Ramp-to-Rim Transition in the Guads – Role of "Mixed System" and Inherited Topography*

Charlie Kerans[1]

Search and Discovery Article #50667 (2012)**
Posted July 31, 2012

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Long Beach, California, USA, April 22-25, 2012

[1]Geosciences, University of Texas at Austin, Austin, TX (ckerans@mail.utexas.edu)

Abstract

The transition from low-angle carbonate ramps to steep reef-rimmed debris-shedding platform margins is a predictable evolutionary path recorded in 2nd-order supersequence stacking patterns. While widely documented in platforms ranging from Proterozoic to Tertiary, the driving mechanisms for this transition and impacts on linked slope deposition have yet to be fully integrated. Ramp slopes are mud-dominated and largely prospective as unconventional targets. Transitional margins begin to exhibit organized architecture and feed channelized grain-rich sediment-gravity flows hosting moderate-sized toe-of-slope and basin-floor-fan reservoirs. True reef-rimmed margins and associated debris aprons provide abundant reservoir capacity, but do not occur with the necessary trap/seal, such as in the Permian Basin, to foster hydrocarbon accumulation. Fundamental controlling parameters for the ramp-to-rim transition include (1) position of precursor margins/paleotopographic breaks, (2) accommodation-controlled stacking patterns/P/A ratios, and (3) the positive feedback loop between sediment bypass, early lithification, and organism colonization.

In order to evaluate the role of these controls on reservoir development in the ramp-to-rim transition, data from Lower-Middle Permian platforms of the Guadalupe and Apache Mountains is synthesized. An evolution is observed from (1) low-angle (0.5-2^{o}) ramps dominated by mud-rich hemipelagites, to (2) steep (2-8^{o}) ramps with gullied slopes , mound colonization, and mud-rich debris flows, to (3) transitional ramp/rim profiles with 8-20^{o} slopes, detachment/slump surfaces, channelization, and mud- and grain-dominated debris flows and turbidites, and finally (4) true reef-rimmed margins with 30-50^{o} dipping debris-dominated aprons.

A critical slope angle for the transition from slump/soft sediment-dominated sediment gravity flows to debris flows and mass wasting varies from platform to platform depending on the composition of slope sediments and P/A ratios. However, a gradient range of 8-15^{o} appears to be a minimum threshold for significant coarser sediment gravity flow deposition and carbonate reservoir development in the Deepwater.

Selected References

Barnaby, R.J., and J.F. Read, 1990, Carbonate ramp to rimmed shelf evolution; Lower to Middle Cambrian continental margin, Virginia Appalachians: GSA, v. 102/3, p. 391-404.

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Playford, G., 1985, Devonian-Carboniferous boundary sequences in Australia; a summary, *in* E. Paproth, and M. Streel, (eds.), The Devonian-Carboniferous boundary: CFS Courier Forchungsinstitut Senckenberg, p. 55-56.

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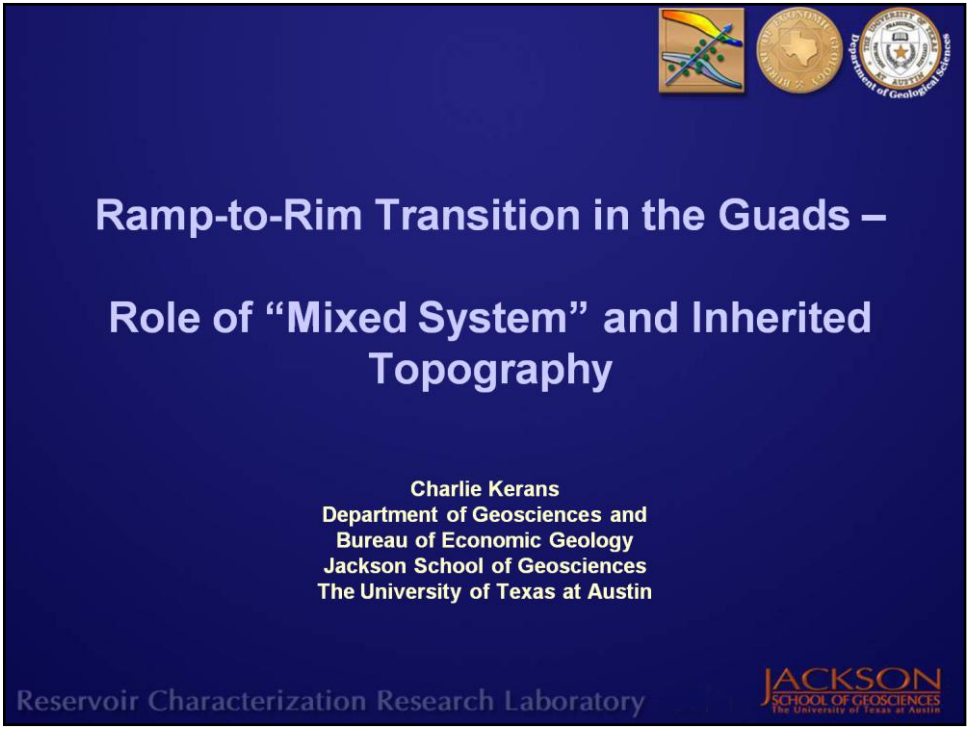


Presenter's notes: This presentation provides important generalizations concerning carbonate reservoir geology and sequence stratigraphy that are considered fundamental predictive attributes useful when exploring for or developing resources in these complex systems.

Acknowledgements

- BEG RCRL consortia funding
- BEG/UT-DGS/Chevron/Conoco-Phillips/ExxonMobil/Statoil funding of airborn lidar
- MSc thesis research Ryan Phelps and Sam Scott in Last Chance Canyon

Objectives

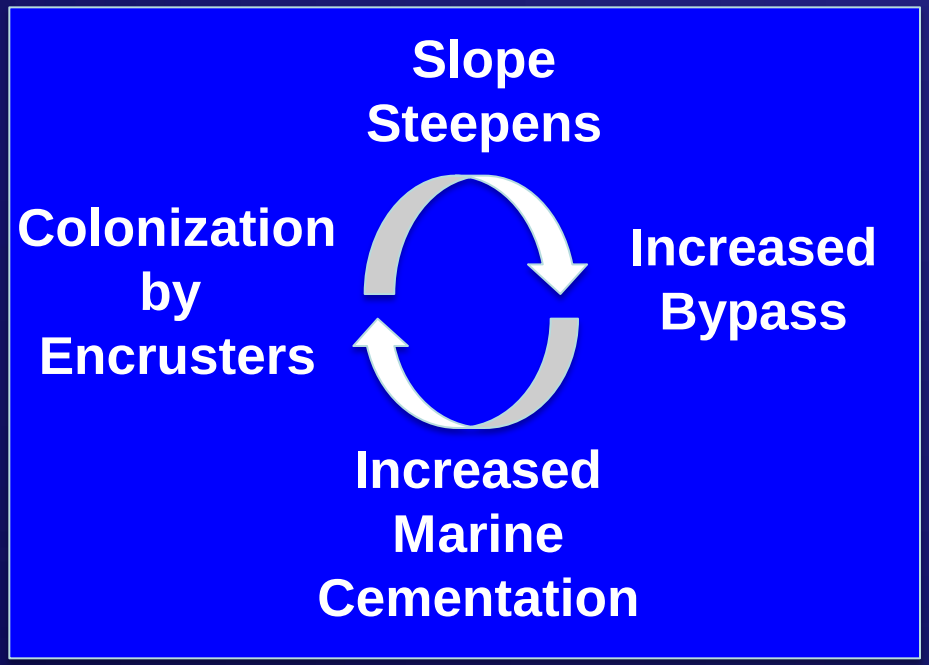
- Review basic patterns of ramp-to-rim evolution
- Document sequence-by-sequence evolution of the Guadalupian ramp to rim transition
- Evaluate relative importance of intrinsic and extrinsic controls and feedbacks;
  - Pre-existing topographic control
  - Siliciclastic poisoning of the carbonate factory and loss of mud production

Ramp to Rim transitions

- Common pattern in carbonate platform evolution
- Examples of platforms across Phanerozoic Record
- Key controlling factors
  - Basin morphology leading to oversteepening
  - Ecological accommodation (Pomar and Kendall, 2010) where reef faunas capable of building to sea-level take over and evolve system
  - Carbonate starvation associated with loss of detrital carbonate factory to narrow microbially bound system removes hemipelagic input to slope

Ramp to Rim Drivers

Autogenic Feedback

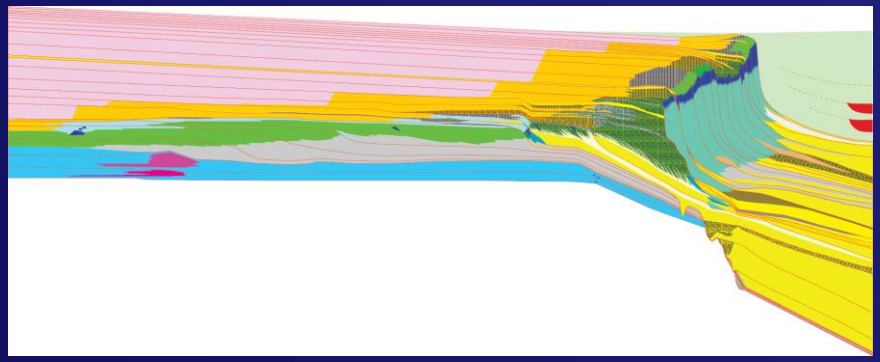


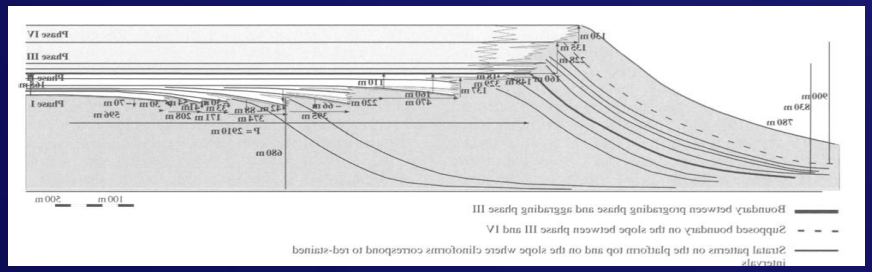
Autogenic Feedback

Progradation over pre-existing margin or 2nd-Order Base-Level Rise

Styles of Ramp to Rim Transition

Prograding Ramp to Rim Systems

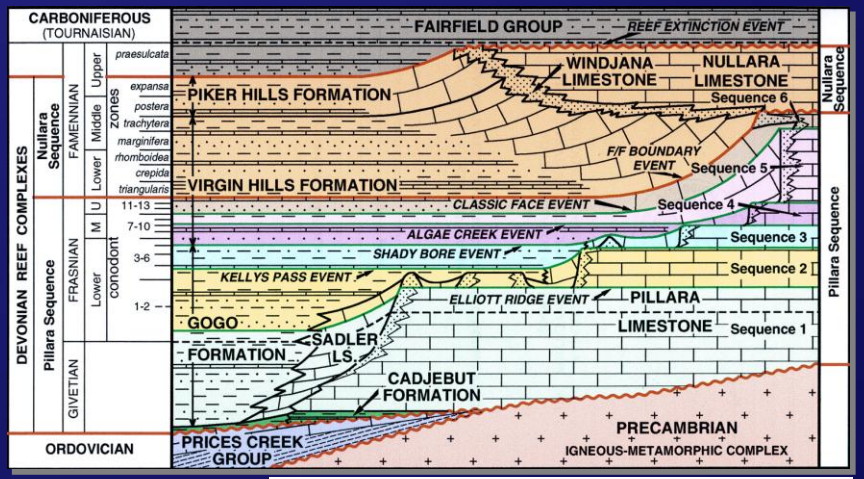


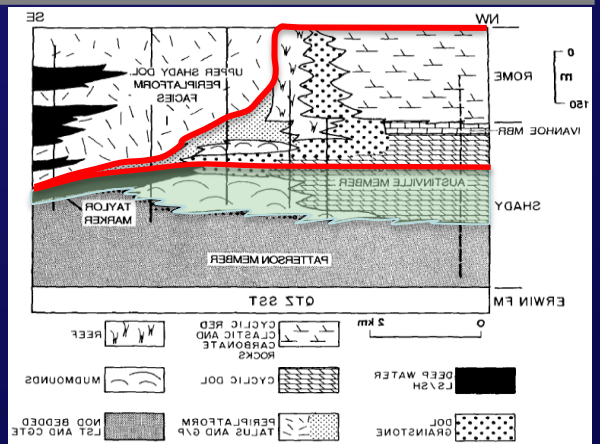


Verwer et al. 2004

Retrograding Ramp to Rim Systems

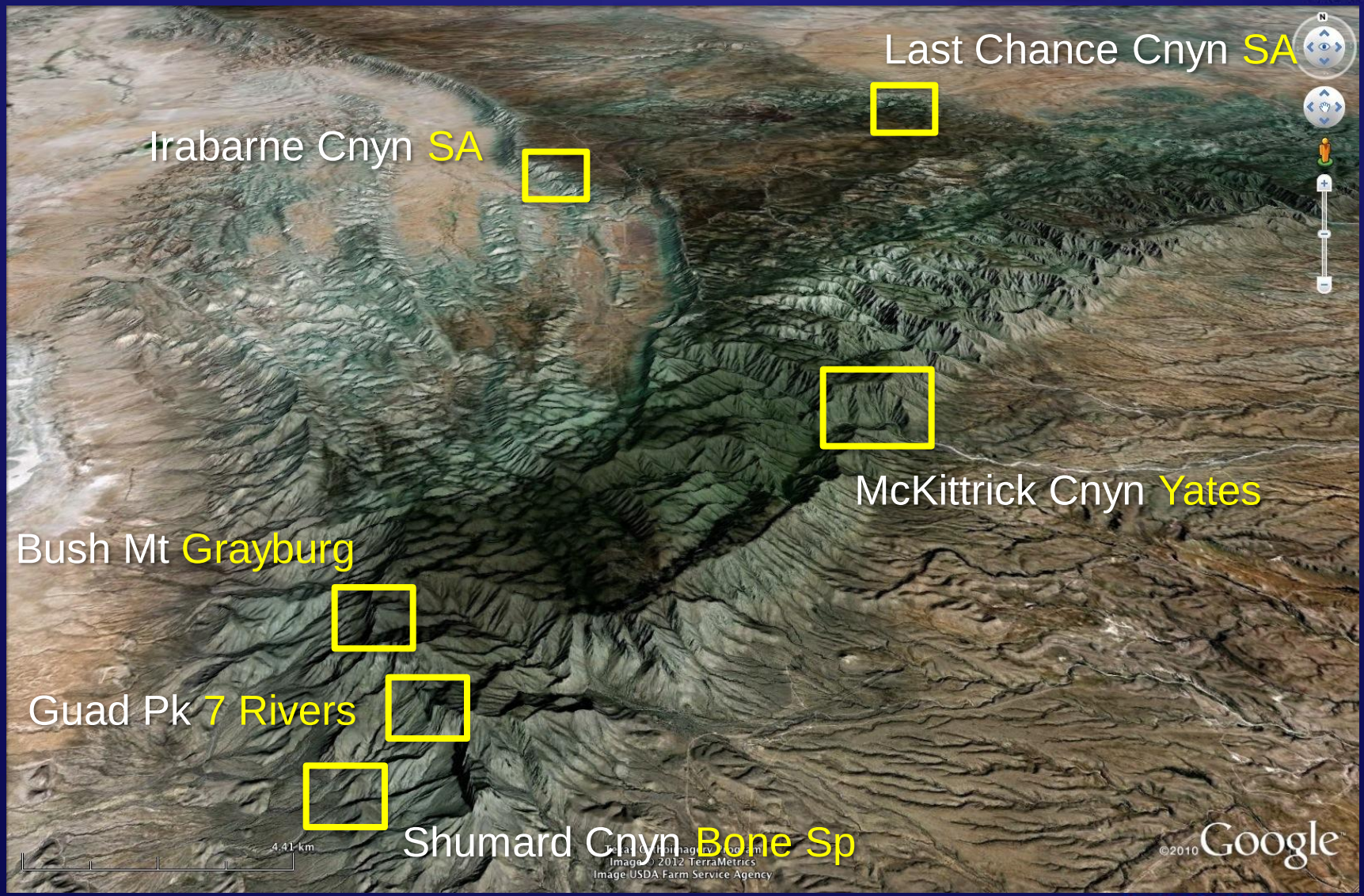
Playford 1984





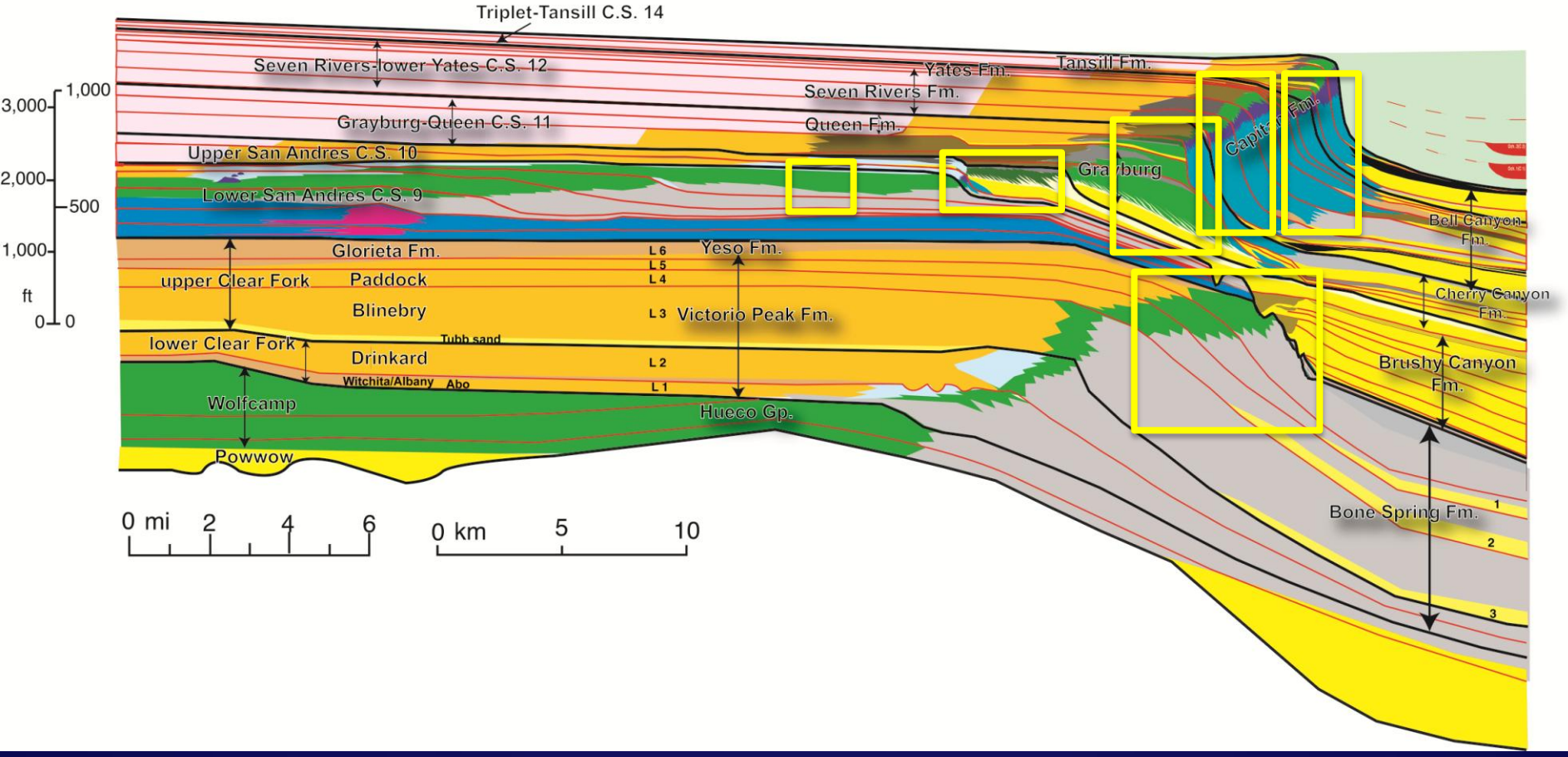
Barnaby and Read 1990

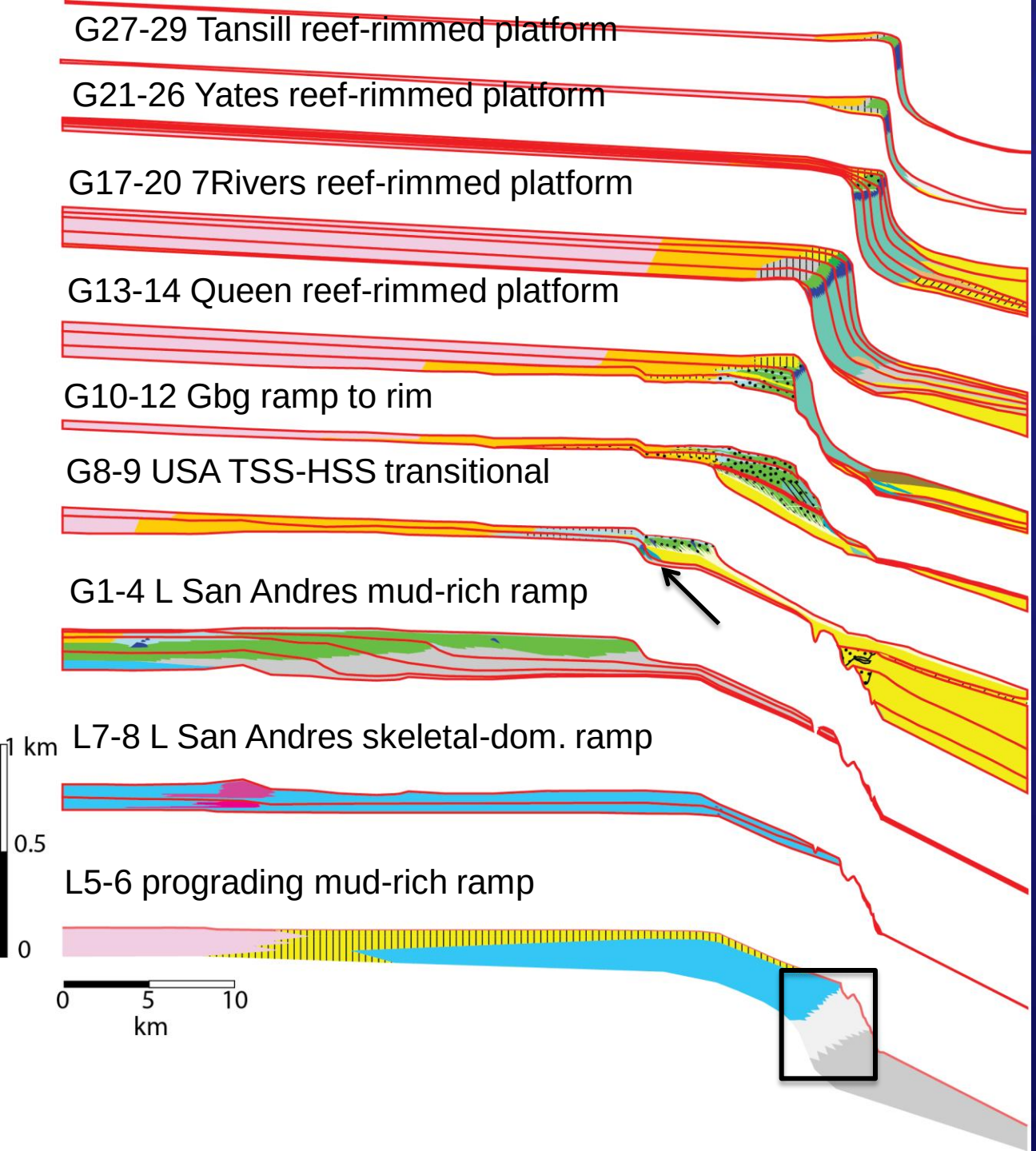
Location of Profiles



Permian Stratigraphic Framework of the Northwest Shelf, Permian Basin

Location of ramp-rim margin data





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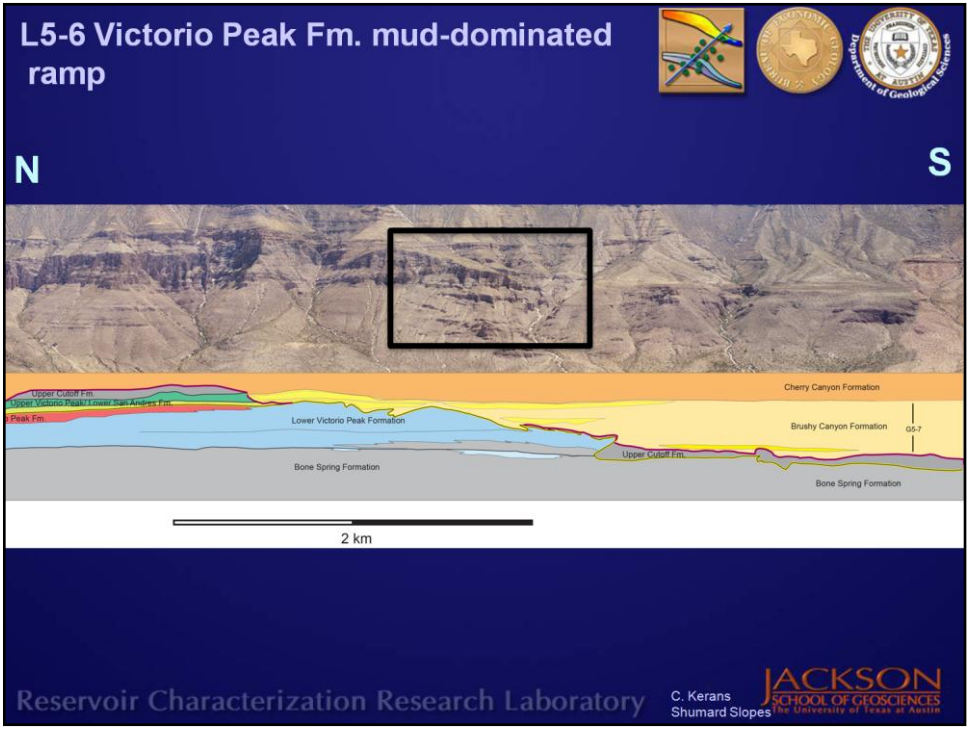
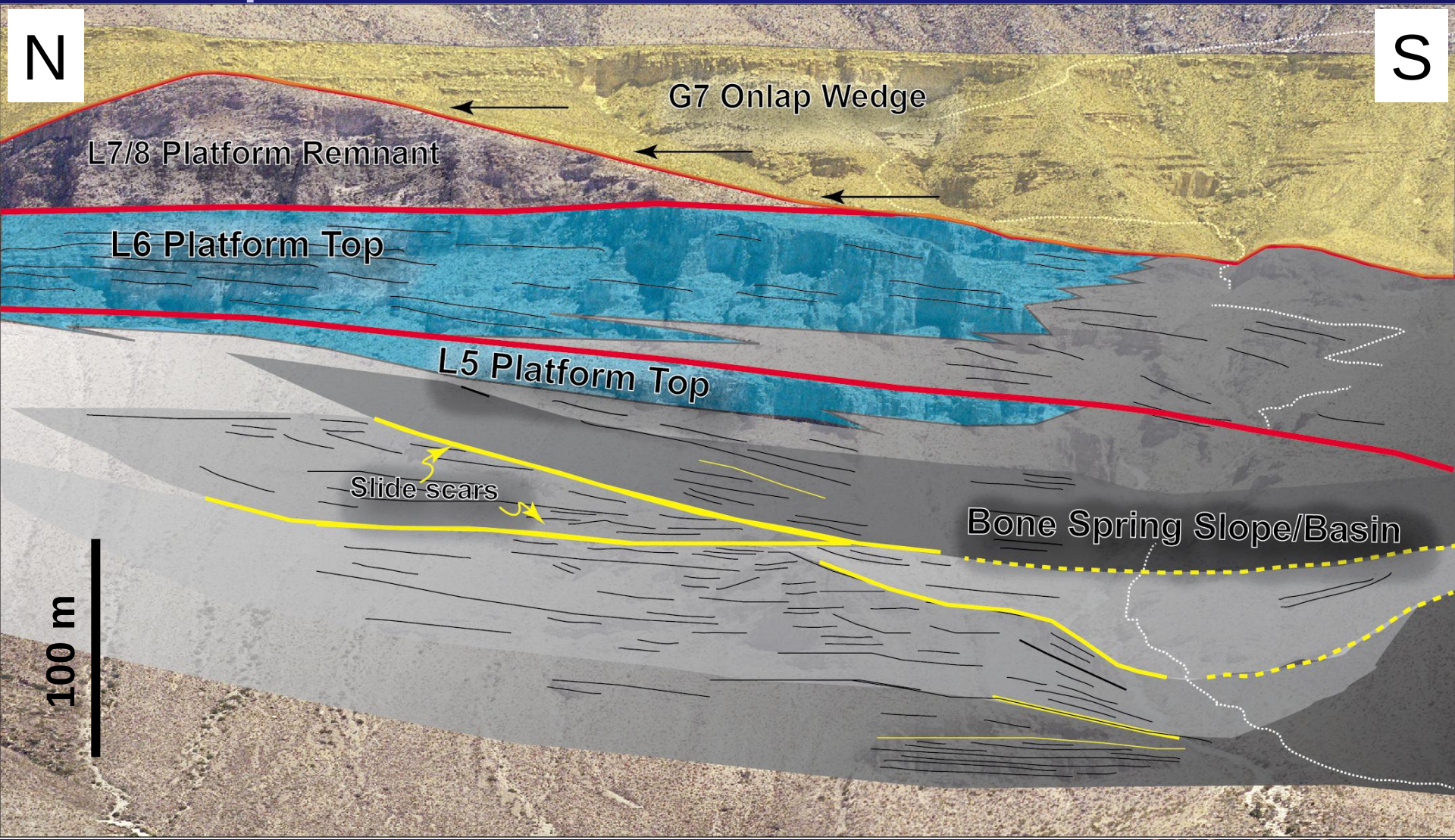
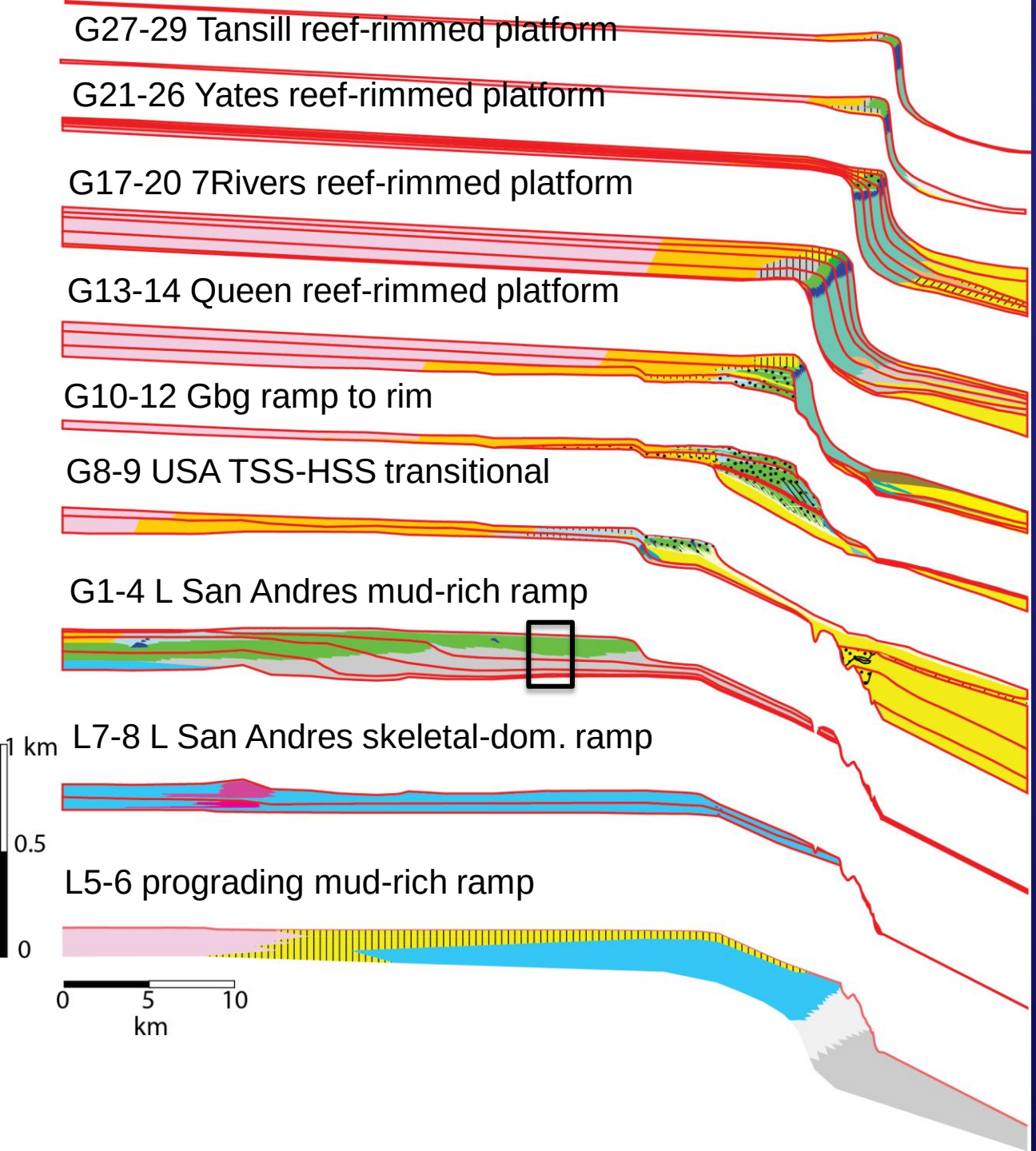


Presenter's notes: Photomosaic and interpreted geologic panel of main stratigraphic units within Lower Leonardian through Middle Guadalupian sequences. The section of interest for this study is the Middle Victorio Peak (VP), Lower VP, and Bone Spring Formation, which comprise a 1-km-thick prograding platform margin.

Interpreted view –
Oblique dip view of Shumard Canyon
L5-6 slump-dominated





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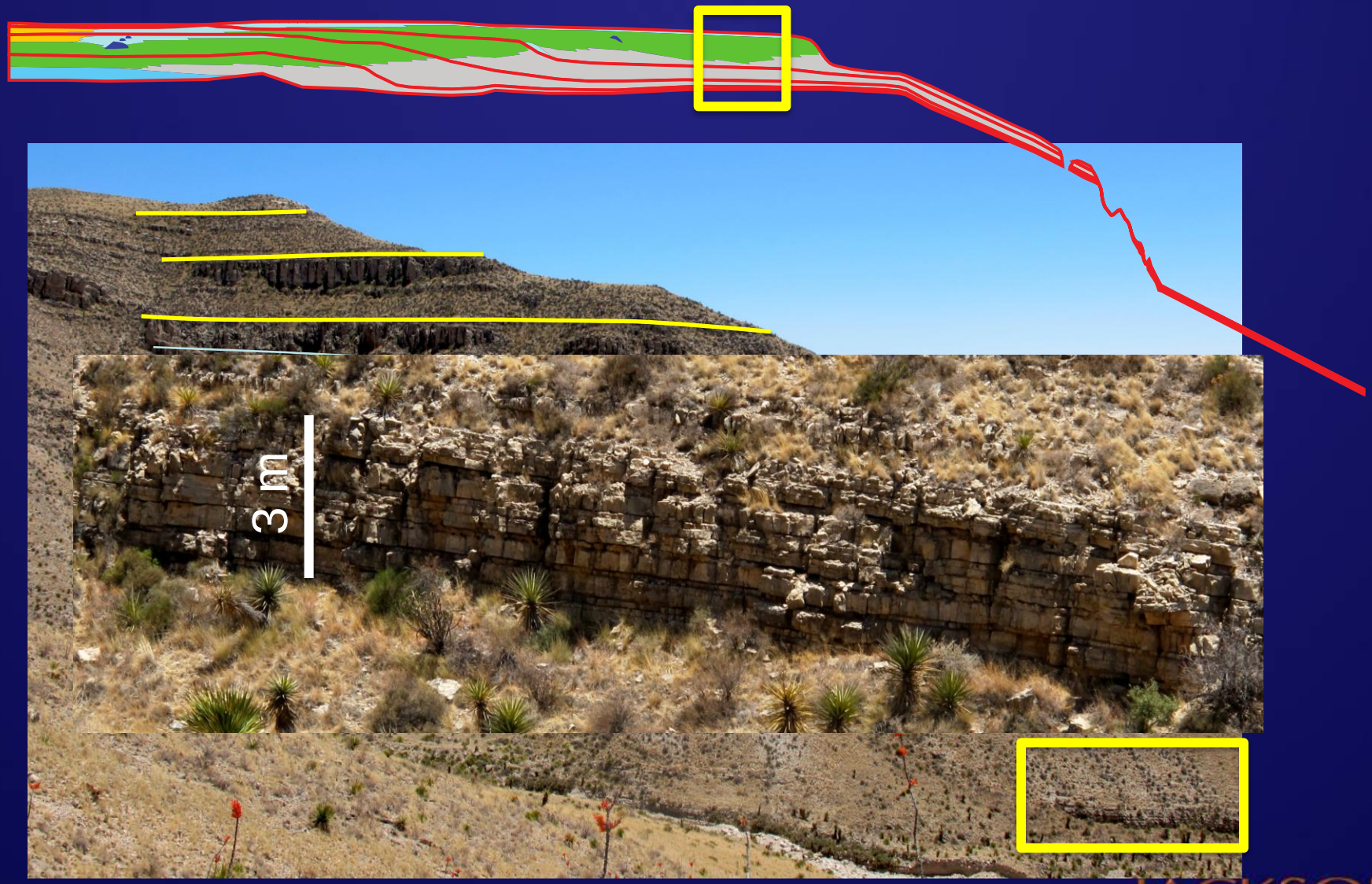
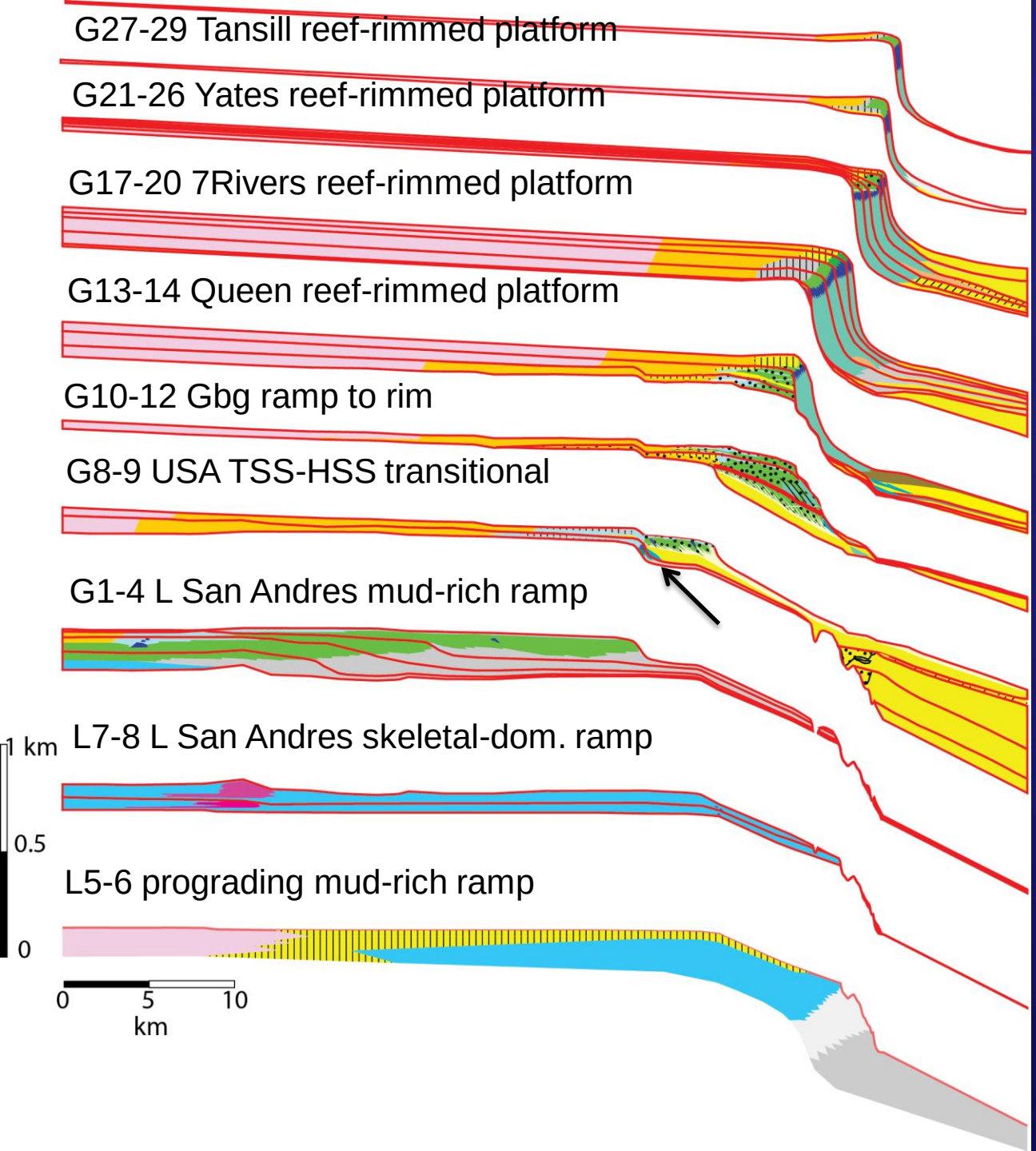
G4 L San Andres Ramp
Relief 60m, 1-2º dip, 2km run-out





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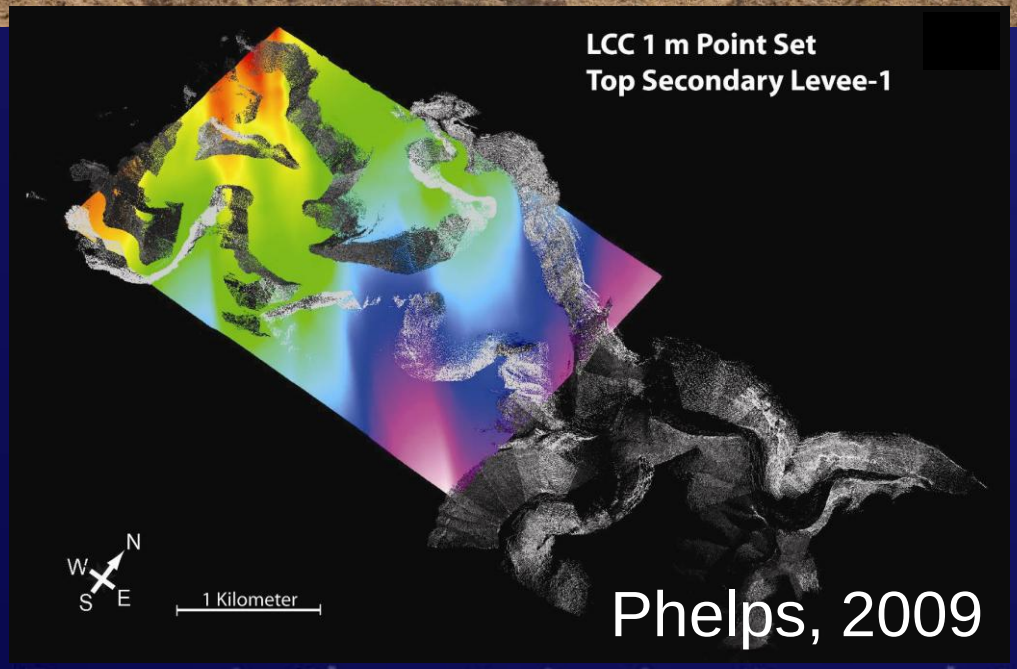
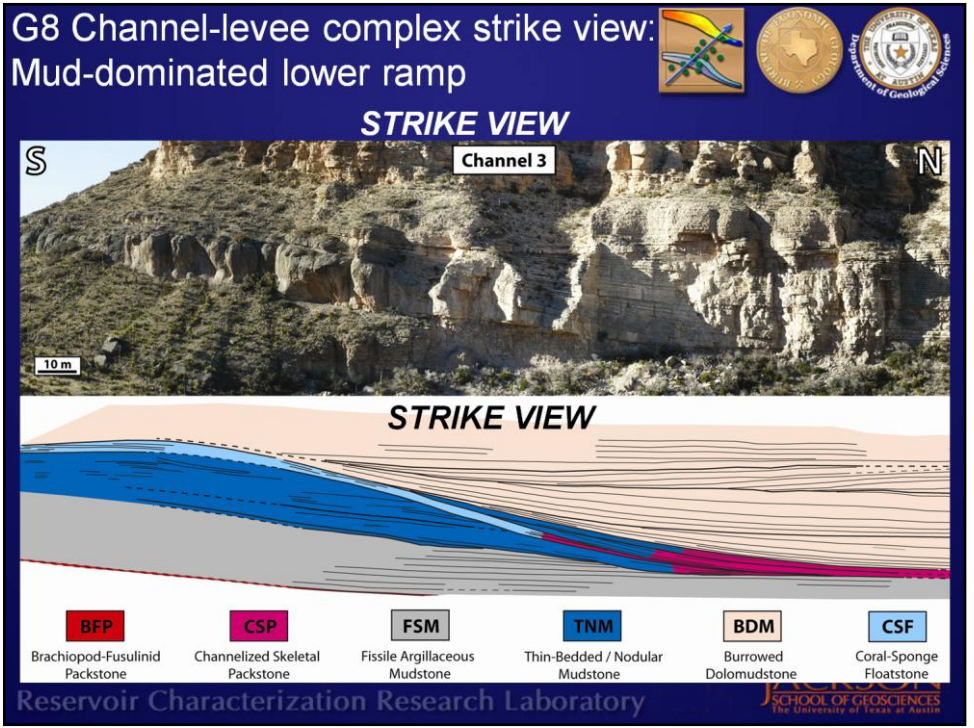
G8 U. San Andres Gullied slope with levees
Relief 60m, 4º ang., Run-out 2 km

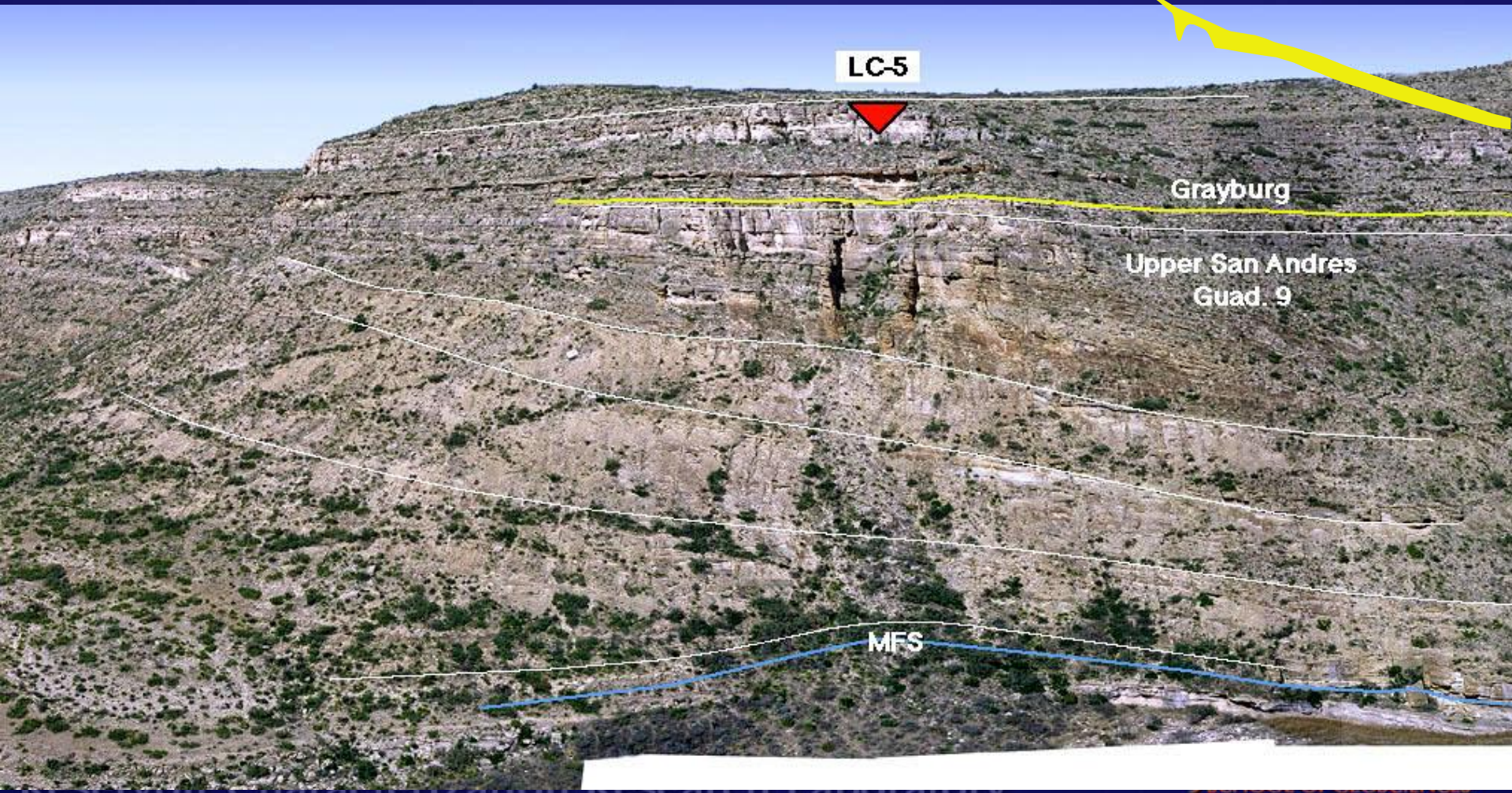


Phelps, 2009

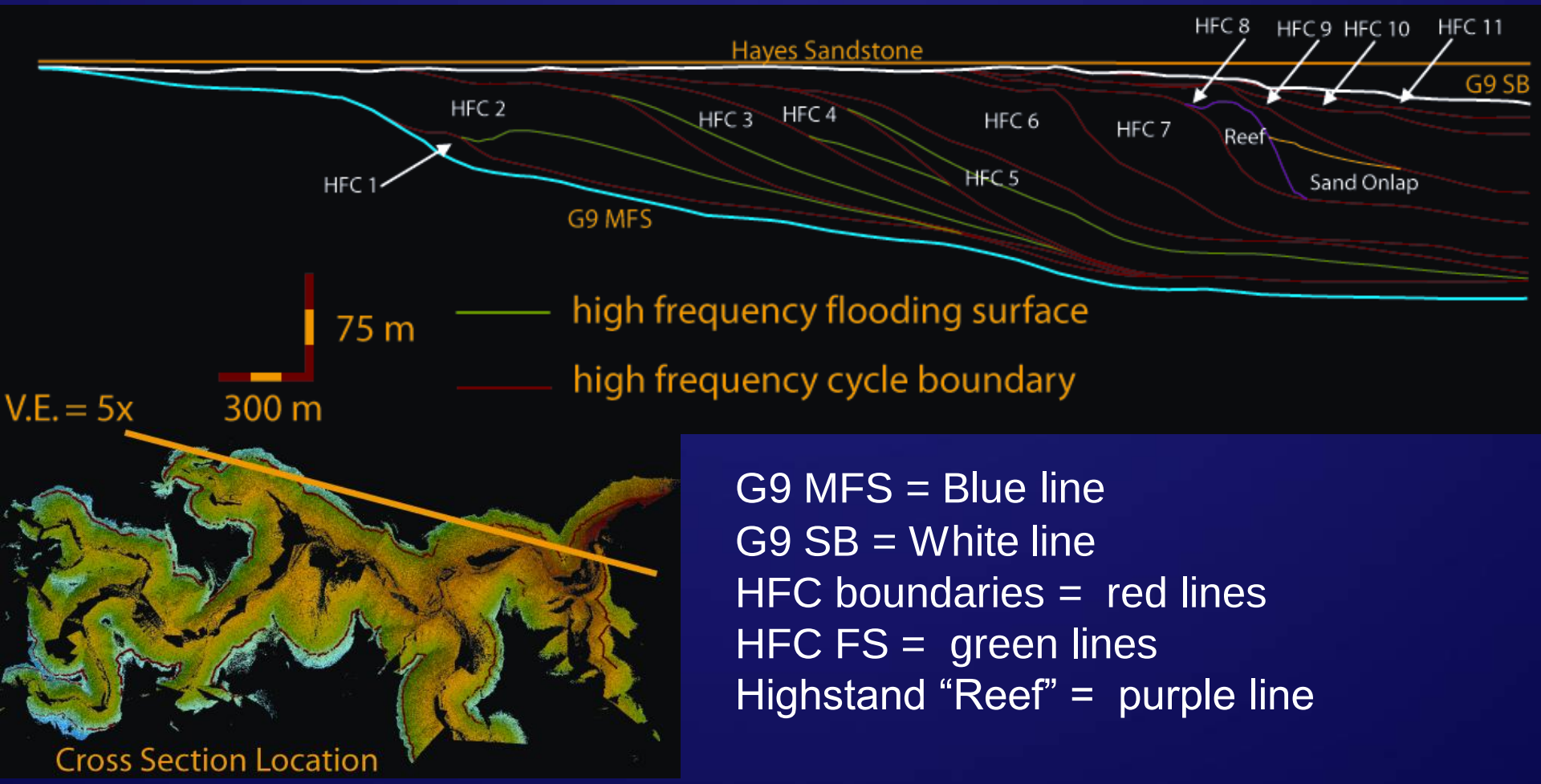


Presenter's notes: This view is up depositional dip through the channel-levee complex present in Last Chance Canyon. The channel system is characterized by mixed erosional and depositional phases with aggradational levees and erosive channels that exhibit minor deposition of packstones in the channel axis.

G9 U. San Andres Mixed clastic-carbonate clinoforms
Relief 60m, Slope 5-7º, Run-out - 1.5



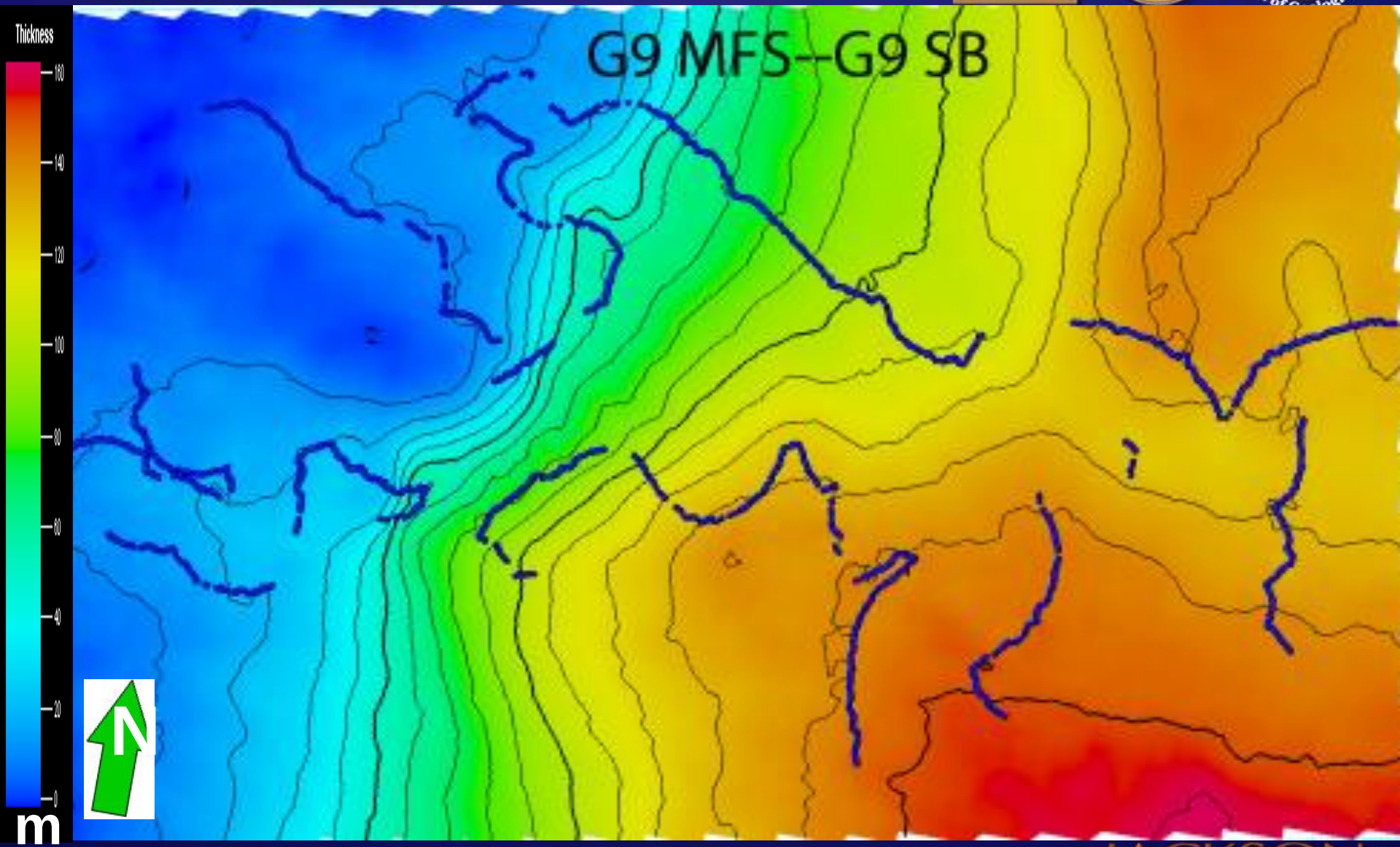
G9 Upper San Andres Steepened ramp and localized build-ups
Relief 60m, Dip 4-15º, Run-out – 2 km



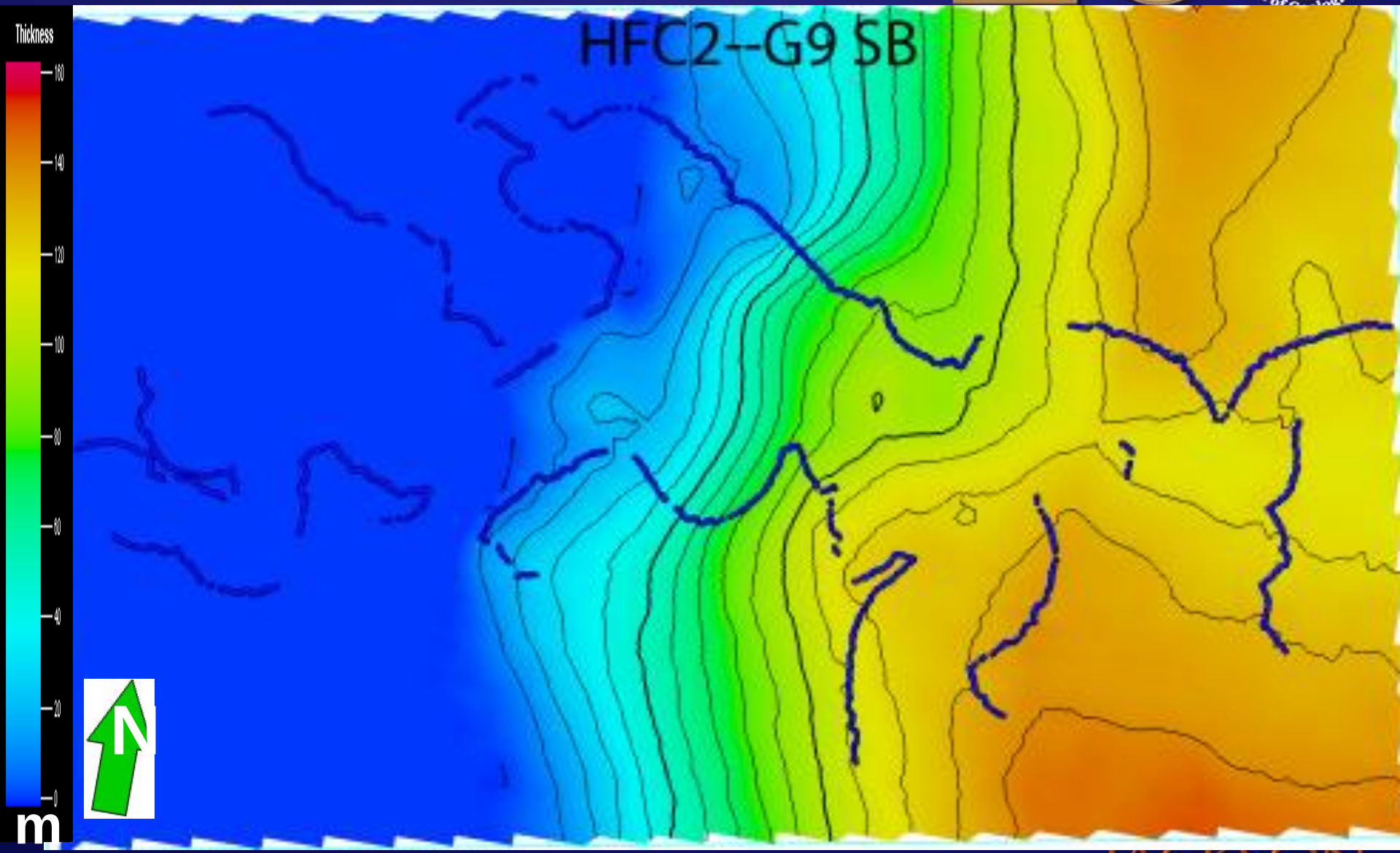
G9 MFS = Blue line
G9 SB = White line
HFC boundaries = red lines
HFC FS = green lines
Highstand “Reef” = purple line

Progradation History Using Isopachs

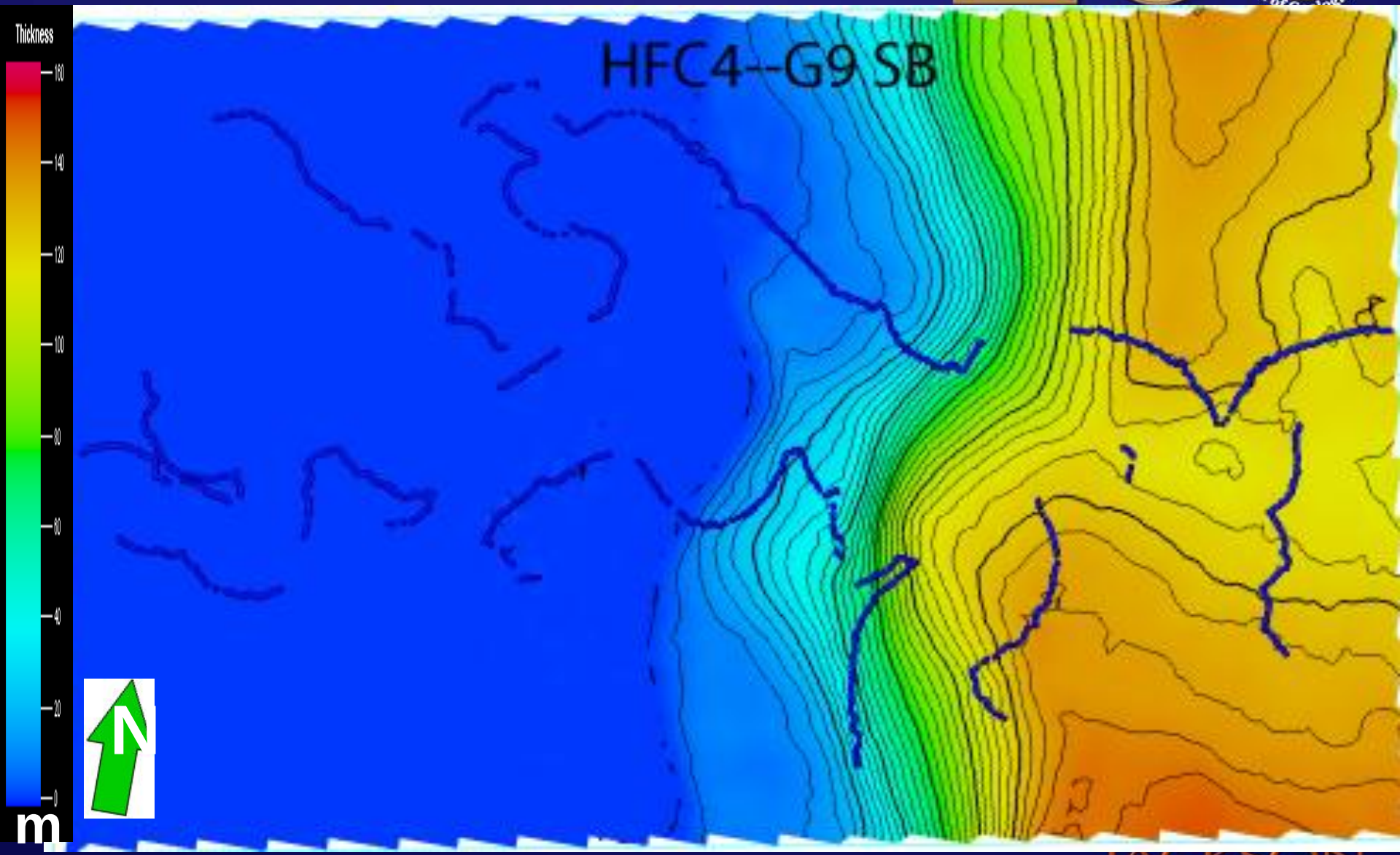
View explanatory notes



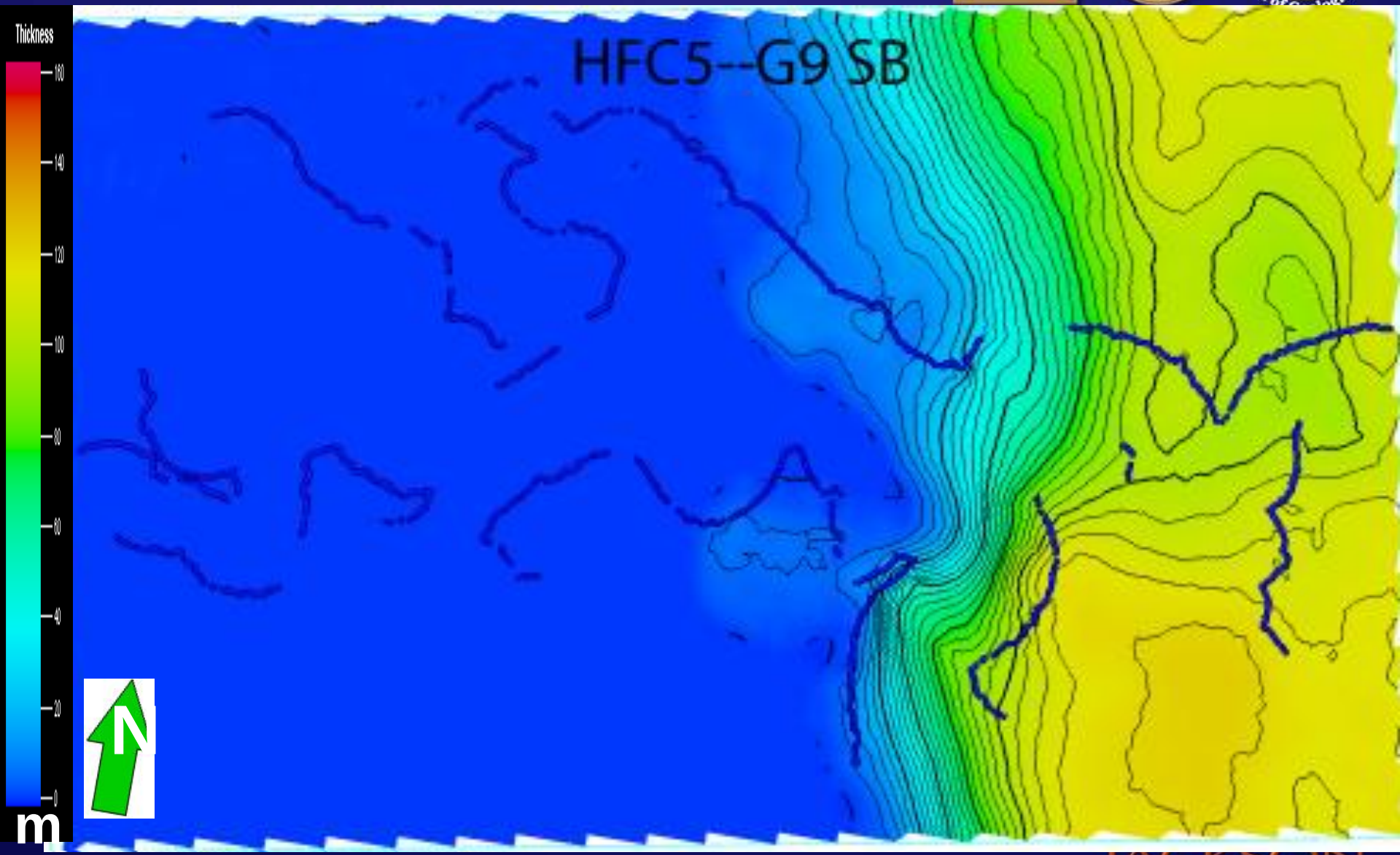
Progradation History Using Isopachs



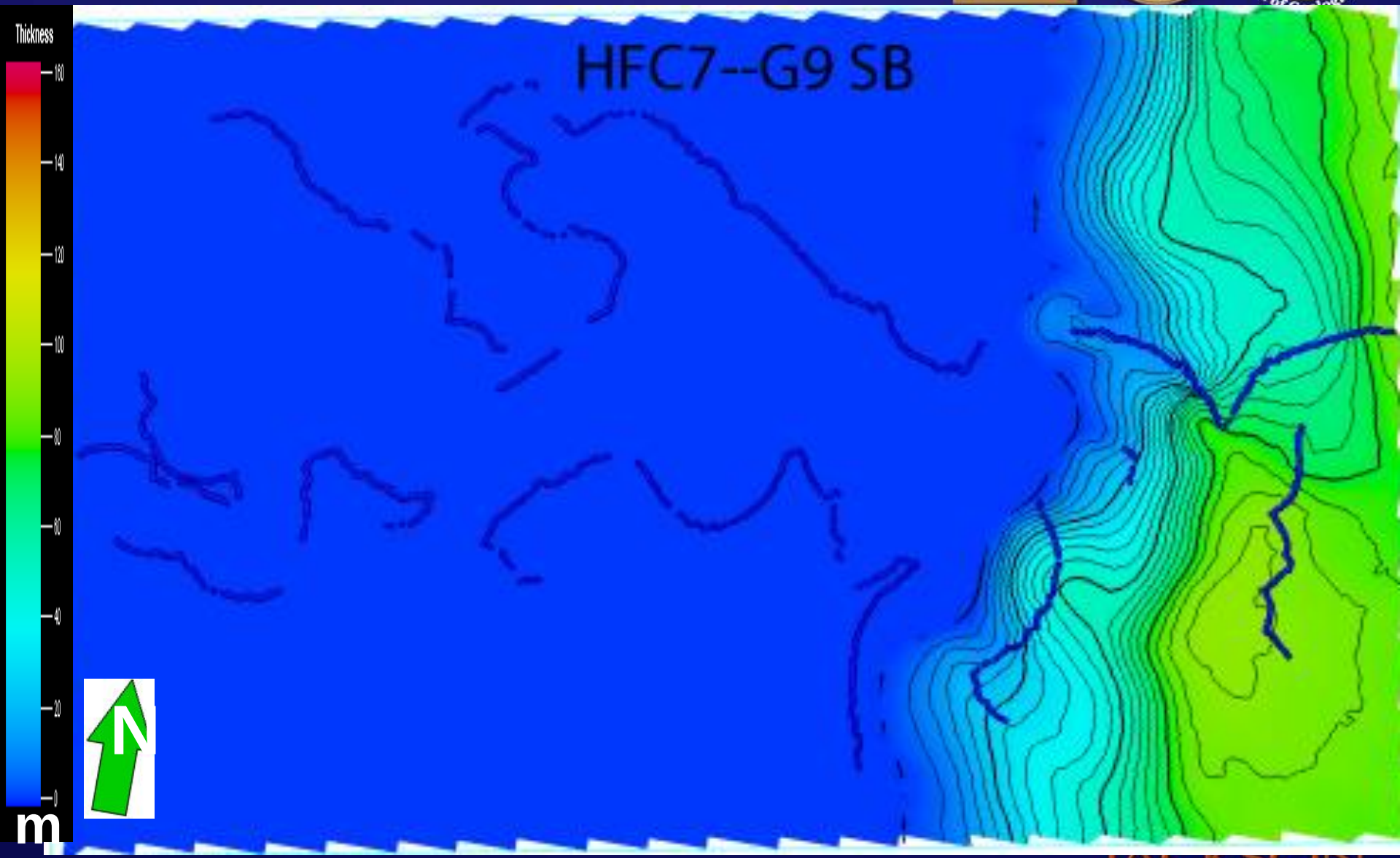
Progradation History Using Isopachs



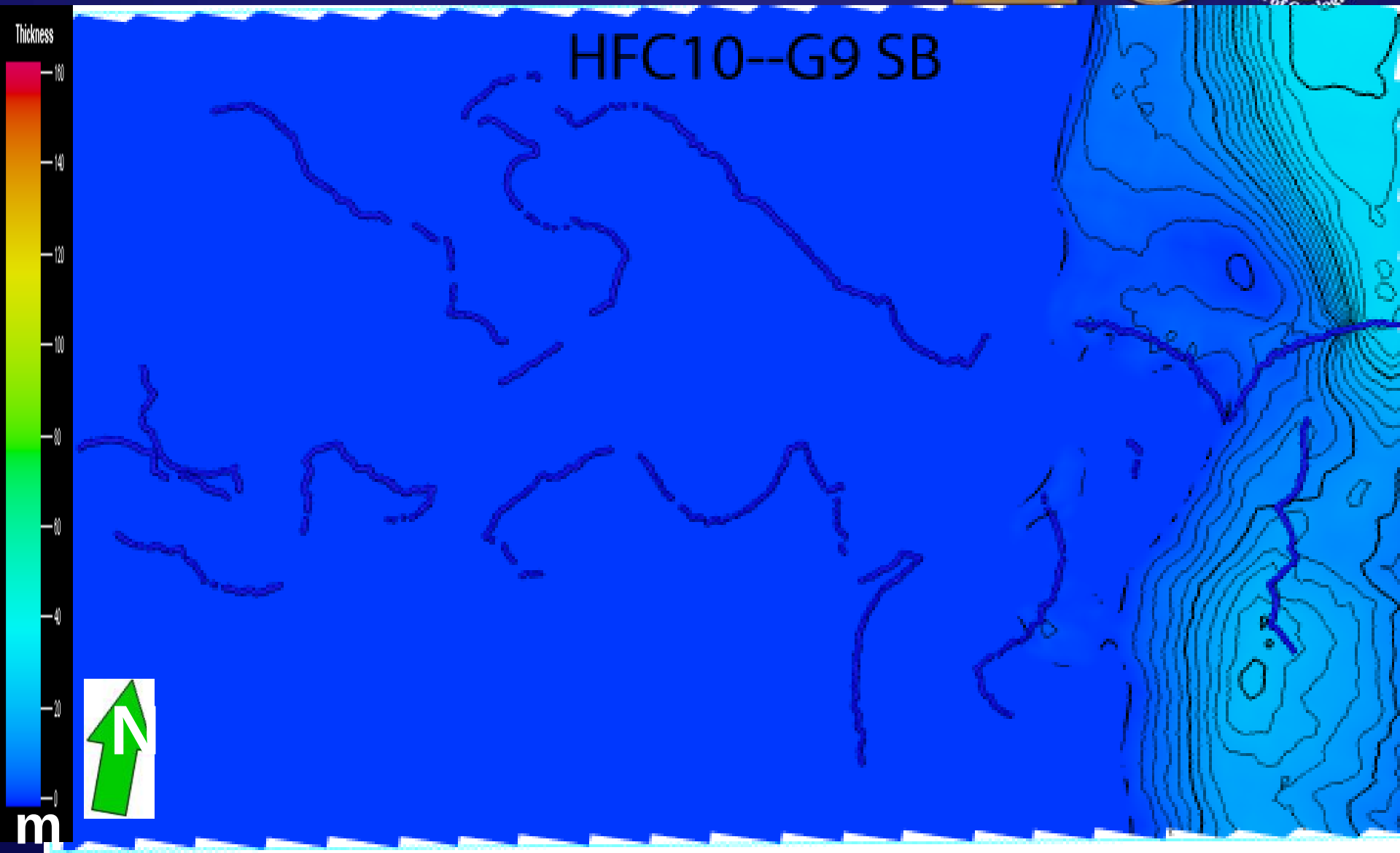
Progradation History Using Isopachs

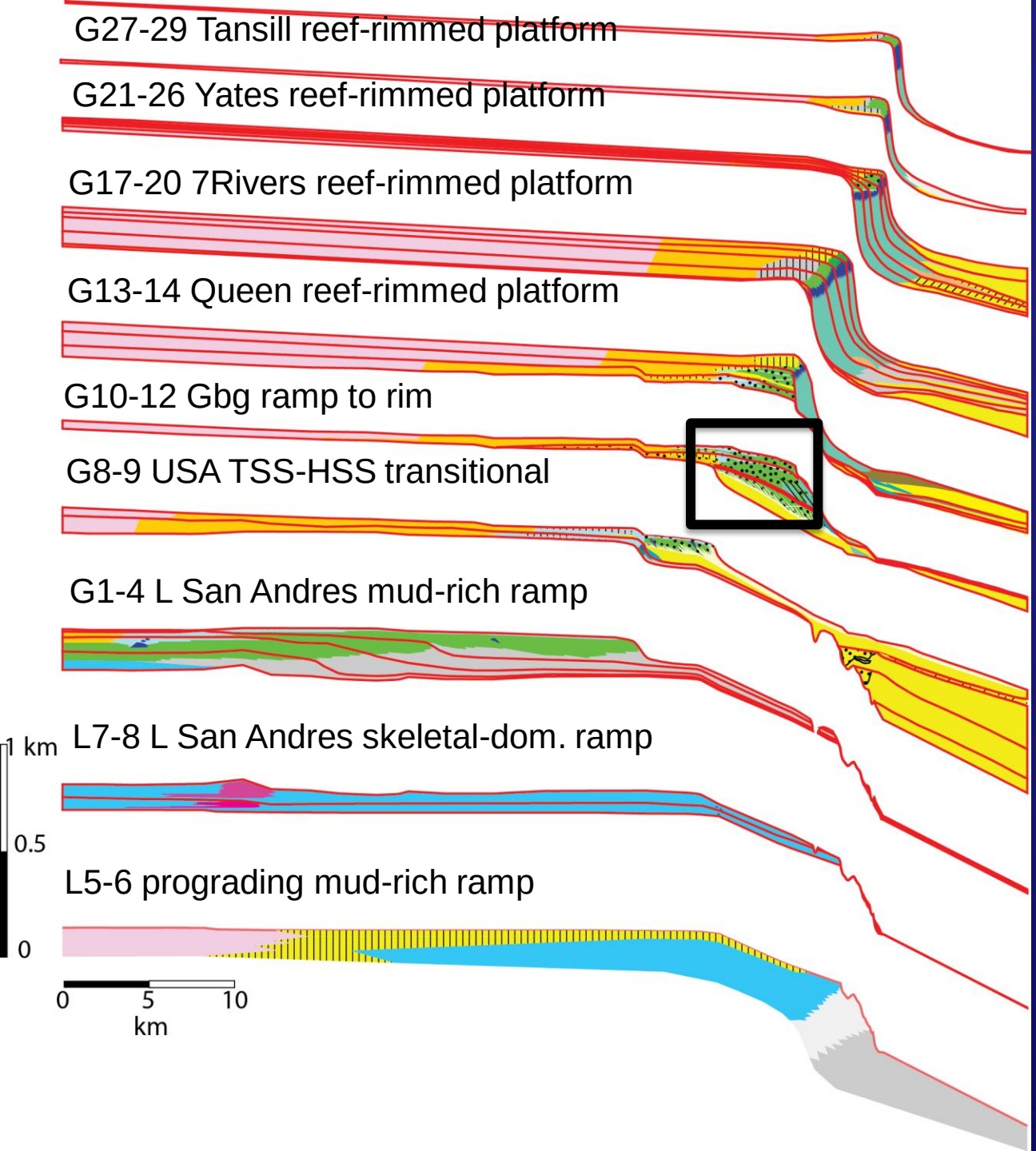


Progradation History Using Isopachs



Progradation History Using Isopachs





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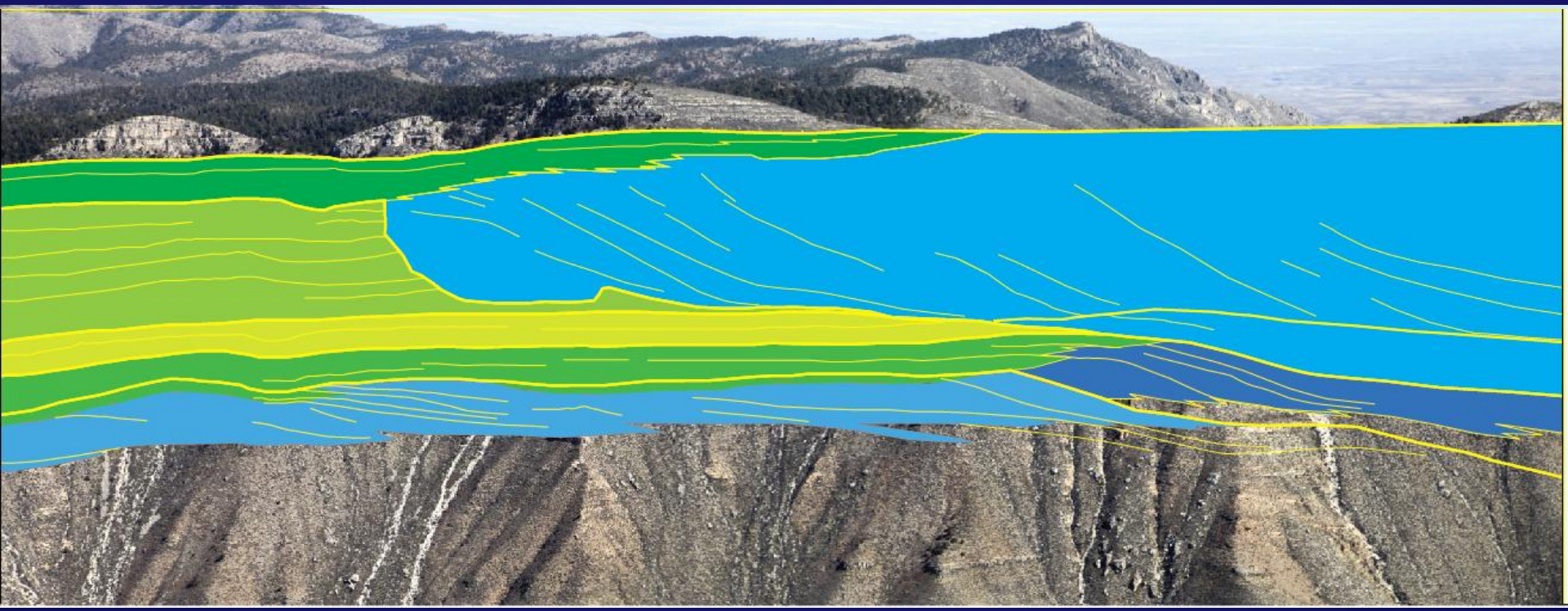
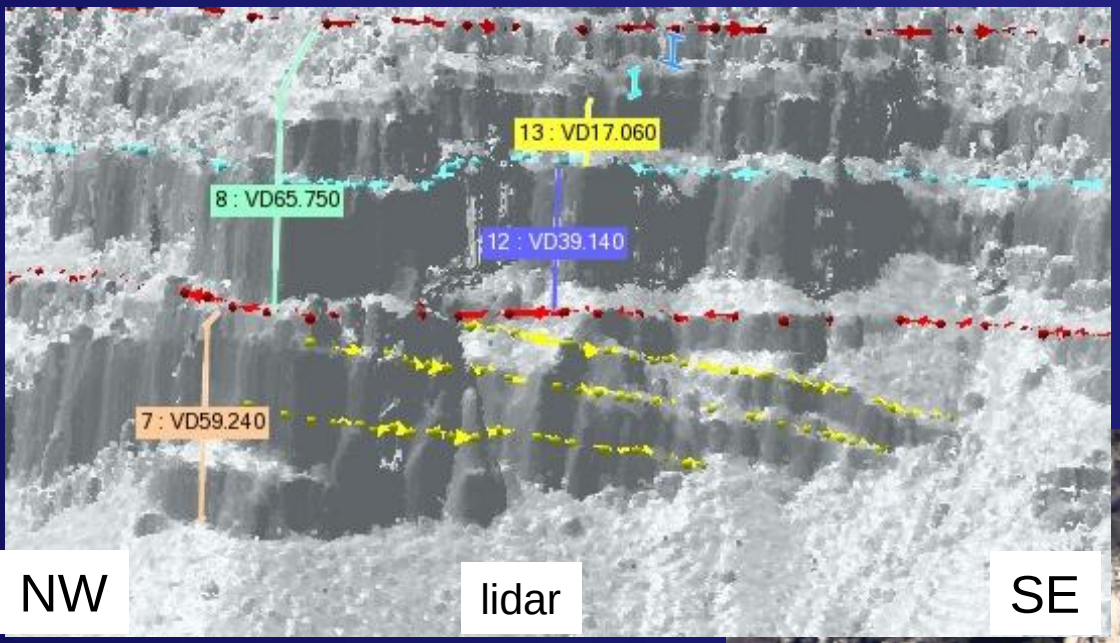
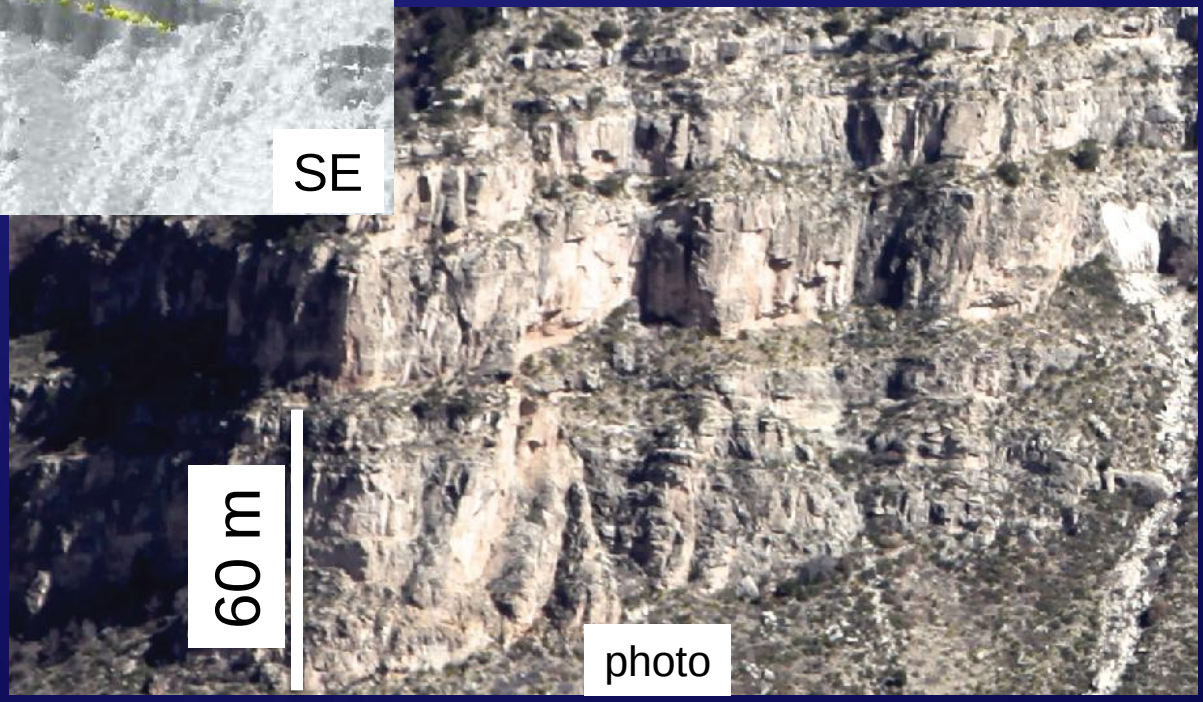
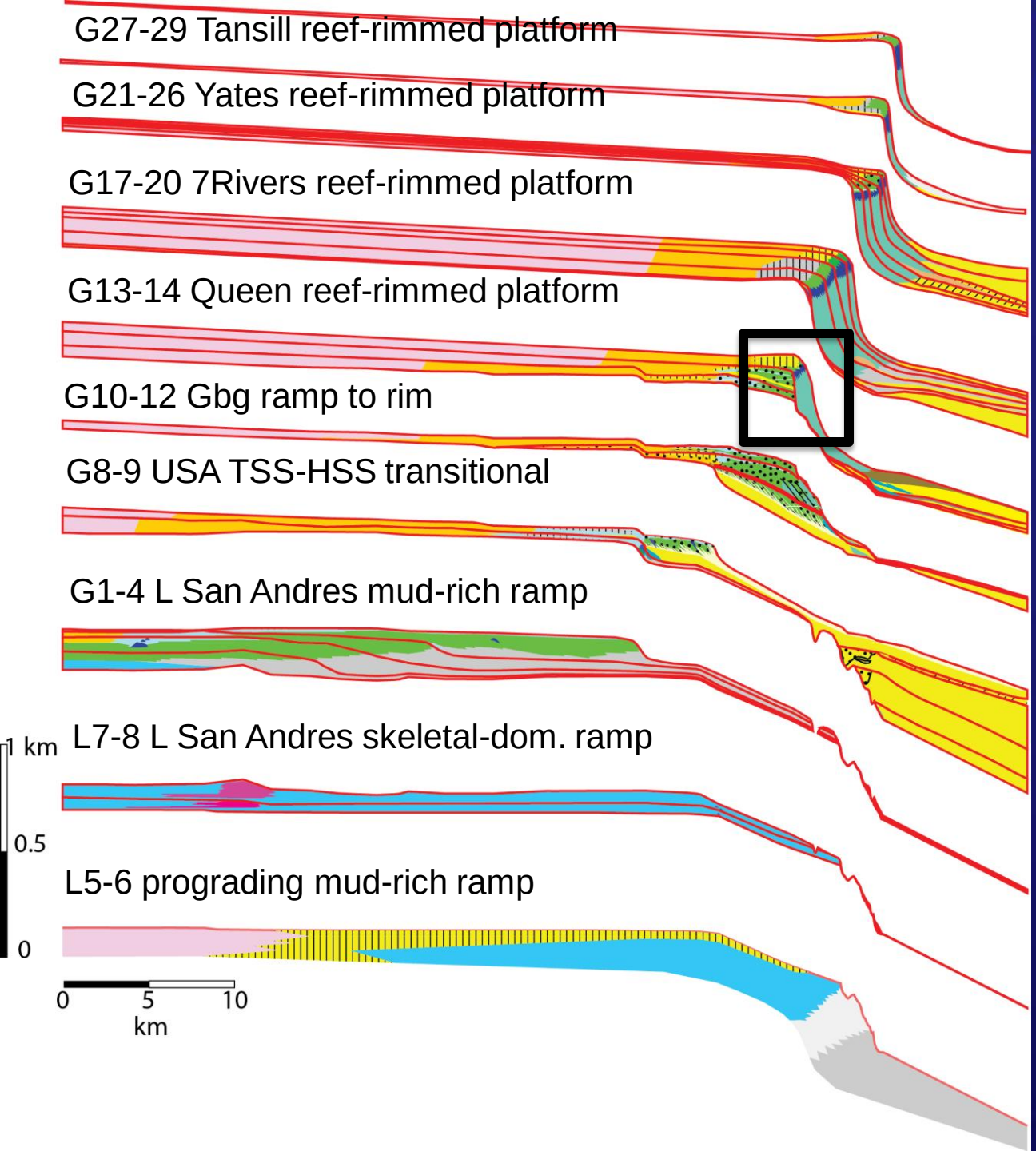
G10-12 Grayburg – Transition to Rim
Western Escarpment



Grayburg G10 Margin 60 m Relief, 10° slope, run-out 0.4 km







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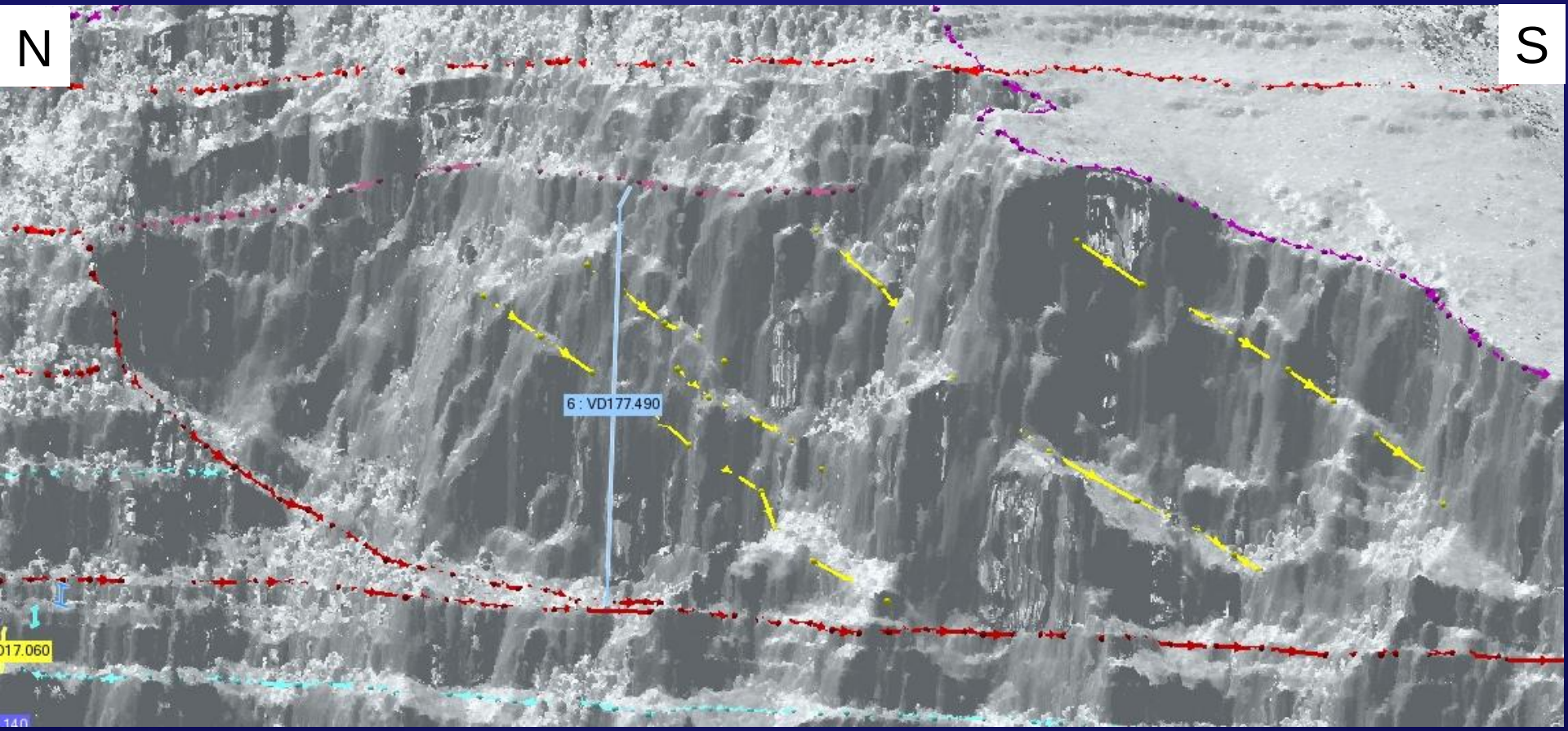
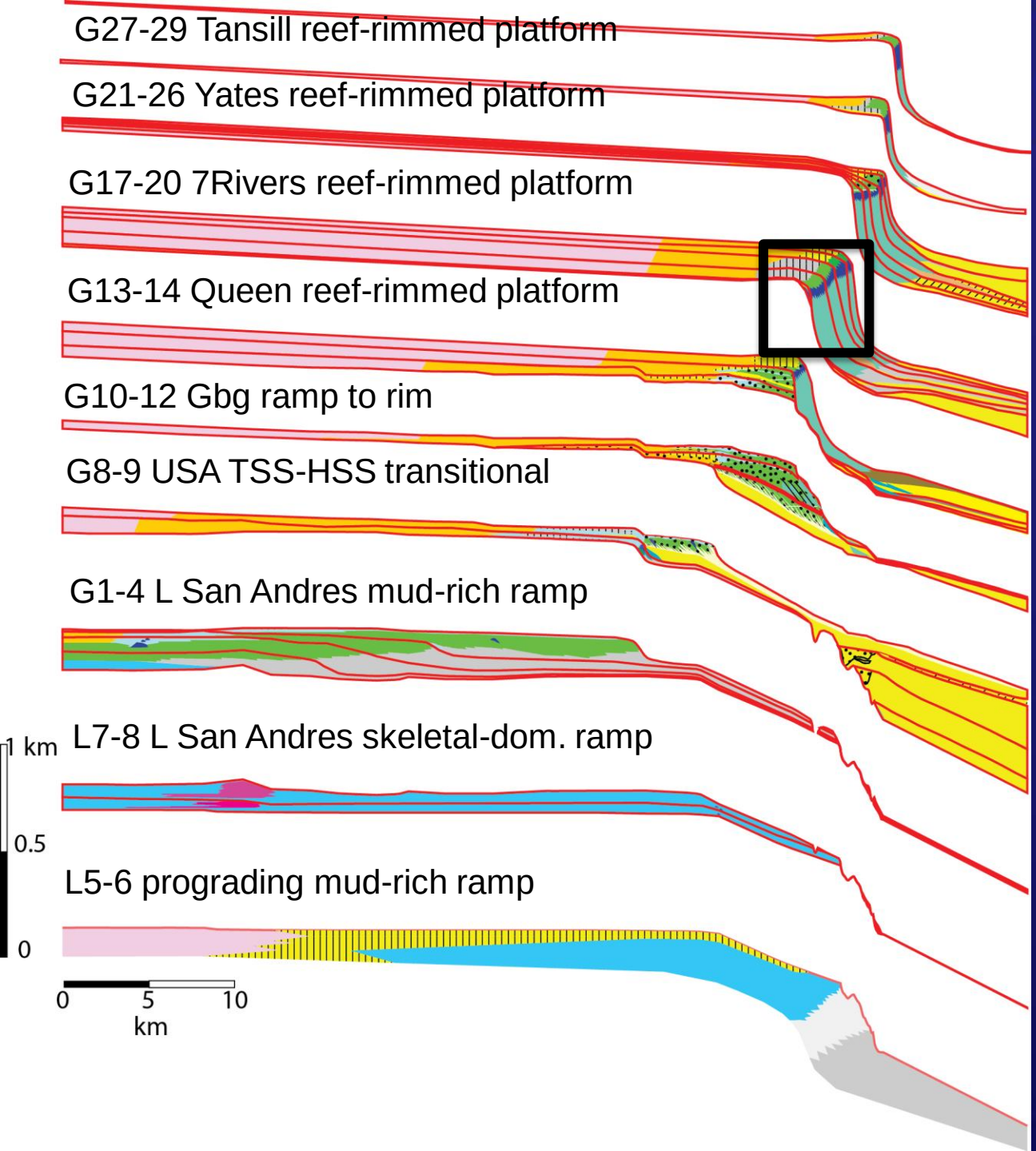
G13 Queen/Goat Seep
178 m relief, 35° slope,
0.5 km run-out





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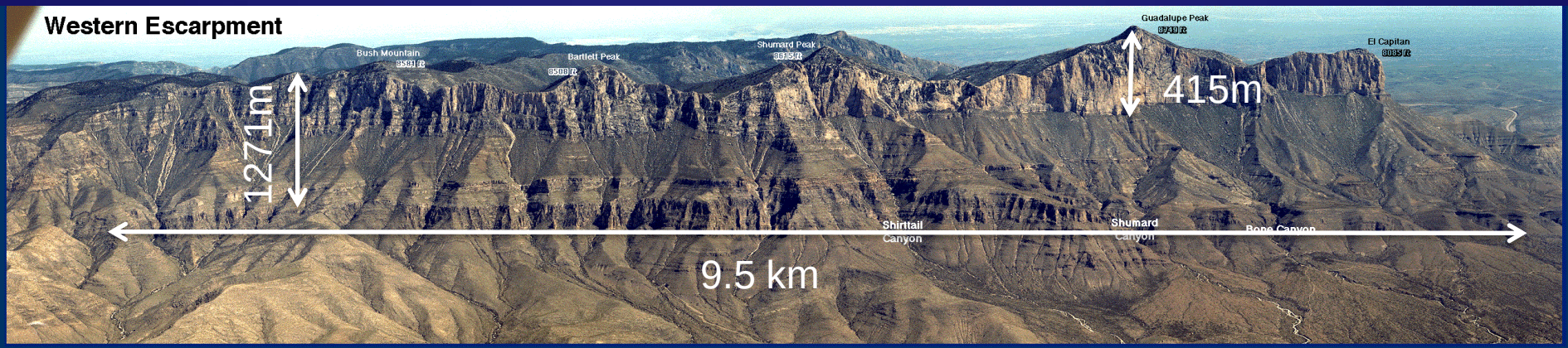
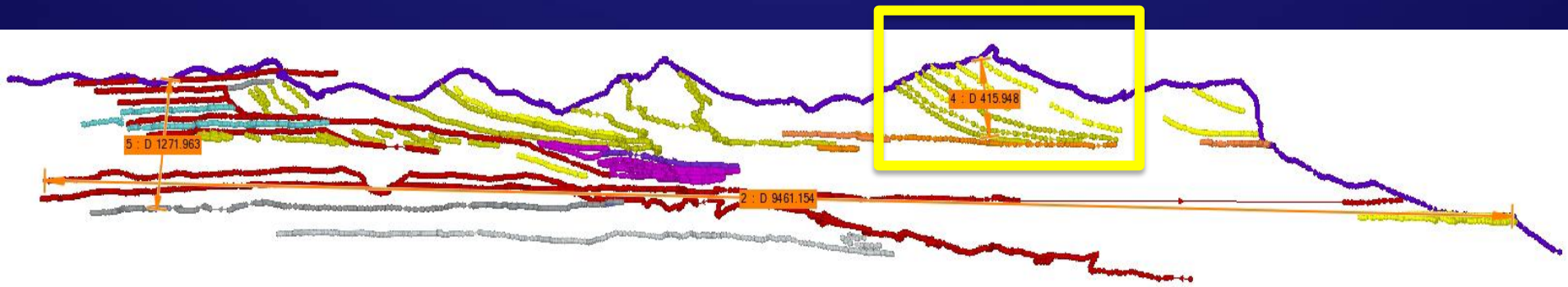
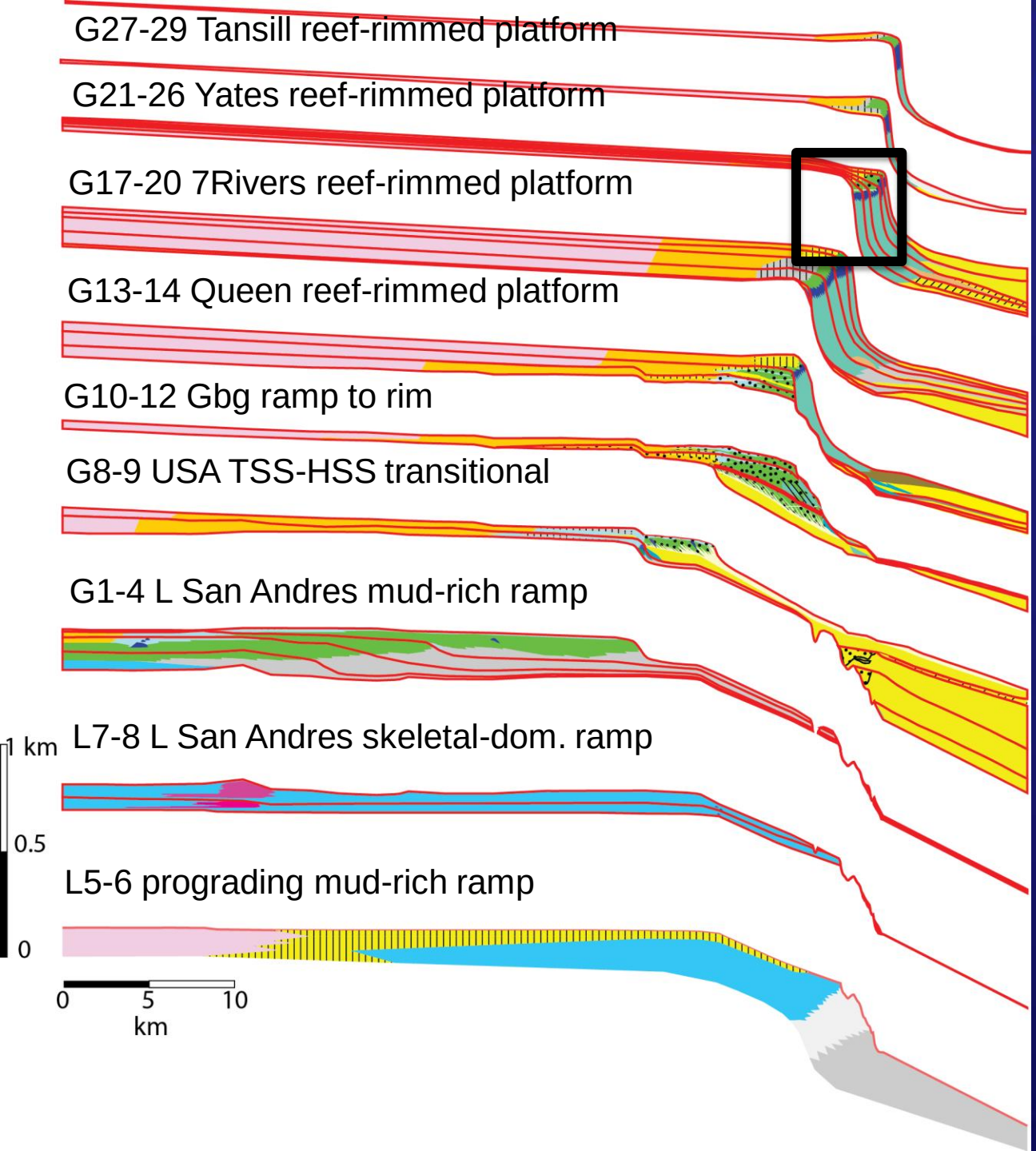
G17-20 Reef Rimmed Clinoforms, Relief-400-500m, Angle 35º, Run-out – 1 km





Lidar-Measured Dimensions, West Face



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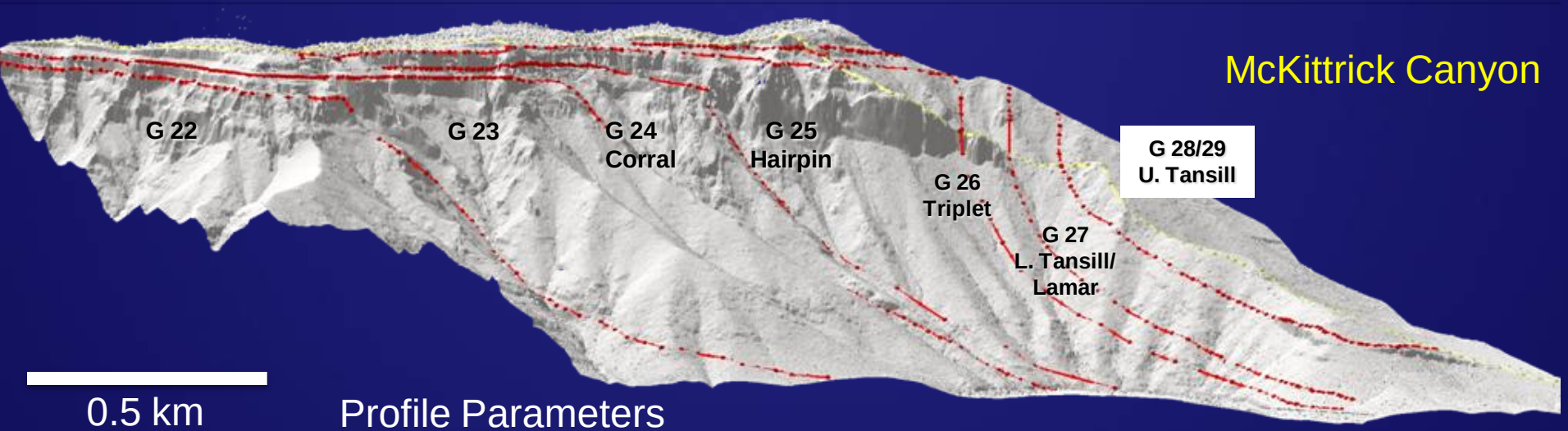
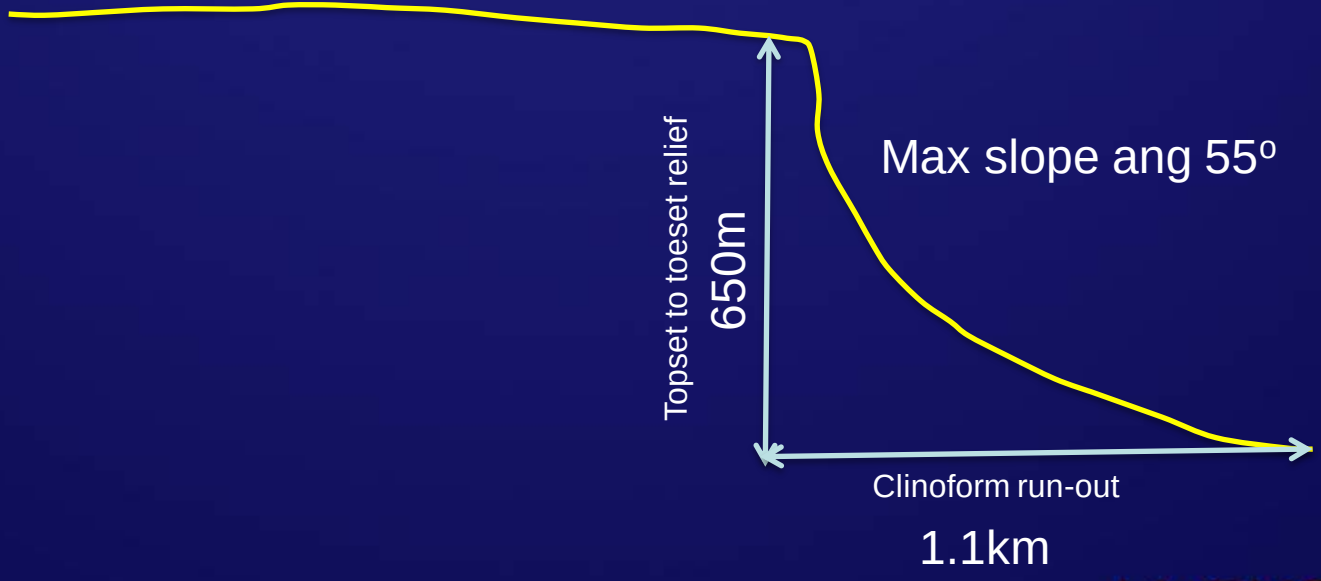
G22-25 Yates
Relief 650m, 55º angle, 1.1 run-out



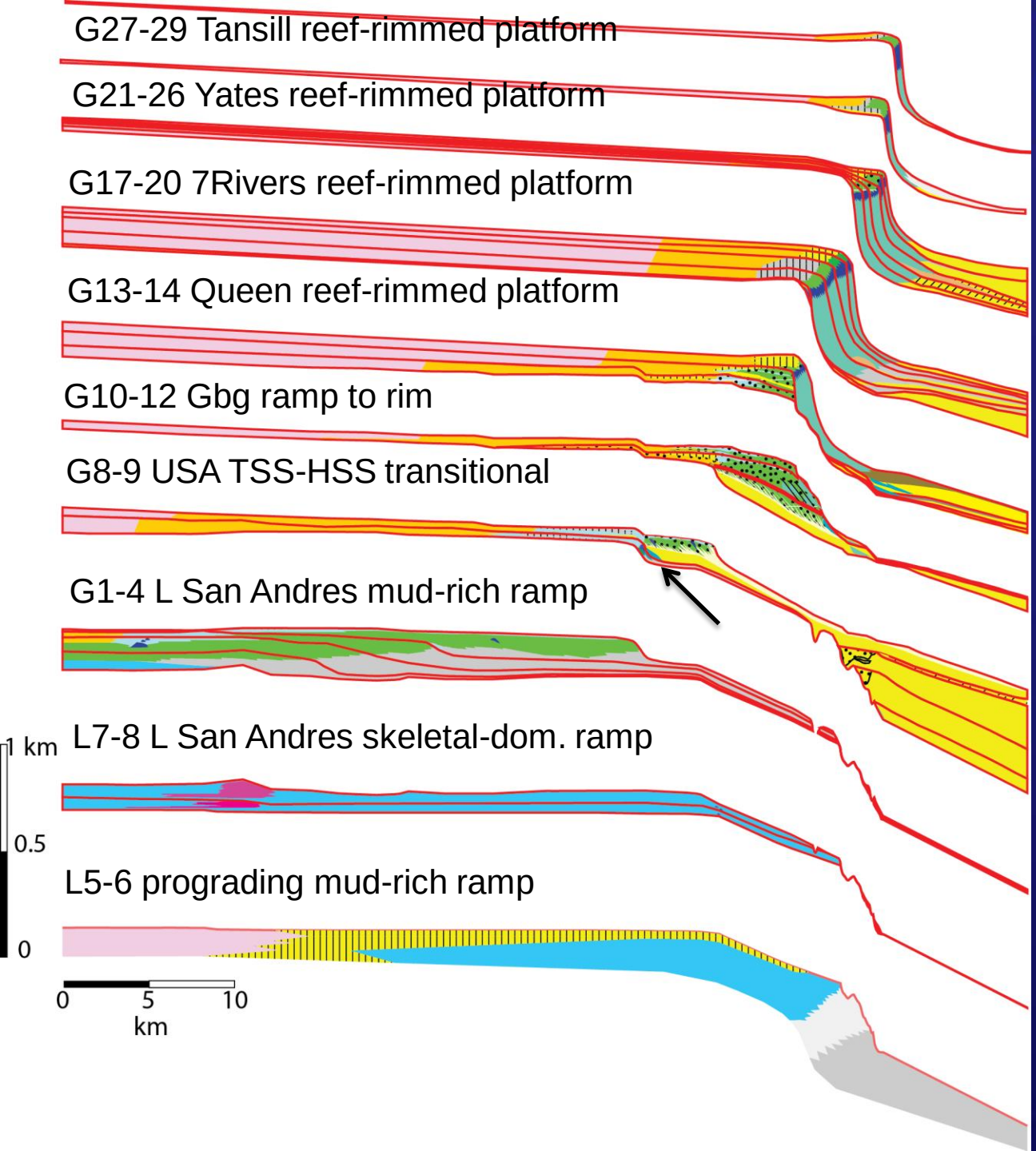
Profile Parameters



Depositional Profiles and Deposits

	SEQ	Fm. Name	Relief	Max Ang.	Run -Out	%Debris	% grain	% mud	%SS
Ramp Phase	***L5-6***	Vic. Pk.	300 m	15°	4km	<5%	60	40	0
	L7-8	l. SA TSS	<100m	5°	?	0%	80	20	0
	G1-4	l. SA HSS	50m	2°	3km	0%	10	90	<5
	G8	u. SA TSS	60m	2-4°	1.5	<5%	40	50	10
Transition	***G9***	u. SA HSS	60m	12°	1.5	5%	40	10	50
	G10-12	Graybrg	70m	10°	0.4	20	20	30	40
Rim Phase	***G13-14***	Queen	180m	35°	0.5	>50	30	10	10
	G17-20	7Rivers	440m	30-50°	1km	>50	30	10	10
	G21-25	L. Yates	600m	55°	1.1	>50	30	10	10
	G26	Triplet	650m	30-50°	1.2	>50	20	10	20
	G27-28	L.Tansill	650m	30-50°	1.0	>50	20	30	0
	G29-30	U.Tansill	650m	30-50°	0.5	>60	40	0	0

Clastic Influx



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Conclusions

- Onset of ramp-rim transition in Guadalupian occurs progressively in stepwise fashion across G8-G13 HFS
- Localization of pre-existing margin relief by older shelf margin is a critical extrinsic forcing function
- Loss of carbonate mud factory associated with influx of siliciclastics in G9-26 significantly reduces export of mud onto slope and basin, enhancing “starved basin” pattern and promoting oversteepening and rim development

Presenter's Notes:
This is the first of six maps, in which the progradationof the G9 highstandis illustrated though a series of isopachstaken from between the G9 SB and surfaces including and subsequent to the G9 MFS. In these sequences clinoformfronts changed from broad sinuous morphologies with characteristic large-scale strike variability to a narrower higher angle front characterized by smaller scale bypass conduits. Please scroll through these at your own pace before moving to a summary slide.

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