Fluvial-Tidal Sandbody Relationships in the "Nonmarine" Iles Formation near Rangely, Colorado*

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Abstract

Tidal influence has been rarely reported in the geologic literature in the nonmarine portions of the Upper Mesaverde Group in the Piceance and Uinta basins. However, a detailed field study of the nonmarine Iles Formation north of Rangely, CO, finds a number of tidal indicators, including paleocurrents in the landward direction, mud drapes and double mud drapes, and sigmodial cross-stratification. Tidal influence is strong within the field area despite its location 60 to 70 km to the closest transgression of the Iles shoreline. Tidal units in the field area occur in six sandbody types: tidal bars, tidally influenced channel fills, fill-and-spill channels, tidally influenced splays, tidal constructional bars, and tidally influenced braided complexes. Fluvially dominated sandbody units are also present within the field area, including point bars, fluvial channel fills, fluvial constructional bars, and minor crevasse splays and channels.

A cyclical pattern of tidal influence is observed in the field area. The lower portion of the field area is strongly tidally dominated. Tidal influence decreases upwards with the middle portion of the field area exhibiting fluvial dominance. The upper portion of the field area shows evidence of increasing tidal influence. This cycle is linked to the migration of relative sea level. Multiple cycles of mudstone to sandstone dominance are also observed within the field area. These cycles occurred on a shorter time scale and represent the migration of the main channel belt in and out of the area. Strata in the field area are correlated into the Cozzette and Rollins members based on the cycles of tidal influence, amalgamation of sandstone units, and evidence of lengthy subaerial exposure.

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Rocky Mt Section AAPG

June 29, 2011

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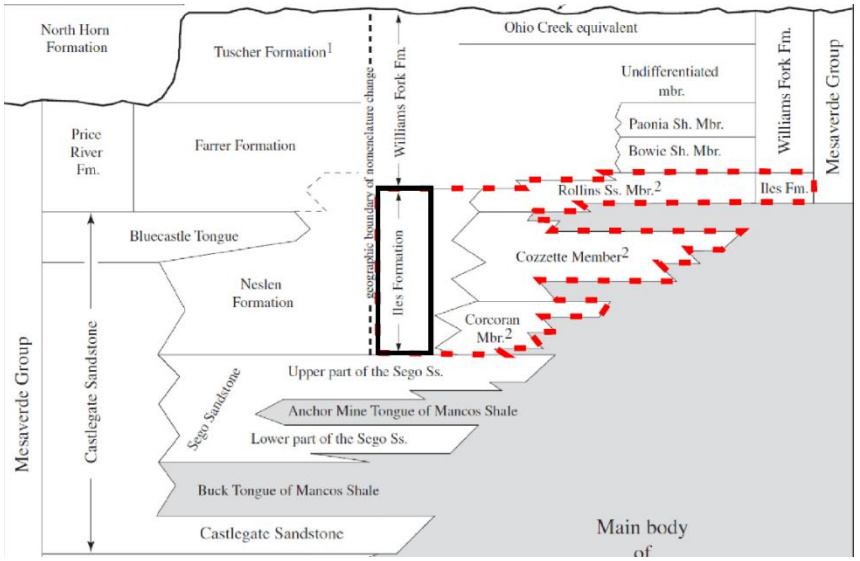
Objectives

- What types of sandbodies are present within the field area?
- How do they vary in geometry and facies architecture?
- How did the depositional environment change over time?
  - Signs of tidal influence?
- What are sequence stratigraphic implications?
  - Correlation with marine members of the Iles Formation?

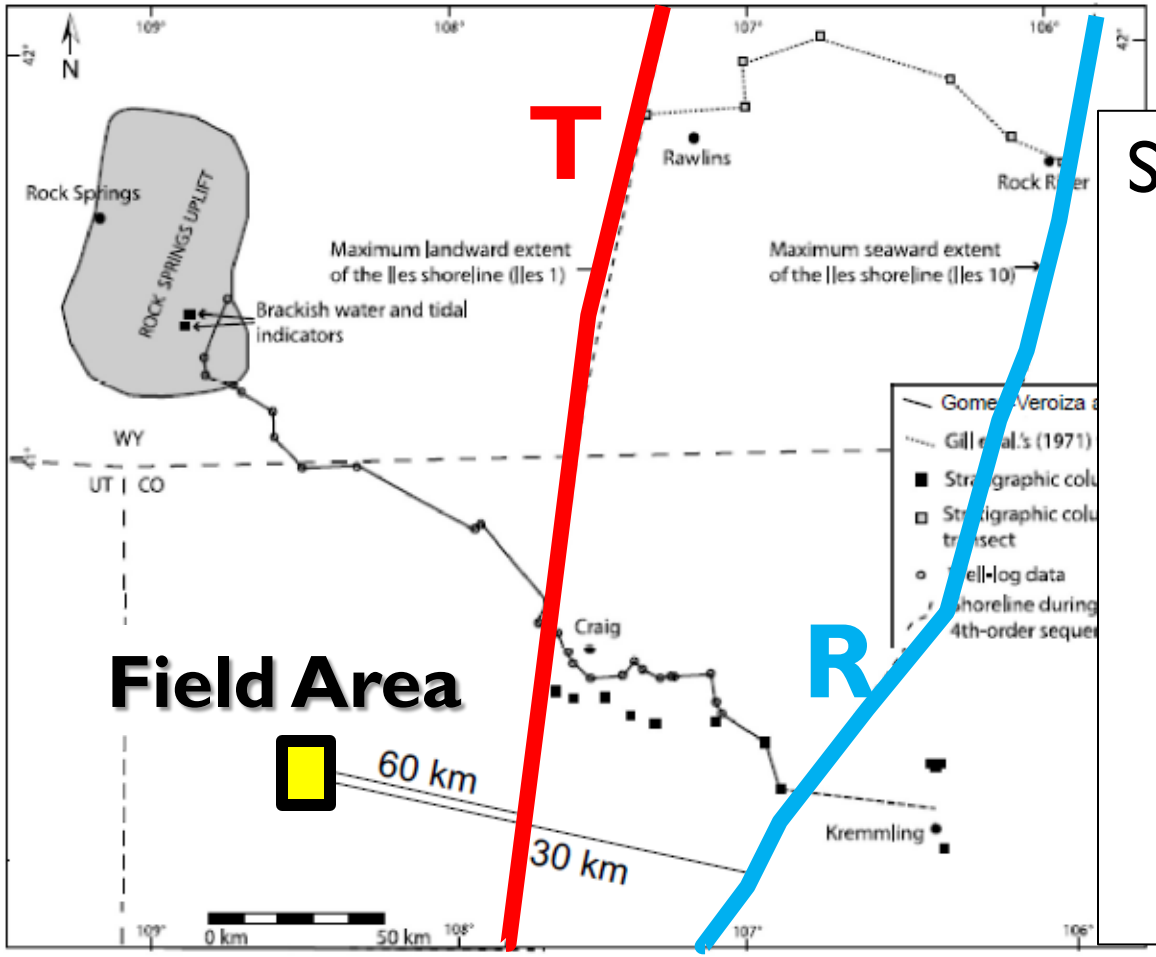
Iles Formation

- Late Campanian (76-70 Ma)
- Mesaverde Group
  - Above Sego Sandstone
  - Below Williams Fork Formation
- Three members (marine shoreface units)
  - Corcoran (lower)
  - Cozzette (middle)
  - Rollins (upper)
- Near Rangely (this study)
  - Lower Unit
  - Coal Unit
    - Main Coal Zone (middle)
  - Upper Unit
  - Described as "nonmarine"



From Hettinger and Kirschbaum (2002)

Iles Formation Shorelines

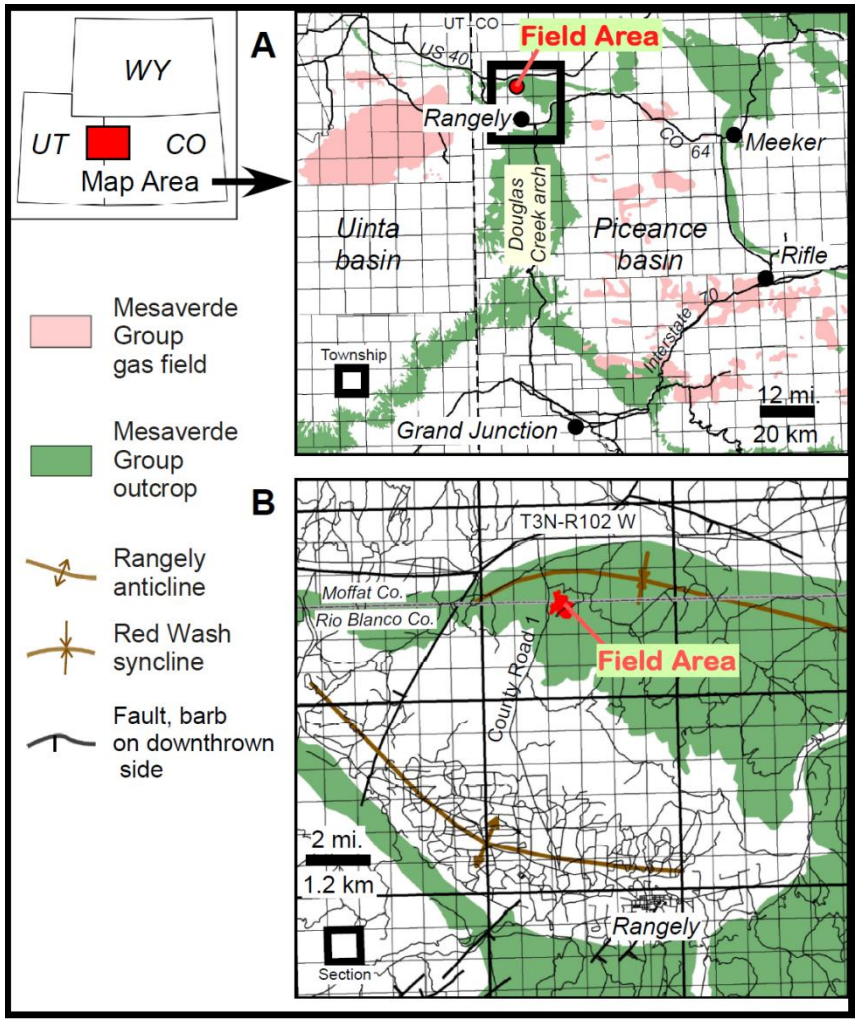


Study Area is 60 to 130 km NNW of Projected Max Transgressive and Max Regressive Iles Shorelines, Respectively

Modified from Gomez-Veroiza and Steel (2010)

Regional Location of Field Area

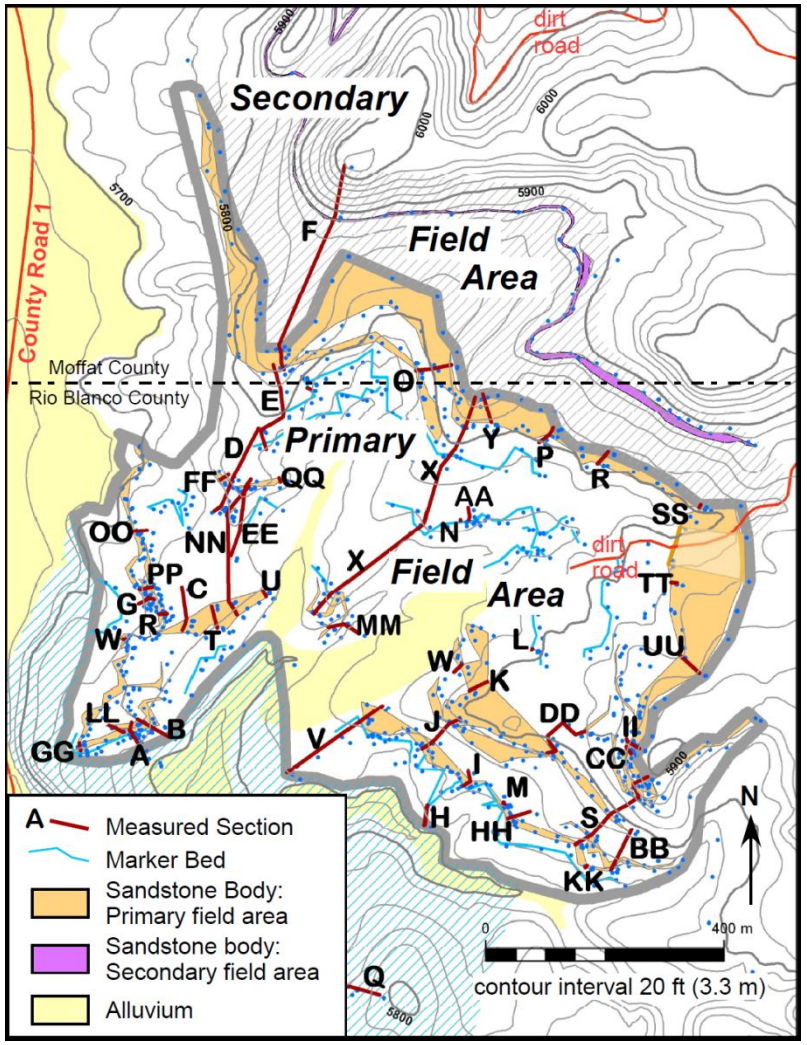
- Northwest Colorado
  - 13 km north of Rangely
- North of Douglas Creek Arch
- North flank of Rangely Anticline, south flank of Red Wash Syncline



Modified from Green (1992), Sprinkel (1999) and Wray et al. (2005)

Field Area Detail

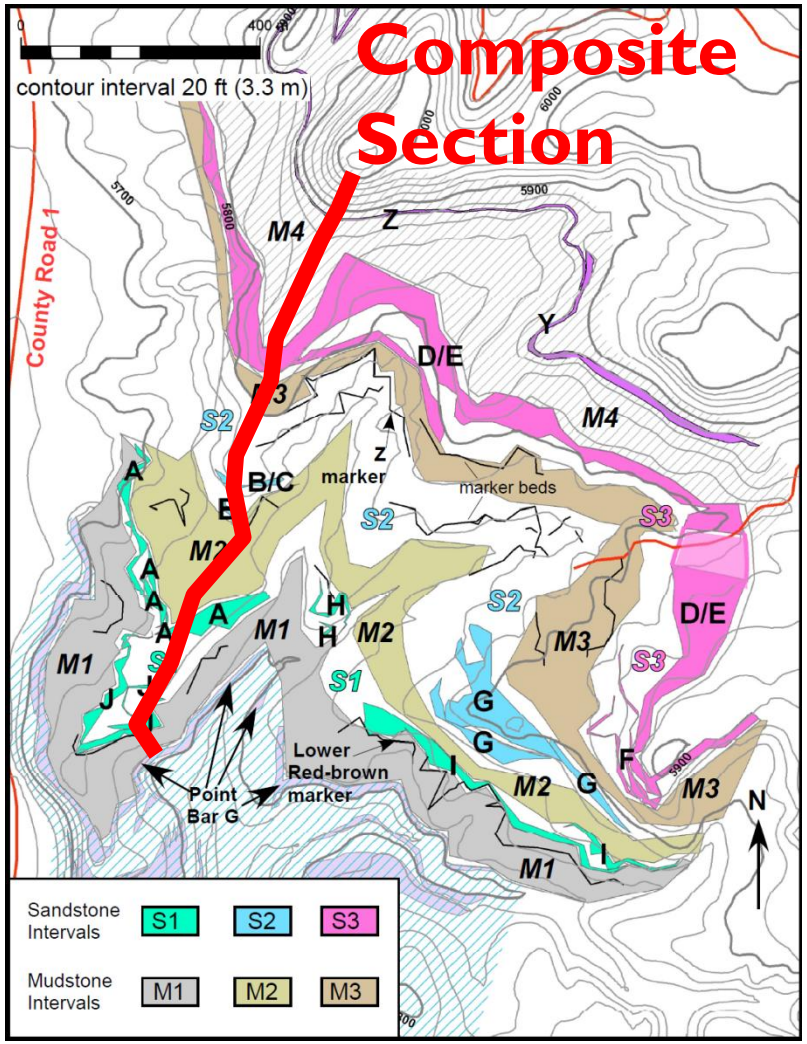
- ~1 sq. km
- ~97 m stratigraphic thickness
  - Above area studied by Anderson (2005)
- Lower ~50 m
  - 8 major sandbodies
    - 23 subbodies
  - 11 thin sandstone units
- Structural dips of 3° NNE

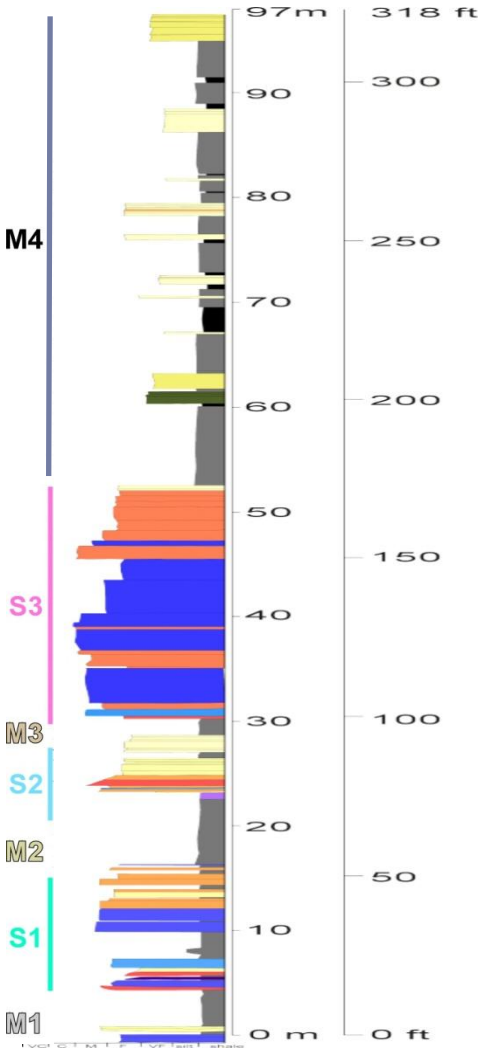


Methods

- GPS Mapping
  - 1:500 scale in 1 km^2
  - >900 waypoints on contacts, marker beds, fossil localities
  - ArcGIS on DEM
- 48 measured sections
  - 1:20 scale
  - 16 Lithofacies (emphasized sandstone)
- 10x V.E. Cross-sections
  - Maps of facies architecture for 8 major and 11 minor sandbodies
  - Calculated facies proportions for each body

Stratigraphic Intervals





3 Sandstone-rich Intervals containing major sandbodies, Separated BY: 4 Mudstone-rich Intervals: Lower 3 lack Coal, Upper (M4) is coal-rich Capped at top by "coal marker sandstones" correlated to base of Williams Fork by Brownfield et al., 2000

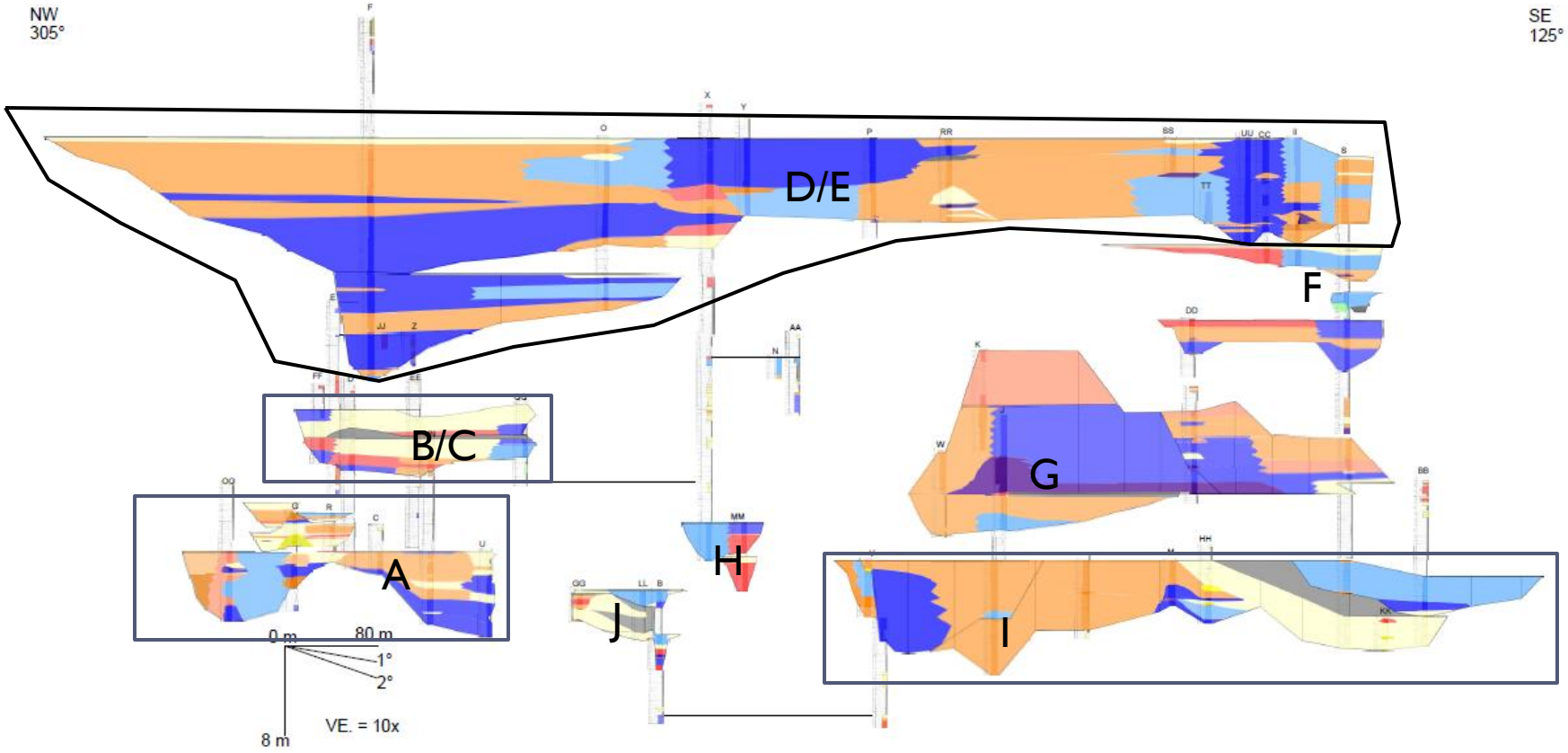
Facies

Color	Facies Name	Characteristics	Interpretation	Facies Association
	Coal	organic material from terrestrial plants	floodplain lake/marsh	Floodplain
	Organic-rich mudstone	organic-rich mud, plant fragments and root traces	shallow floodplain lake/marsh	Floodplain
	Undiffentiated mudstone	mud and silt sized grains, plant and vertebrate fossils common	overbank and abandonment deposits	Floodplain, Channelbelt
	Root-trace dominated sandstone	abundant root traces, lower very fine to lower fine sand	highly rooted, bioturbation index 5	Floodplain
	Bioturbated sandstone	vertical and horizontal burrows, upper very fine sand	highly burrowed, bioturbation index 3-4	Floodplain
	Wave-rippled sandstone	symmetrical ripples, vertical burrows, medium very fine sand	wave ripples in floodplain lake	Floodplain
	Mud-draped current-rippled sandstone	mud-draped, sigmoid shape ripples, upper fine to lower medium sand	tidally modified low velocity traction flow	Channelbelt
	Current-rippled sandstone	current ripples, lower very fine to lower medium sand	low energy traction flow	Floodplain, Channelbelt
	Climbing-rippled sandstone	climbing ripples, upper very fine to upper fine sand	low energy traction flow with high deposition rate	Channelbelt
	Mud-draped planar tabular cross-stratified sandstone	mud-draped, planar tabular cross-strata, lower fine to lower medium sand	moderately high velocity traction flow with periodic hiatuses	Floodplain, Channelbelt
	Sigmodial cross-stratified sandstone	35 cm thick sigmodial cross-sets, lower fine sand	moderately high velocity traction flow with subordinate current direction	Channelbelt
	Convolute sandstone	convolute laminations, upper very fine to lower medium sand	post-depositional liquification	Floodplain, Channelbelt
	Structureless sandstone	no sedimentary stuctures, lower very fine to lower medium sand	post-depositional liquification	Floodplain, Channelbelt
	Planar tabular cross-stratified sandstone	10 to 90 cm thick planar tabular cross-sets, lower very fine to lower medium sand	moderately high velocity traction flow	Floodplain, Channelbelt
	Trough cross-stratified sandstone	5 to 35 cm thick trough cross-sets, upper very fine to lower medium sand	high velocity traction flow	Floodplain, Channelbelt
	Mud-clast conglomerate	pebble to lower boulder mud clasts in very fine to fine sand matrix	very high energy traction flow (units with boulder sized clasts- bank collapse)	Channelbelt

Low energy

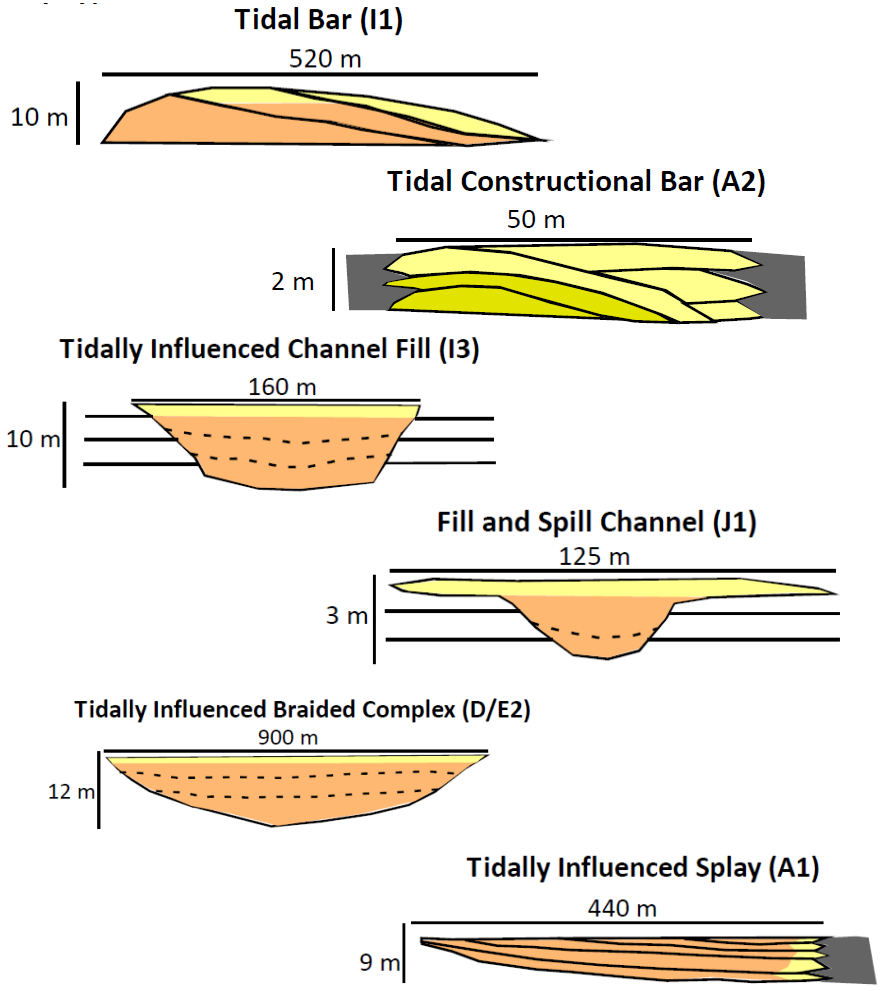
High energy

Sandbodies: Tidal & Fluvial Recognized

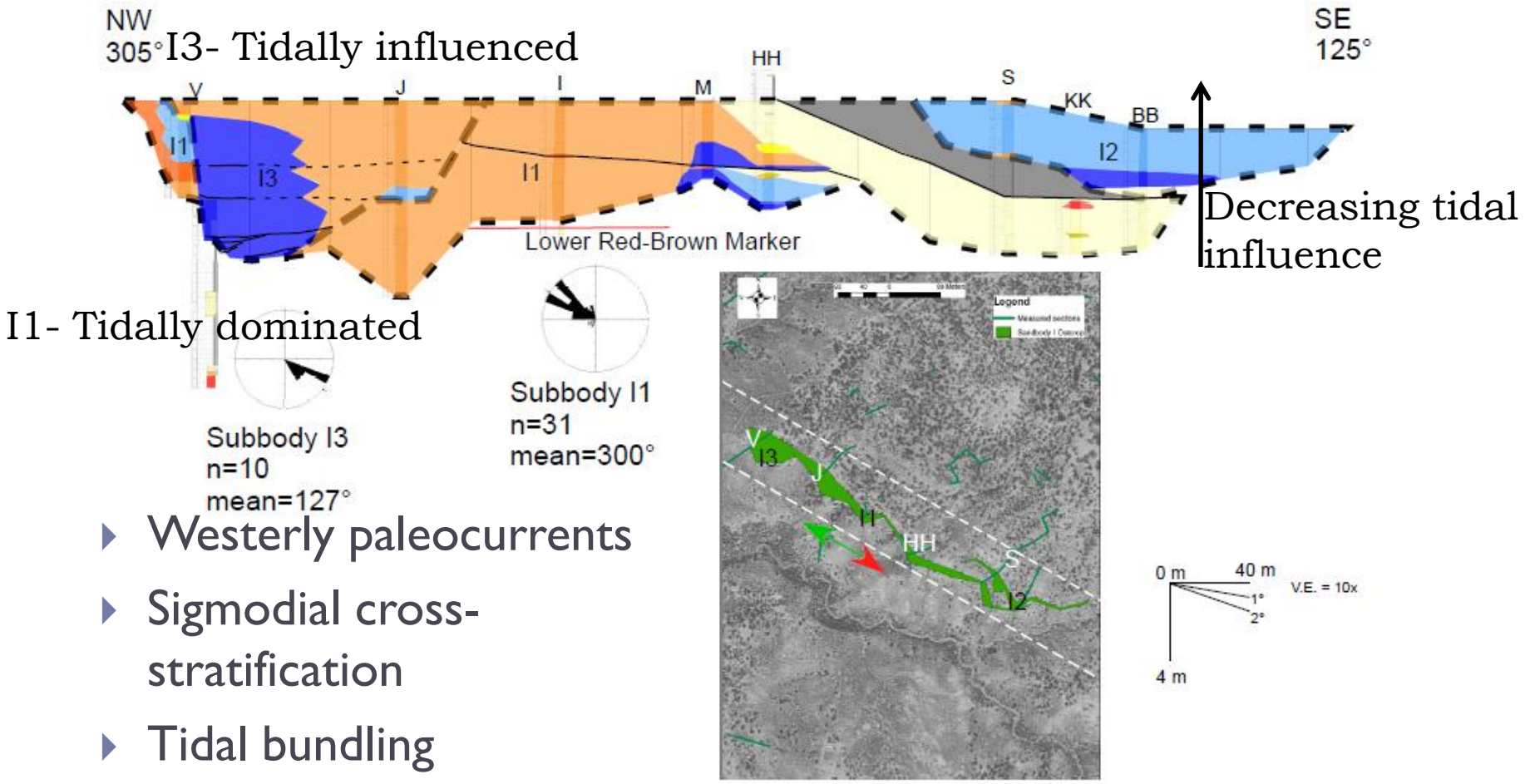


Tidally Influenced Sandbody Types

- Tidal Bars
  - 3 (Subbodies I1, I2, and J2)
- Tidal Constructional Bar
  - 1 (Subbody A2)
- Tidally Influenced Channels
  - 2 (Subbodies I3 and D/E1)
- Fill-and-Spill Channels
  - 2 (Subbodies J1 and J3)
- Tidally Influenced Braided Complex
  - 1 (Subbody D/E2)
- Tidally Influenced Splay
  - 1 (Subbody A1)

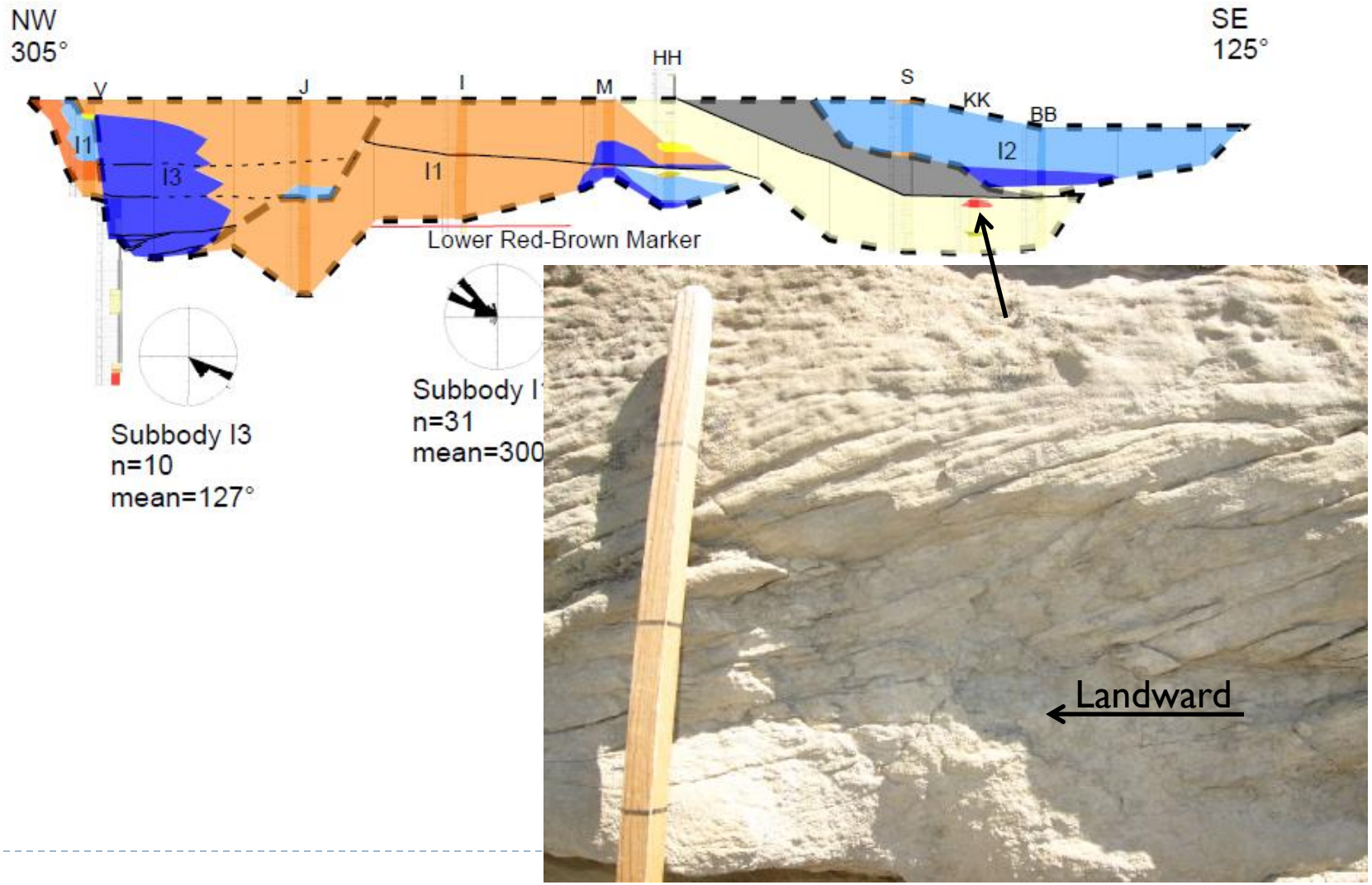


Sandbody I [S1 Interval] (Tidal bars/Tidally Influenced Channel Fill)



- Westerly paleocurrents
- Sigmodial cross-stratification
- Tidal bundling
- Mud drapes and double mud drapes

Sandbody I [S1 Interval] (Tidal bars/Tidally Influenced Channel Fill)



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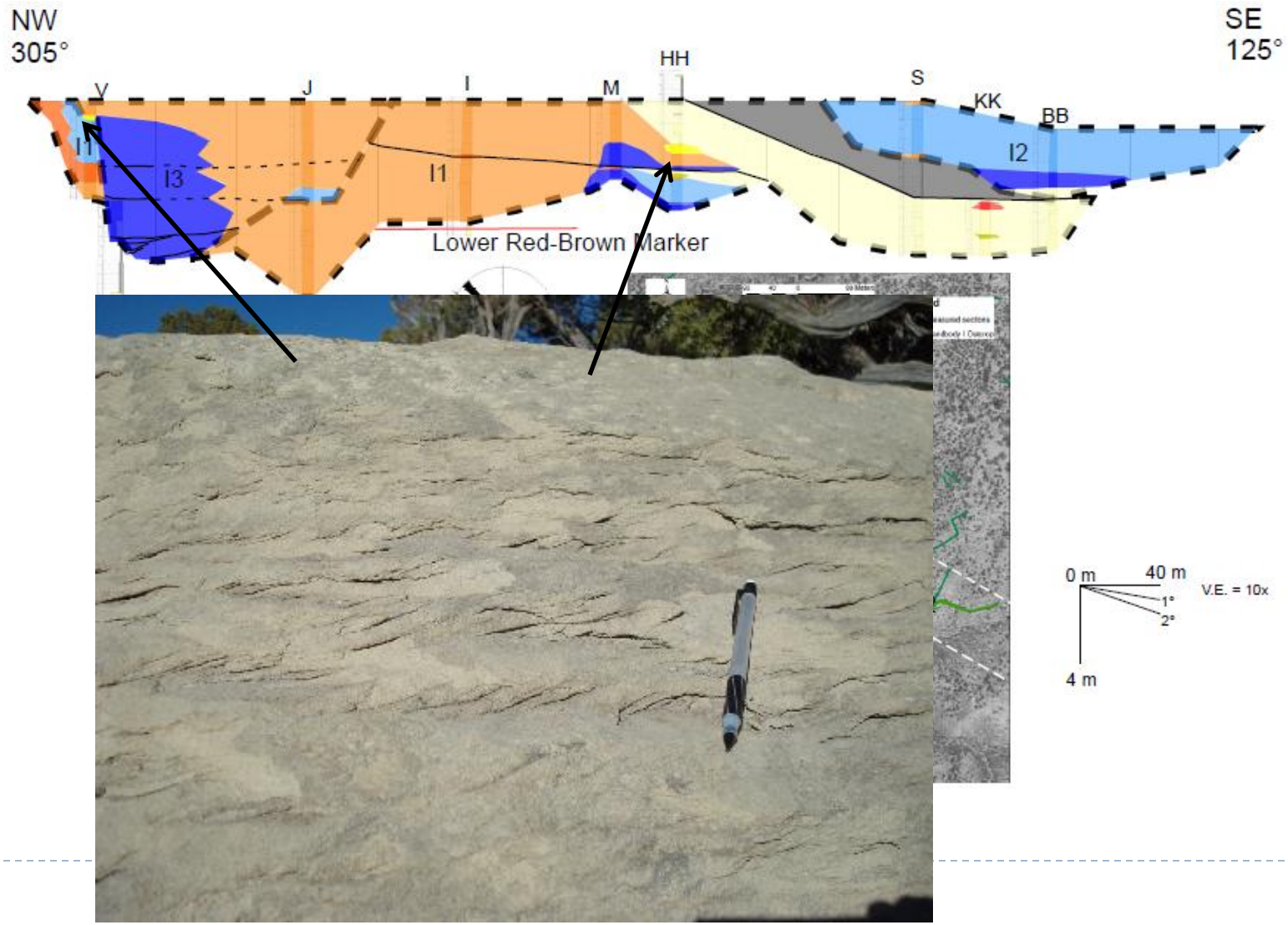
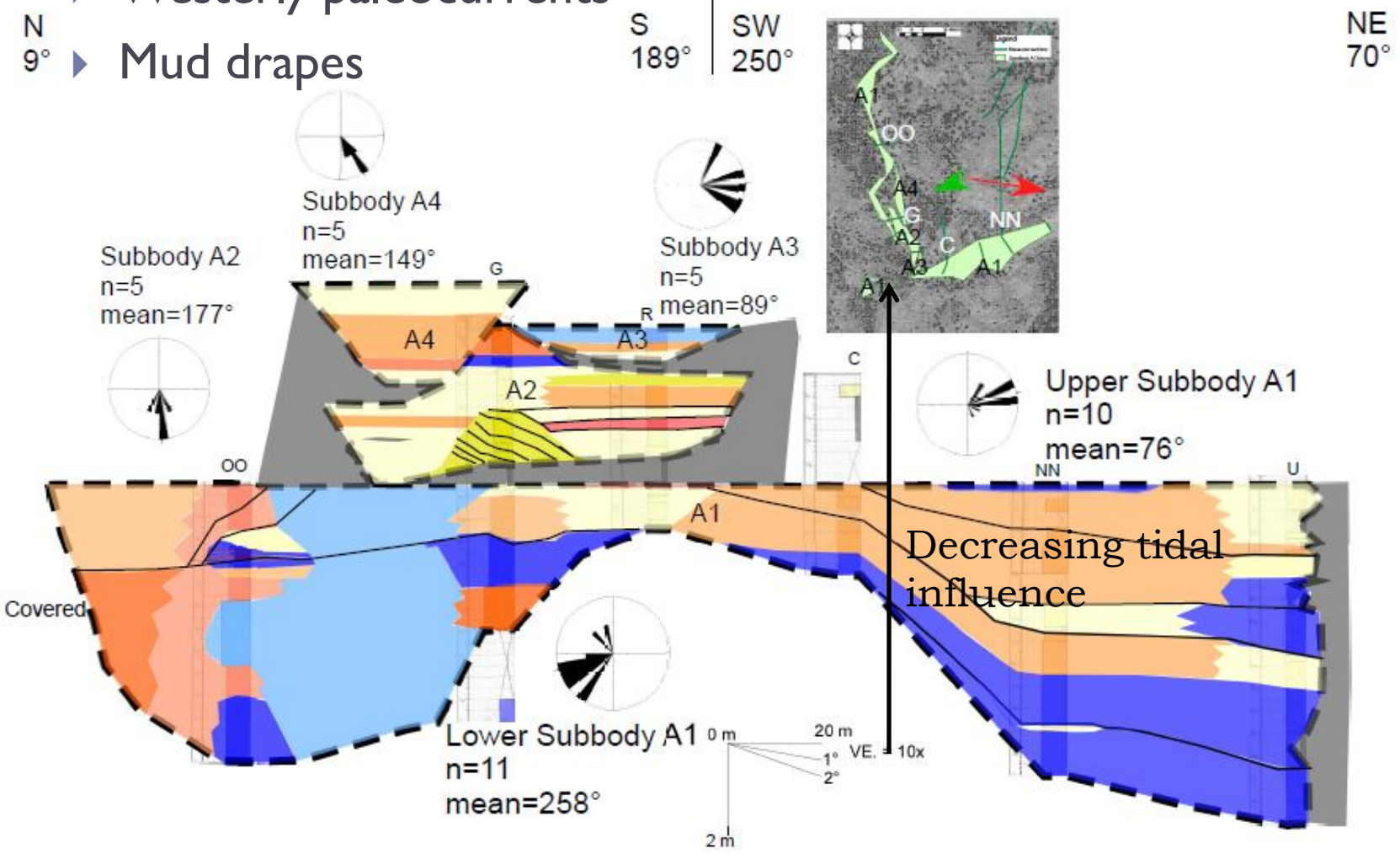
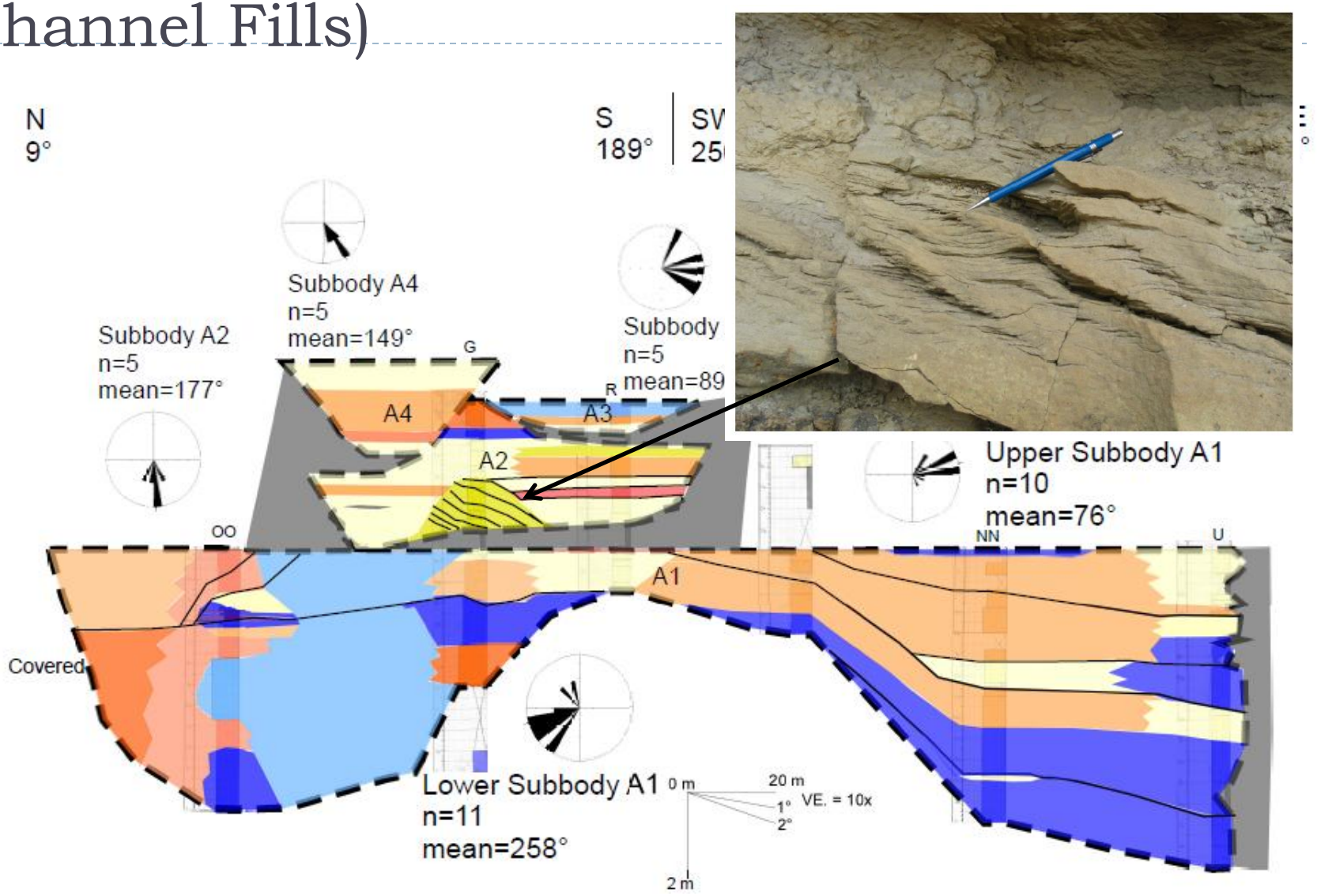


Sandbody A [S1 Interval] (Tidally Influenced Splay/Tidal Constructional Bar/Fluvial Channel Fills)

- Westerly paleocurrents
- Mud drapes

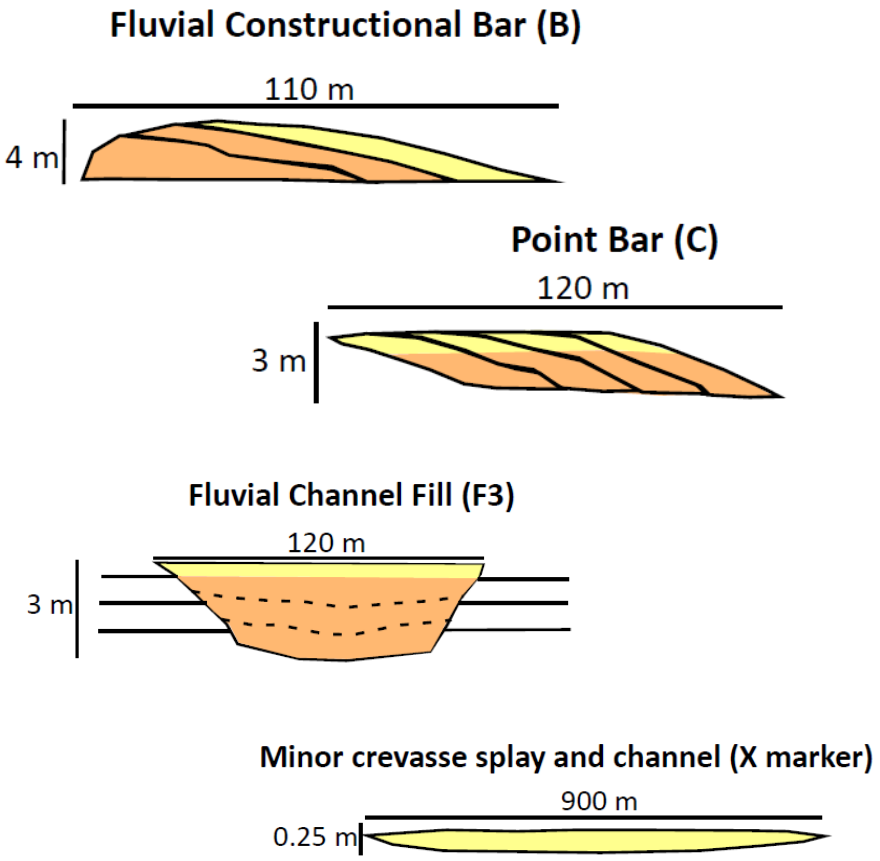


Sandbody A [S1 Interval] (Tidally Influenced Splay/Tidal Constructional Bar/Fluvial Channel Fills)

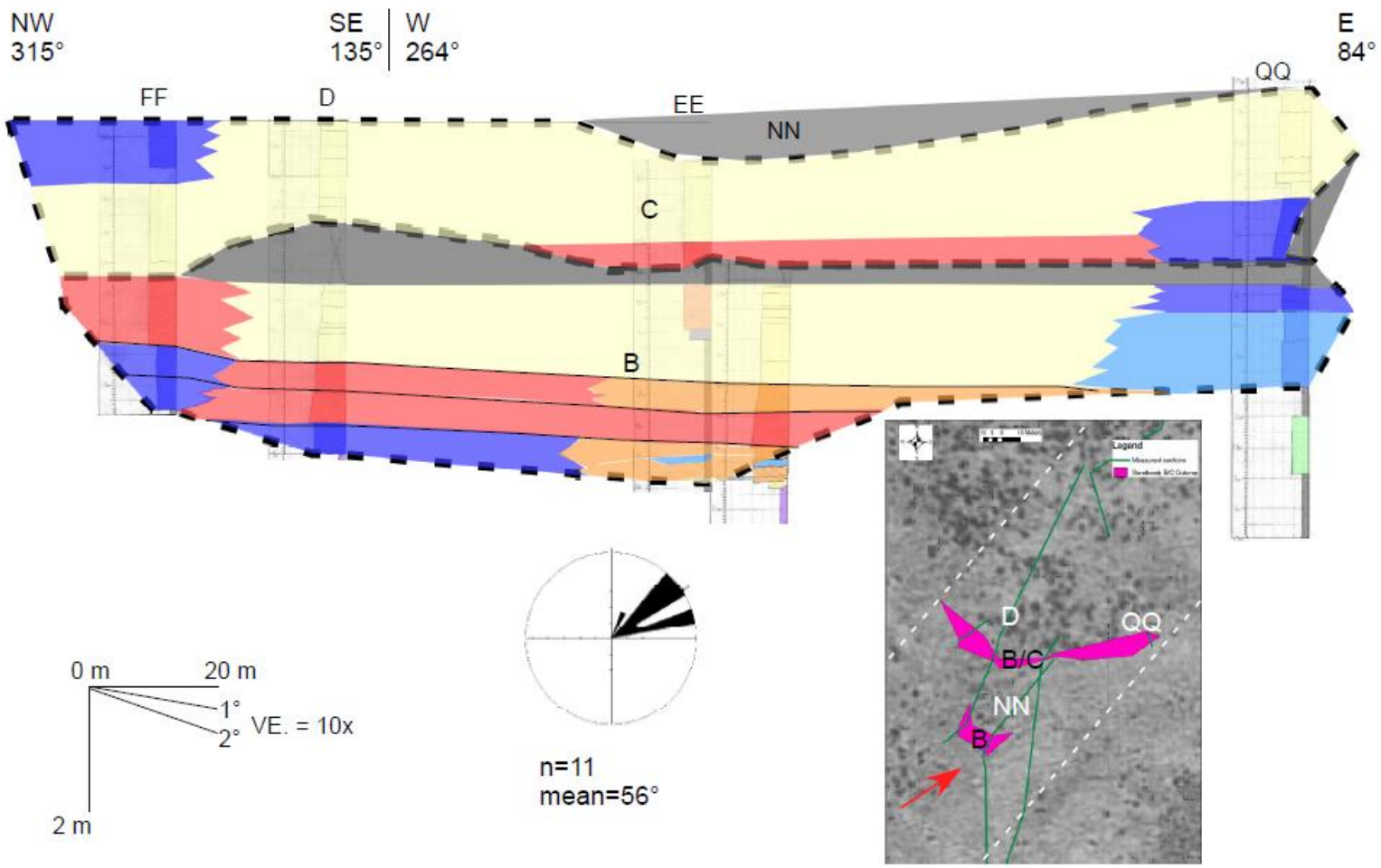


Fluvially Dominated Sandbody Types

- Fluvial Constructional Bars
  - 4 (Subbodies G2, G3, G4, and B)
- Point Bars
  - 1 (Subbody C)
- Fluvial Channel Fills
  - 8 (Subbodies A3, A4, H1, H2, G1, F1, F2, and F3)
- Minor Crevasse Splays and Channels
  - 11 (Minor Sandbodies)

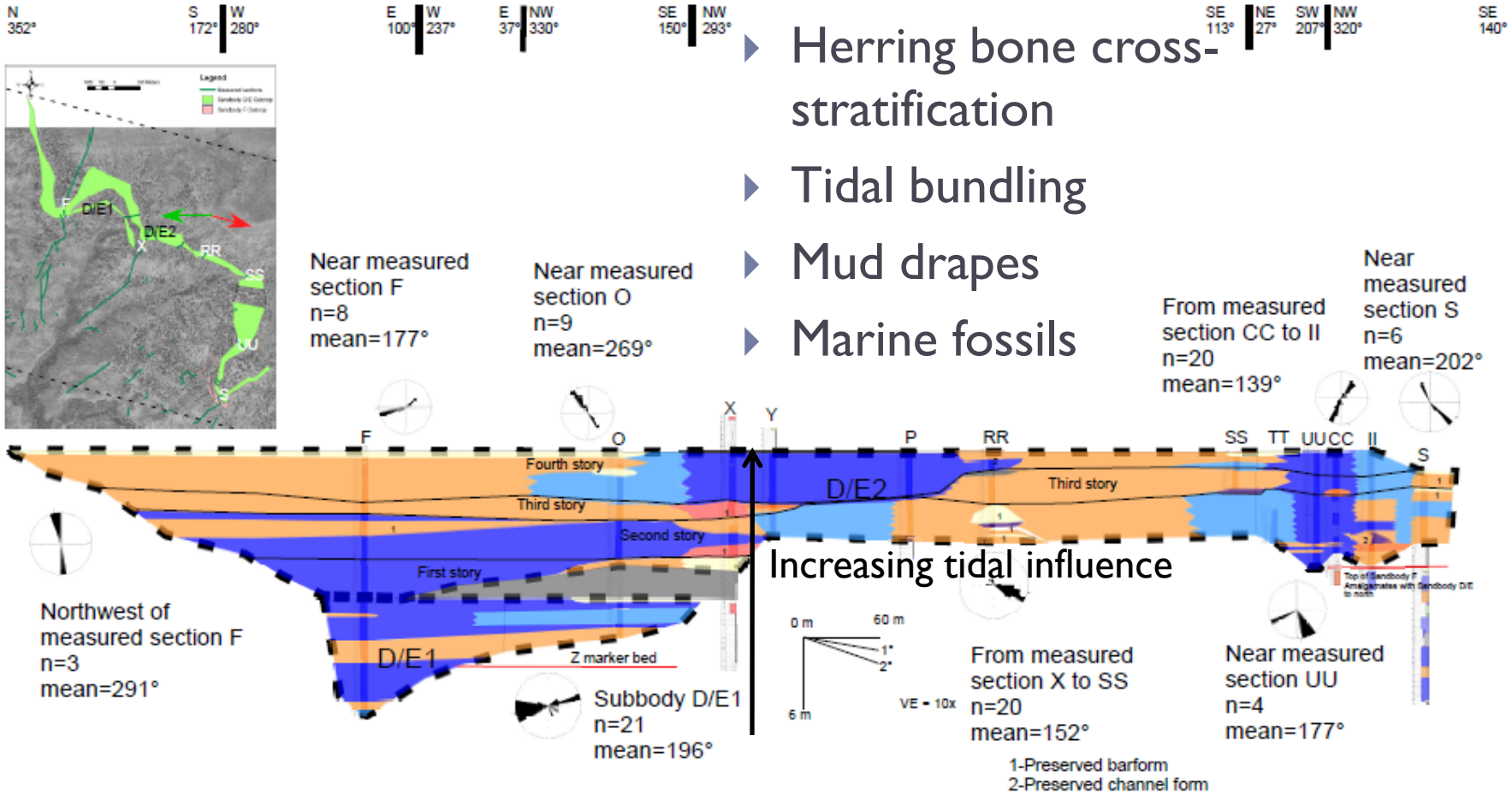


Sandbody B/C [S2 Interval] (Fluvial Constructional Bar/ Point Bar)

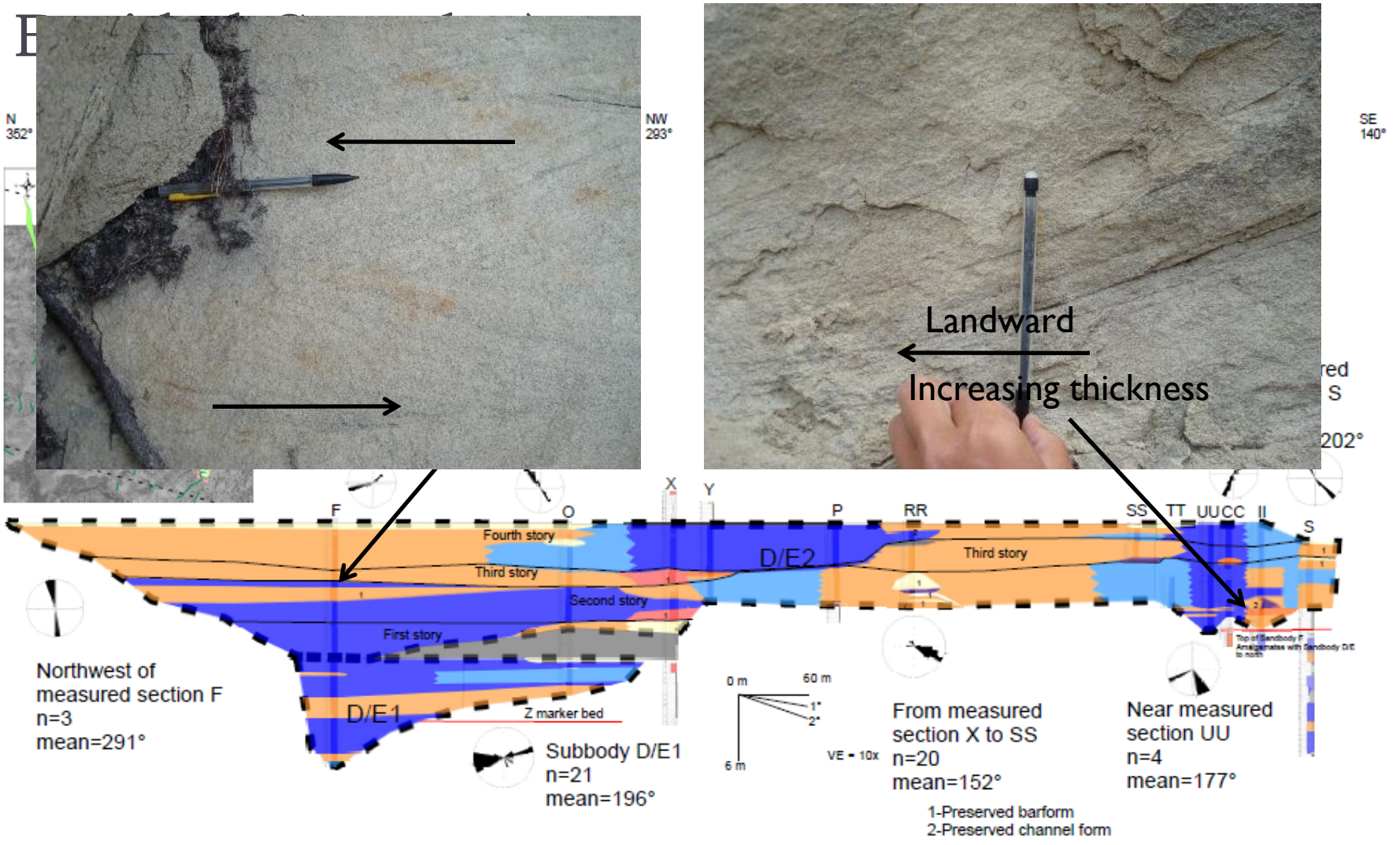


Sandbody D/E [S3 Interval] (Tidally Influenced Channel Fill/Tidally Influenced Braided Complex)

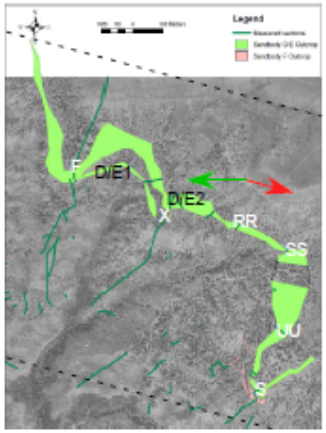
- Westerly paleocurrents
- Herring bone cross-stratification
- Tidal bundling
- Mud drapes
- Marine fossils



Sandbody D/E [S3 Interval] (Tidally Influenced Channel Fill/Tidally Influenced



Sandbody D/E [S3 Interval] (Tidally Influenced Channel Fill/Tidally Influenced Braided Com



N 352°
S 172°
W 280°
E 100
SE 113°
NE 27°
SW 207°
NW 320°
SE 140°

Near mea
section F
n=8
mean=177°

n=9
mean=269°

From measured
section CC to II
n=20
mean=139°

Near
measured
section S
n=6
mean=202°

F
O
X
Y
P
RR
SS
TT
UU
CC
II
S

Fourth story
Third story
Second story
First story
D/E2
Third story
D/E1
Z marker bed

Northwest of
measured section F
n=3
mean=291°

Subbody D/E1
n=21
mean=196°

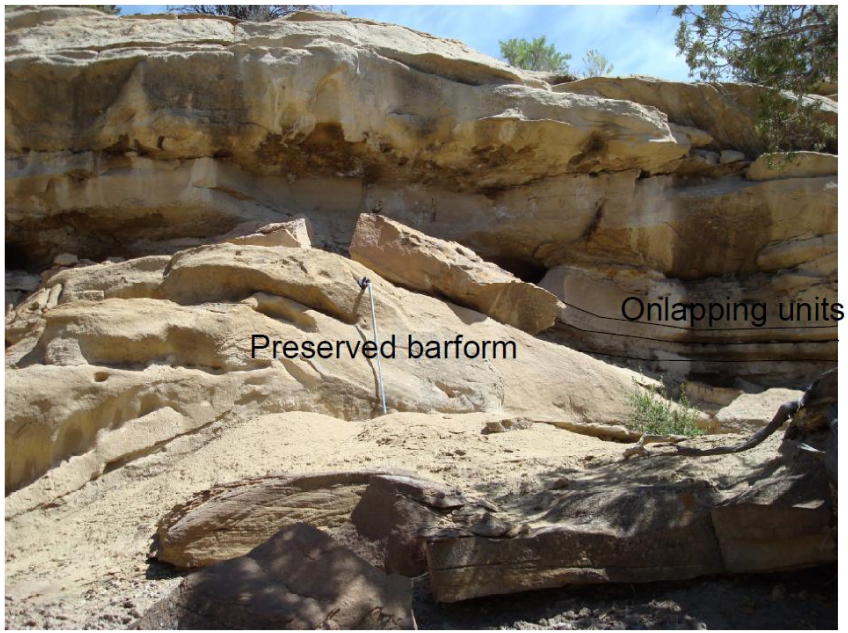
0 m
60 m
6 m
VE = 10x

From measured
section X to SS
n=20
mean=152°

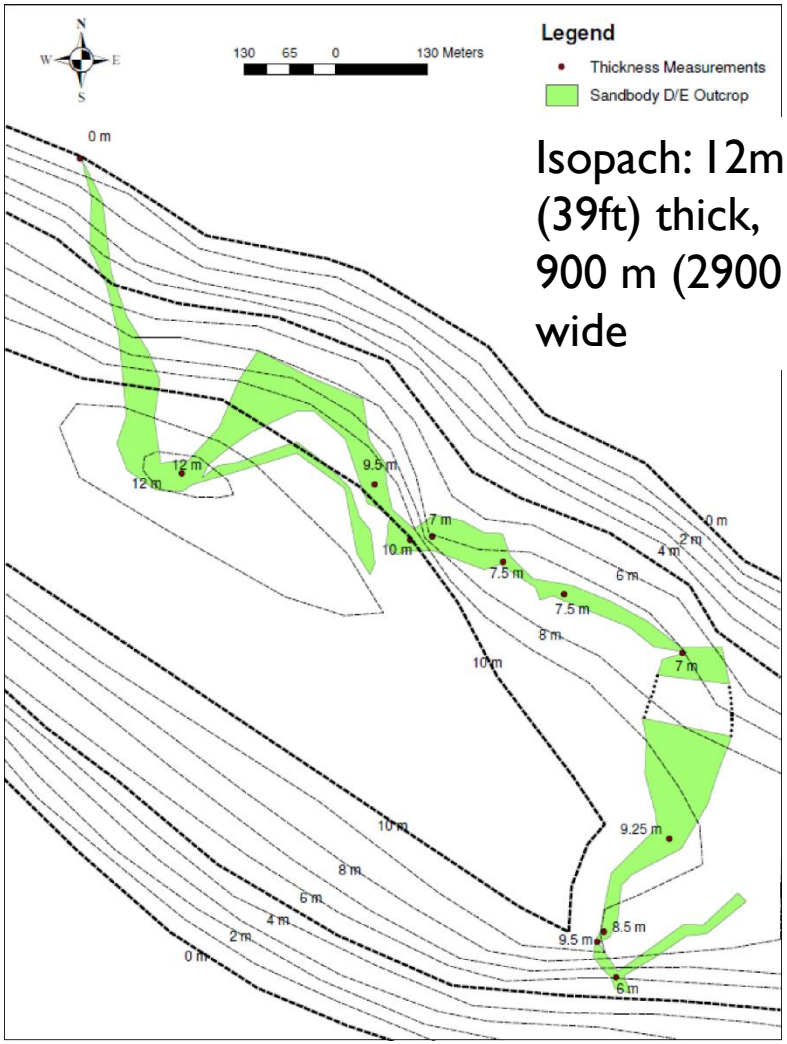
Near measured
section UU
n=4
mean=177°

1-Preserved barform
2-Preserved channel form

Subbody D/E2 (major body in Zone S3)



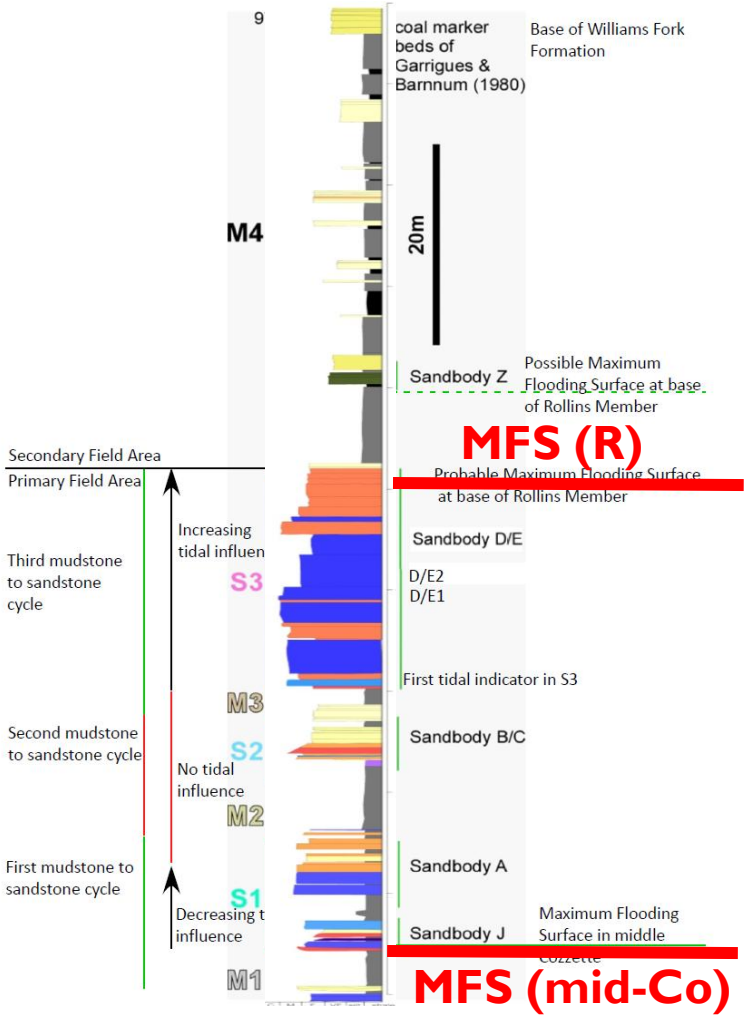
High barform preservation within a thick succession of high net:gross sandstone



Isopach: 12m (39ft) thick, 900 m (2900 ft) wide

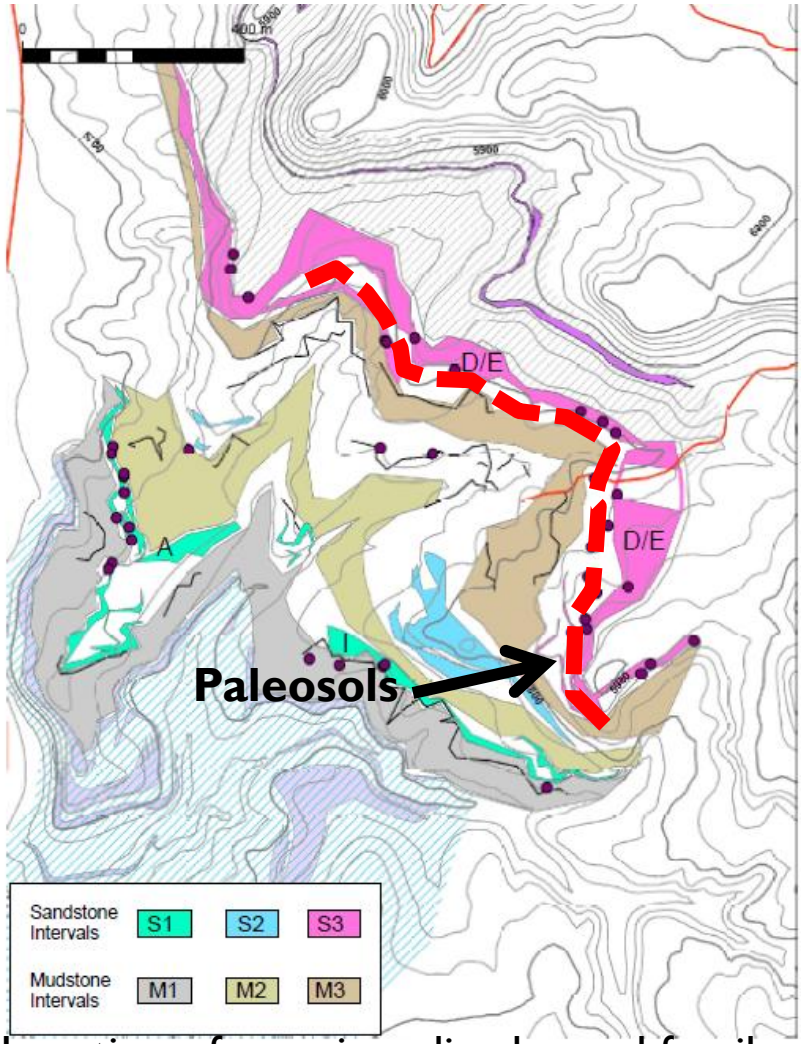
Maximum Flooding Surfaces

- Tidal indicators
  - Decreasing in S1
  - Increasing in S3
- Regional coal
  - Above Sandbody D/E (M4 interval)
- Two maximum flooding surfaces
  - Base of S1 interval
  - Top of S3 interval or coal bed in M4 interval



Sequence Boundaries

- Sandstone amalgamation
  - Up to 22m of continuous sandstone in S3
- Lengthy subaerial exposure
  - Concentration of terrestrial fossils at base of S1 and S3
  - Possible paleosols in S3
- Two sequence boundaries
  - Base S1 interval (merged with MFS)
  - Lower S3 interval



Location of permineralized wood fossils

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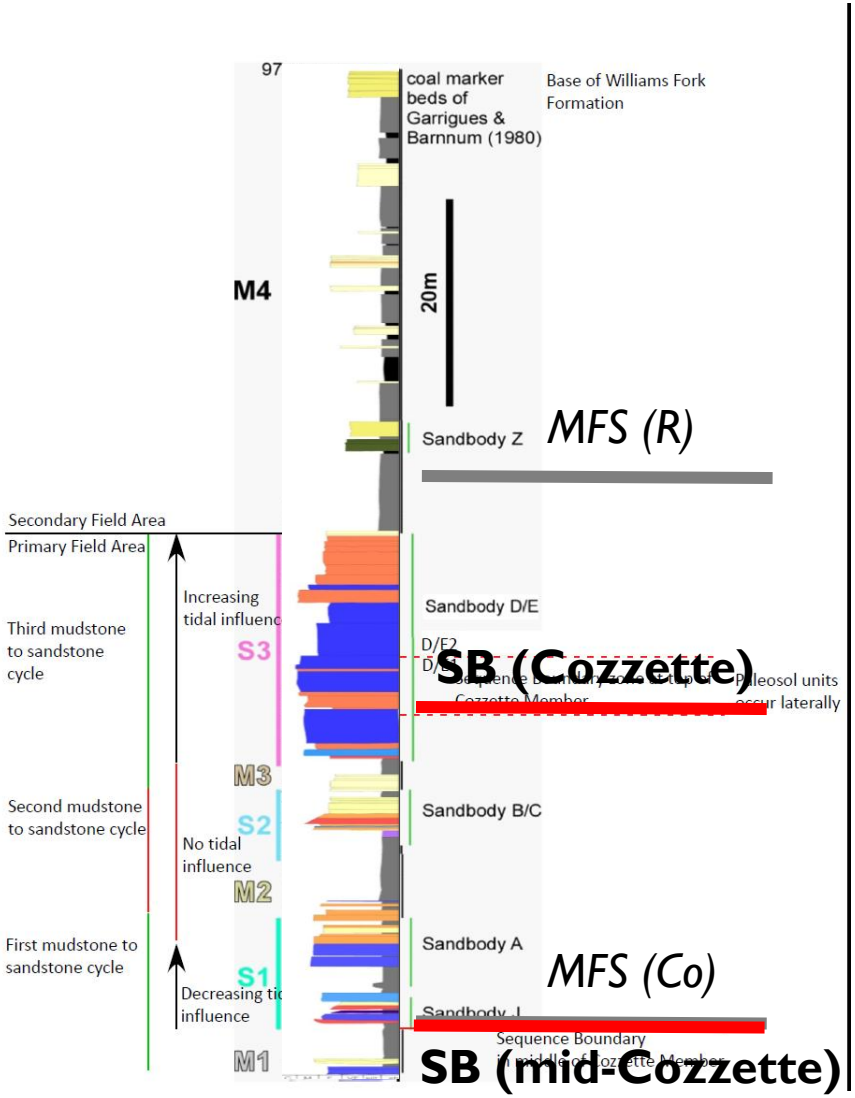
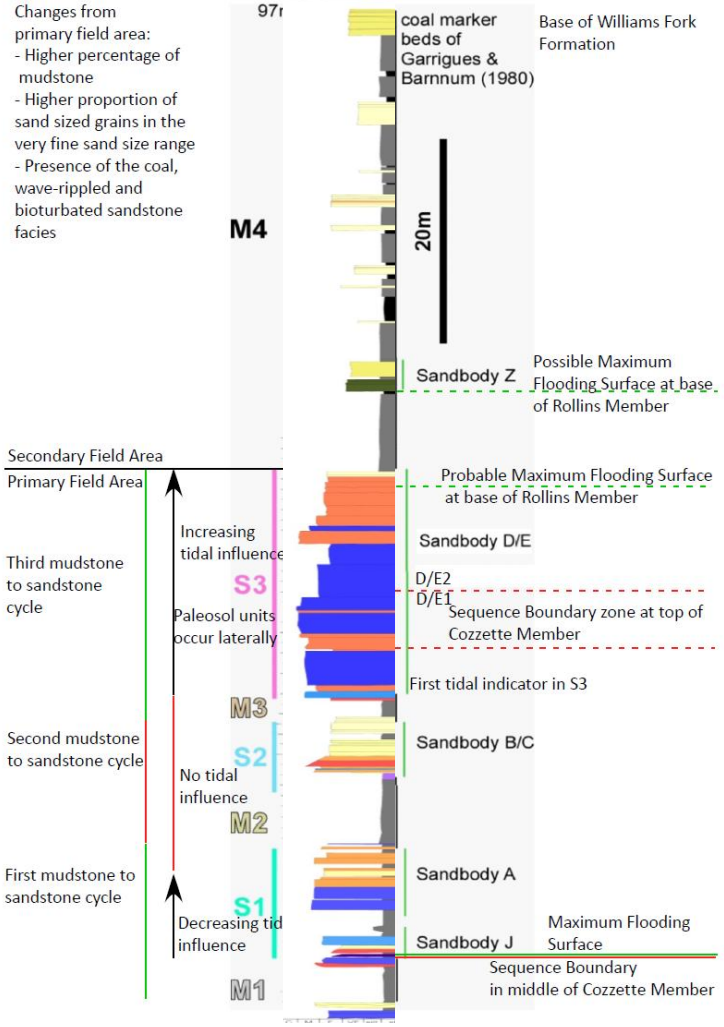


Conclusions

- 10 Sandbody Types
  - 6 tidal
  - 4 fluvial
- Low gradient coastal plain
  - Tidal Influence > 60 km inland
- Strong tidal influence in alternating, cyclical pattern
  - Decreasing then increasing
  - Linked to 4th-order relative sea-level changes?
- Likely Correlates to Cozzette to Rollins members of Iles Fm.
  - Based on tidal indicators, sandstone amalgamation, and evidence of lengthy subaerial exposure



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Questions?