What Happened to My Marine Reservoir? Implications of Falling Stage and Lowstand Fluvial Sediment Storage during "Sequence-Boundary" Scour for Sand Starvation of Coastal Marine Reservoirs*

John M. Holbrook[1] and Janok Bhattacharya[2]

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Abstract

Recent flume and field studies show that sediment may be stored by fluvial aggradation and lateral migration during regression, resulting in sediment starvation in coeval marine environments. In extreme cases, this may result in storage of all sediment within the fluvial system and complete starvation, or "autodetachment," of the contemporary marine shoreline. Complete sediment starvation of the shore is still theoretical, and likely rare. Several recent field studies, coupled with new ideas regarding the scour processes of sequence boundaries, however, suggest that significant falling and lowstand fluvial sand storage commonly results in diminished to near total reduction of marine reservoir sand.

Newer views on scour of the "subaerial unconformity" sequence boundary show that it does not actually record a surface of exposure and near-complete bypass of sediment at lowstand as originally presumed, but rather records a composite surface formed by lateral migration and incision of rivers that 'carve-and-cover' the subaerial unconformity throughout regression. This carve-and-cover process means that fluvial sediment is deposited above this surface throughout the regressive phase. Because transport of sand lags transport of suspended load, regressive fluvial sediments disproportionally sequester the sandy fraction. Coastal Quaternary systems and the Cretaceous of the Western Interior provide several examples where coastal systems were deprived of sandy sediment to varying degrees during regression. Sand starvation ranges from minimal, resulting in prominent regressive coastal sand reservoirs, to near-complete, in which case lowstand terminal estuaries with negligible coastal sand deposition result. Partial to near-complete "sand autodetachment", in which there is sand starvation of marine reservoirs, appears more pronounced where regressive slopes are low, compared to river profiles and where base-level remains relatively stable during regression. Such minimally incised systems are common where stable base-level promotes lateral migration of channels during falling and lowstand stage, enhancing fluvial sand storage.

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Texas Christian University

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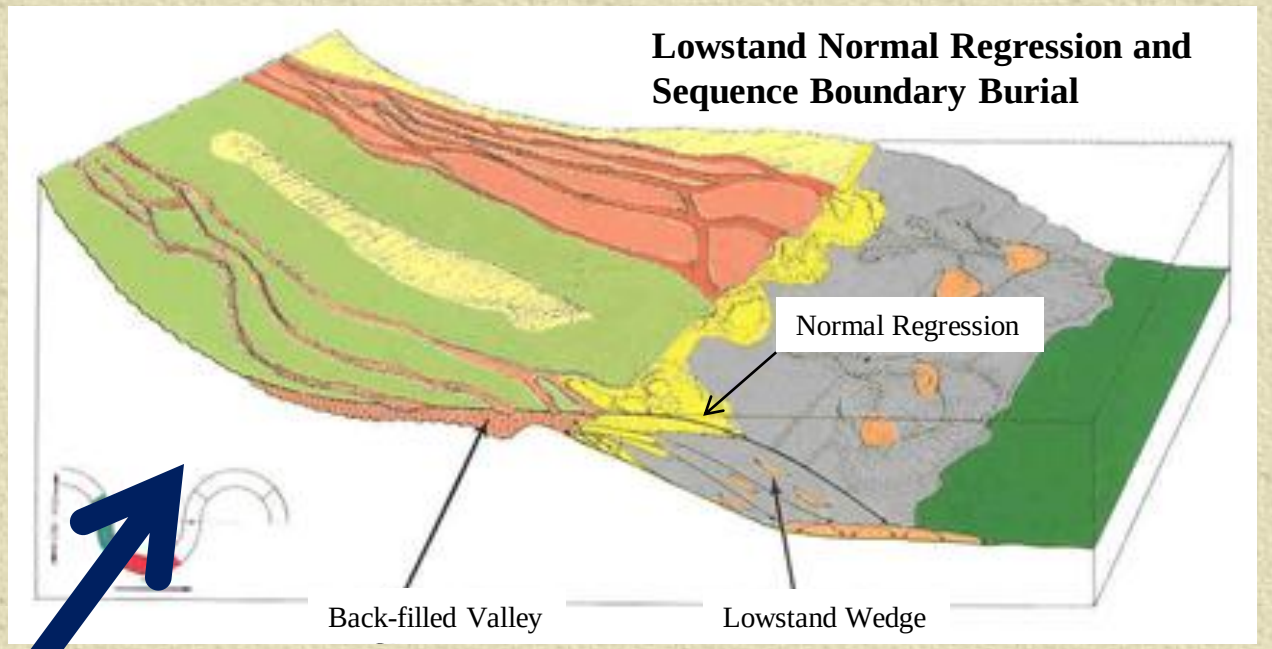
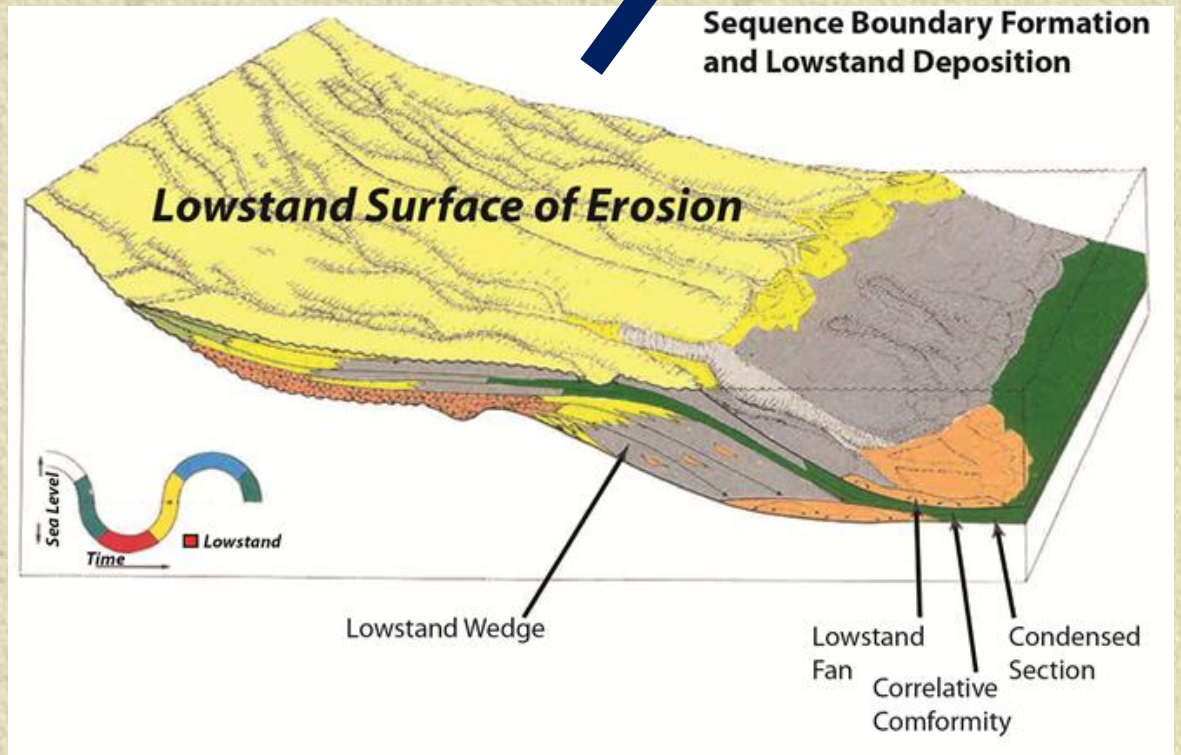
University of Houston

"Back-Filling"

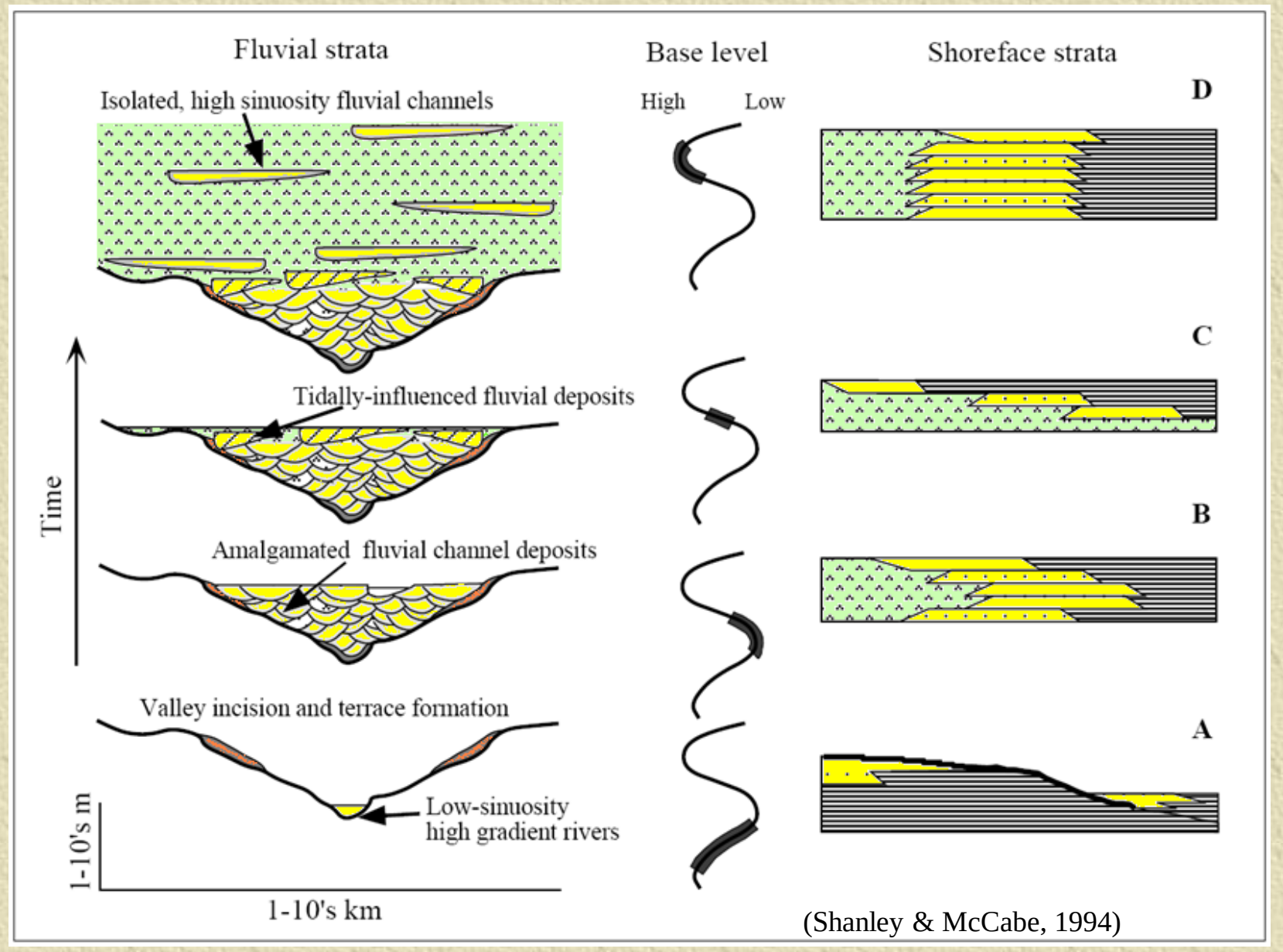




Sediment "Bypass"

(Van Wagoner et al., 1990)

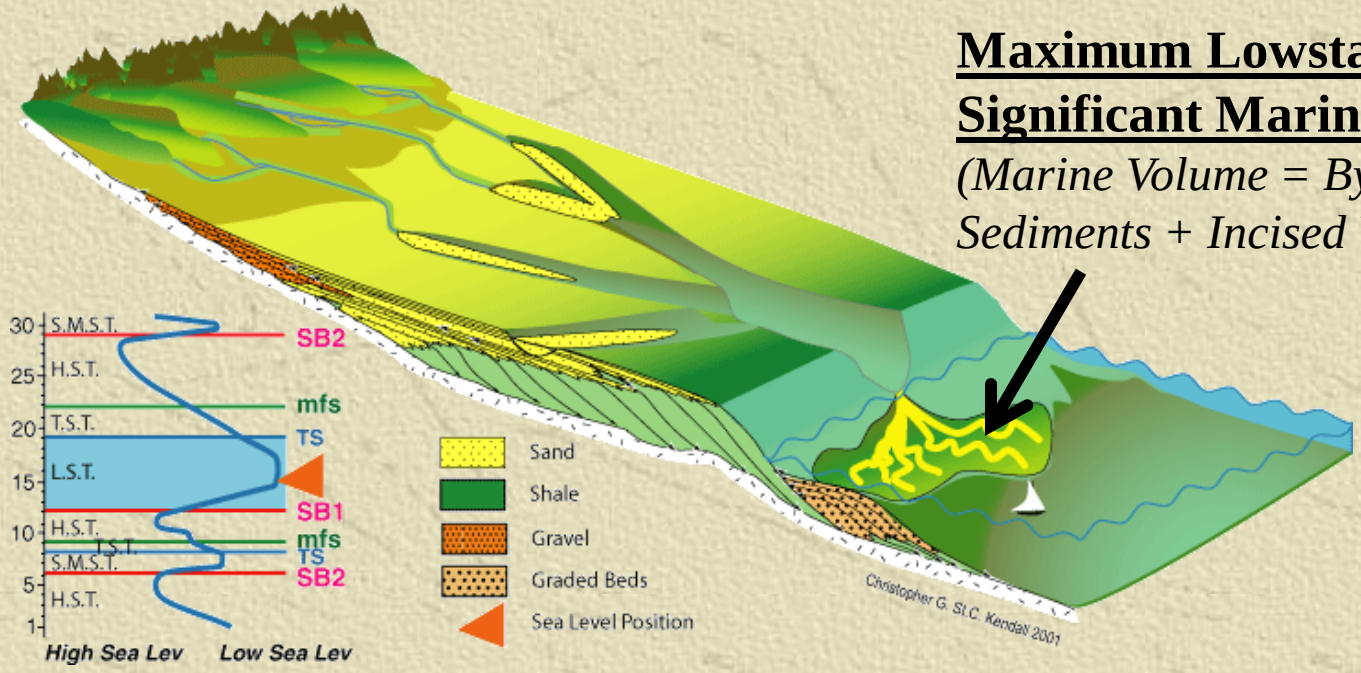
Fluvial Sequence Stratigraphy



(Shanley & McCabe, 1994)

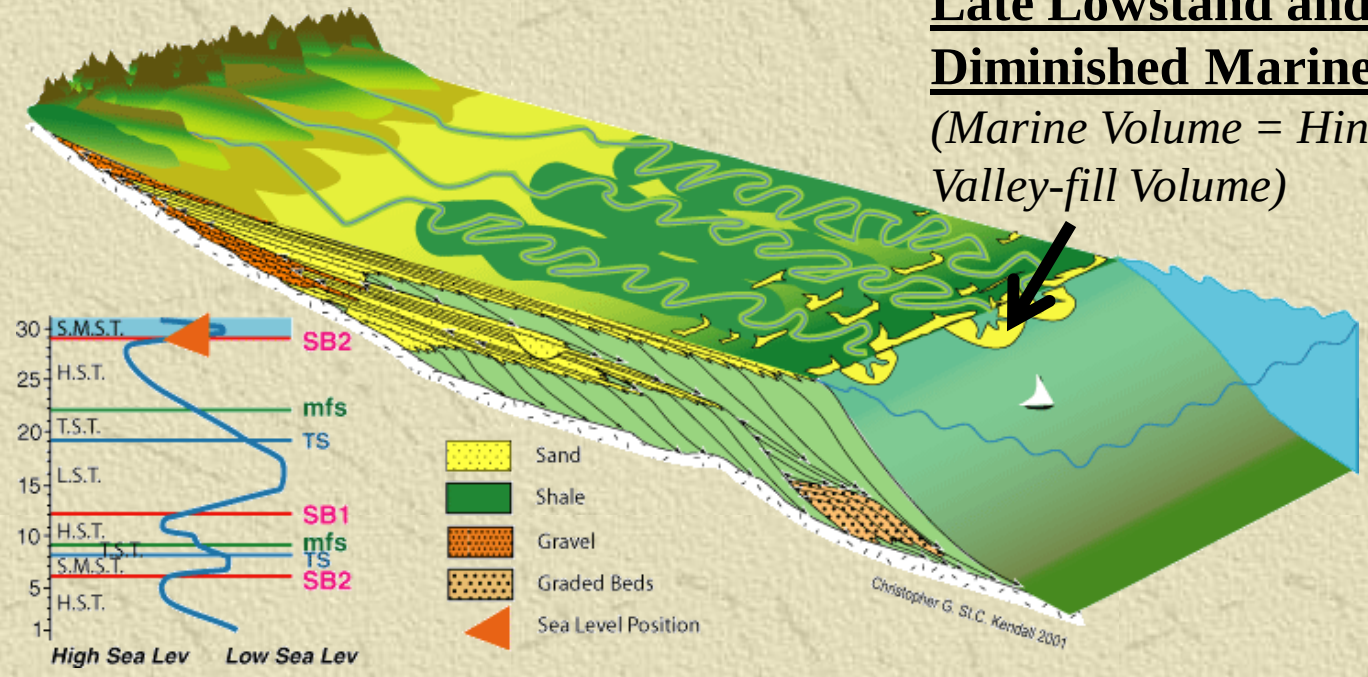
Maximum Lowstand and Significant Marine Deposition

(Marine Volume = Bypassed Hinterland Sediments + Incised Valley Volume)

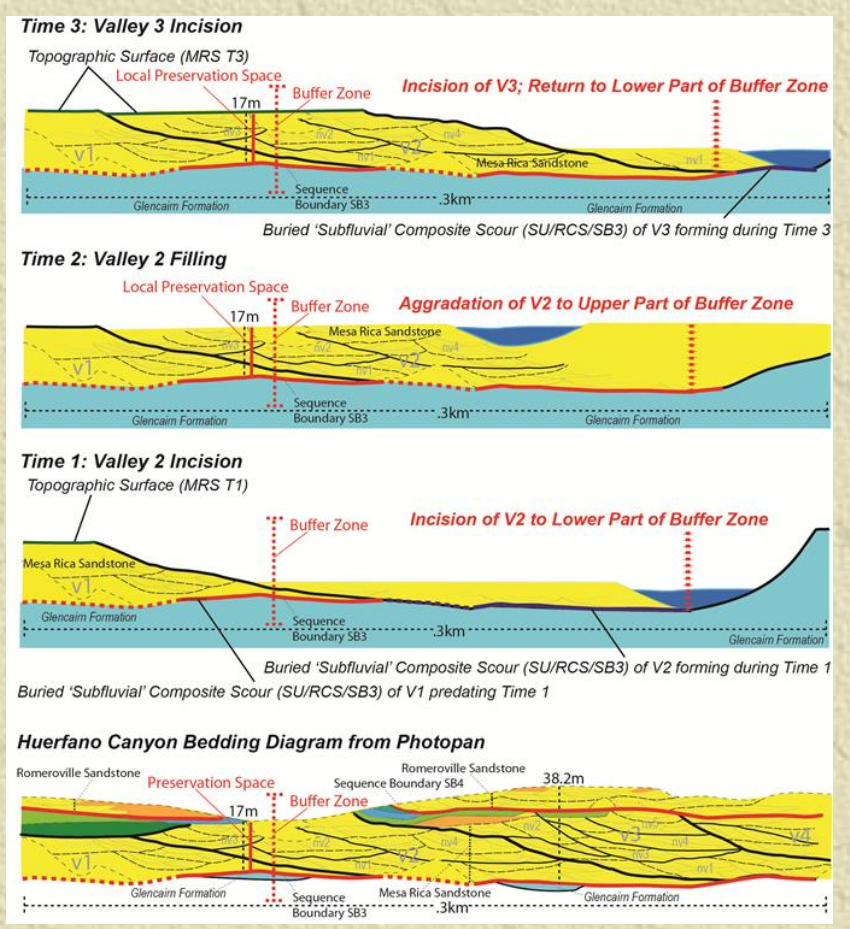


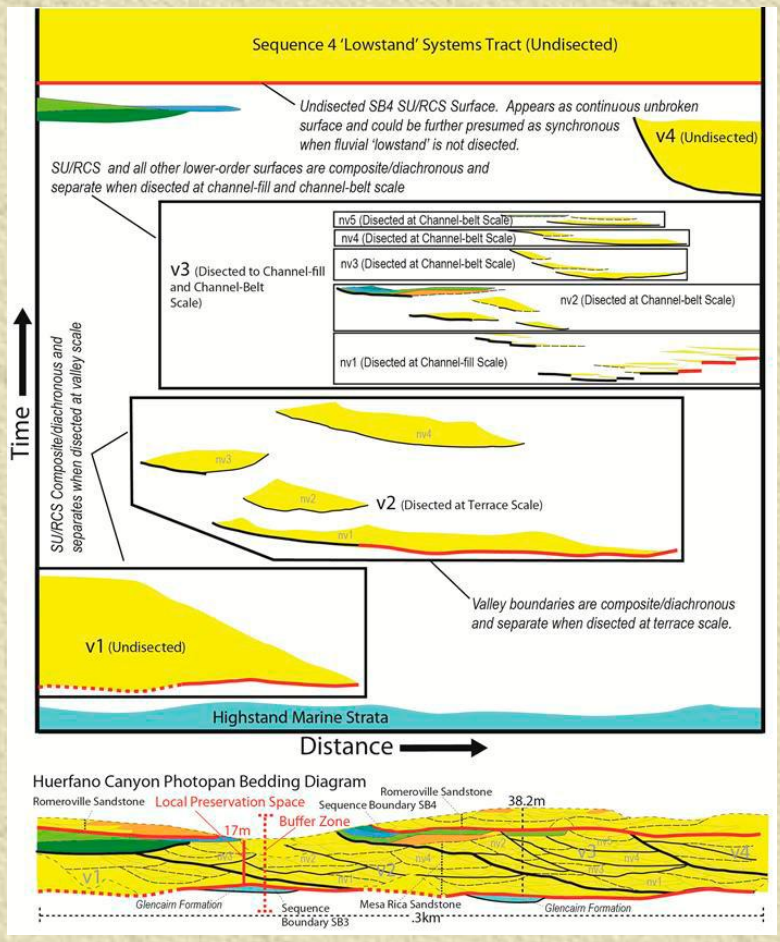
Late Lowstand and Diminished Marine Deposition

(Marine Volume = Hinterland Sediments – Valley-fill Volume)



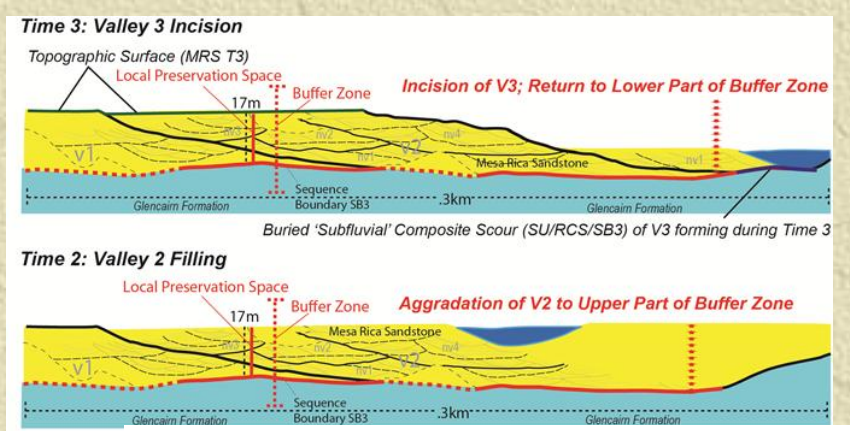
A Bypass Alternative

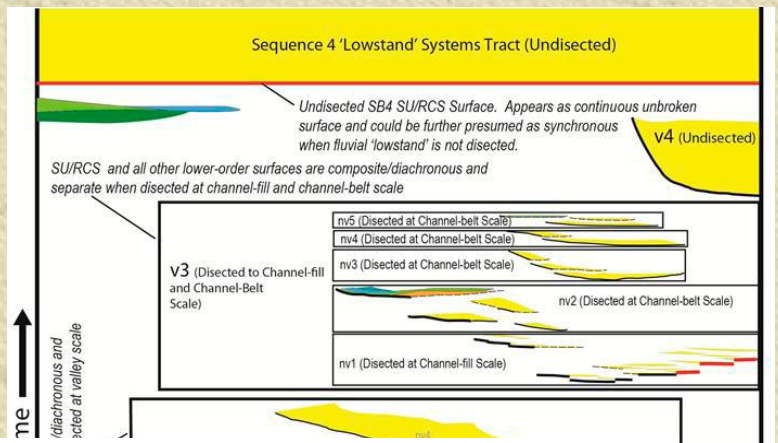


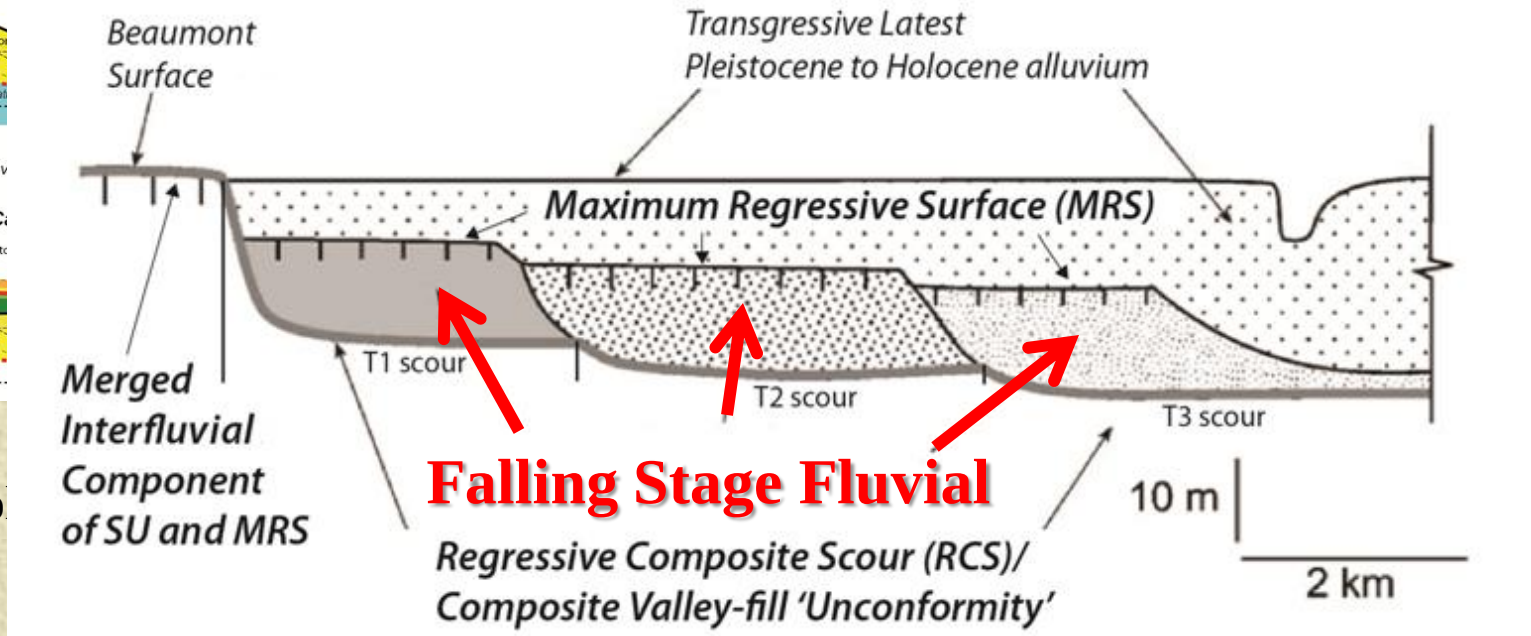


(Holbrook and Bhattacharya, 2012)

A Bypass Alternative







(Blum and Aslan, 2006)

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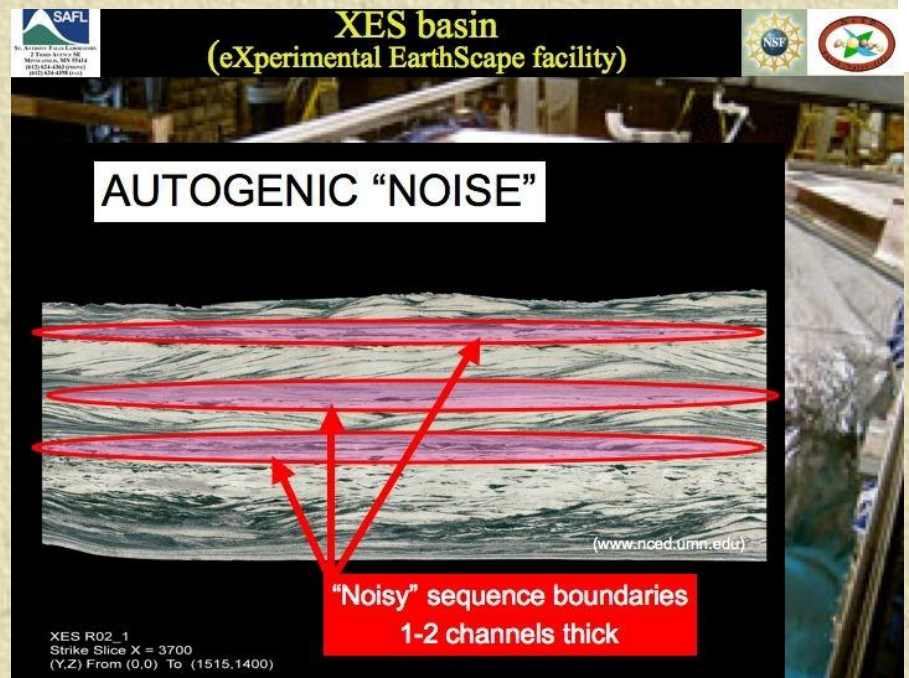
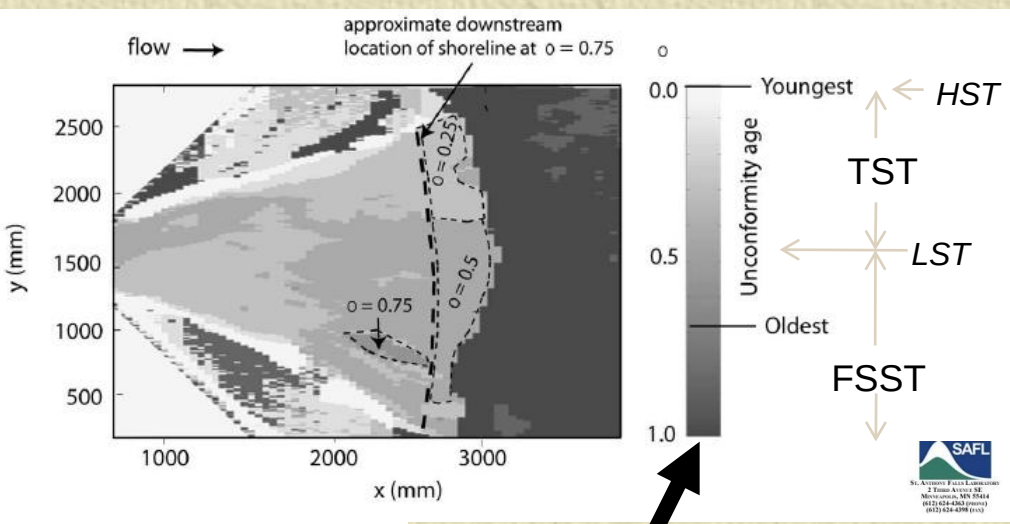
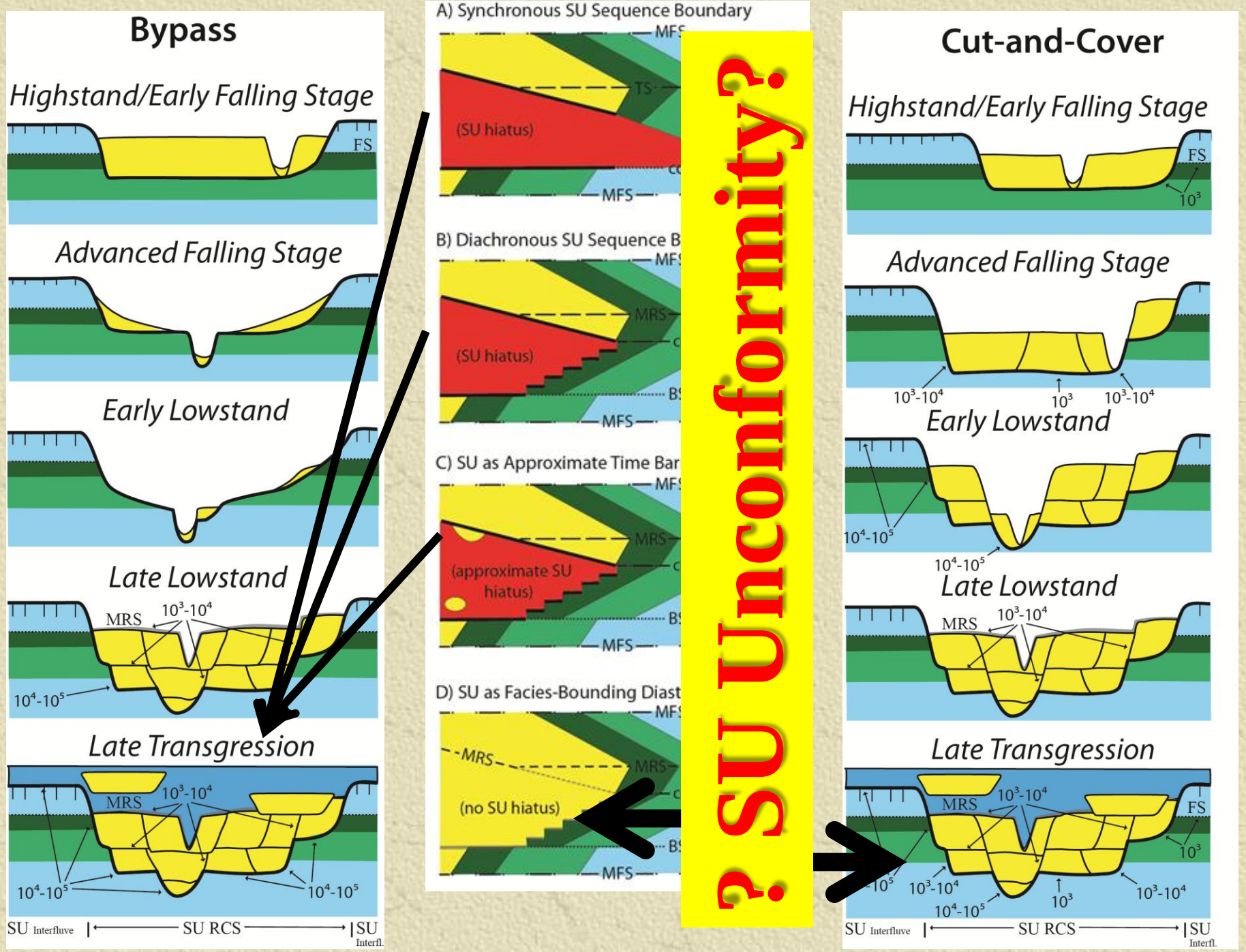




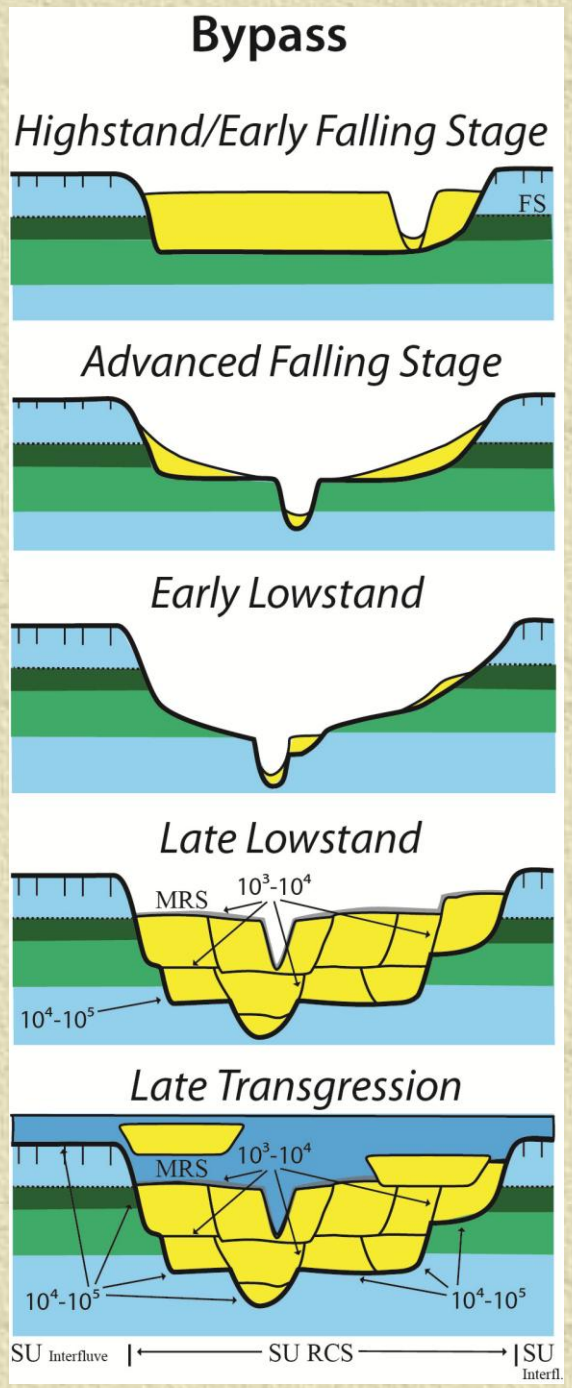
(Strong and Paola, 2008)

Sequence boundary formed over 75% of the entire sea level cycle!!!

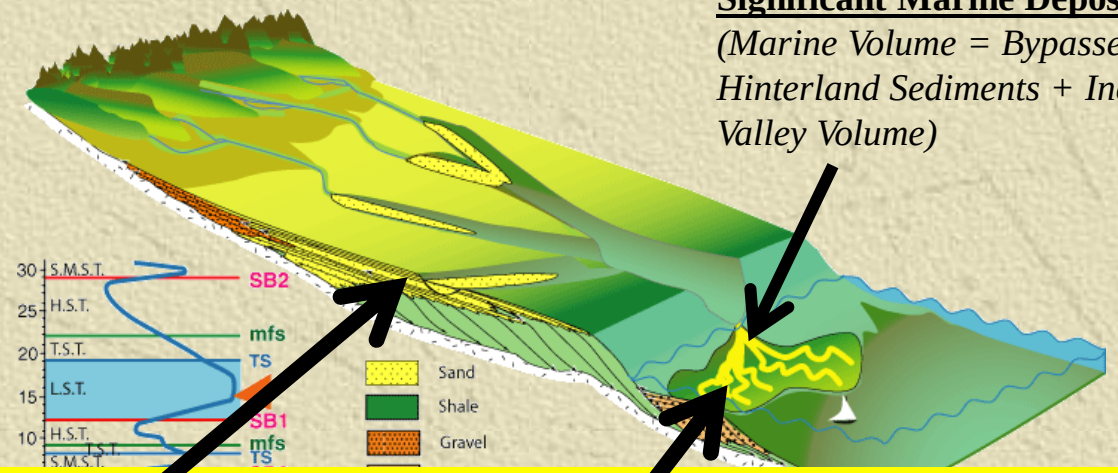
(Holbrook and Bhattacharya, 2012)



Sediment Storage?

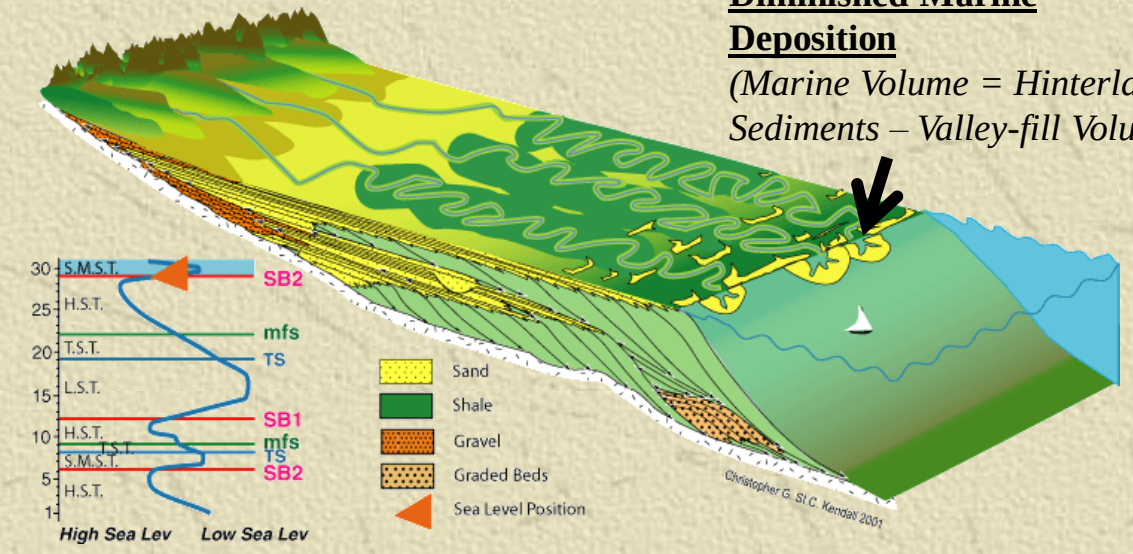


Maximum Lowstand and Significant Marine Deposition
(Marine Volume = Bypassed Hinterland Sediments + Incised Valley Volume)



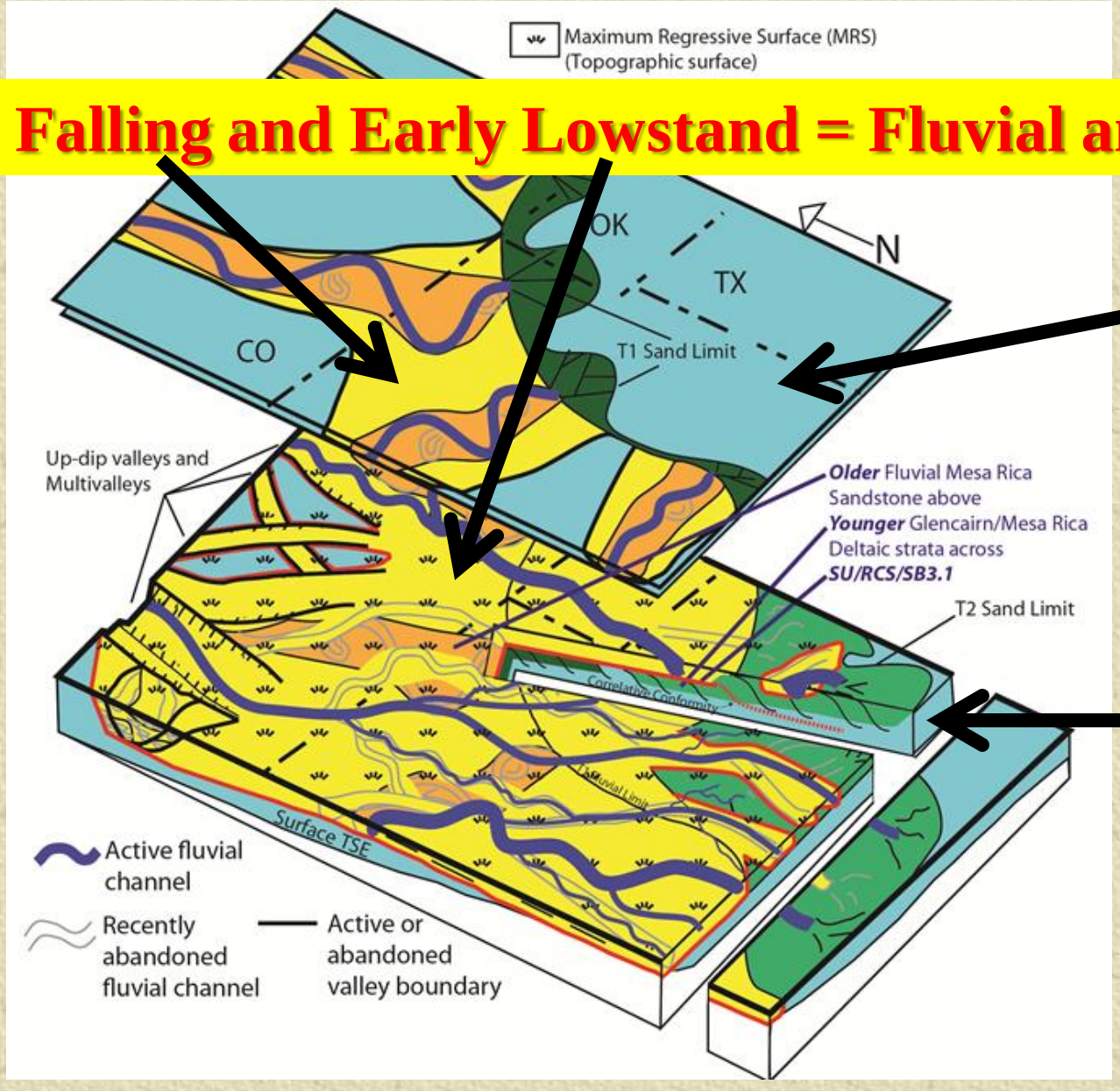
Falling and Early Lowstand = Marine

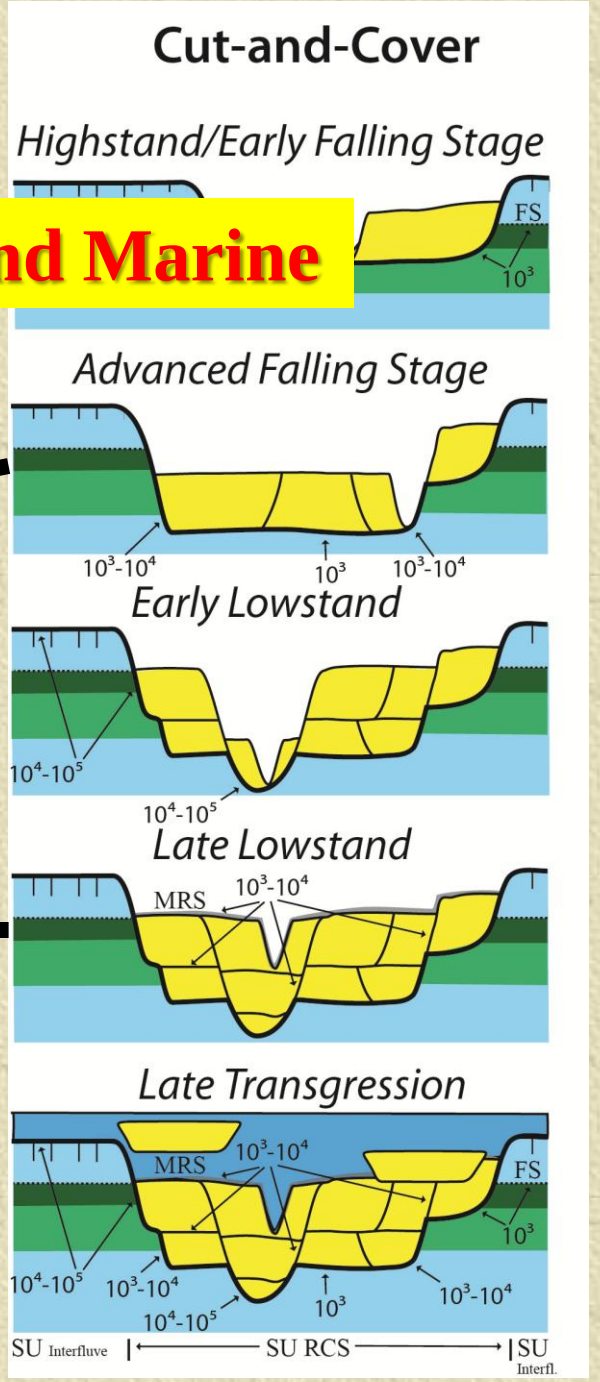
Late Lowstand and Diminished Marine Deposition
(Marine Volume = Hinterland Sediments – Valley-fill Volume)

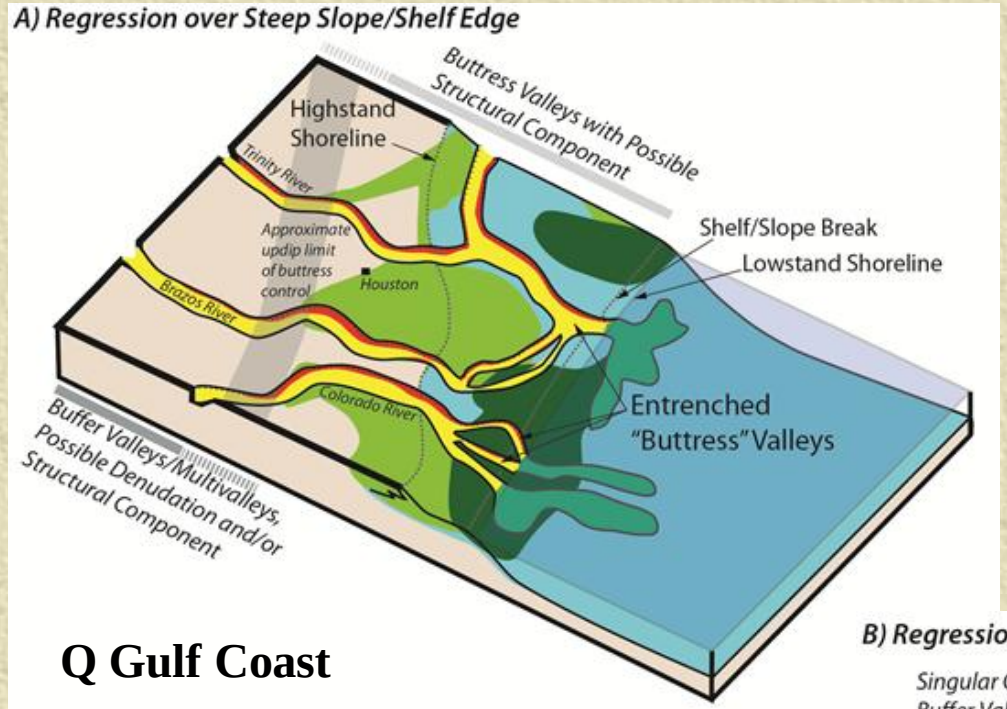


Sediment Storage?

Falling and Early Lowstand = Fluvial and Marine

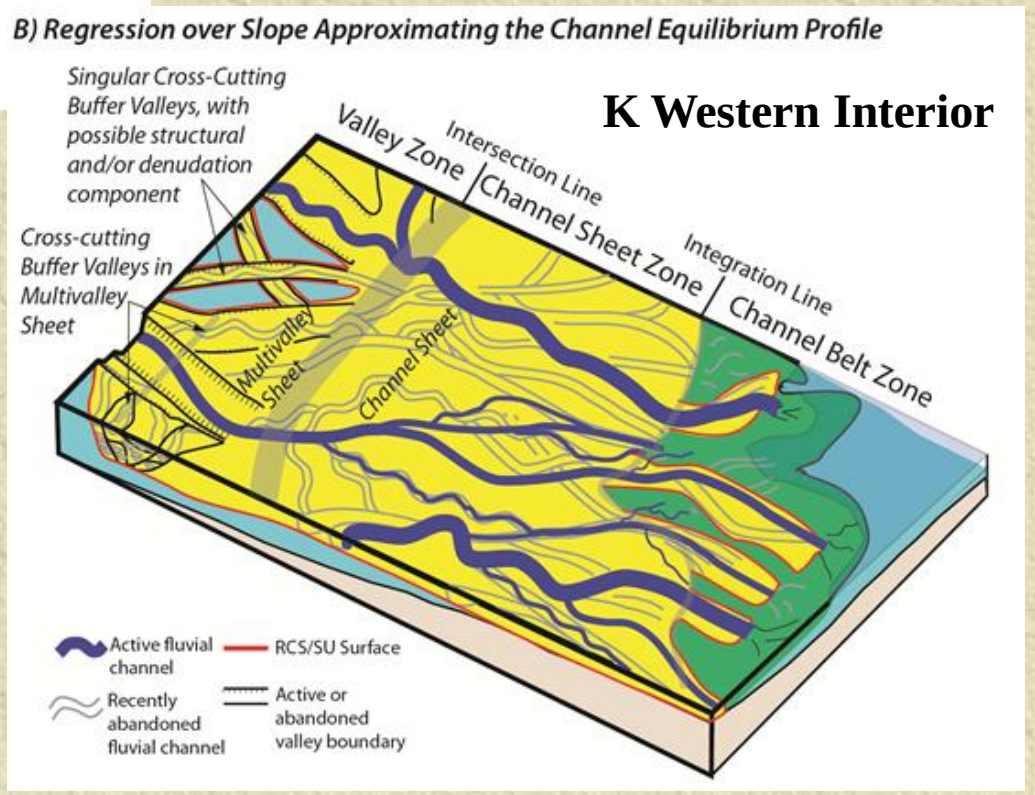






Q Gulf Coast

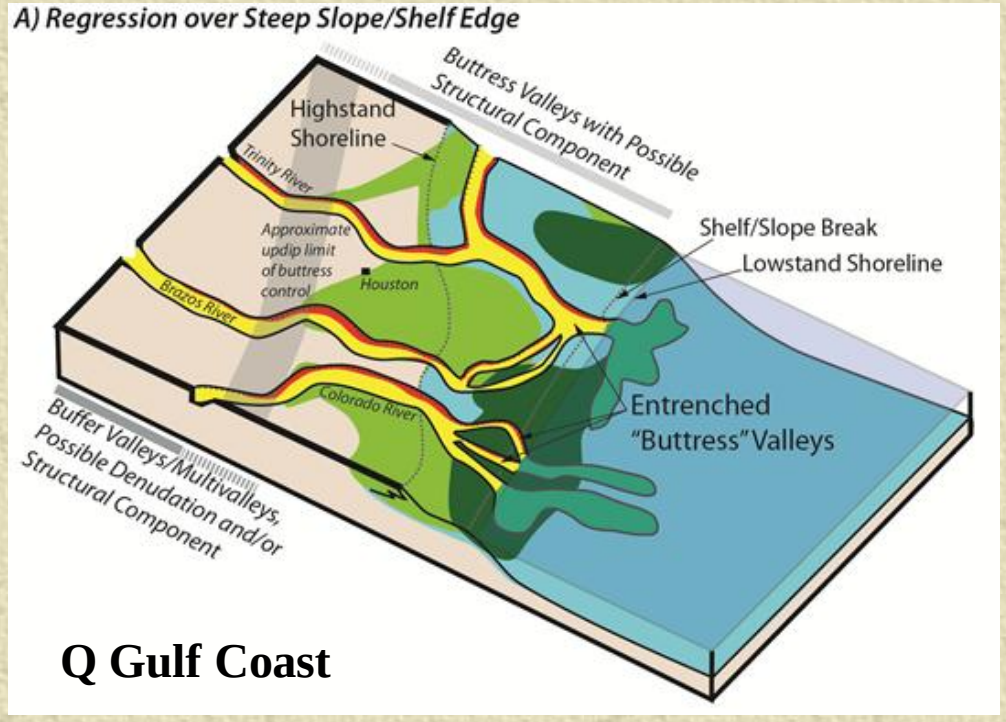
Narrow "Buttress" Valleys and Minimal Storage



K Western Interior

"Buffer" Valleys with Lateral Planation and Significant Storage

(Holbrook and Bhattacharya, 2012)



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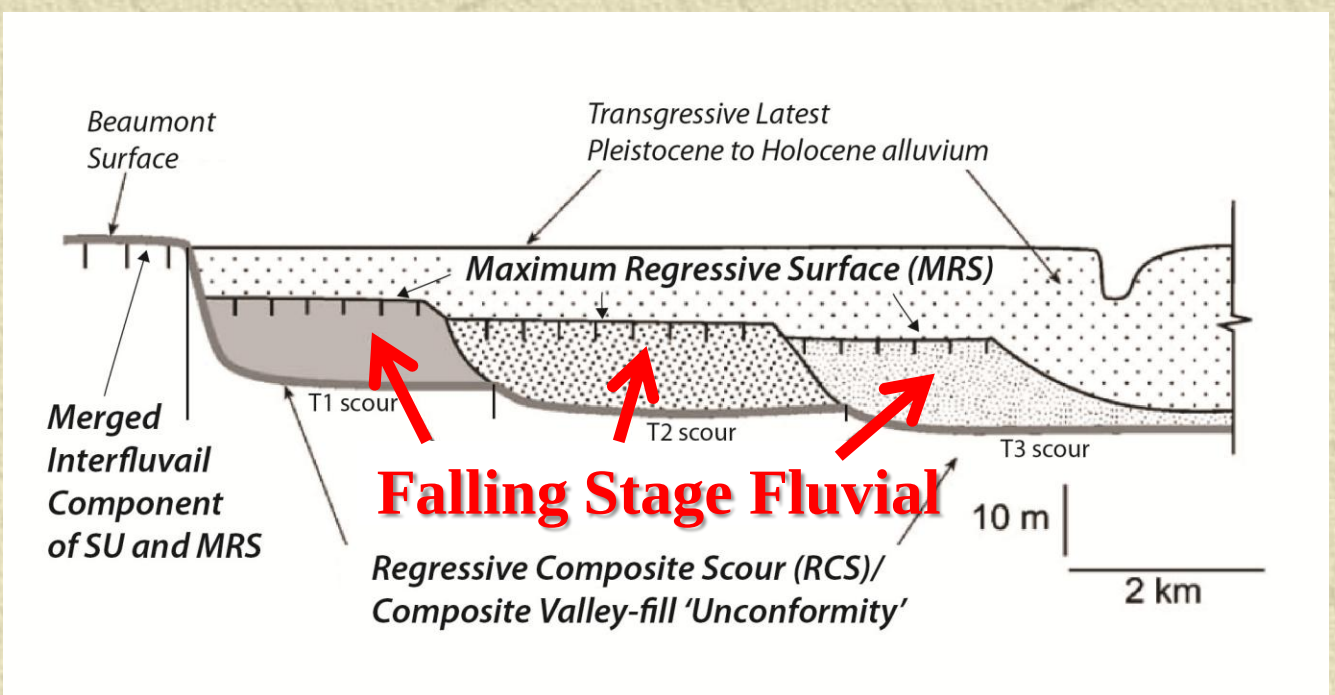
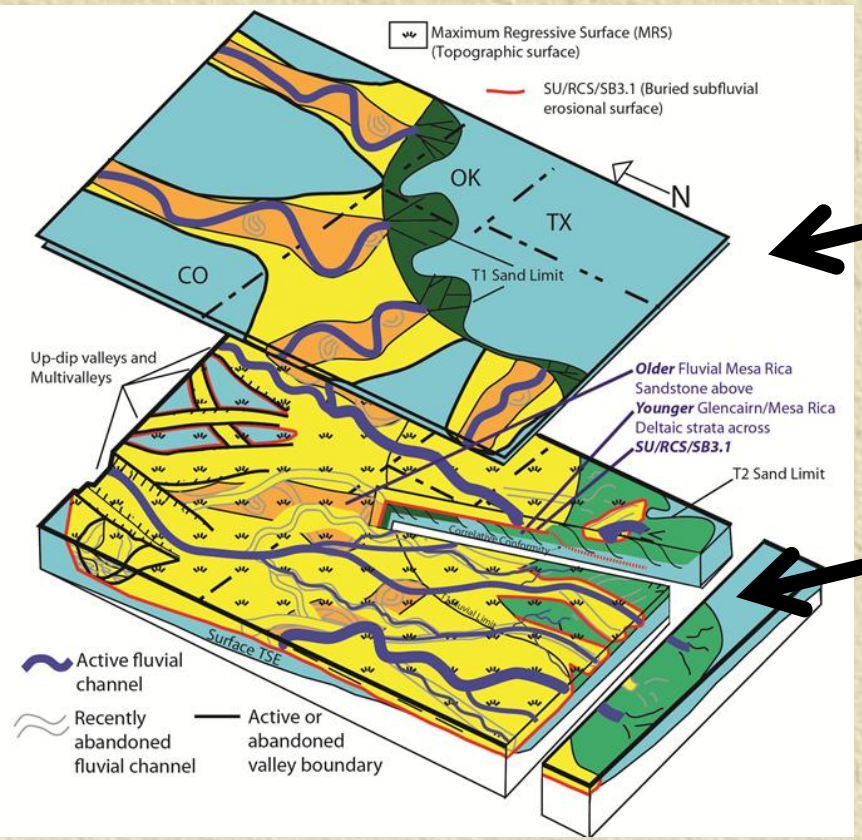
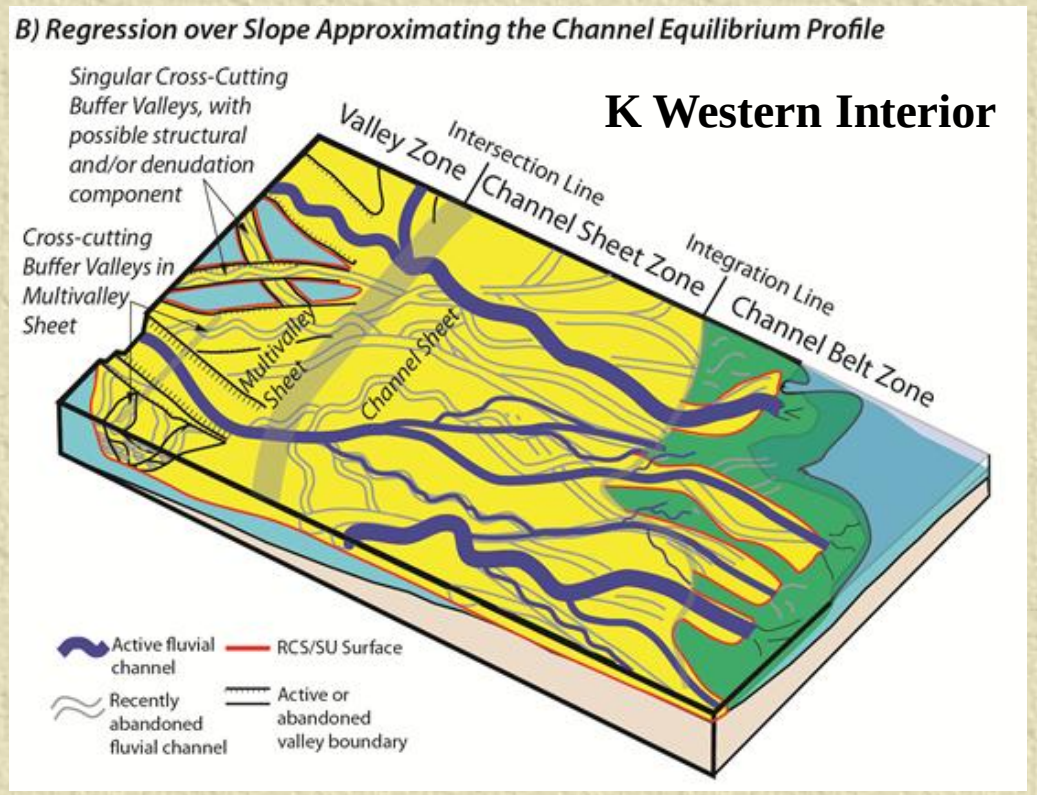


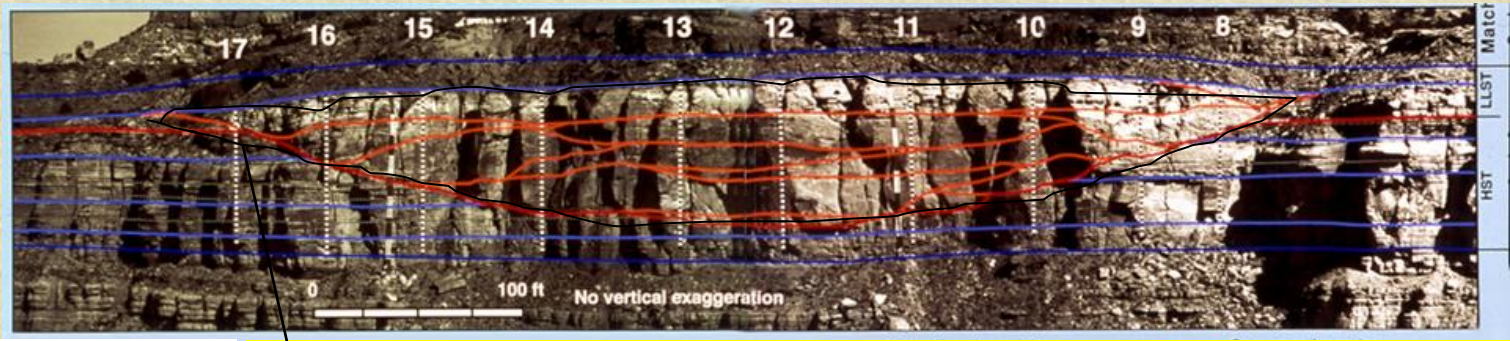


Falling Stage

Maximum Lowstand



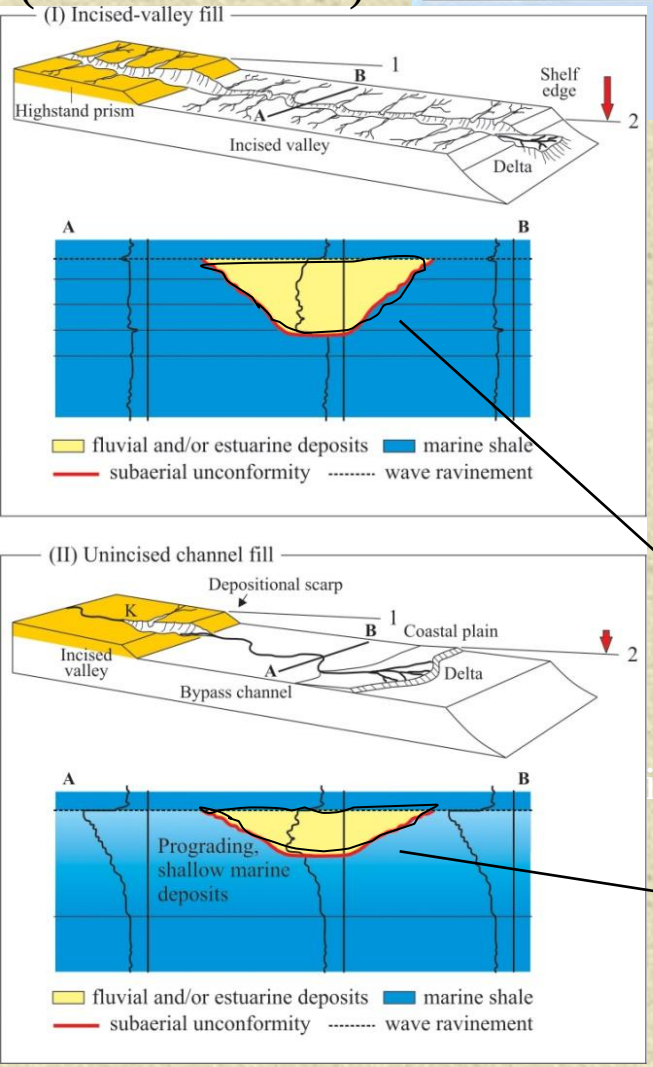
“Buffer” Valleys with Lateral Planation and Significant Storage

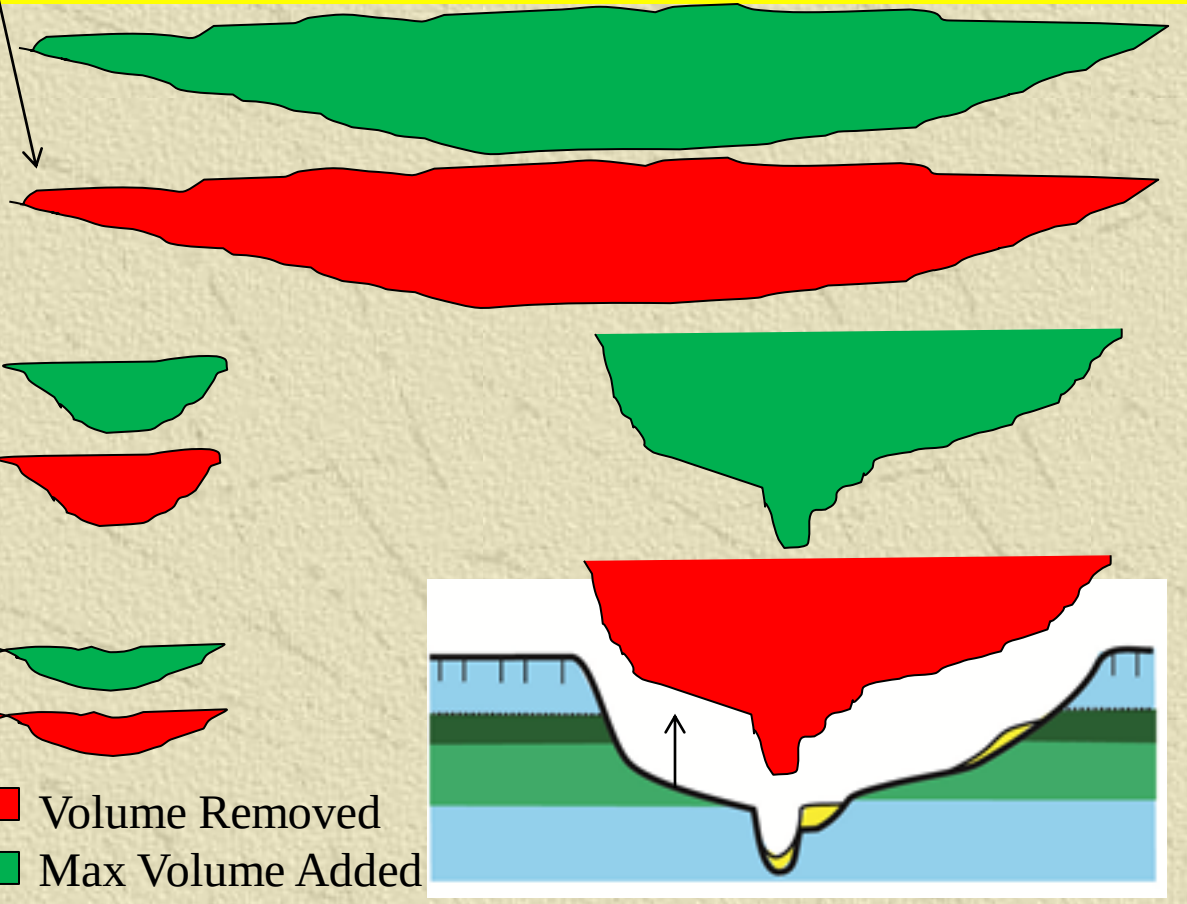


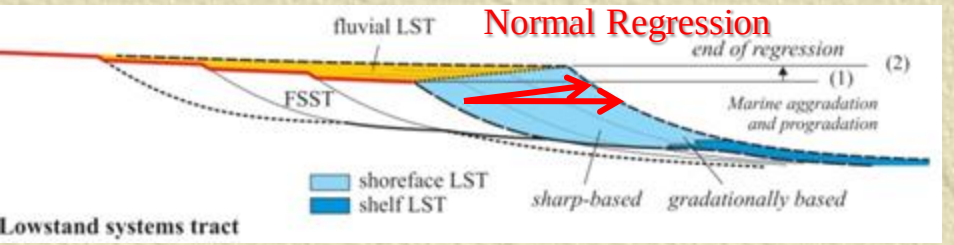
(Catuneanu 2006)

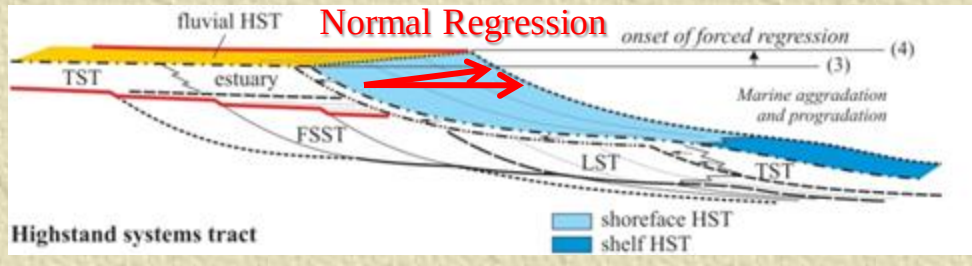
(C.O. Janok Bhattacharya)

- Multistory incision and fill, south side of I-70.
- These incisions have historically been interpreted as distributary channels.
- Detailed analysis suggest that they are small, incised valleys.









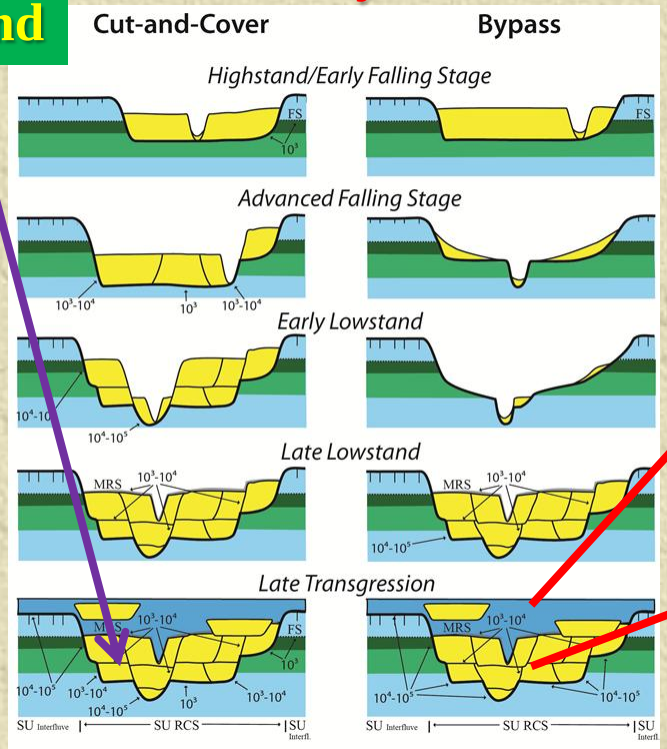
(Catuneanu 2006)

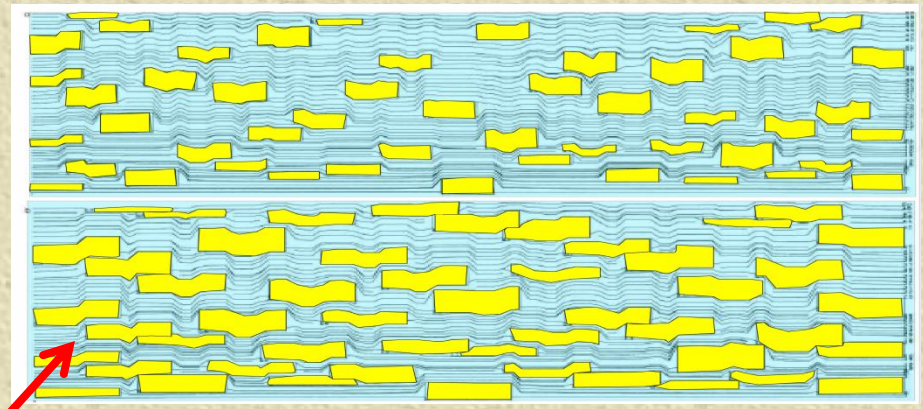
Normal Regression

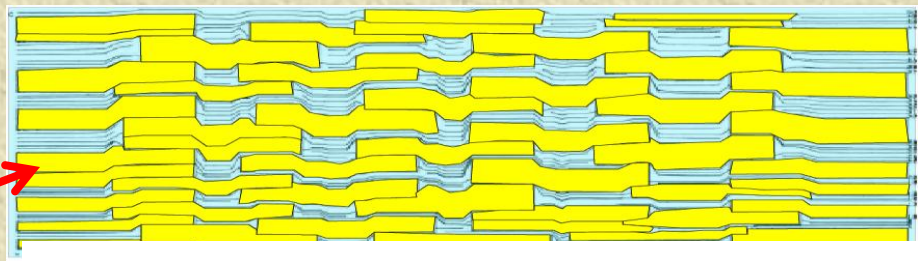
Low Sand

Higher Sand

Valley Fill





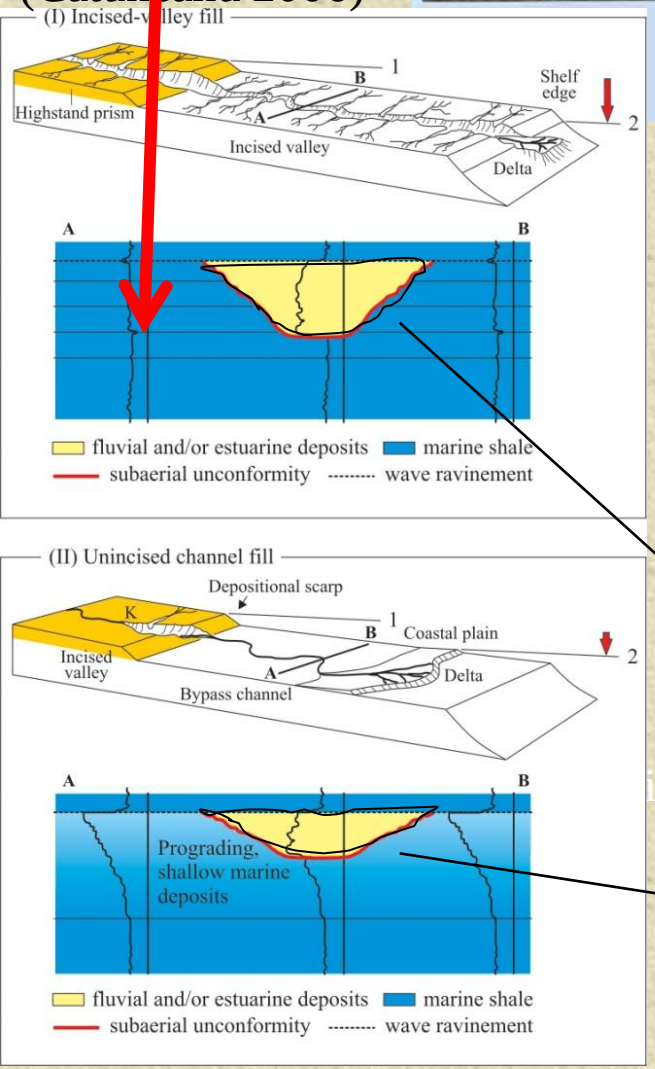


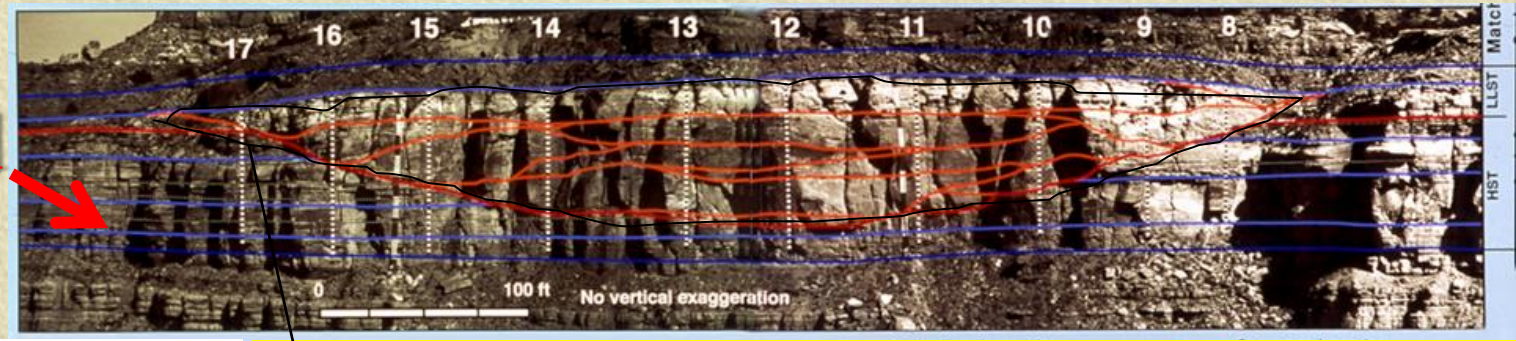
The "LAB" Models (Leeder, Allen, Bridge)

(Bridge and Leeder 1979)

≤50% Sand

(Catuneanu 2006)





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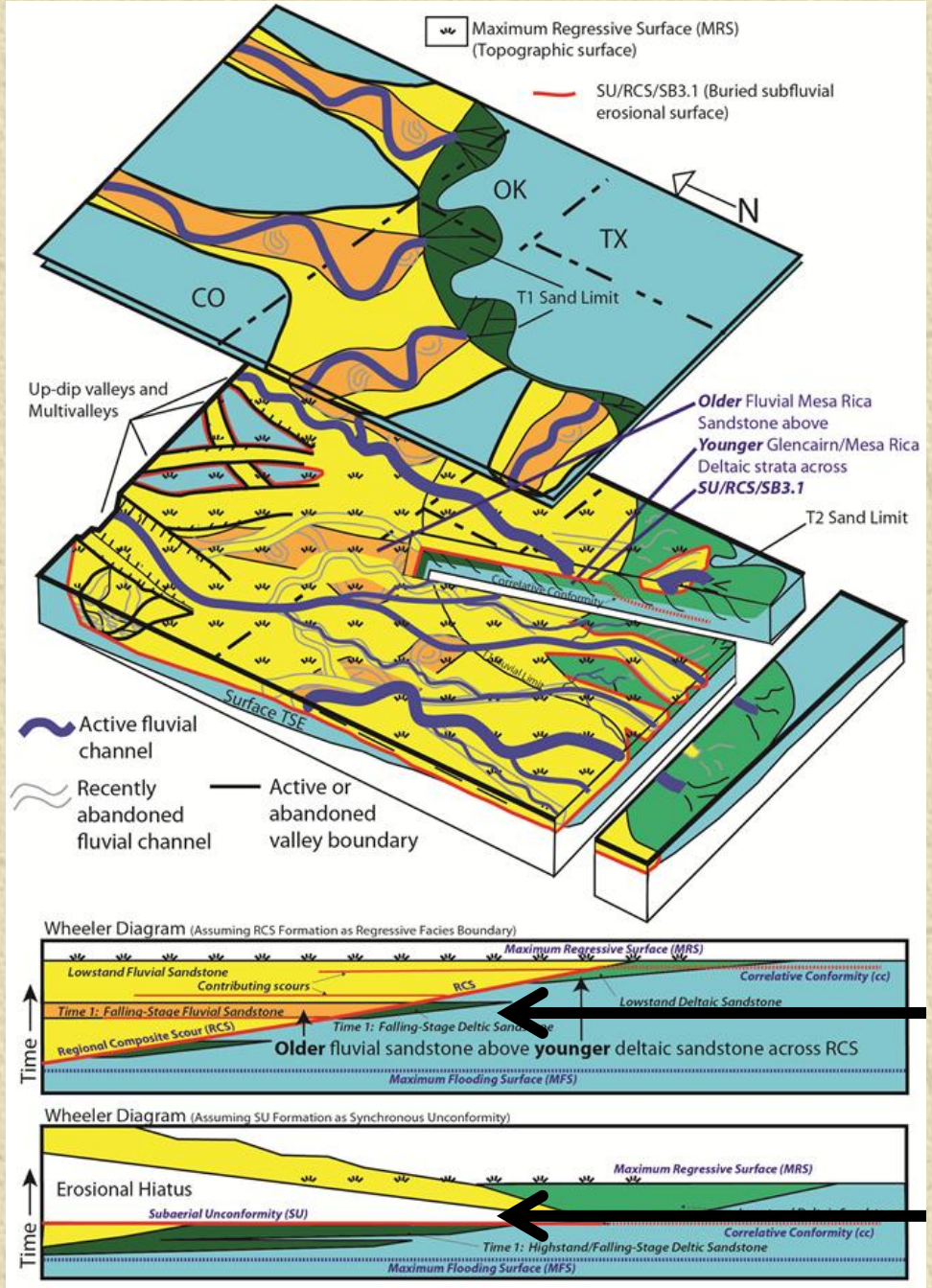
Volume Removed

Max Volume Added



(Holbrook and Bhattacharya, 2012)

Mesa Rica and Glencairn Fms

Fluvial Volume

14m x 37500km^2=

500km^3

Marine Volume at (50% sand)

150km^3 (Falling) + 250km^3 (Lowstand) =

400km^3

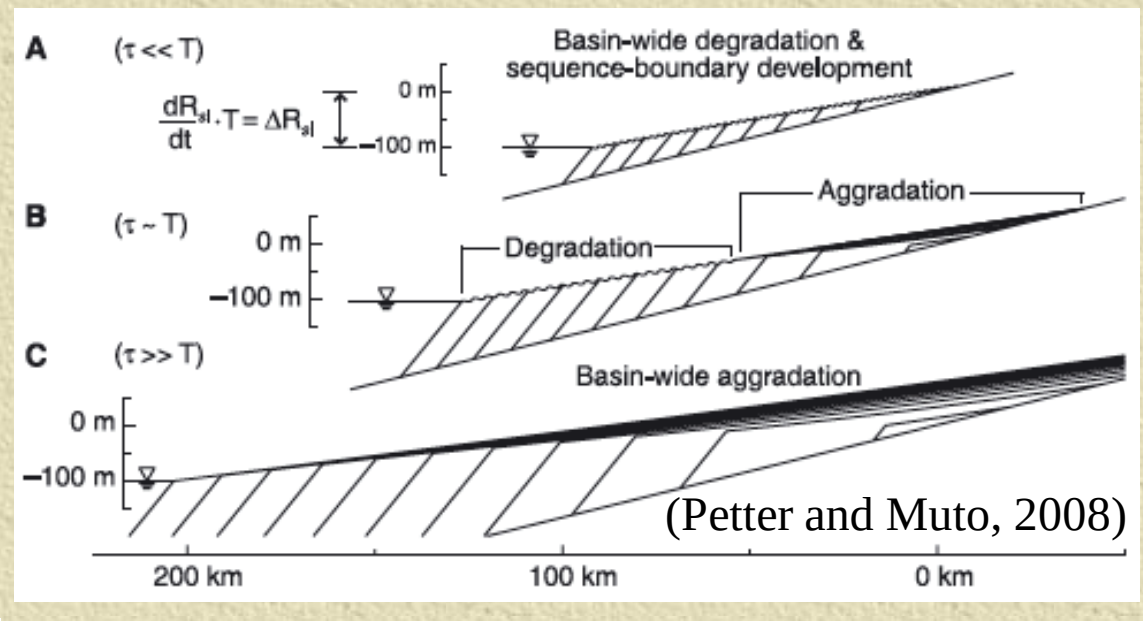
If SU is Cut-and-Cover Diastem

Sand storage equal for Fluvial and Marine

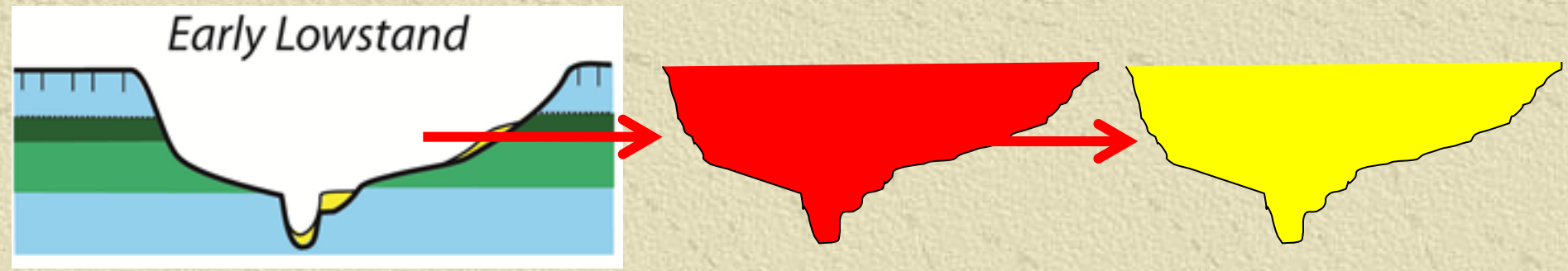
If SU is Bypass Unconformity

Marine Sand, Minor Fluvial Sand Storage

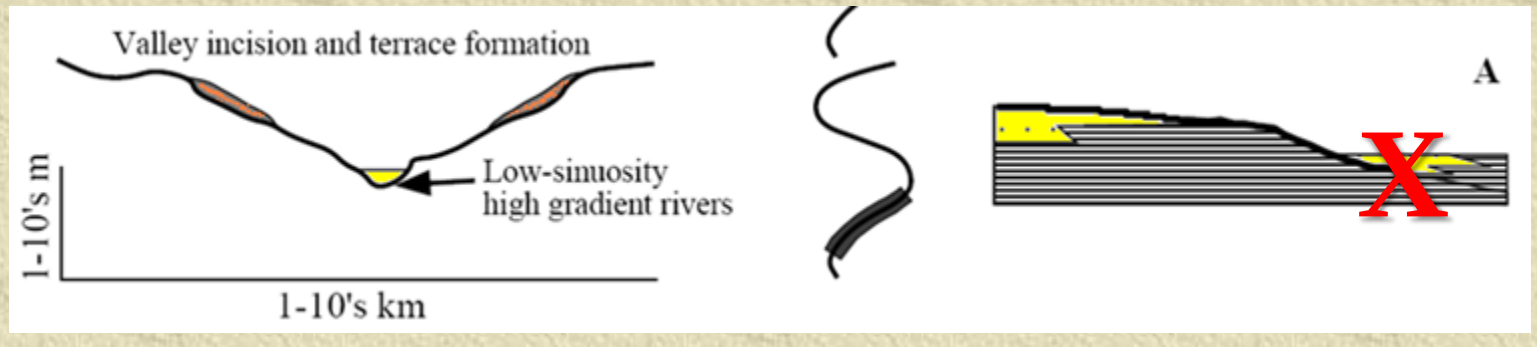
Autodetachment?



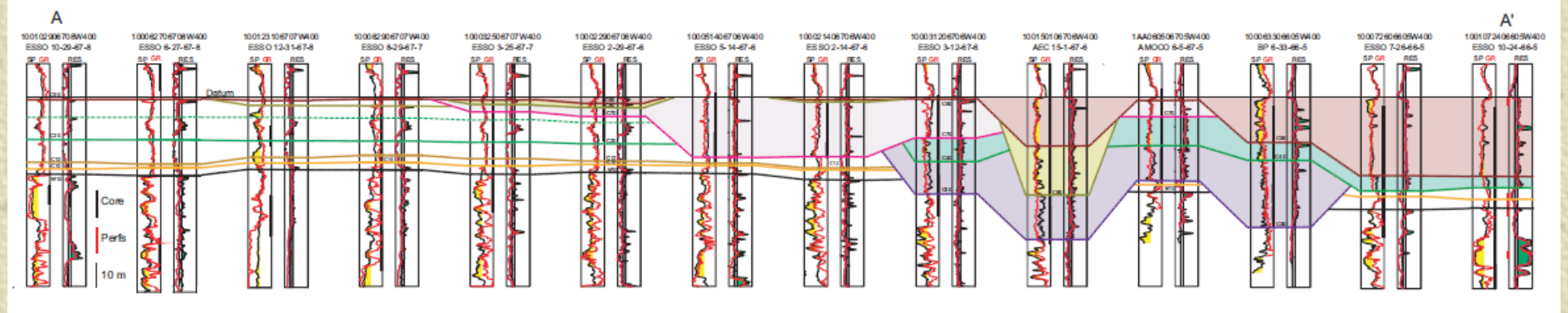
(Petter and Muto, 2008)

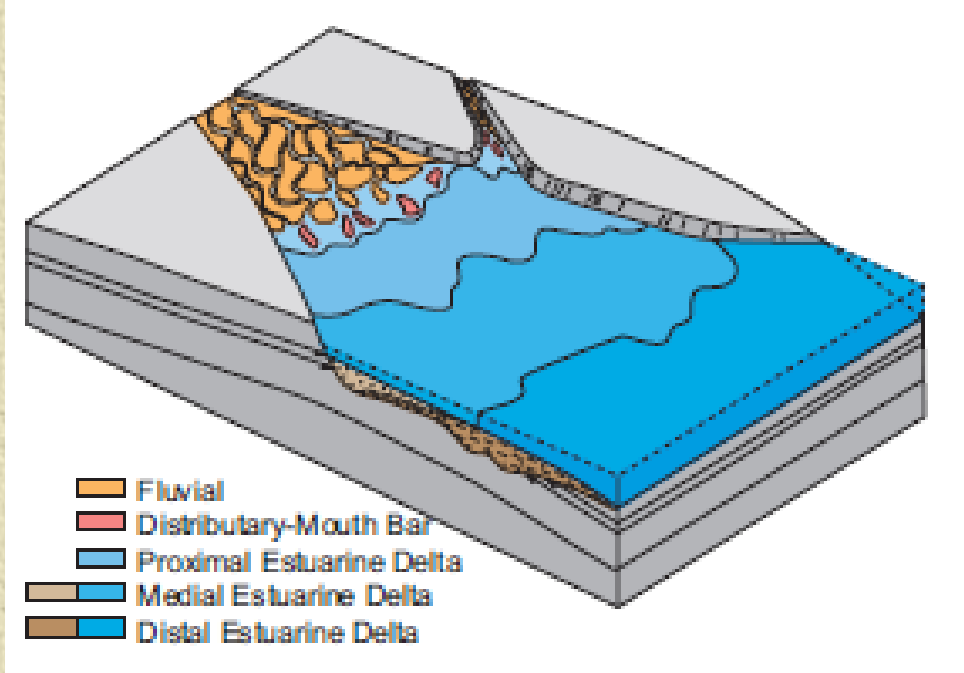


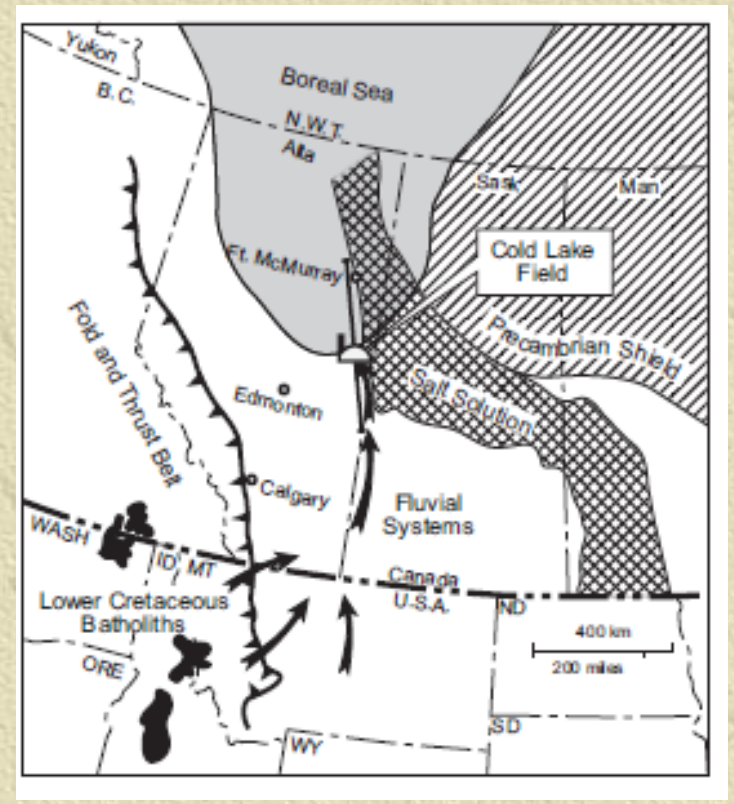
Sand Autodetachment?



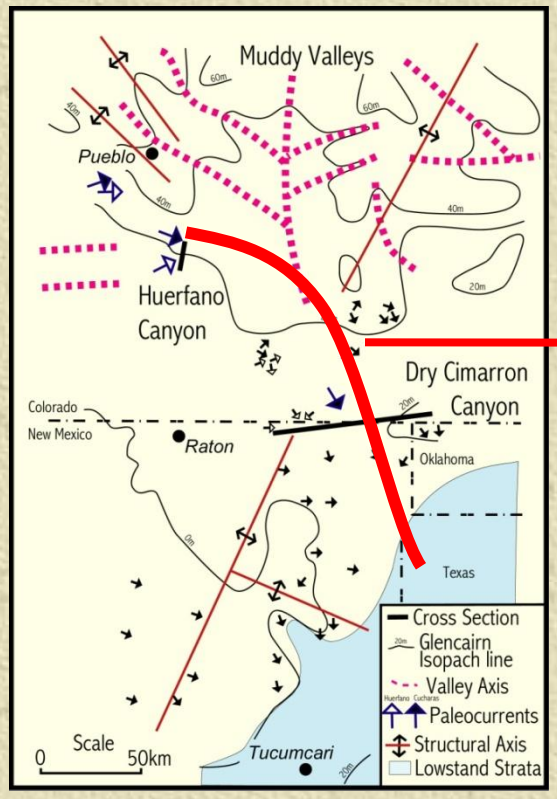
Terminal Estuaries in the K Clearwater Fm, Canada

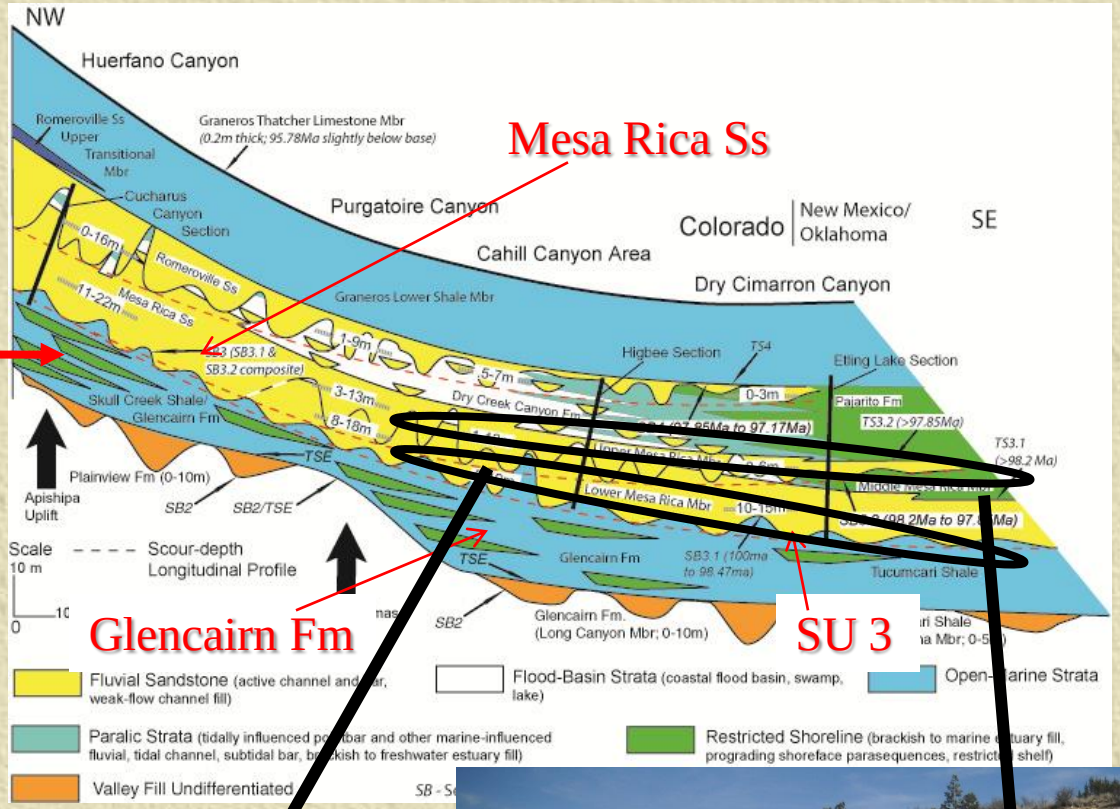






(Feldman et al., 2008)



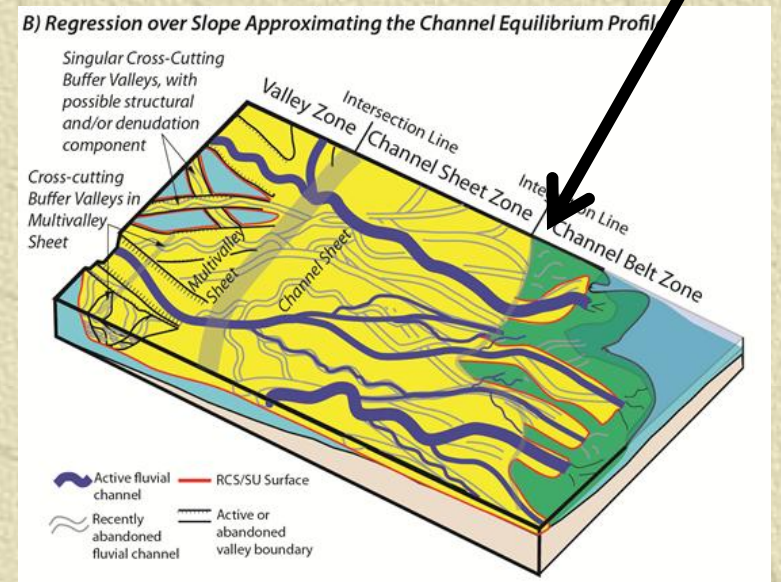


Glencairn Fm

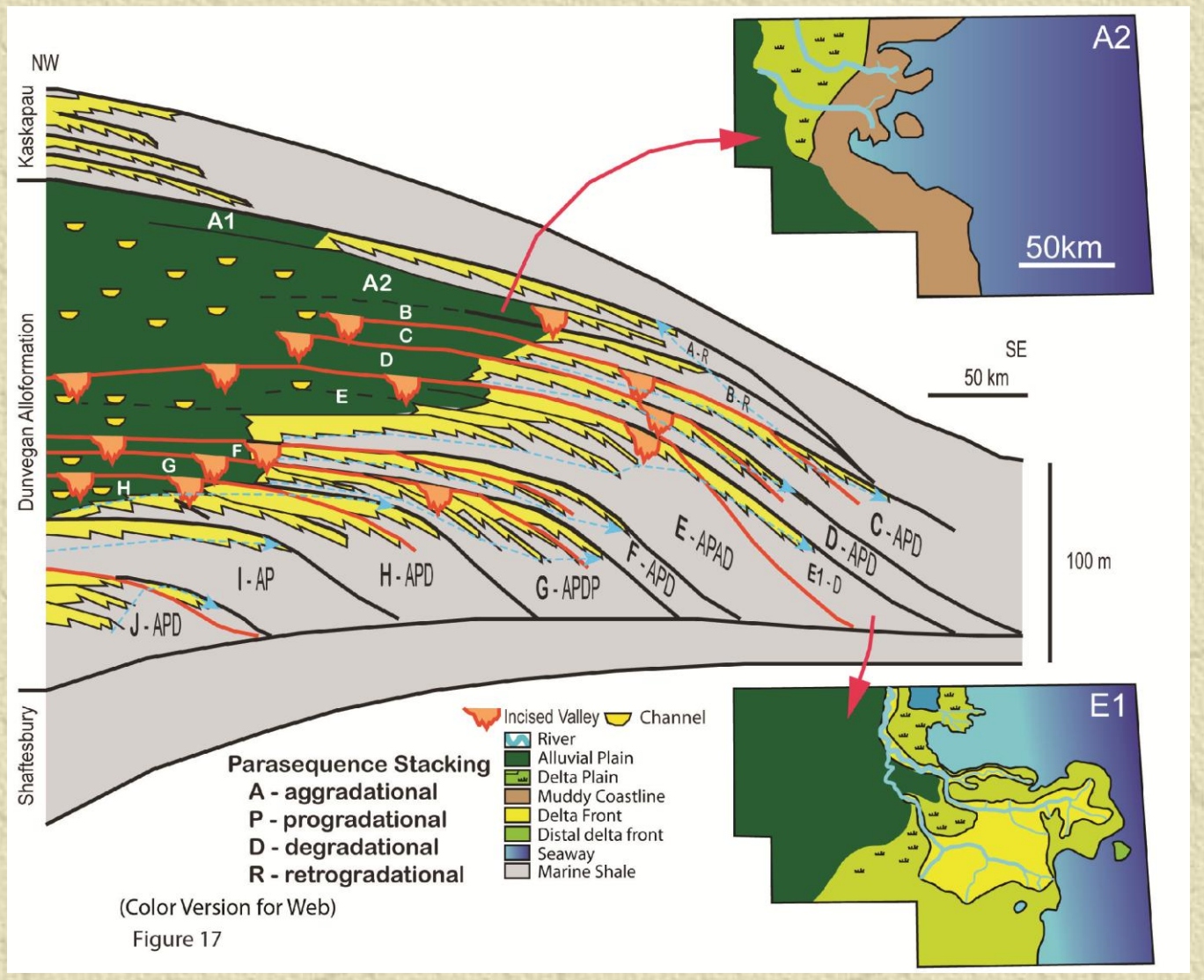
Mesa Rica Ss

SU 3

(Holbrook, et al., 2006)

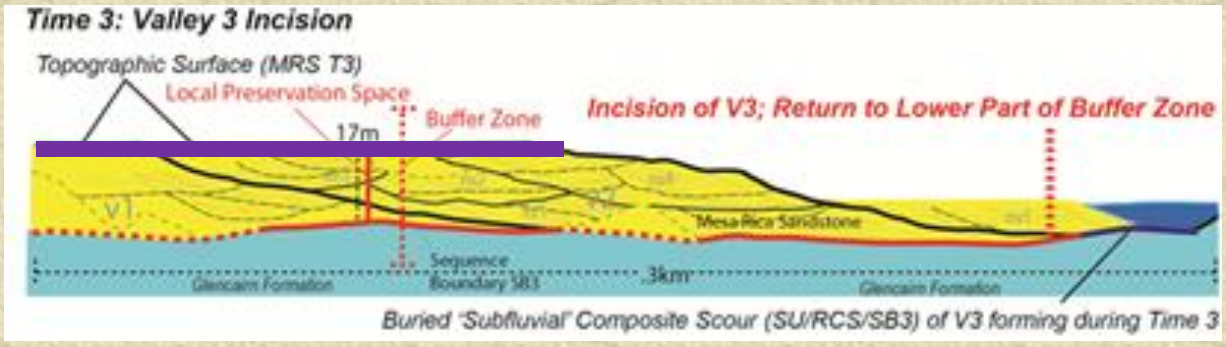


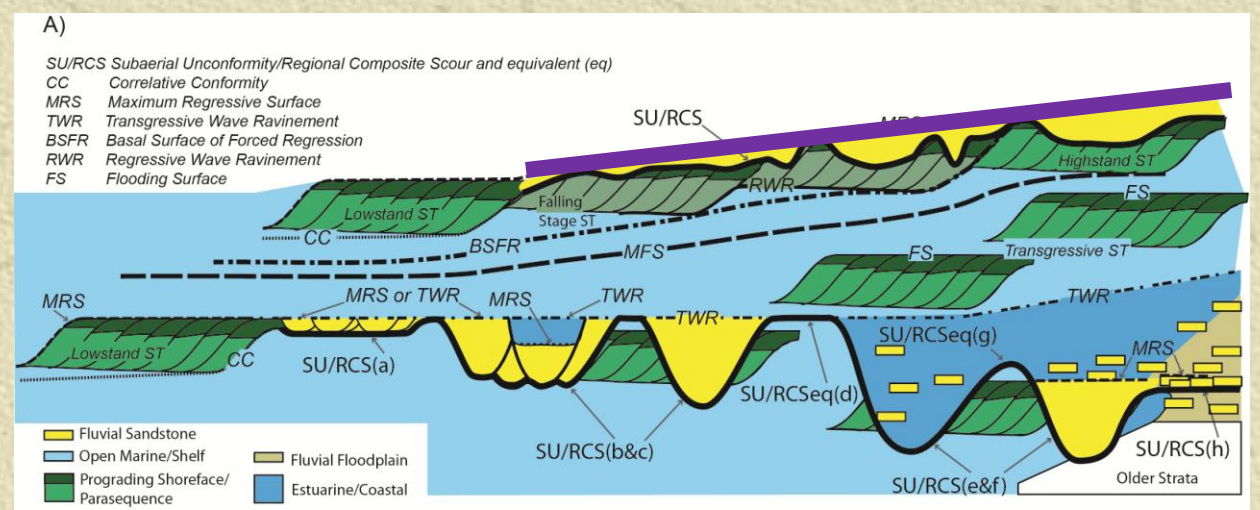
Variation in Shoreline Sand Preservation
K Dunvegan Fm, Alberta



(Holbrook and Bhattacharya, 2012)

(Holbrook and Bhattacharya, 2012)





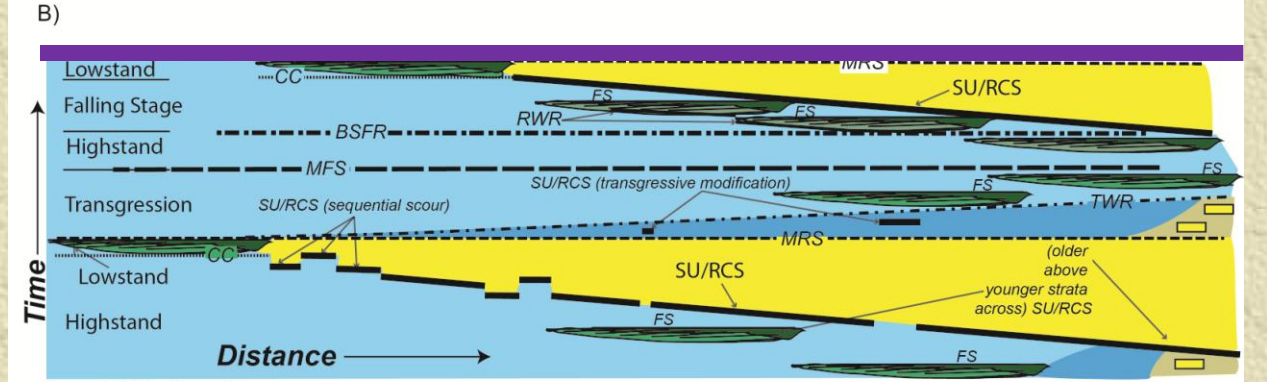
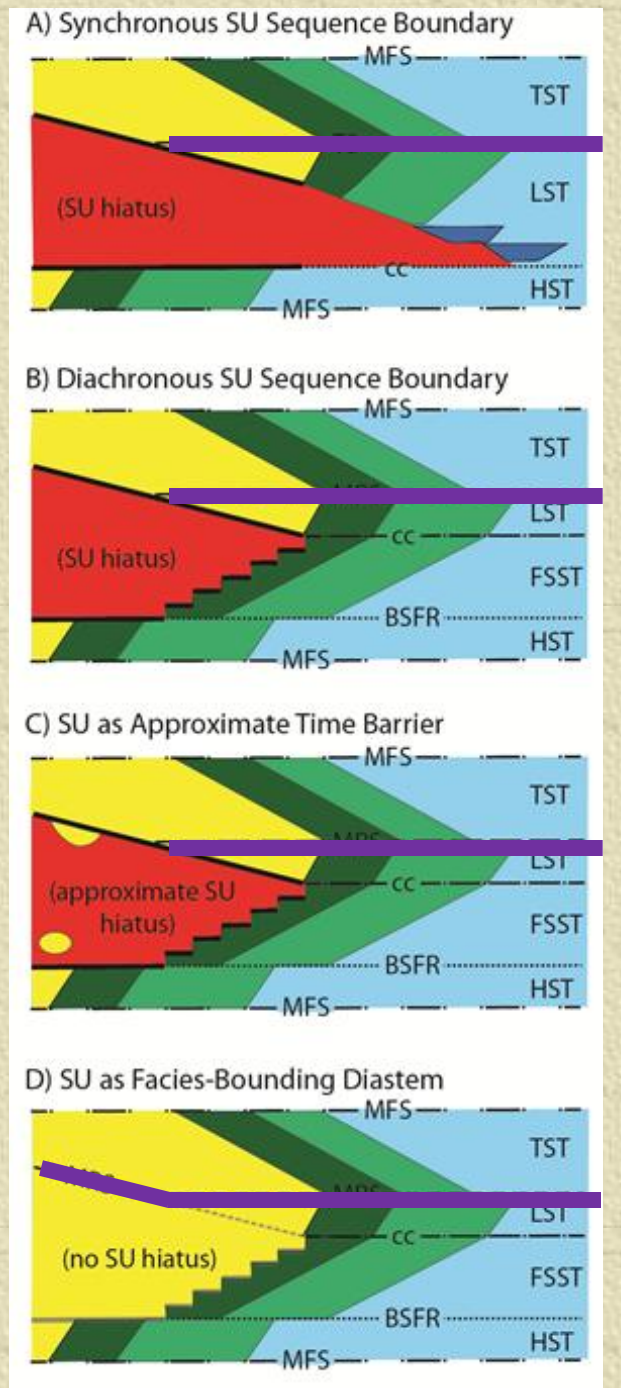
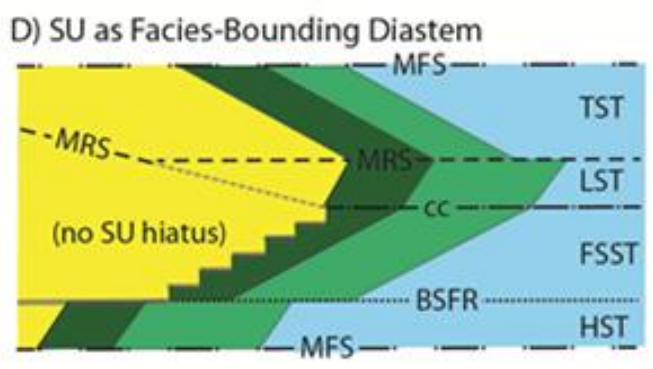


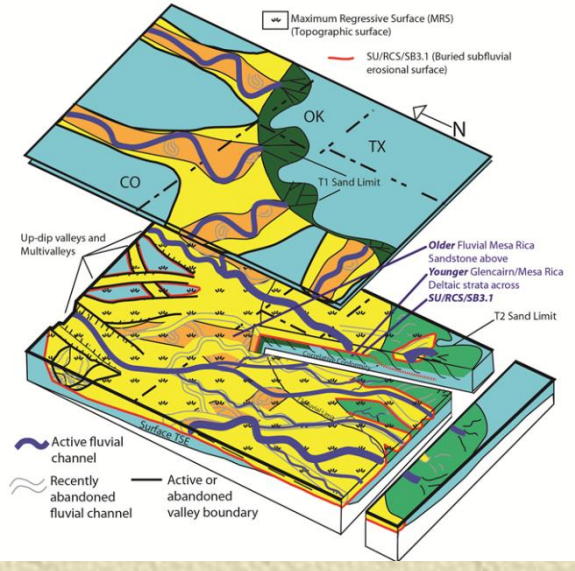
Figure 1 (Color for web)



Conclusions



SU is probably not a bypass surface or unconformity



Falling and lowstand fluvial sand storage can be high to the expense, and possible autodetachment, of marine reservoirs

MRS is probably a better correlation surface than given credit