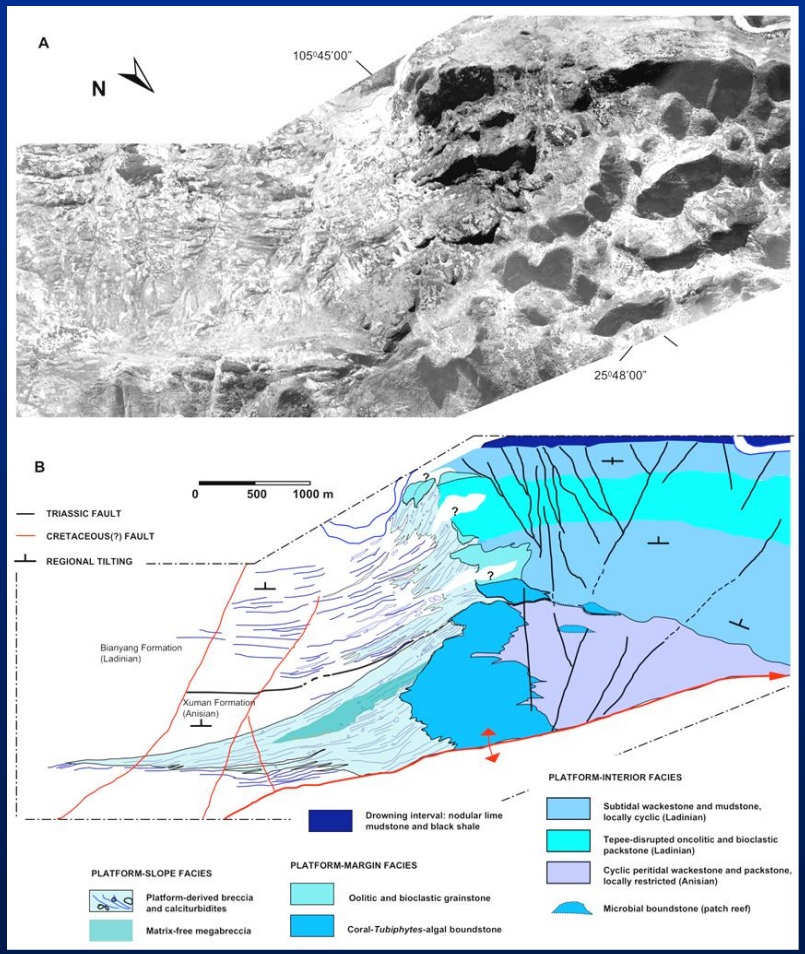
Olenekian (late Early Triassic): Low-relief platform; marked (?) progradation; depositional slope; low rate of basin fill

Anisian (early Middle Triassic): low-relief platform; moderate aggradation; margin erosion and retreat; large blocks shed to basin; initial high to moderate rate of basin fill

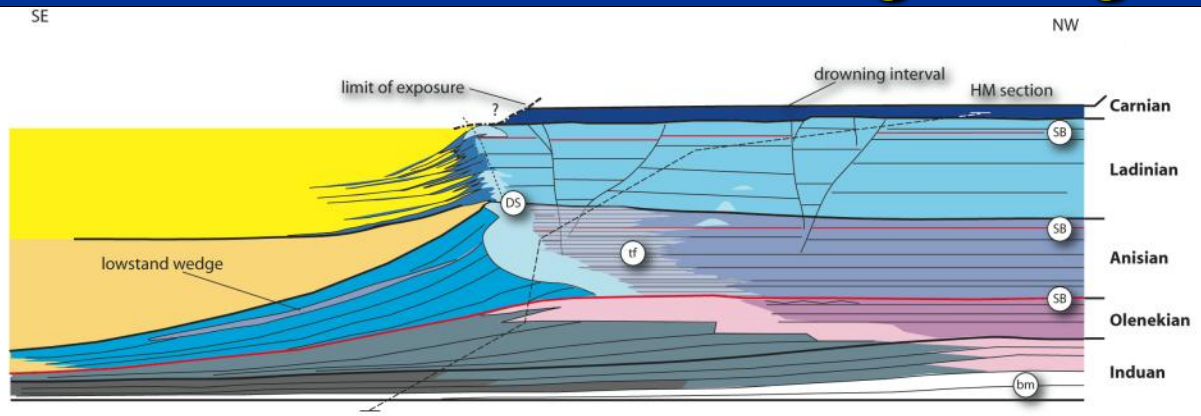
Ladinian (late Middle Triassic): marked progradation and little aggradation; depositional slope (?); decreasing rate of basin fill to starved basin

Carnian (early Late Triassic): marked progradation; very little aggradation; high rate of basin fill; platform termination later, in shallow water

Platform Margin Architecture - Guanling Margin



Architecture of Guanling Margin



Induan (early Early Triassic): ramp morphology; low rate of basin fill

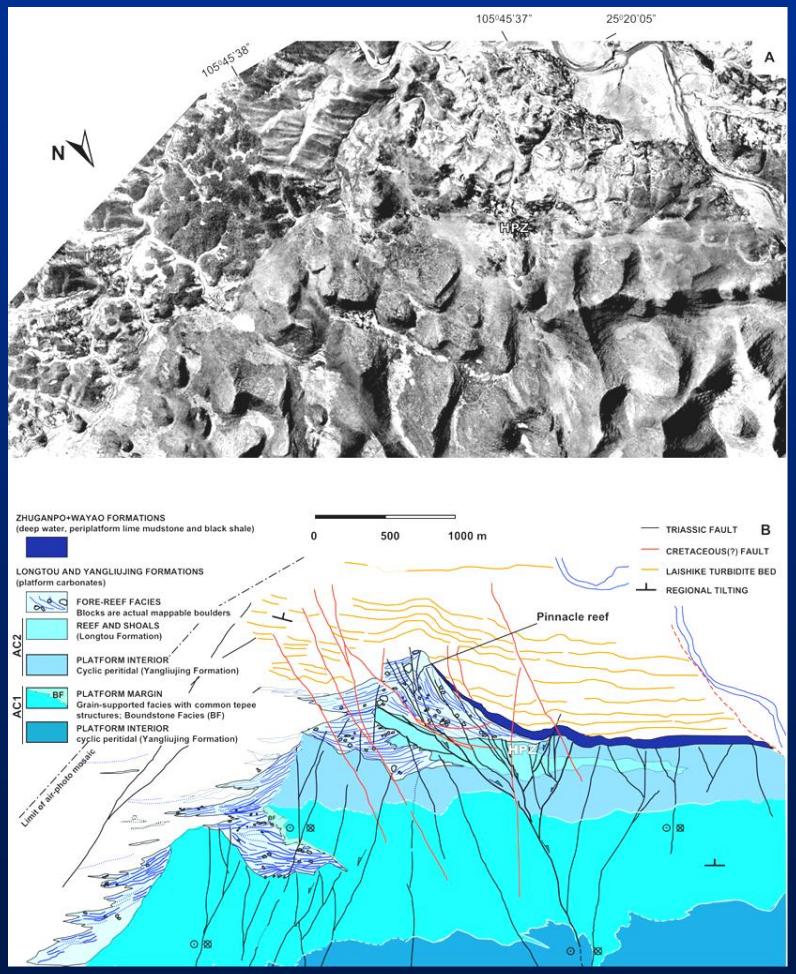
Olenekian (late Early Triassic): Low-relief platform; marked (?) progradation; depositional slope; low rate of basin fill

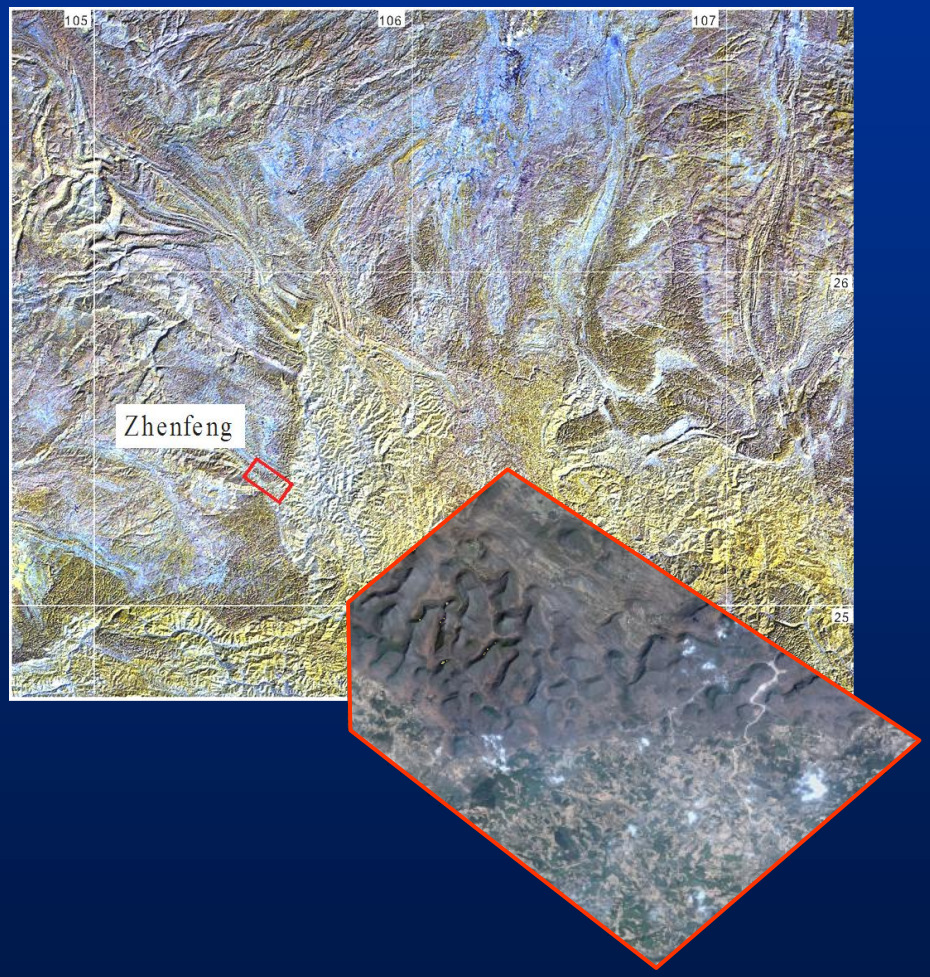
Anisian (early Middle Triassic): progradation to aggradation margin; Steepening geometry; mostly depositional slope; siliciclastics during late Anisian (starved to rapidly-filling basin)

Ladinian (late Middle Triassic): marked aggradation; vertically stacked, low-relief platforms; high to moderate rate of basin fill

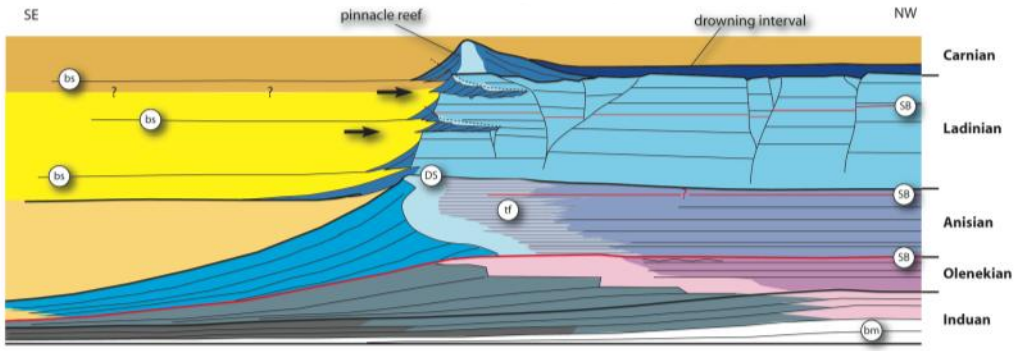
Carnian (Early Late Triassic): faulting and drowning below photic zone

Platform Margin Architecture - Zhenfeng Margin





Architecture of Zhenfeng Margin

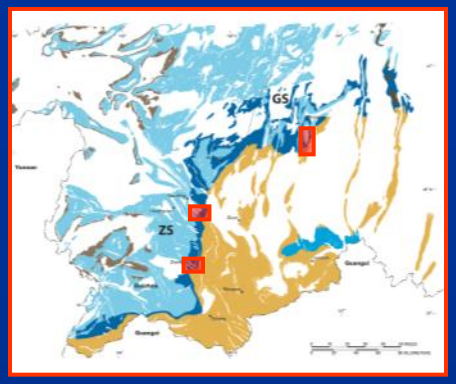


Induan and Olenekian (Early Triassic): same as Guanling (?)

Anisian (early Middle Triassic): same as Guanling

Ladinian (late Middle Triassic): marked aggradation, backstepping, and progradation (complex); erosional and depositional slope; intermittent basin fill

Carnian (early Late Triassic): faulting and drowning below photic zone; pinnacle reef



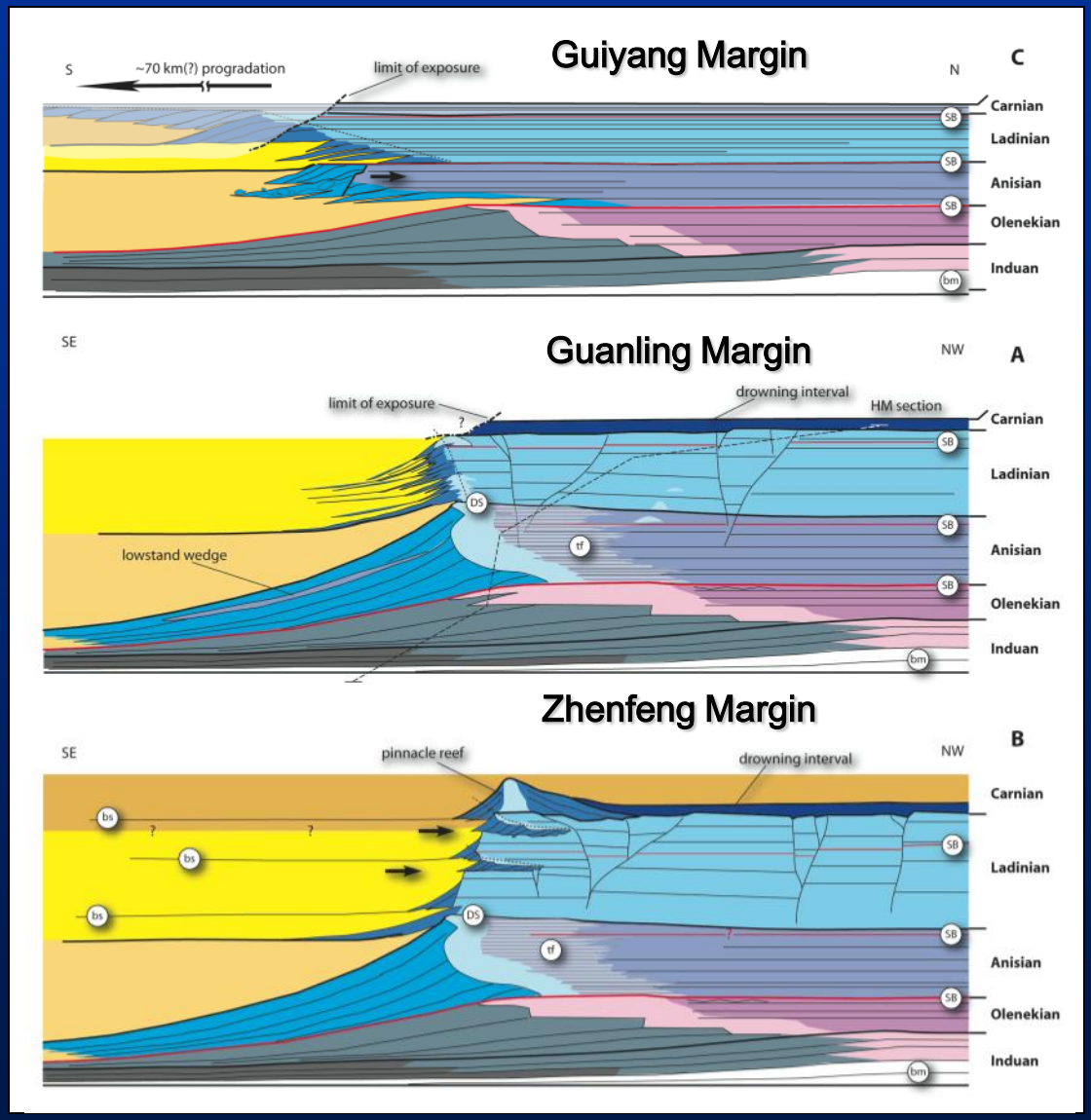
Comparative Analysis

Early Triassic (Induan & Olenekian): similar evolution in all transects

Middle Triassic (Anisian): stark difference between SW and NE sectors

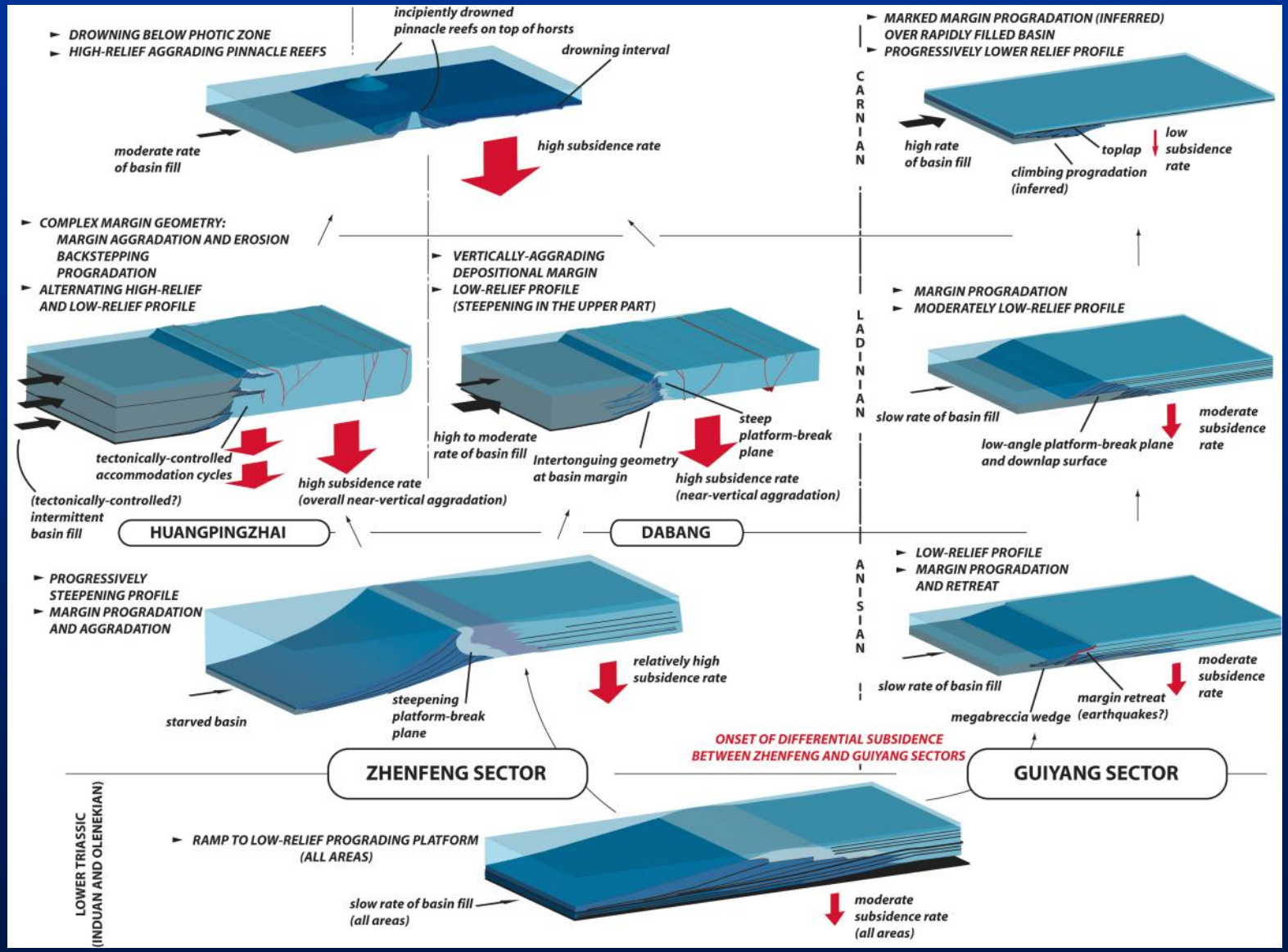
Middle Triassic (Ladinian): different evolution in all transects

Late Triassic (Carnian): early drowning in SW sector; late burial by shallow-water siliciclastics in NE sector

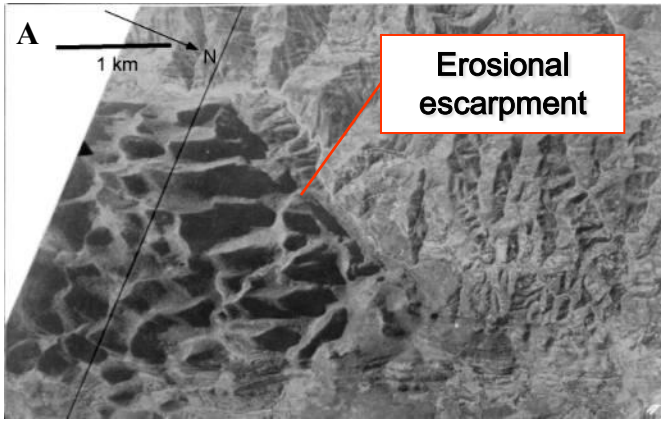


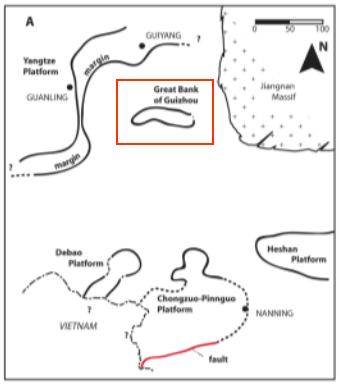
Controls on YP Margin Evolution

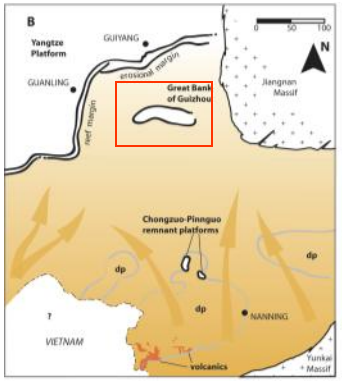
S N

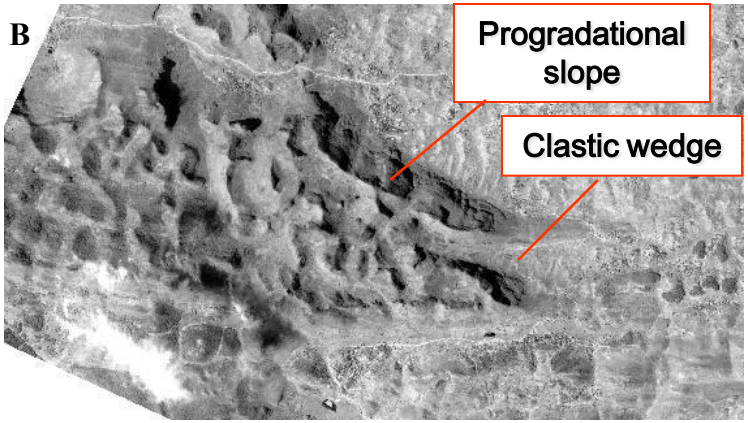


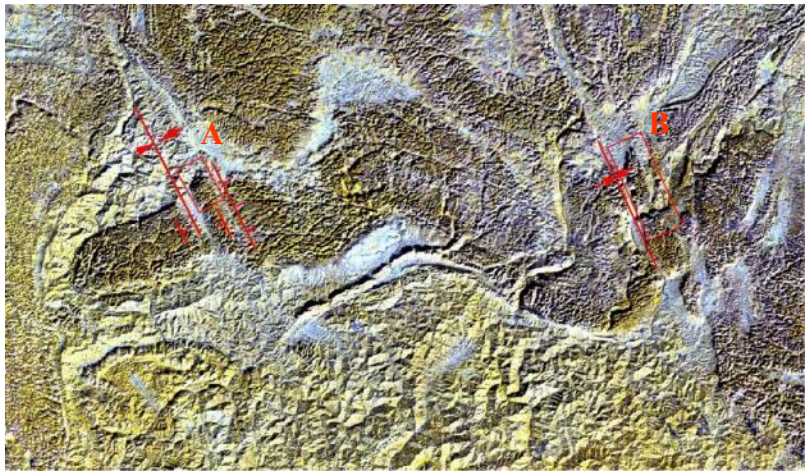
Architecture of Isolated Platforms-GBG



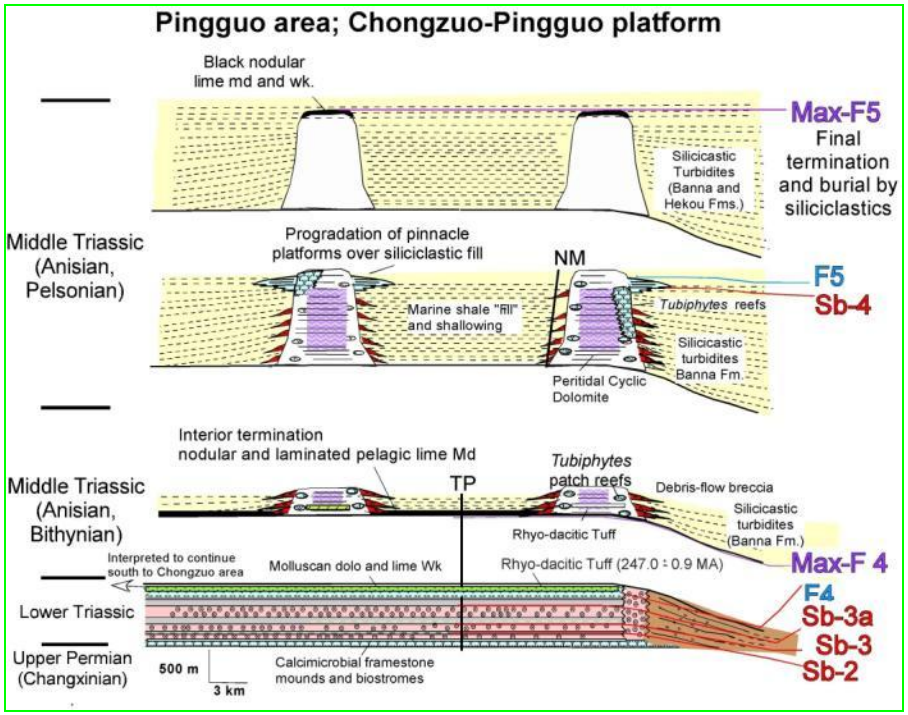


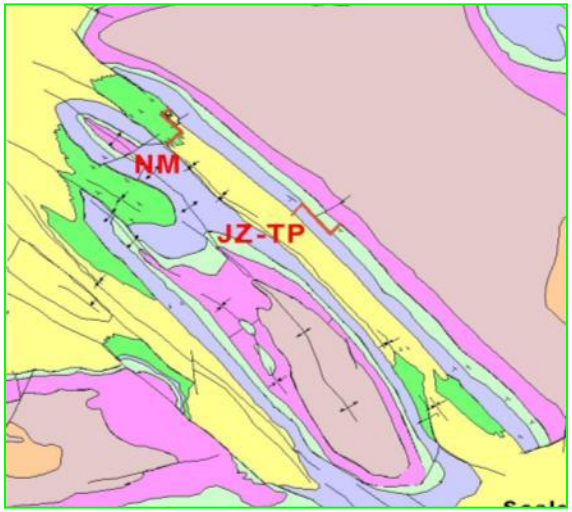


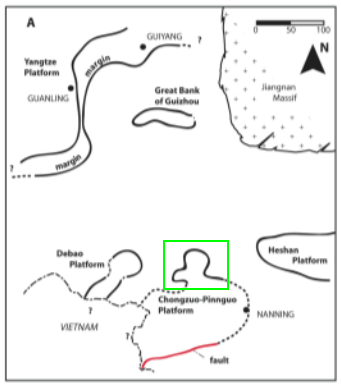


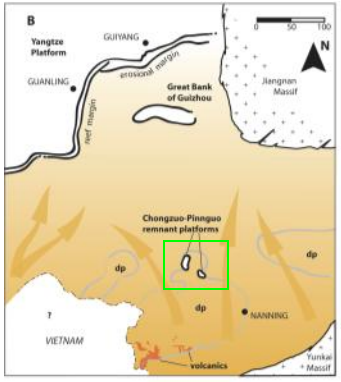


Architecture of Isolated Platforms-PG

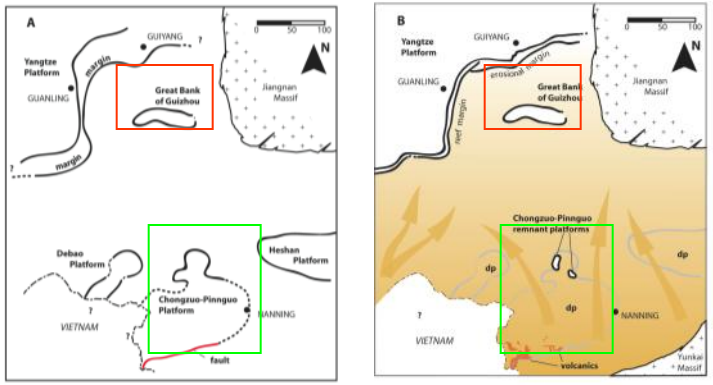


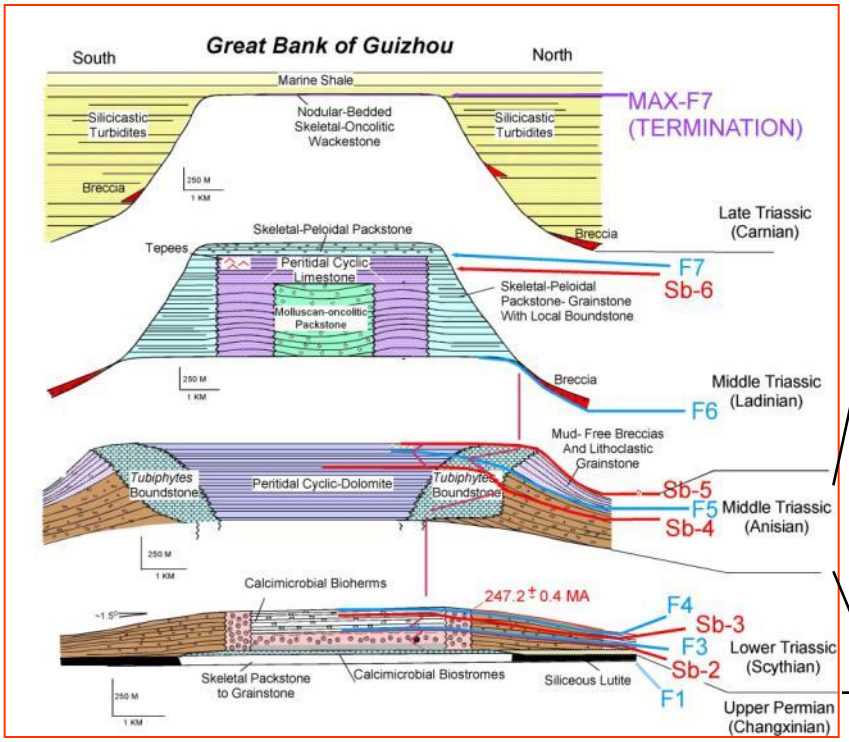


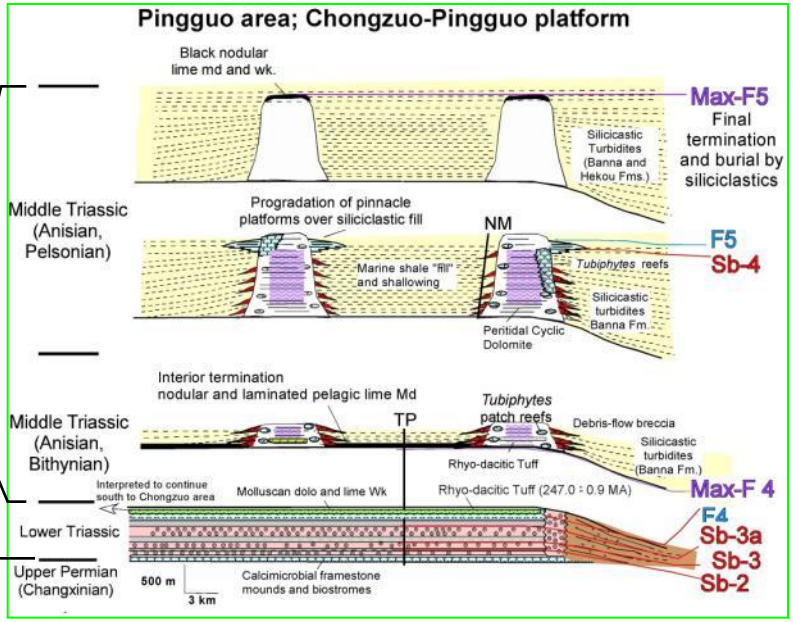




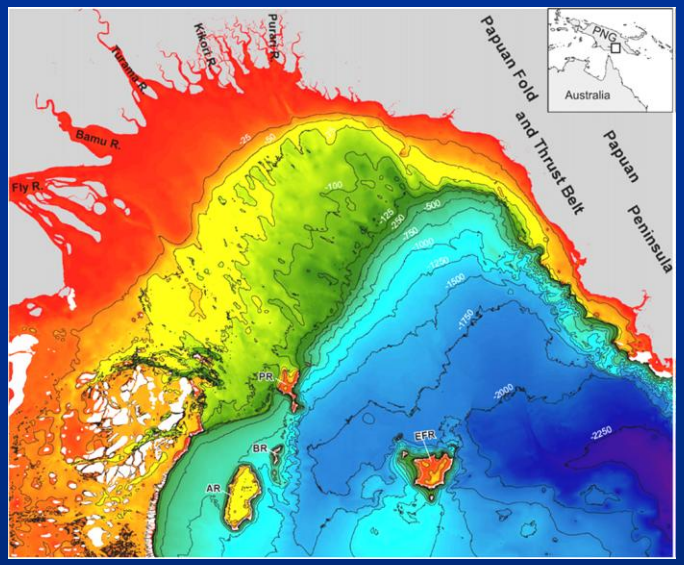
- **Great Bank of Guizhou**: Low-relief bank to steep *Tubiphytes* reef-rimmed profile followed by high-relief, retreating, erosional escarpment; Carnian drowning
- **Southern platforms**: Low-relief bank followed by early Anisian drowning and development of remnant edifices; volcanics

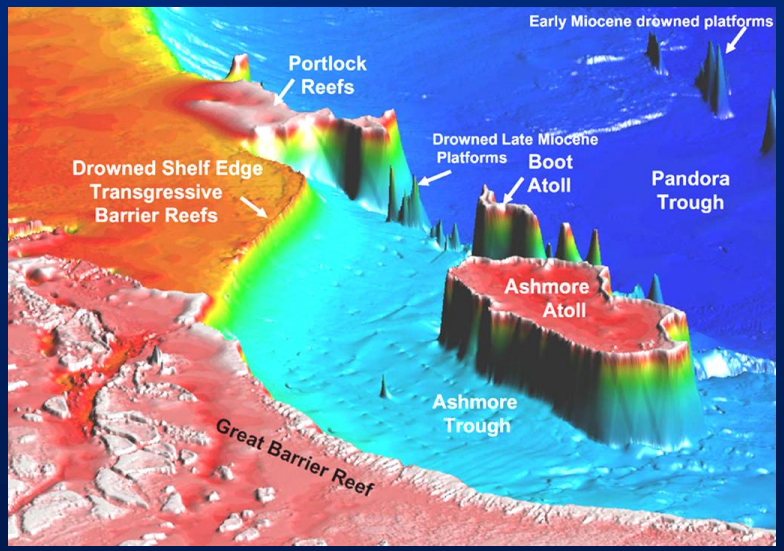




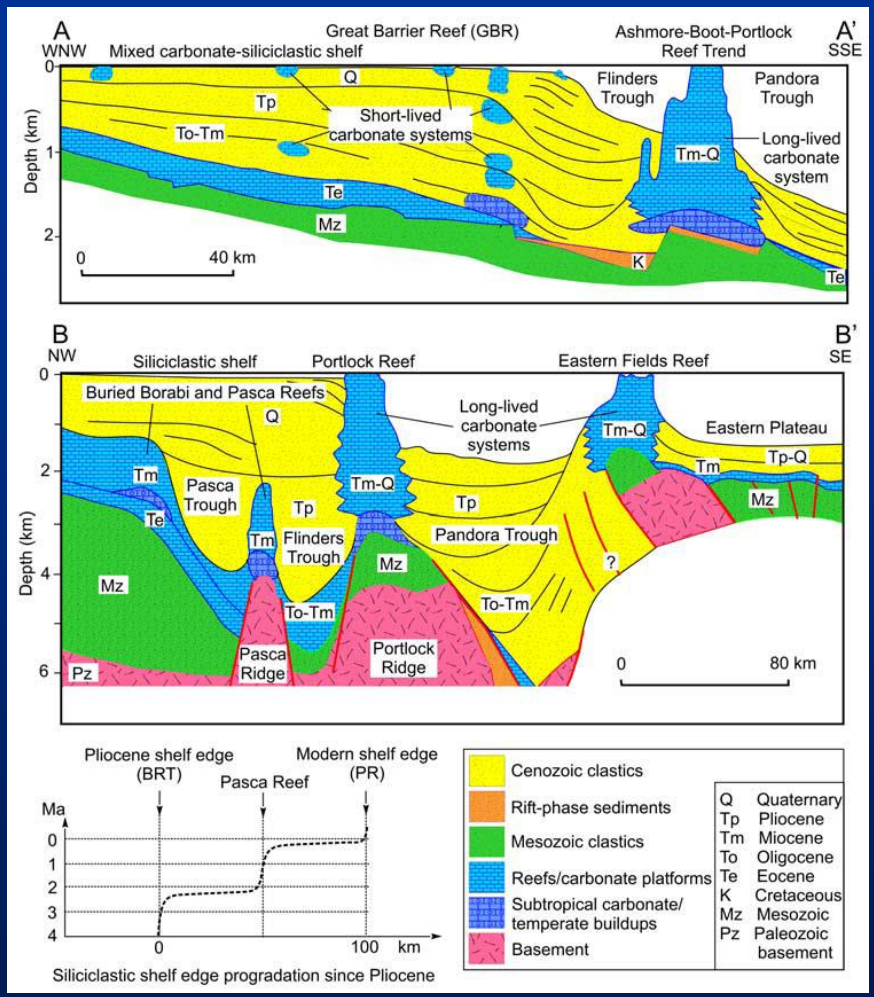


Holocene Analog – Gulf of Papua



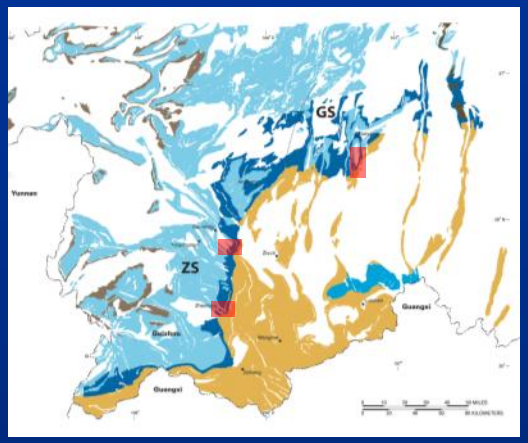


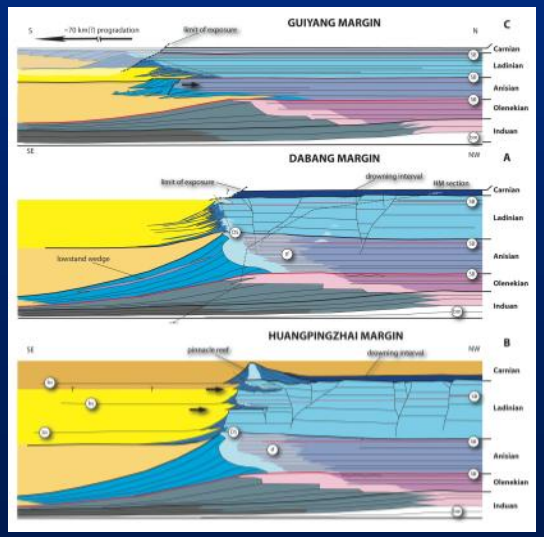
(from Tcherepanov et al., 2010)



(from Tcherepanov et al., 2008)

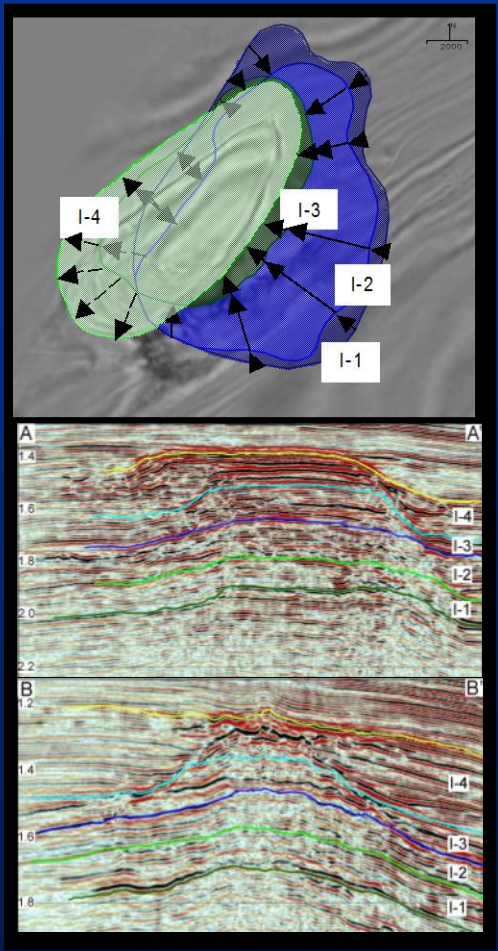
CONCLUSIONS





- Significant along-strike variability in large-scale architecture of the Yangtze Platform margin during the Middle Triassic.
- Regional differences in platform evolution were driven by tectonics: differential tectonic subsidence, syndepositional faulting, and timing of turbidite basin fill.
  - Reflected in margin geometry and overall architecture.
- Basin-wide signals recorded in response to global mechanisms
  - Sea level change: reflected in platform interior stacking patterns but little impact on margin architecture.
  - Organic evolution & factory type: Global development of L. Triassic ramps after end-Permian extinction.

CONCLUSIONS



- Important analog for understanding, quantifying, and predicting lateral variability in seismic-scale characteristics of carbonate reservoir systems
- Significant lateral variability in the architecture of margins bordering vast carbonate platforms should be expected, especially in tectonically active basins.
- Given subsidence history and source of siliciclastic input, basin-wide, seismic-scale evolution of carbonate accumulation may be predictable. Resulting models can help exploration of carbonate reservoirs in frontier or under-explored basins

THANKS!