Paleohydrology, 3D facies architecture, and plan view meanderbelt evolution of ancient point bars, Ferron Sandstone, Notom Delta, South-Central Utah

Janok P. Bhattacharya, Proma Bhattacharyya, Martin Harrison, Shuhab D. Khan, Mohammed S. Ullah, Jiangqaio Wang & Chenliang Wu

NSERC CRSNG

bp

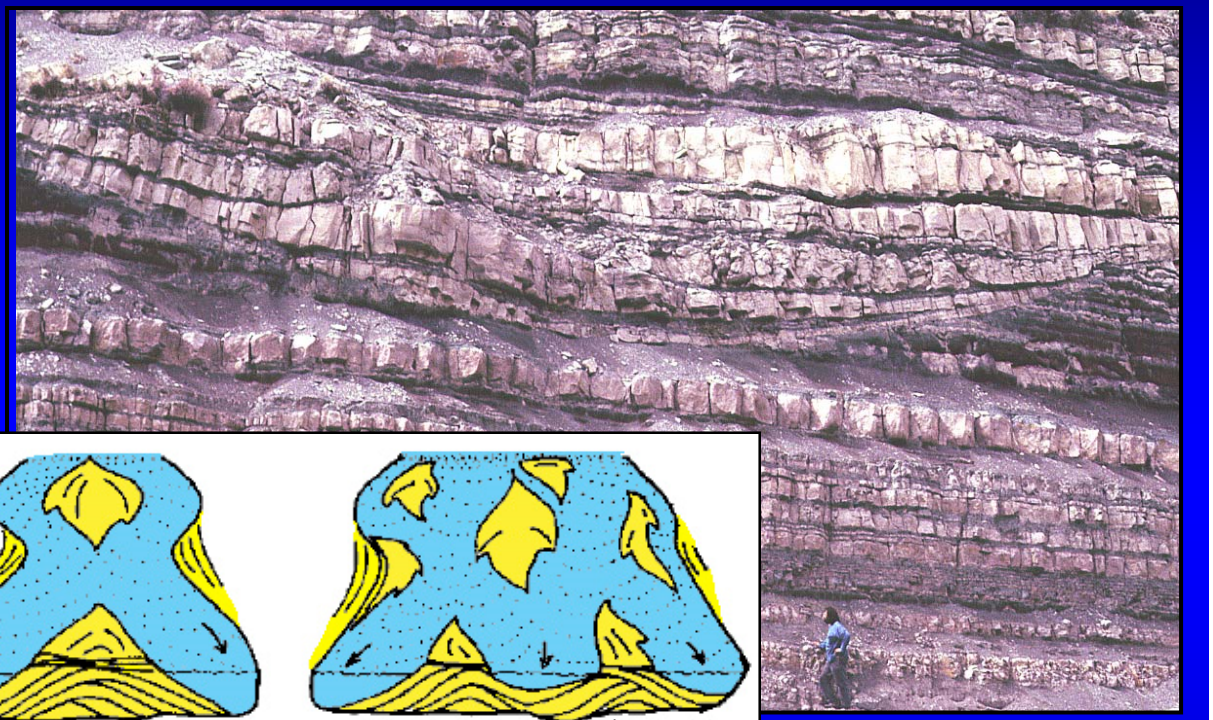
McMaster University

Outline

- Introduction
- The Ferron examples
- Conclusion

Most ancient river outcrops…

Present vertical exposures from which plan view must be inferred.

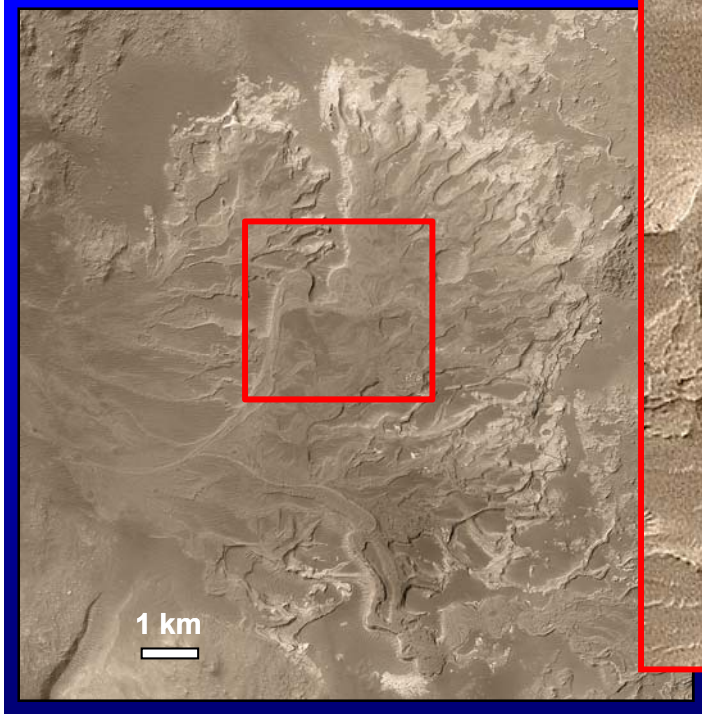


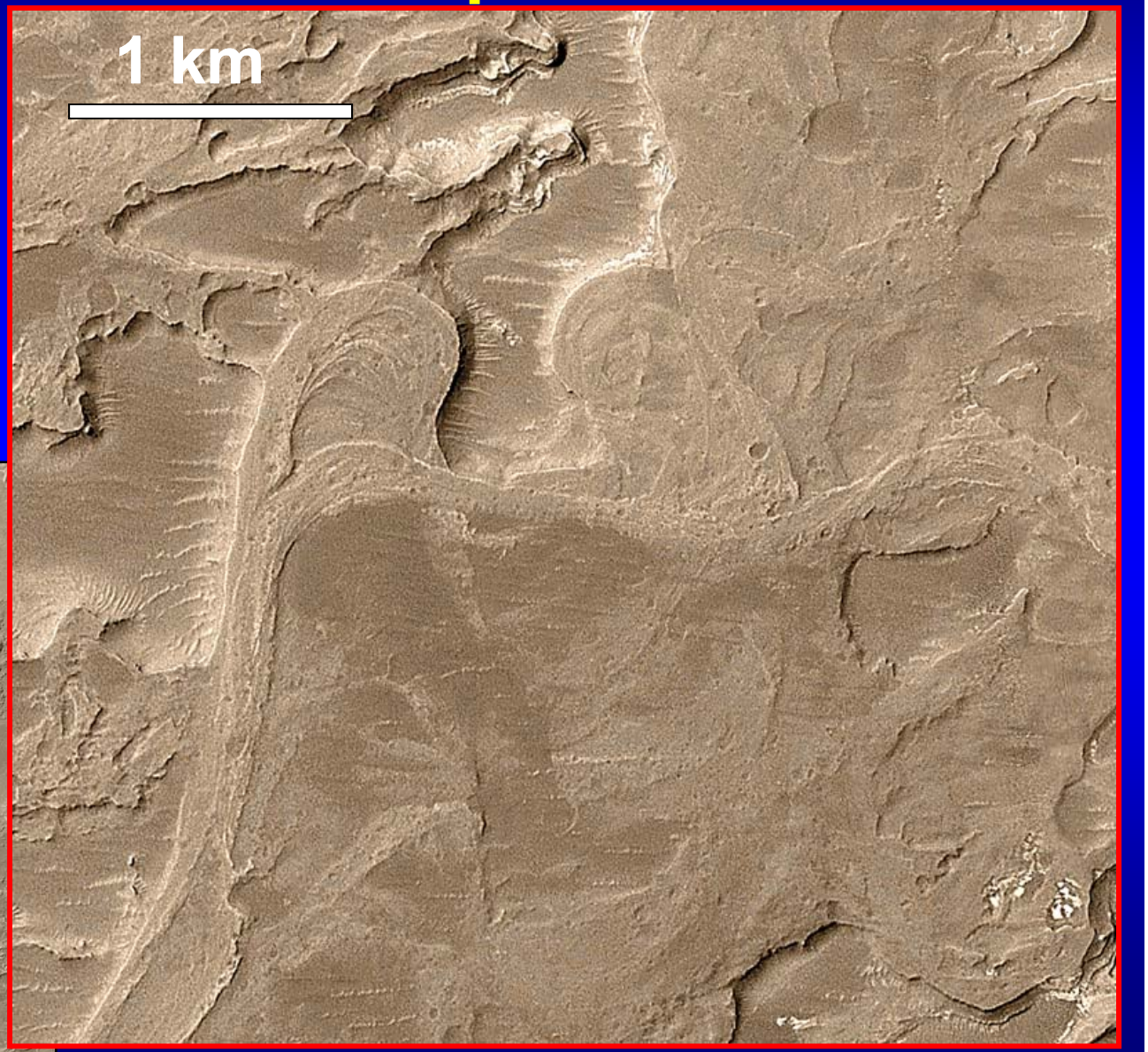
Bristow, 1993

But, flow-perpendicular exposures are required to determine bar and channel types.

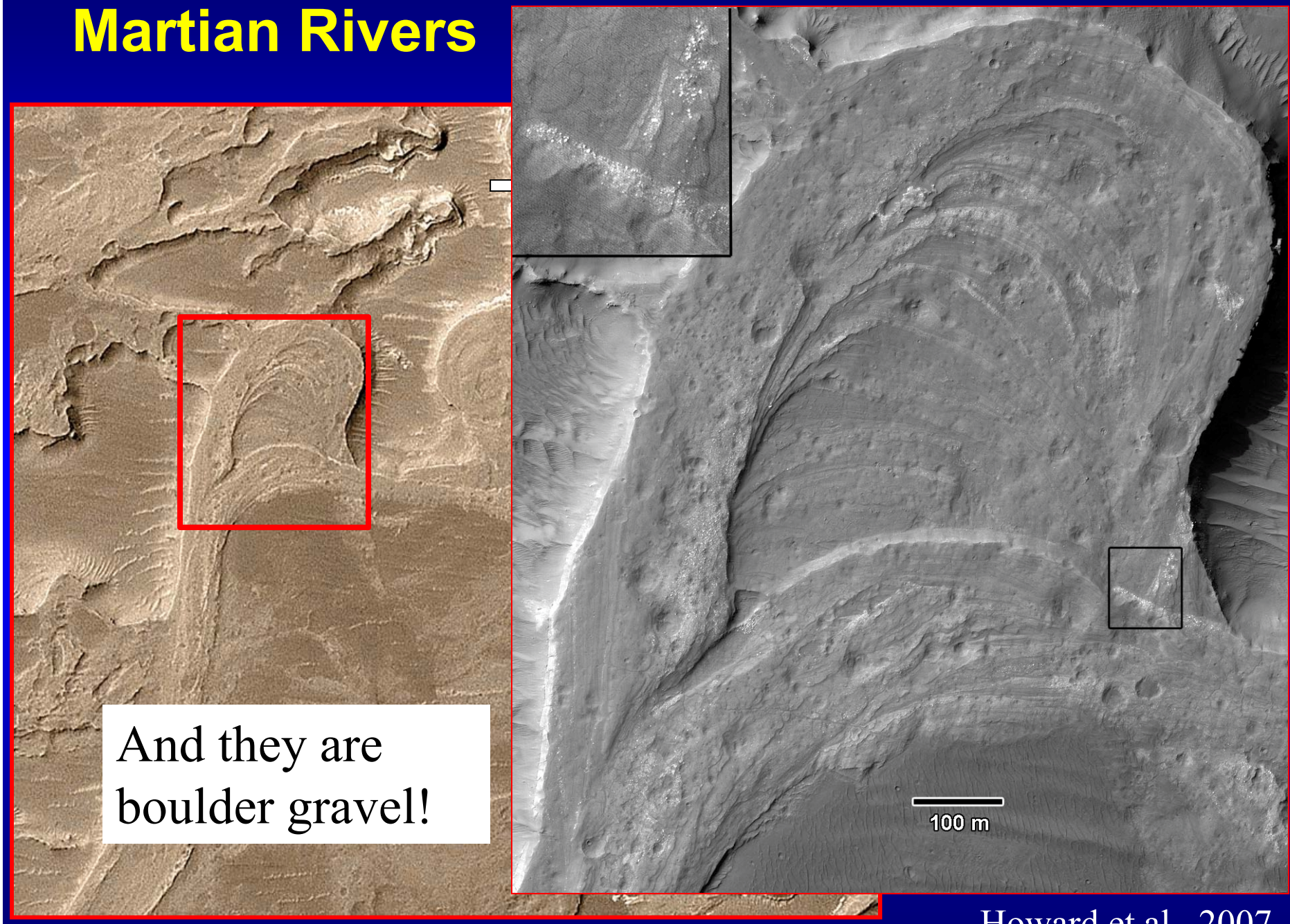
Some ancient river outcrops…

Martian outcrops show 3.5 billion year old meanderbelts in plan view!





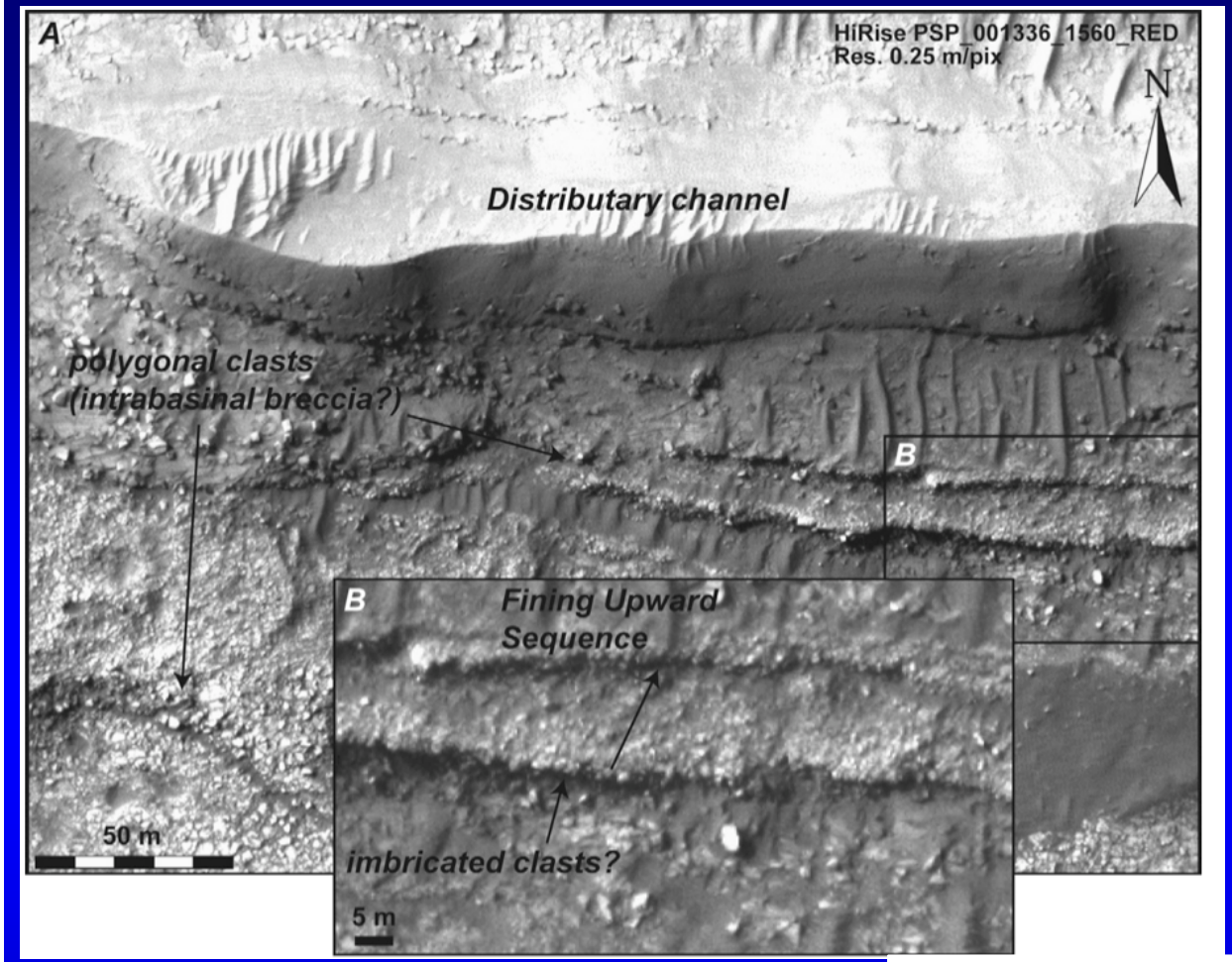
Martian Rivers



And they are boulder gravel!

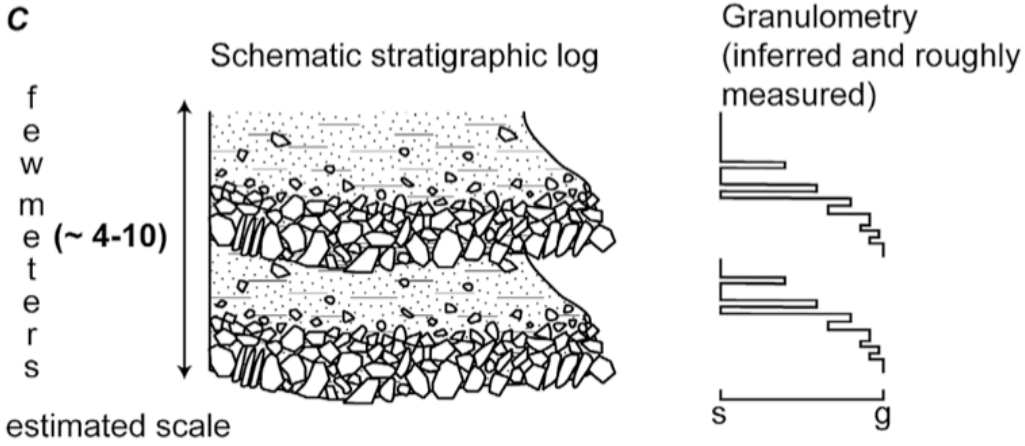
Howard et al., 2007

Martian cliff sections



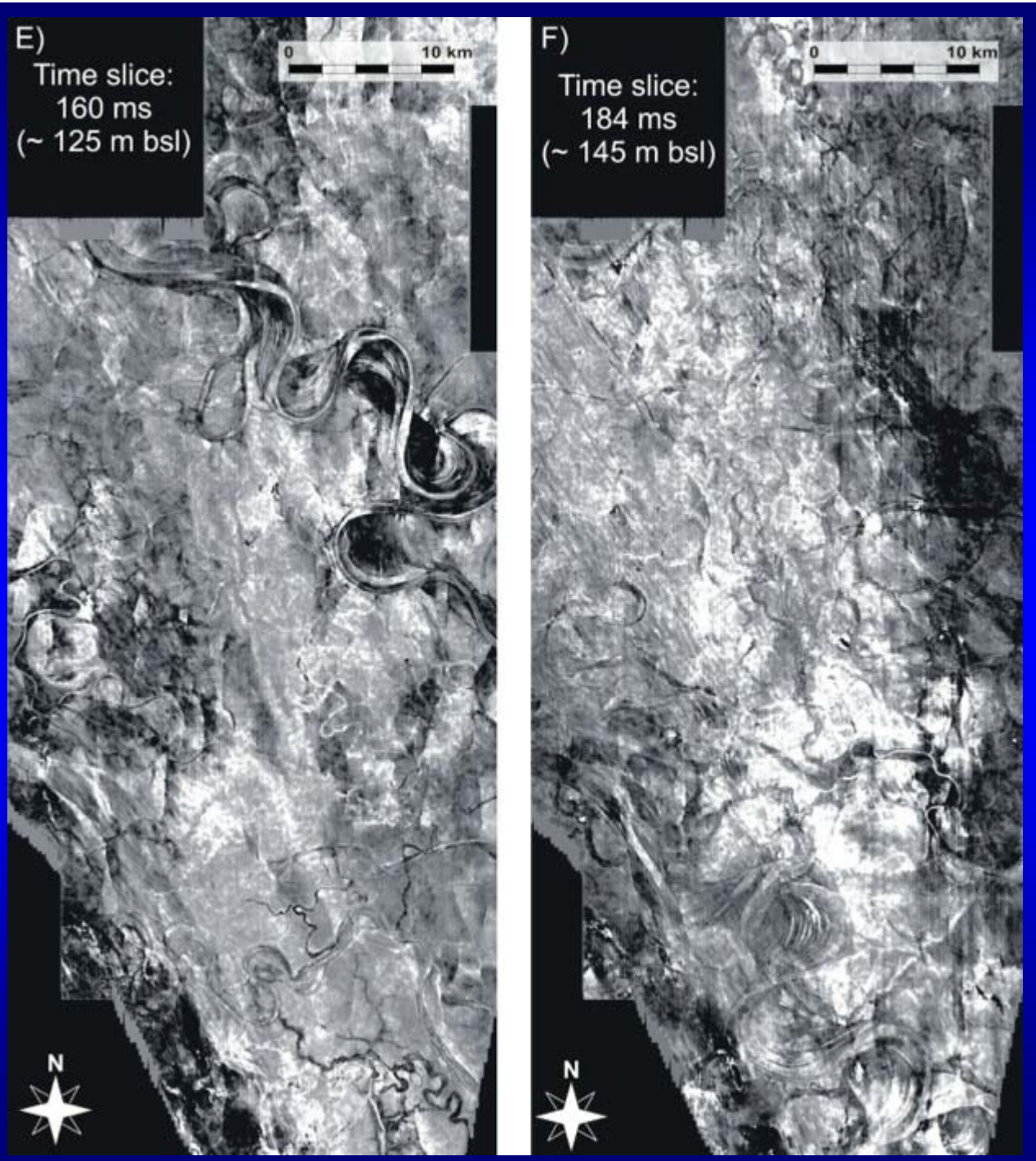
Pondrelli et al., 2008

Amalgamated boulder gravel channel storeys sure look "braided" in cross section.



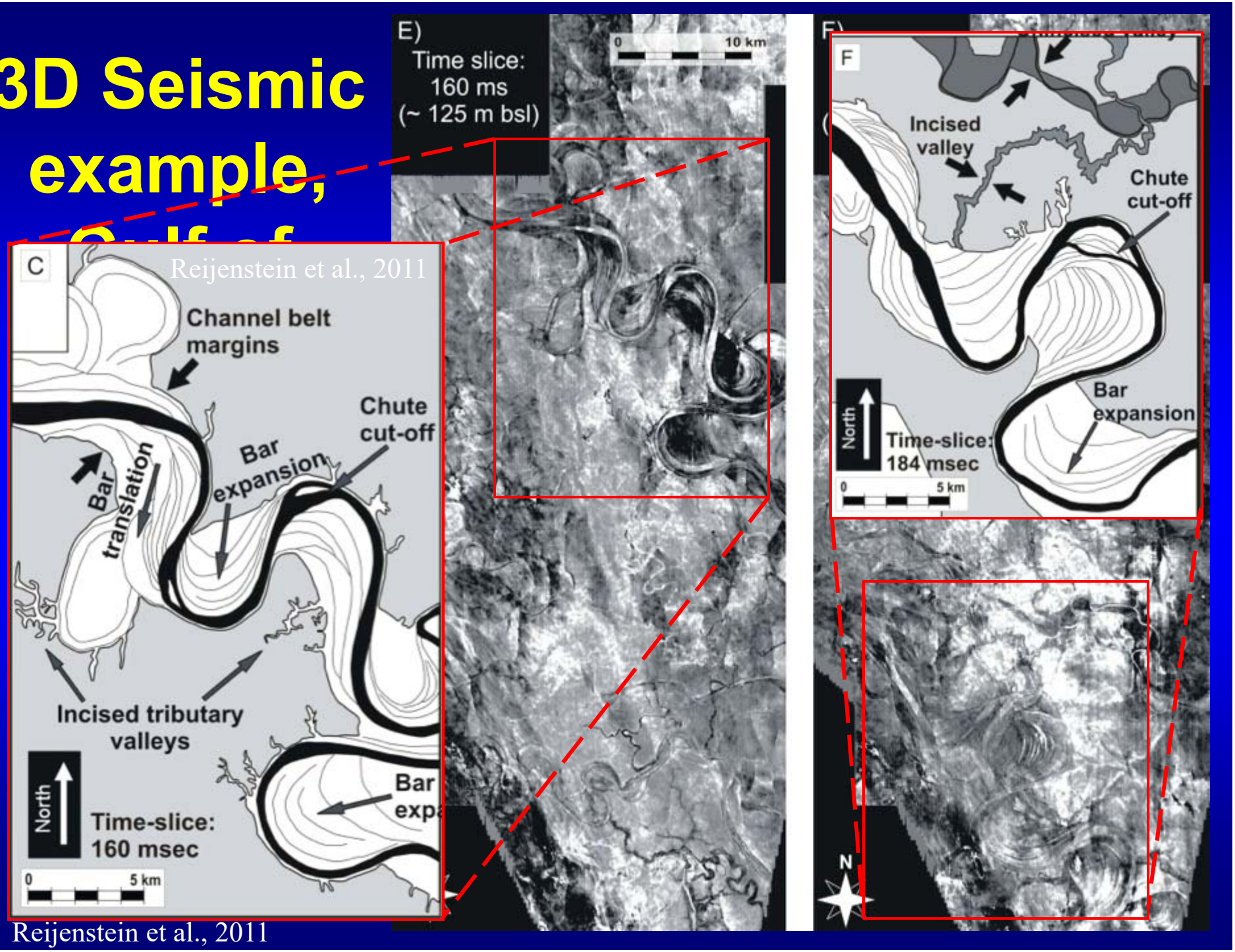
3D Seismic example, Gulf of Thailand

Plan views are common in 3D seismic data.



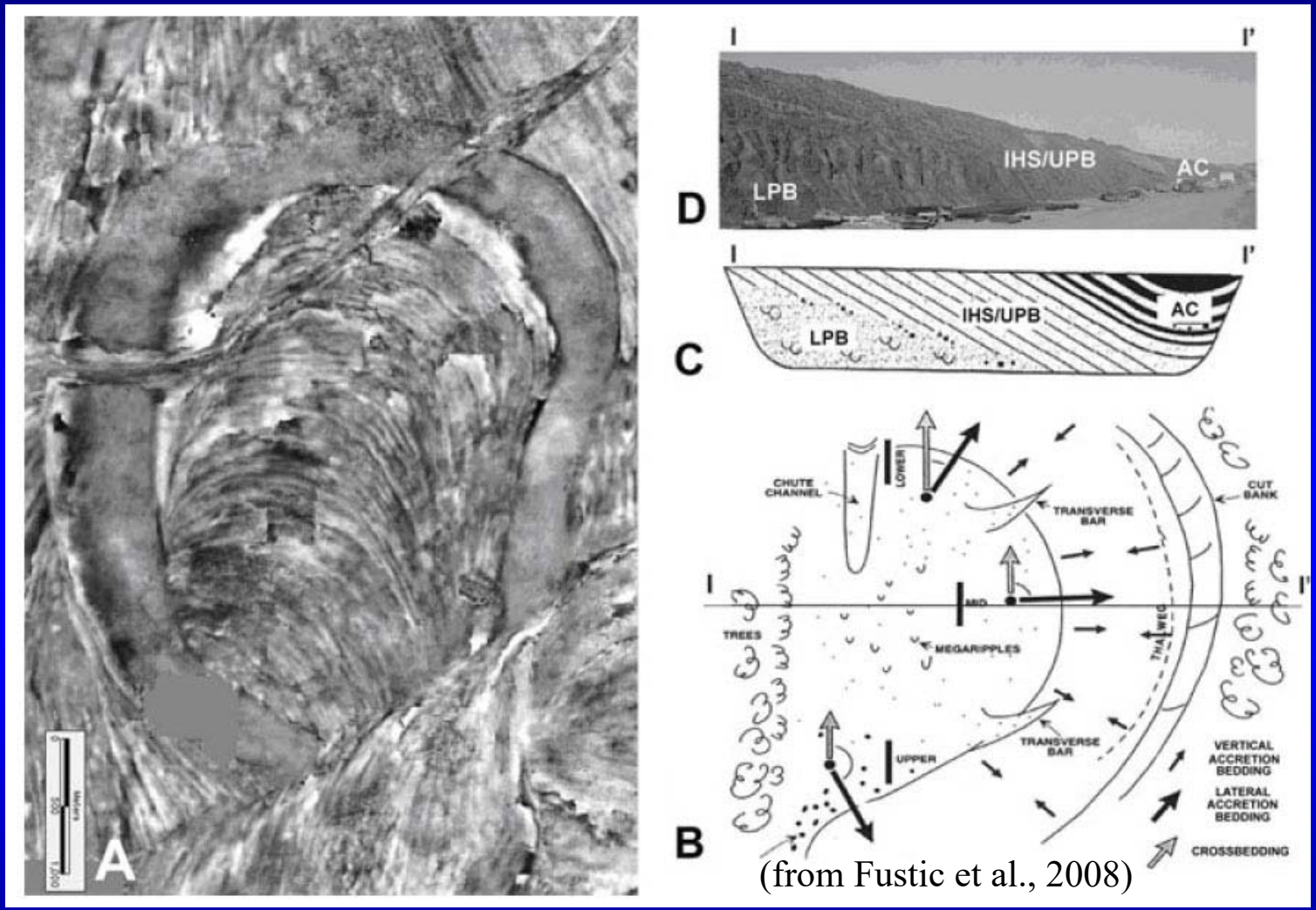
Reijenstein et al., 2011

3D Seismic example, Gulf of



Reijenstein et al., 2011

The McMurray Formation



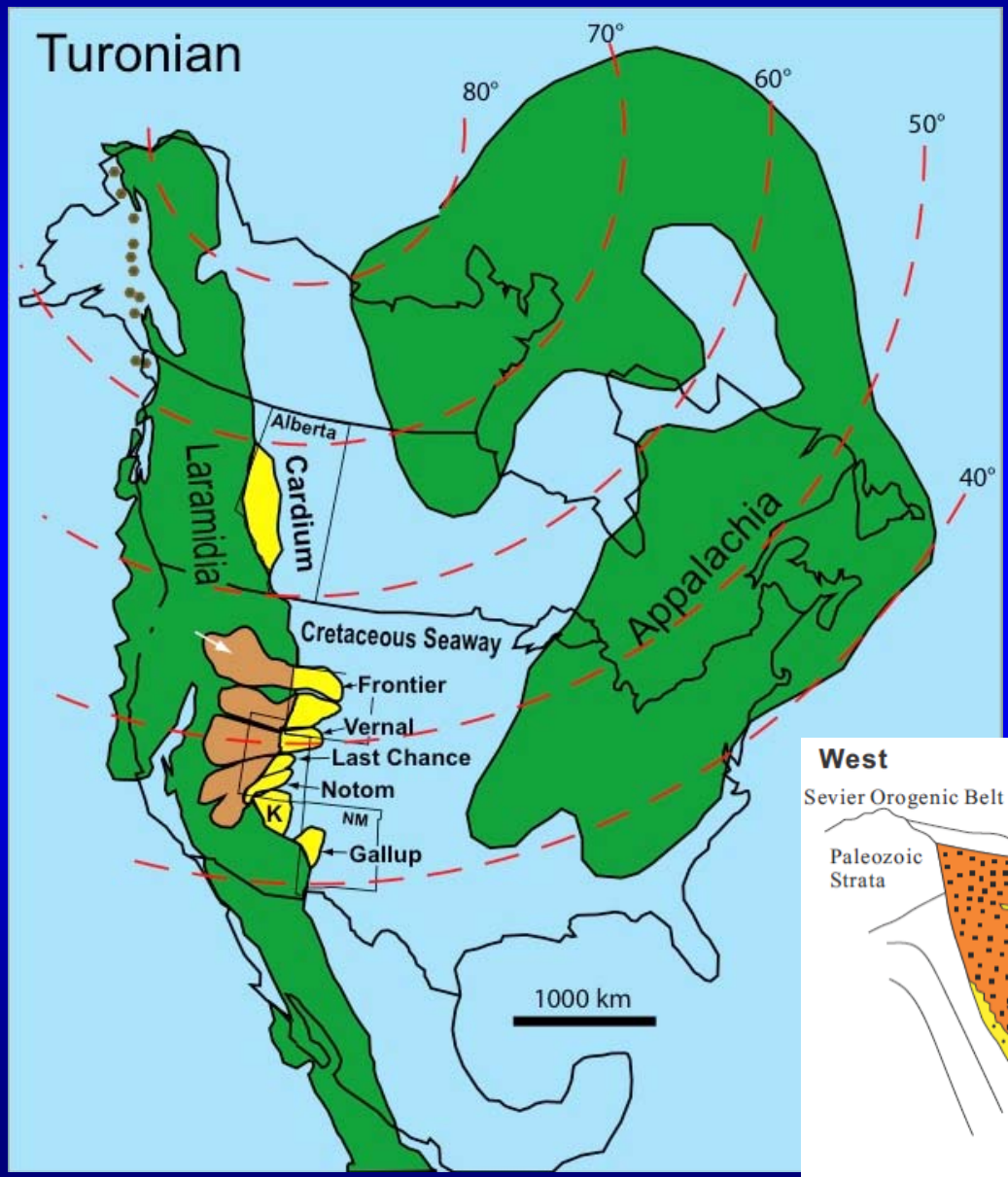
(from Fustic et al., 2008)

174 billion barrels ($8.7 Trillion) of oil contained in huge point bars requires stunningly detailed and sophisticated reservoir characterization. If 1% of this value were devoted to research, every single attendee at this conference could receive a $3.5 million grant!

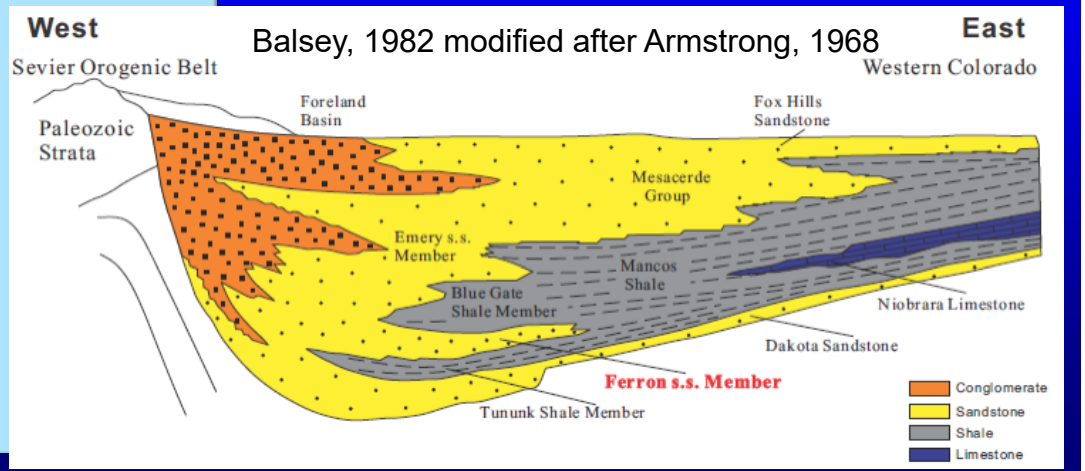
Outline

- Introduction
- The Ferron examples

Turonian

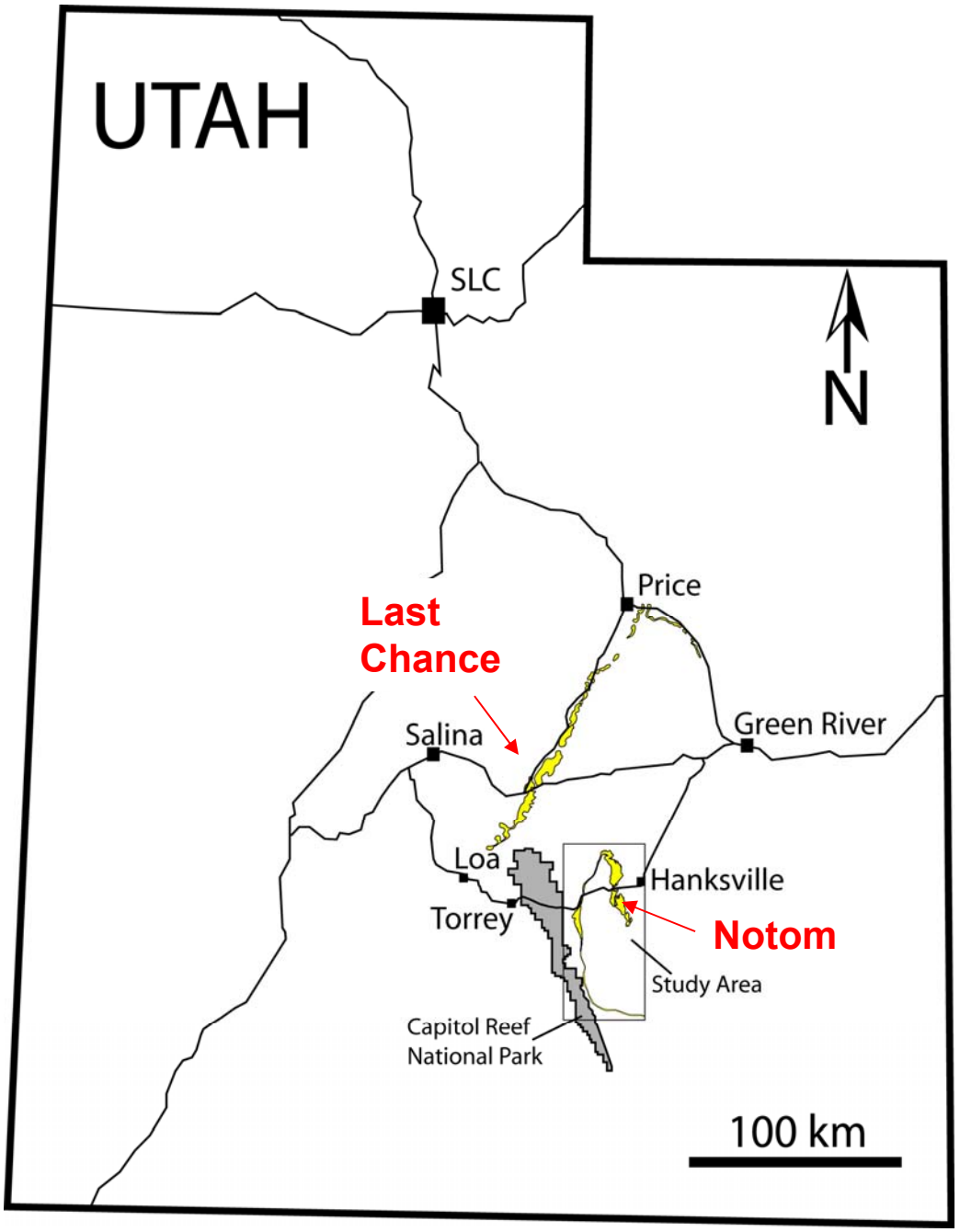


- The Ferron is one of a series of Cretaceous fluvio-deltaic clastic wedges in Western North America

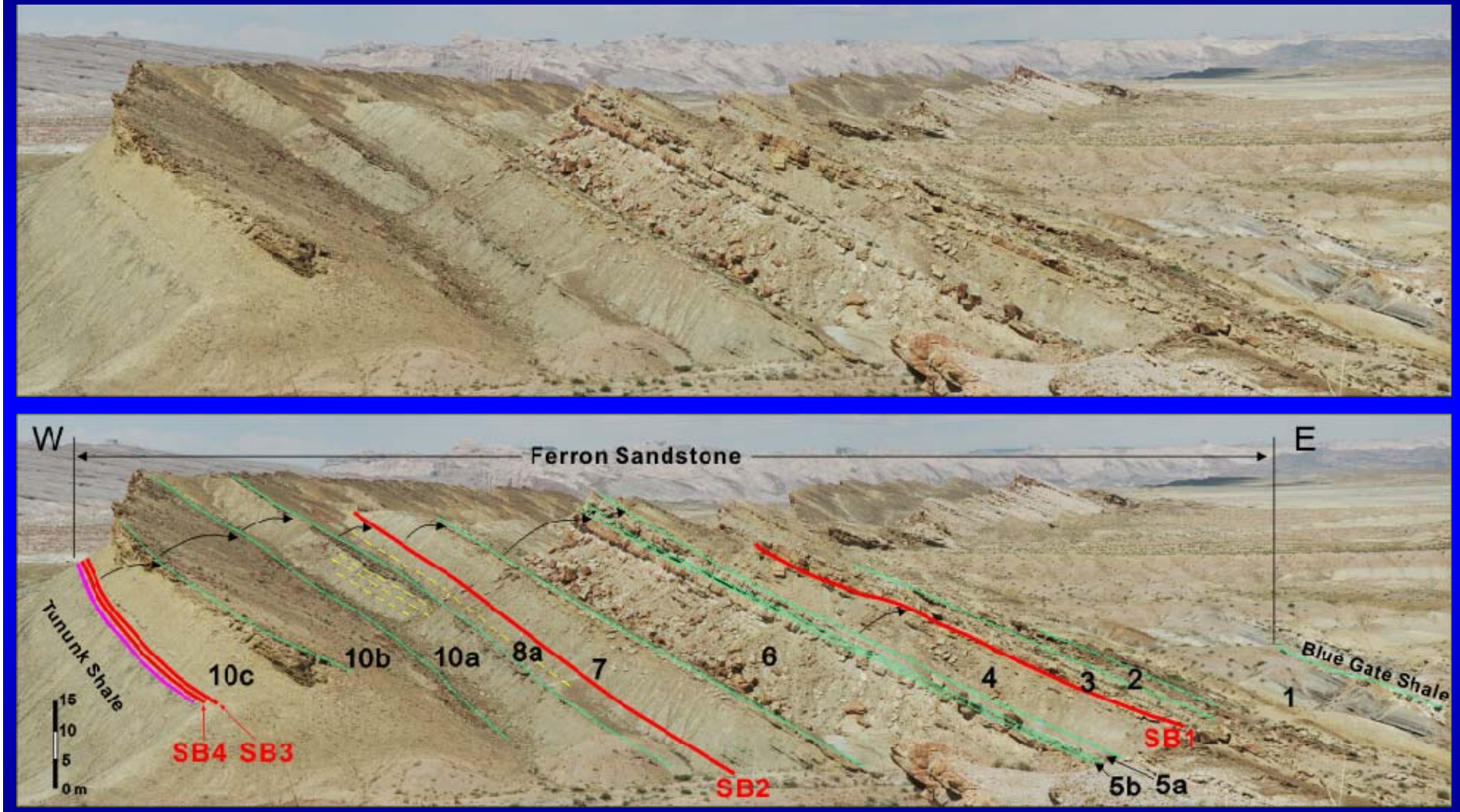


Turonian Ferron Sandstone

- Superb exposures near Capitol Reef, Utah
- 33 students over 12 years

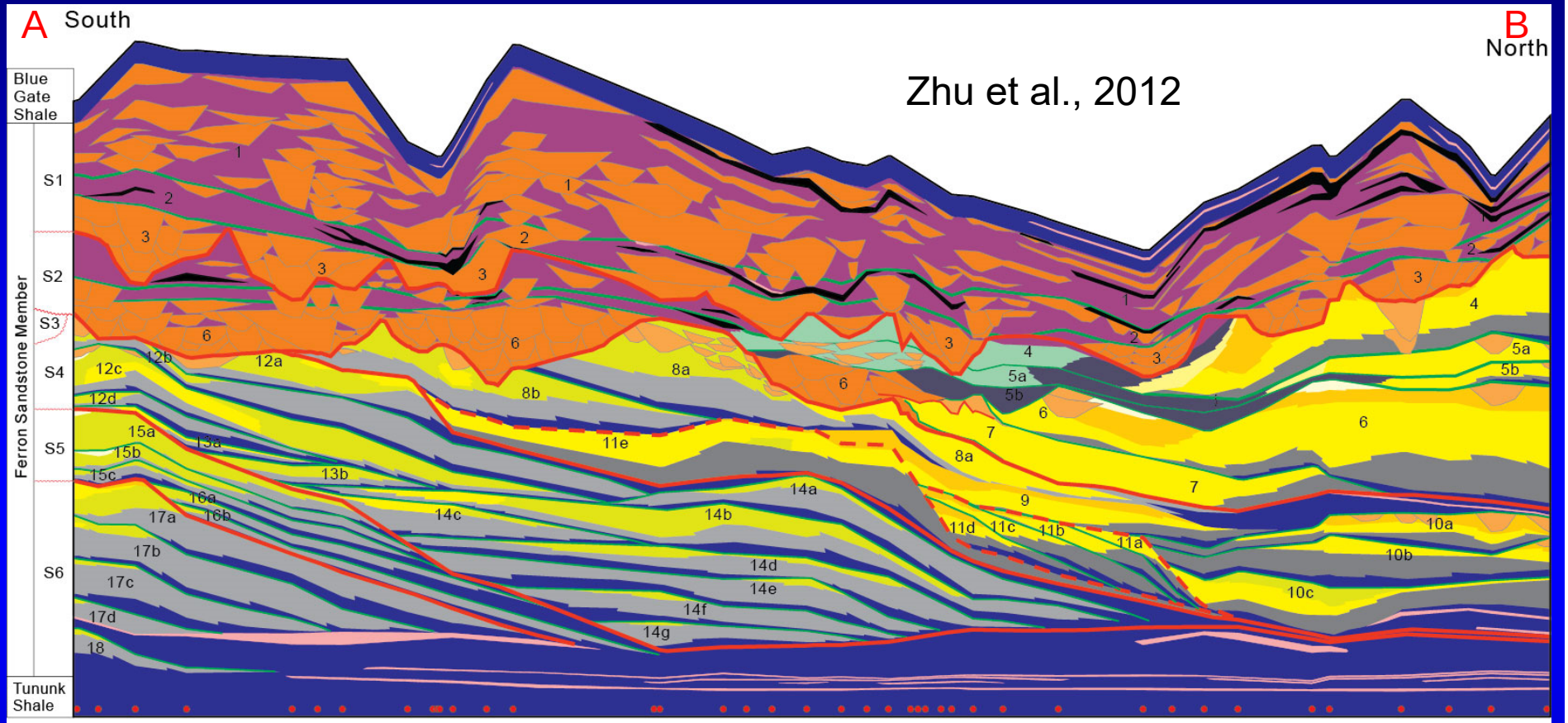


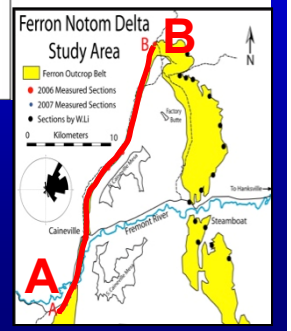
Caineville Reef, Utah



- 20°-30° structural tilt of the outcrops enable walking on hogsback ridges to trace key surfaces and sandstone bodies.

Ferron Sandstone Dip Sequence Stratigraphy



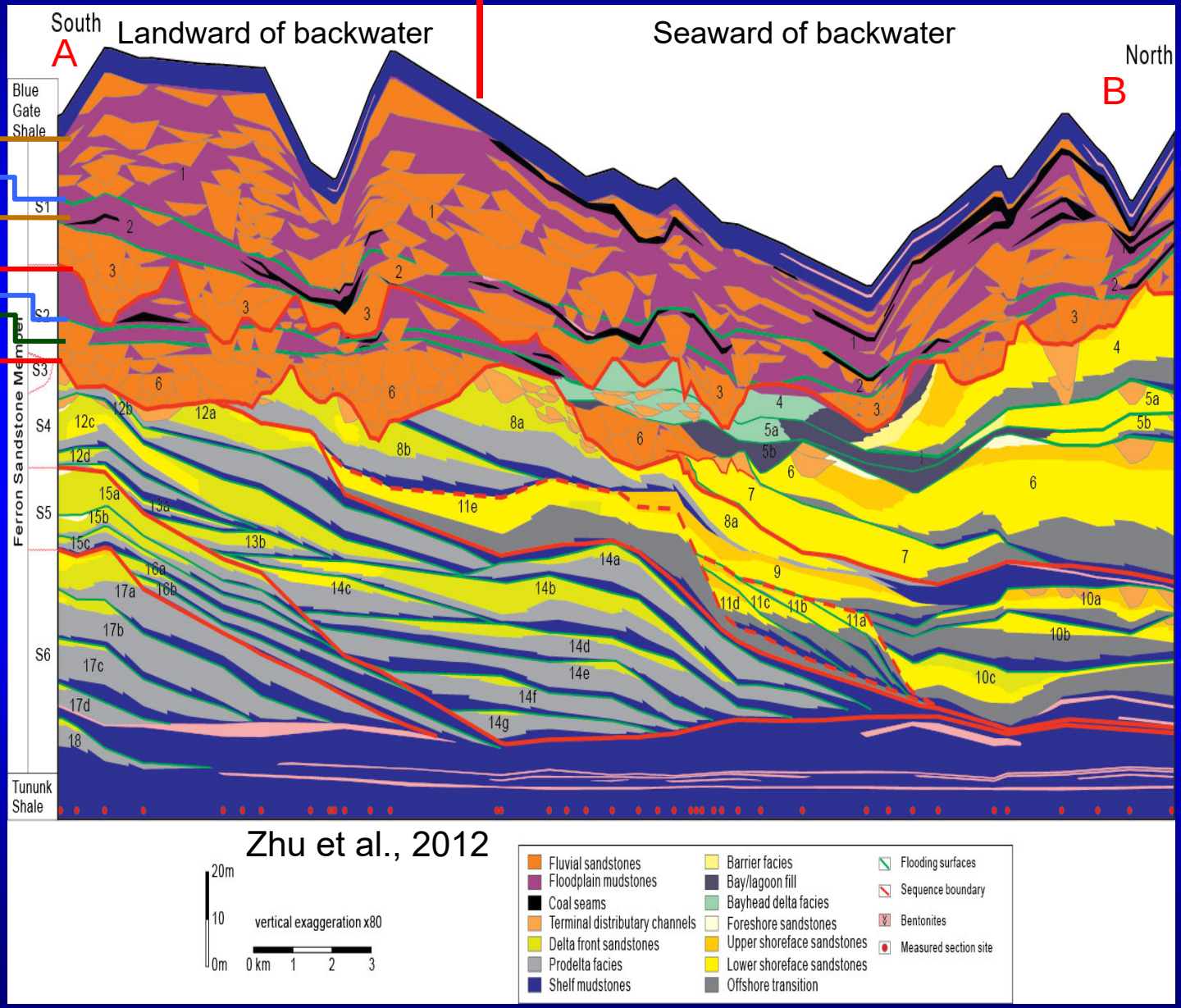


- **43 Parasequences, 18 Parasequence Sets, 6 Sequences**
- **Upper ½ is largely fluvial.**

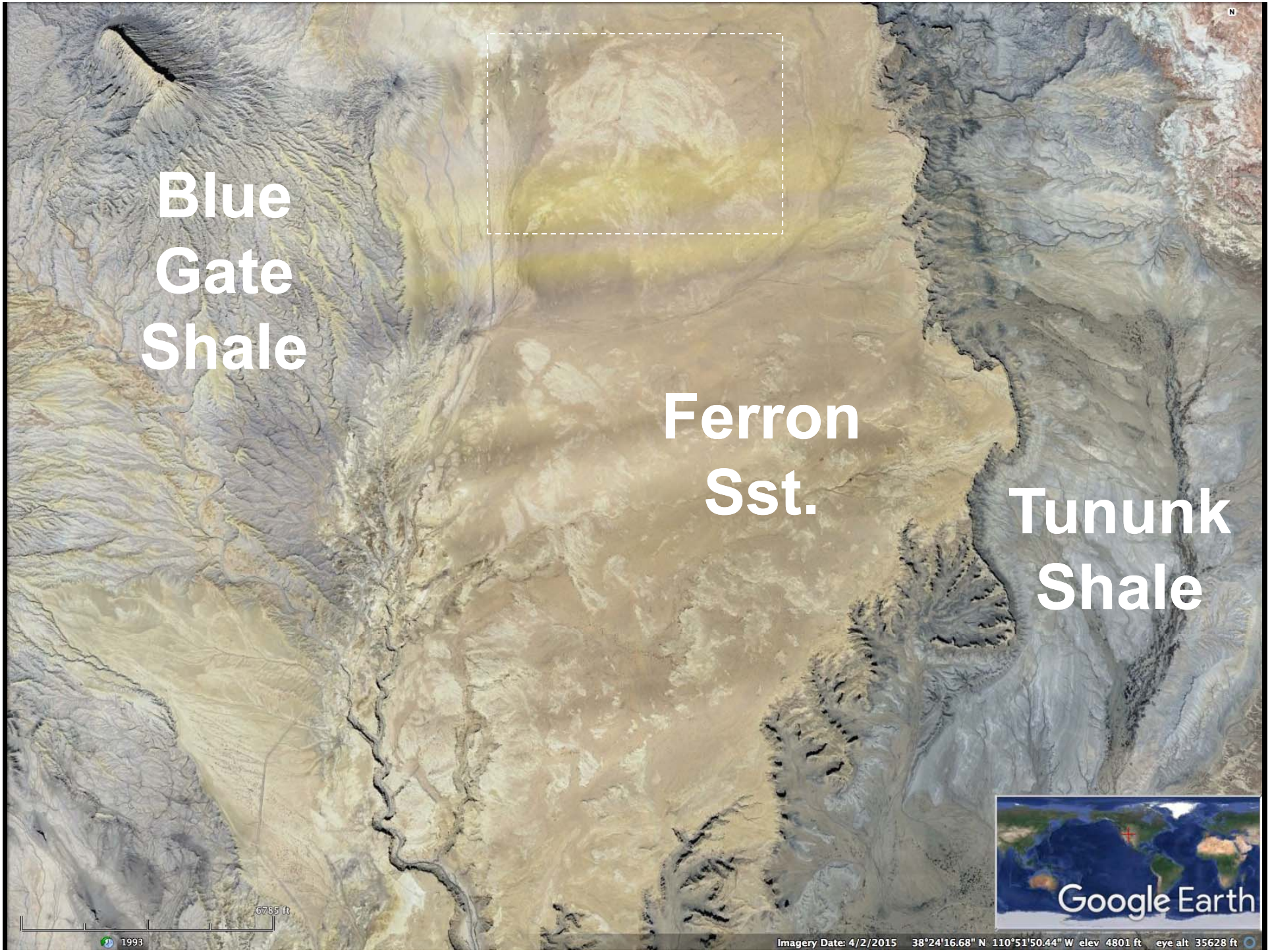
Non-Marine Sequences

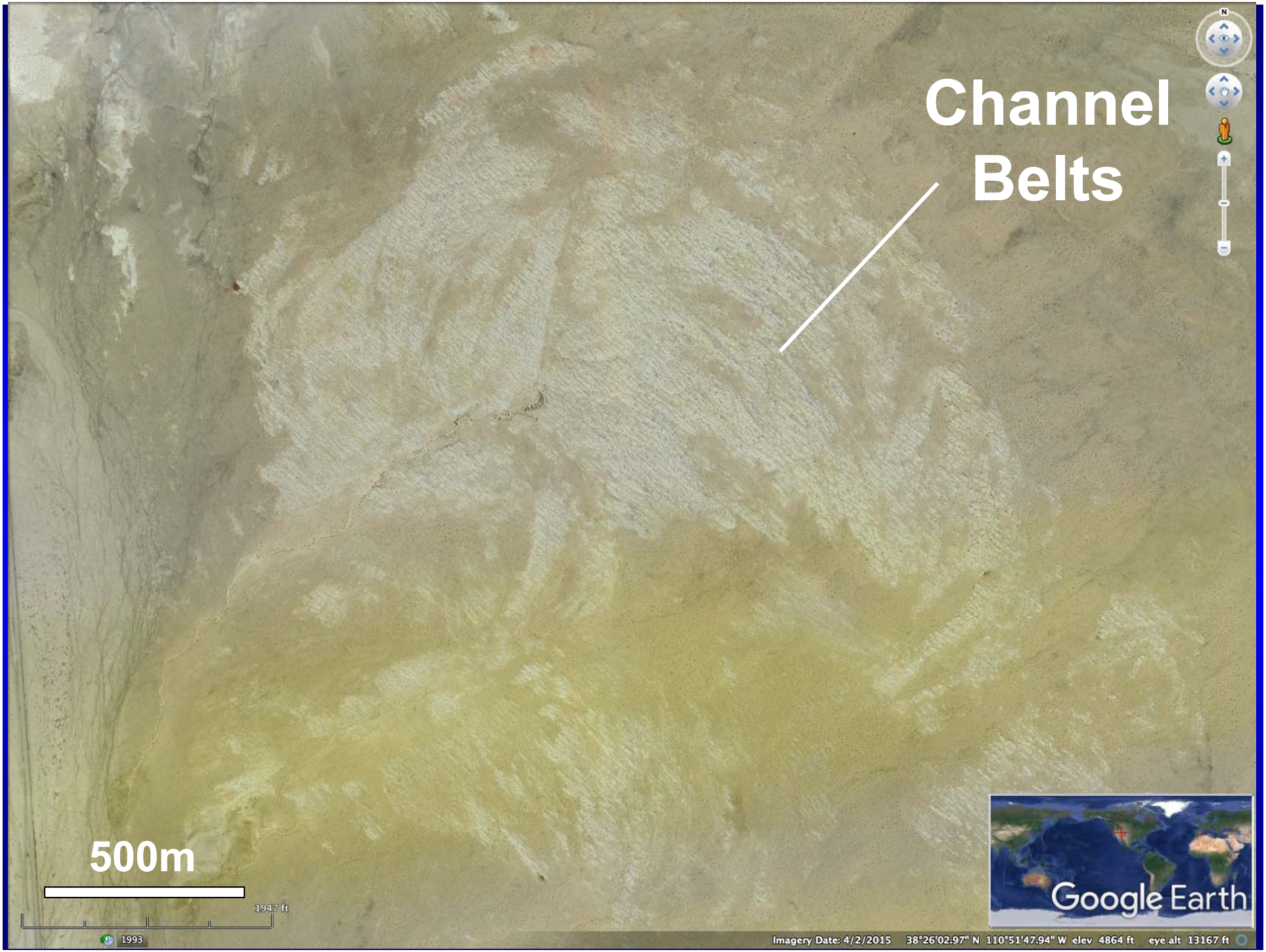
HST
TST
LST SB confined
HST
TST
LST SB confined

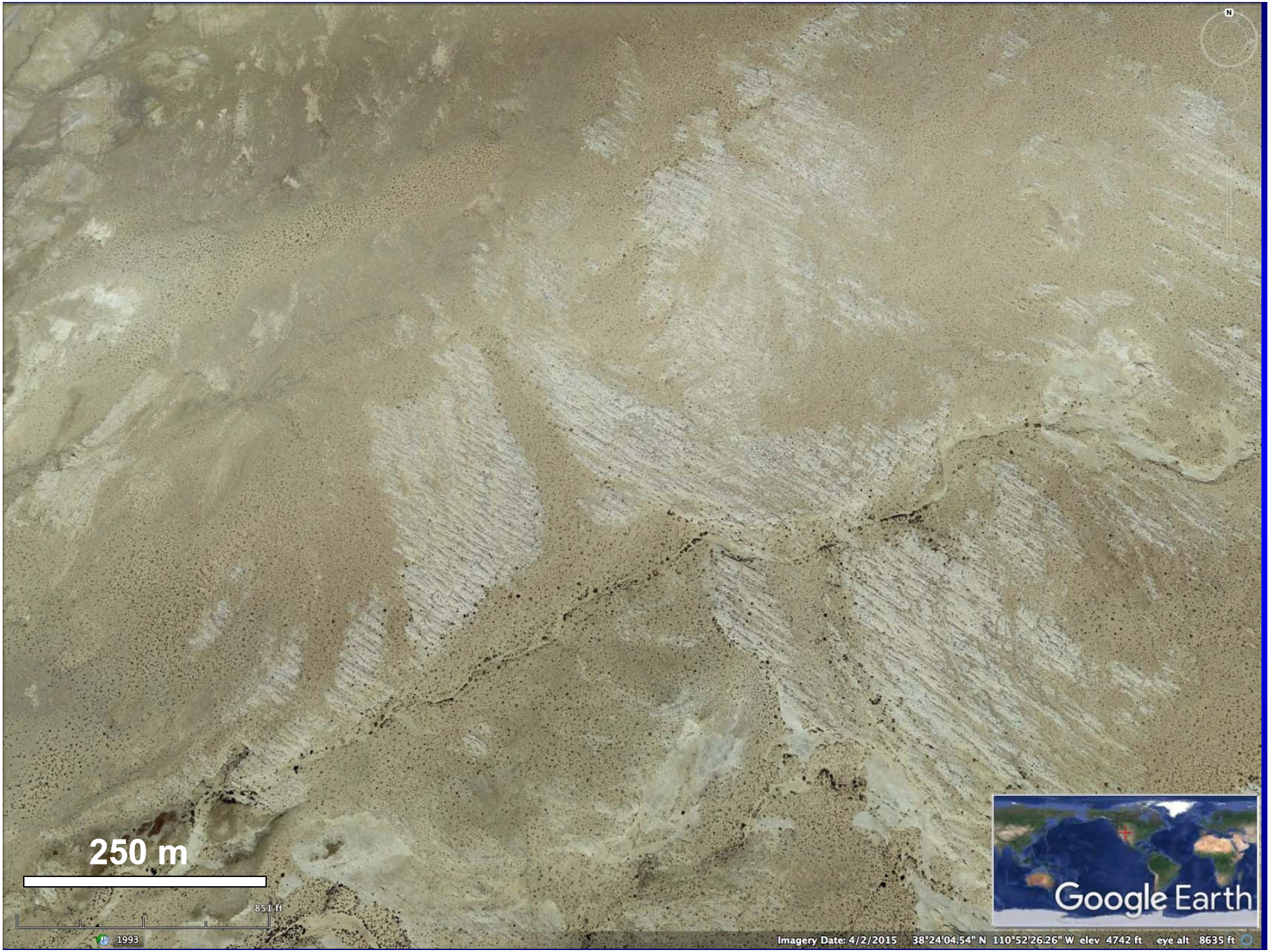
Systematic changes in Fluvial stacking styles are associated with different systems tracts



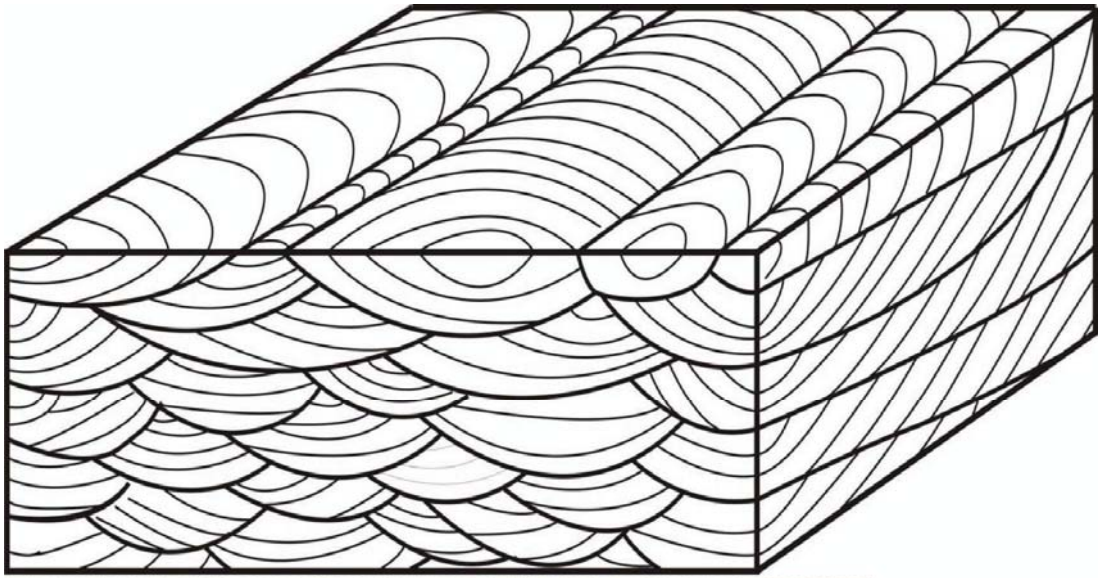

Plan View?
3.69 mi
Google Earth
Imagery Date: 7/5/2016 38°25'20.30" N 110°53'34.02" W elev 4750 ft eye alt 16.85 mi


Blue
Gate
Shale
Ferron
Sst.
Tununk
Shale
6785 ft
1993
Google Earth
Imagery Date: 4/2/2015 38°24'16.68" N 110°51'50.44" W elev 4801 ft eye alt 35628 ft

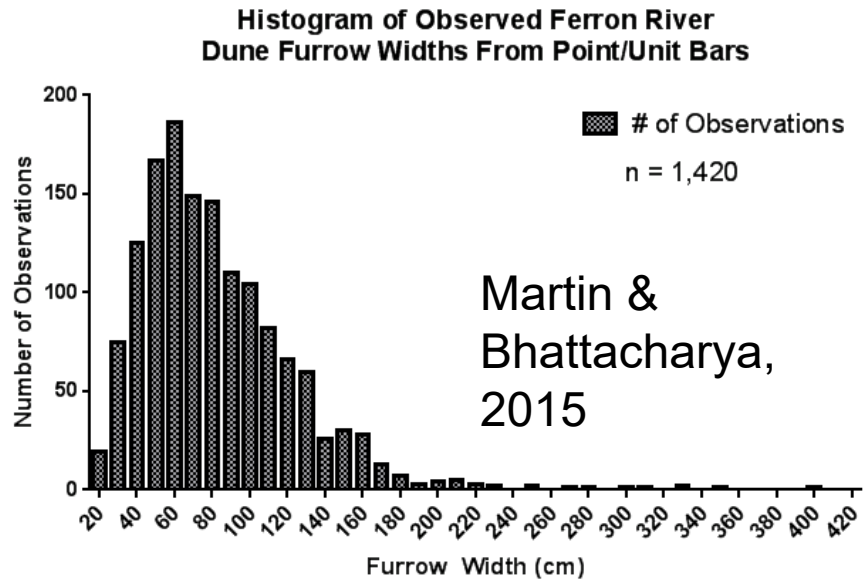

Channel Belts
500m
1947 ft
1993
Google Earth
Imagery Date: 4/2/2015 38°26'02.97" N 110°51'47.94" W elev 4864 ft eye alt 13167 ft


250 m
851 ft
1993
Google Earth
Imagery Date: 4/2/2015 38°24'04.54" N 110°52'26.26" W elev 4742 ft eye alt 8635 ft

Paleocurrents



- Rib and furrows can be used to decipher flow field.
- Also compile data on rib width to examine scaling relationships of dunes and channels.



Martin & Bhattacharya, 2015

Bar accretion versus dune foresets

Bar accretion and dune foresets are integrated to document flow direction and bar accretion direction.

Sedimentary Geology 325 (2015) 17–25

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Sedimentary Geology

journal homepage: www.elsevier.com/locate/sedgeo

Paleo-channel reconstruction and grain size variability in fluvial deposits, Ferron Sandstone, Notom Delta, Hanksville, Utah

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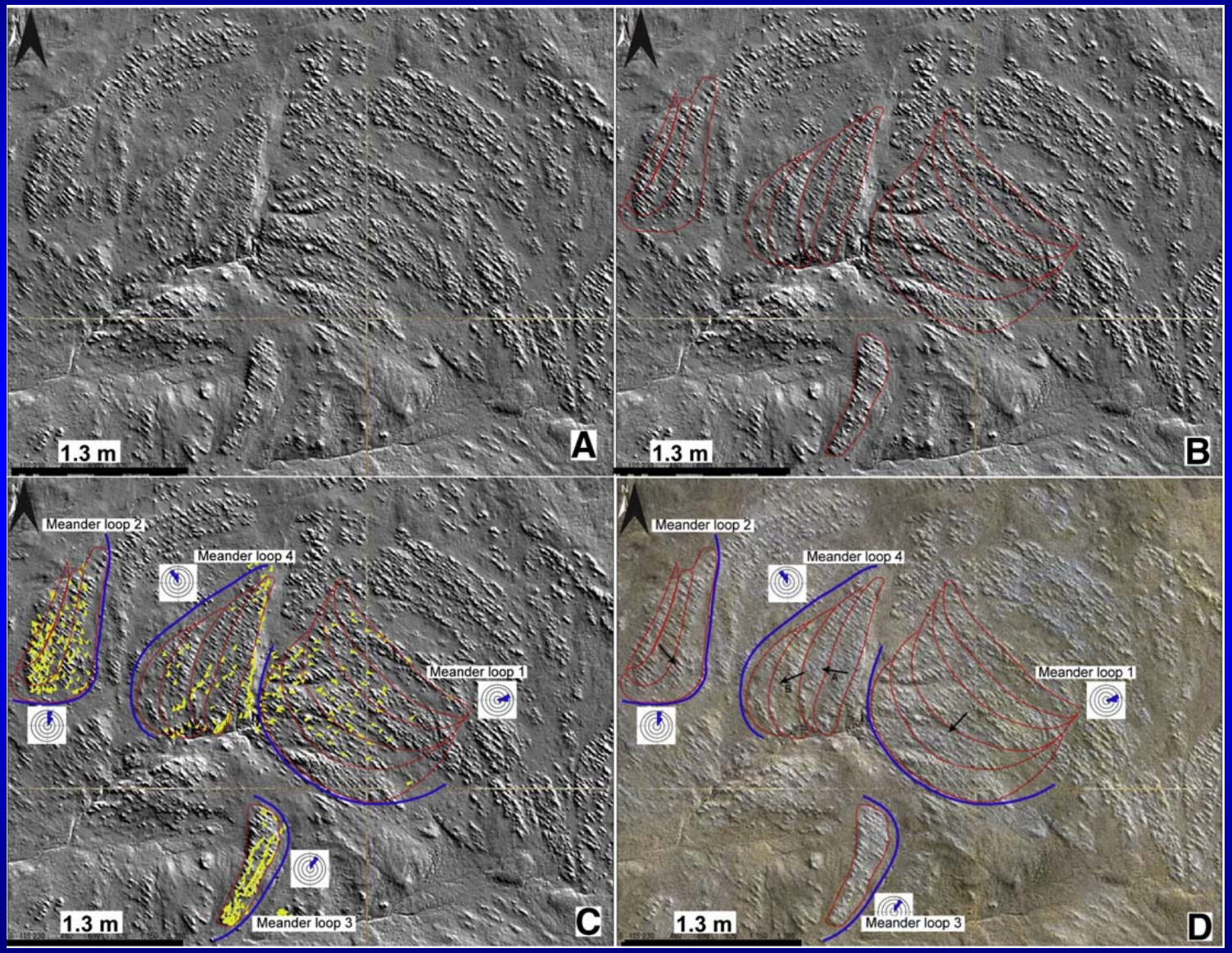
[b] School of Geography and Earth Sciences (SGES), McMaster University, 1280 Main Street West, Hamilton, ON L8S 4 L8, Canada

Hillshade Images



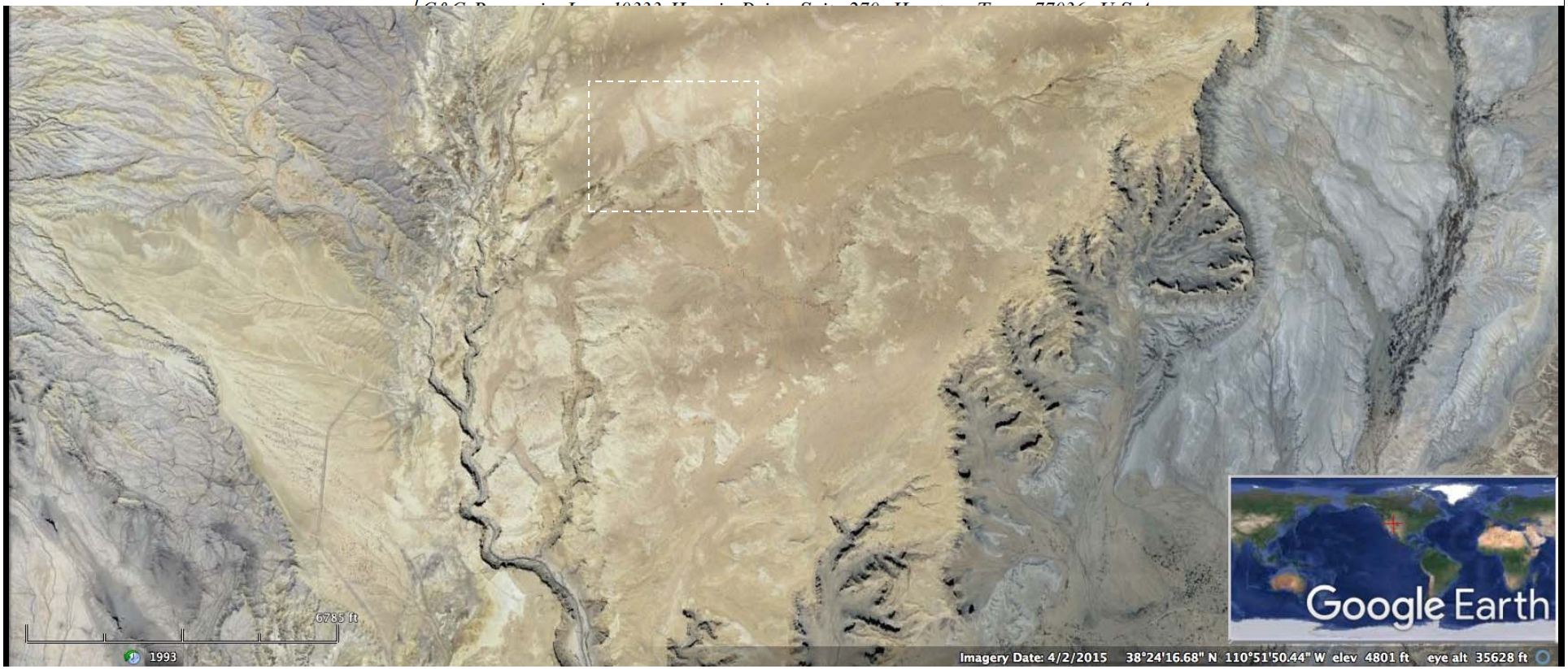
Bhattacharyya et al., 2015

Journal of Sedimentary Research

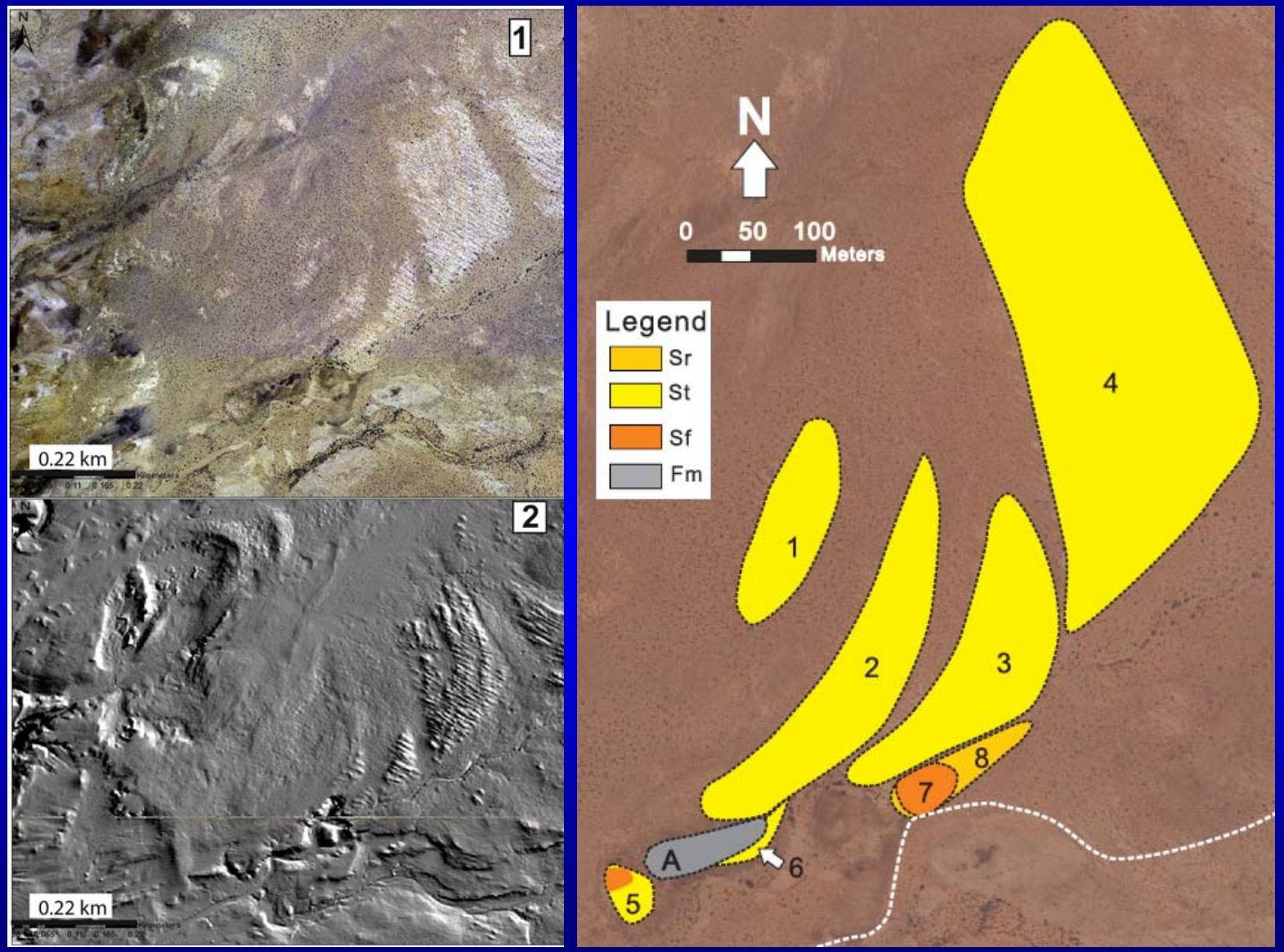
Journal of Sedimentary Research, 2015, v. 85, 399–418
Research Article
DOI: http://dx.doi.org/10.2110/jsr.2015.29

PALEOHYDROLOGY AND 3D FACIES ARCHITECTURE OF ANCIENT POINT BARS, FERRON SANDSTONE, NOTOM DELTA, SOUTH-CENTRAL UTAH, U.S.A.

CHENLIANG WU,[1] JANOK P. BHATTACHARYA,[2] AND MOHAMMAD S. ULLAH[3]



Architectural Element identification



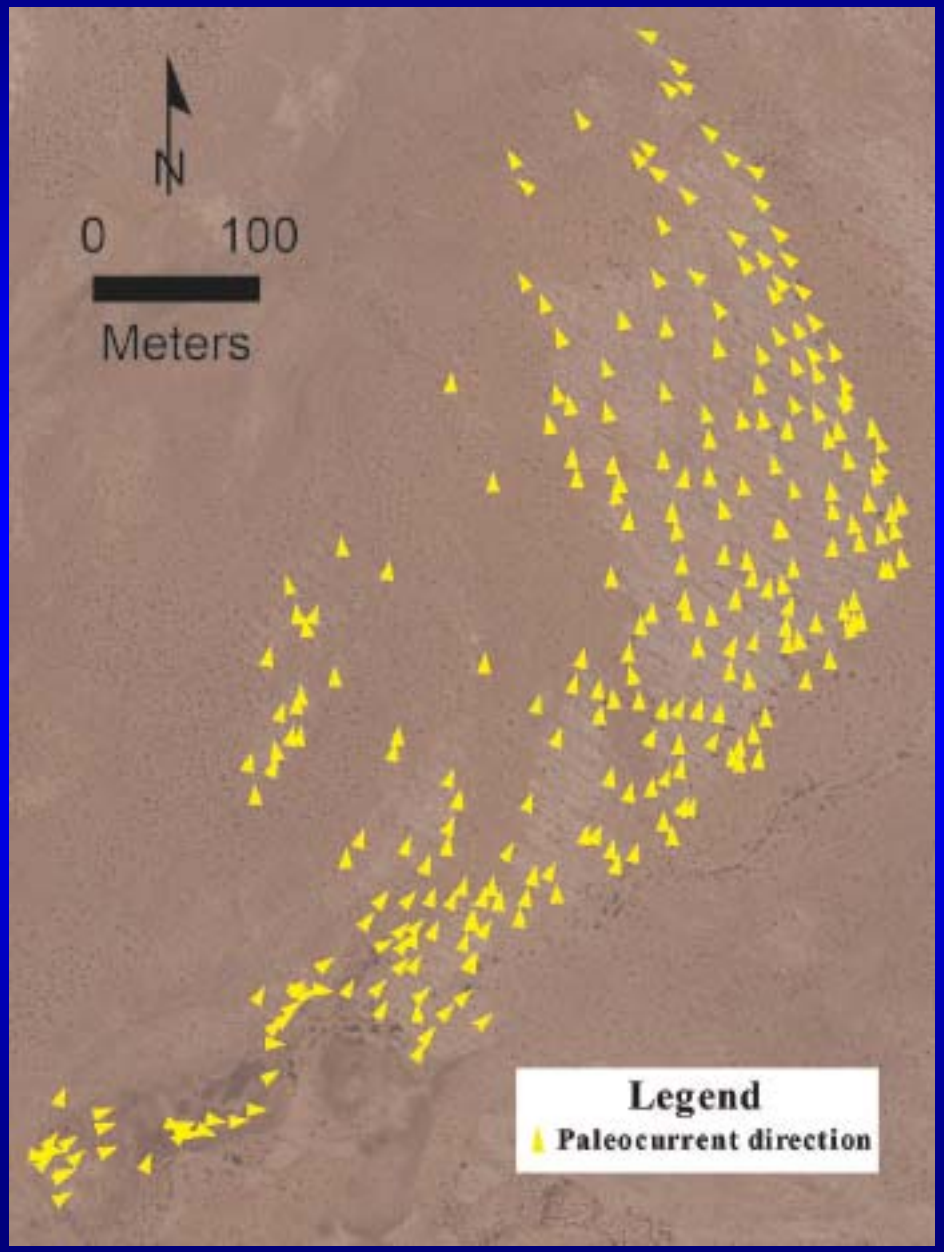
Wu et al., 2015

Paleocurrent Fields

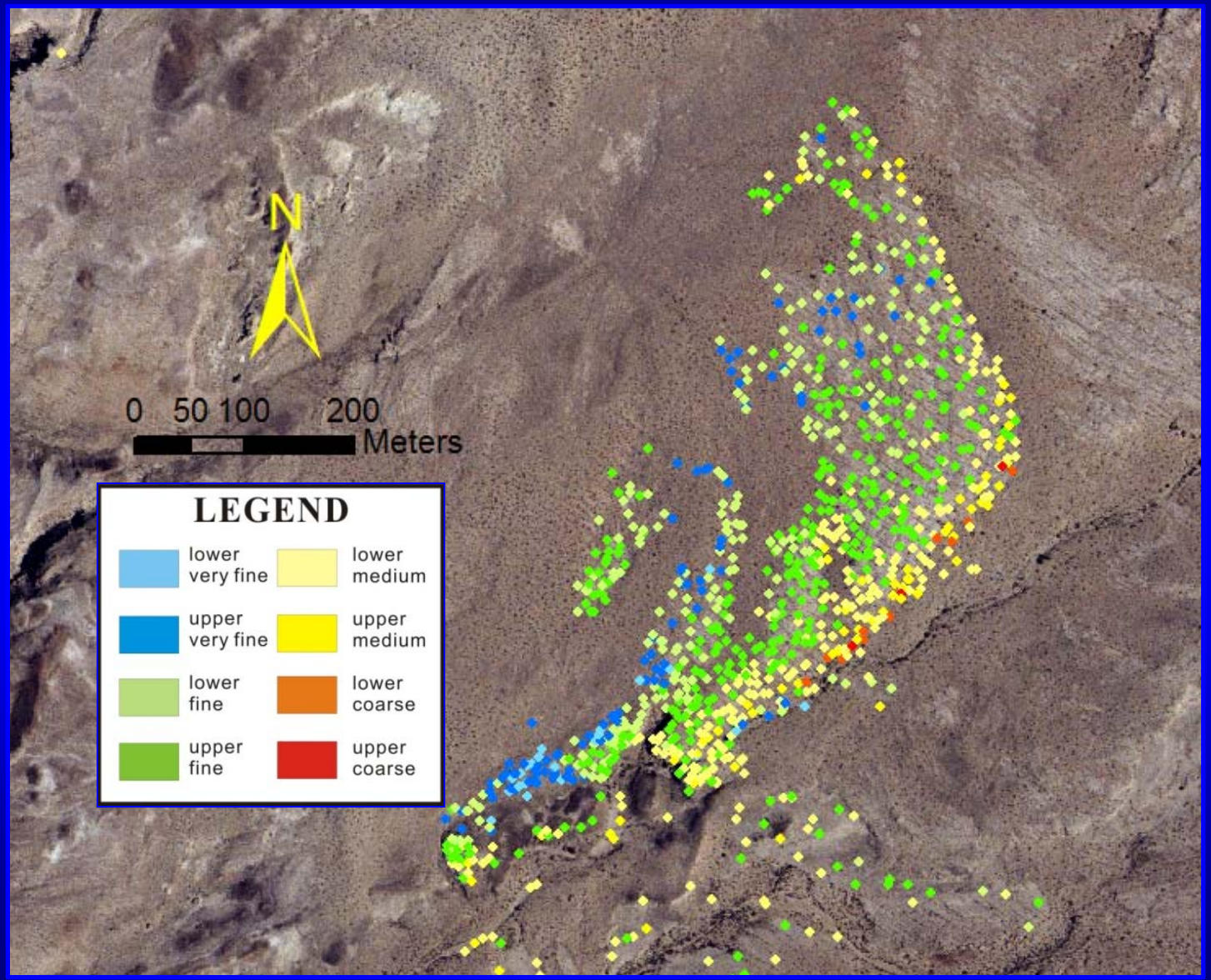
Dune-scale cross beds

Rib ‘n Furrow

Wu et al., 2015

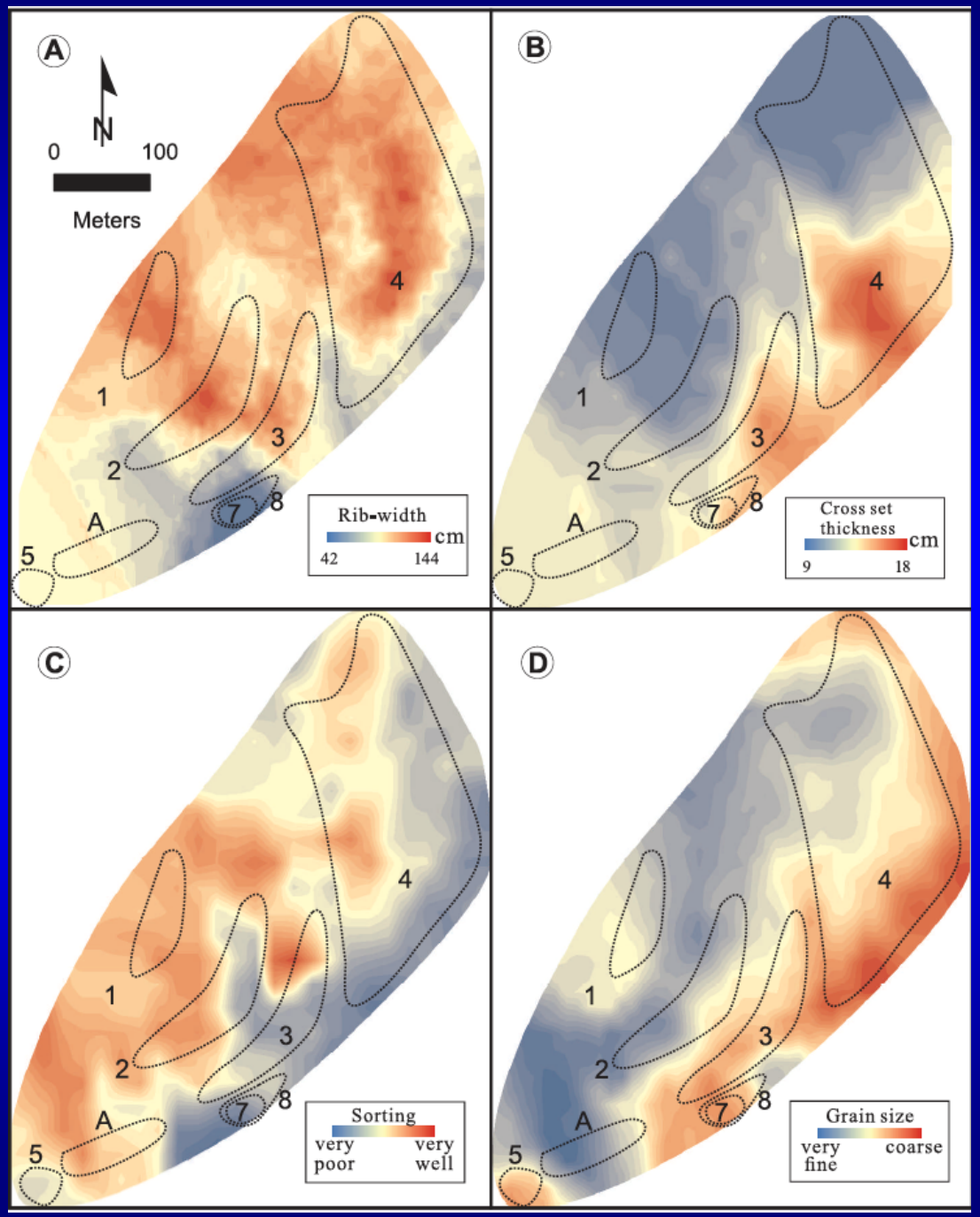


Grain Size



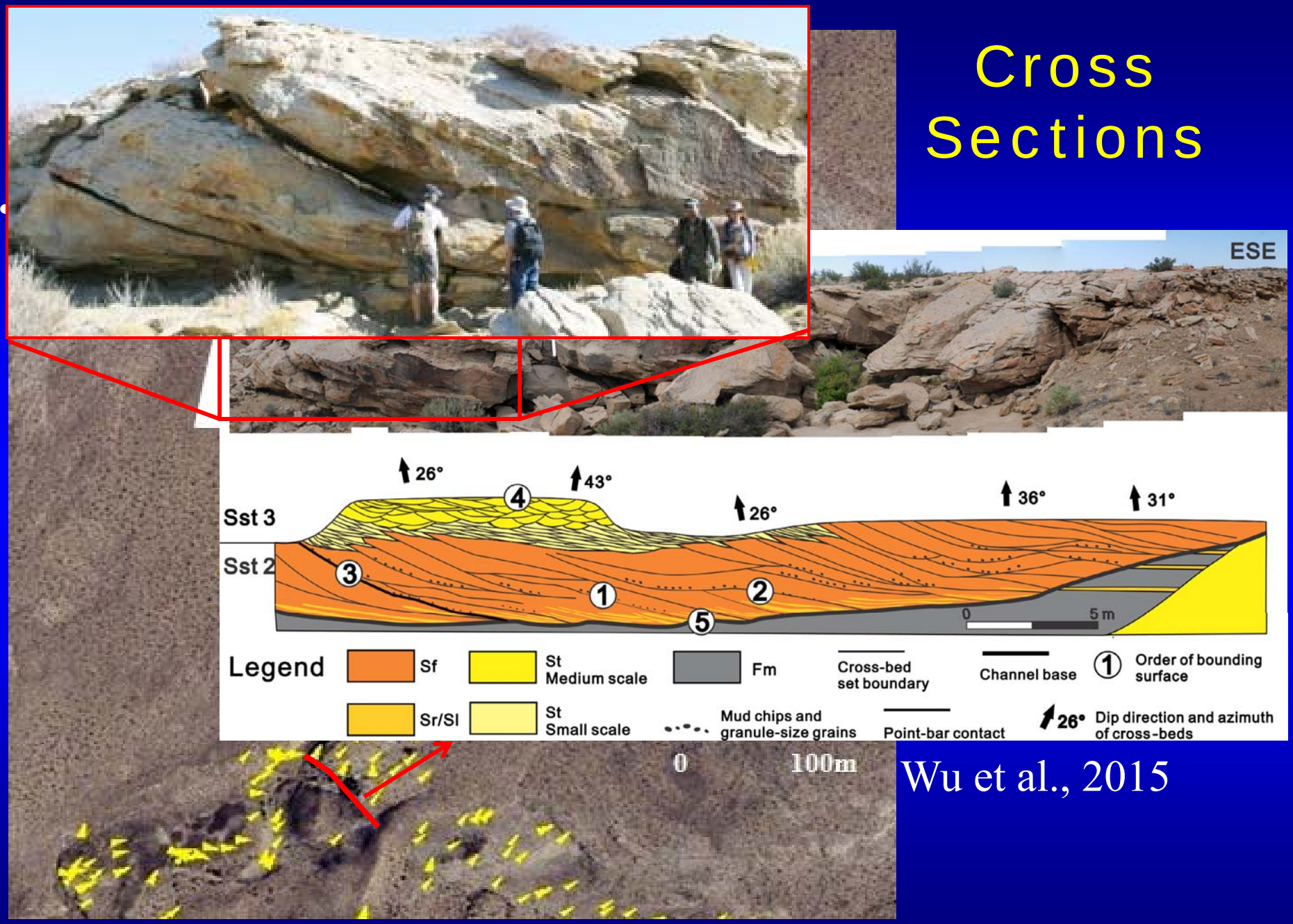
Wu et al., 2015

Areal parameters



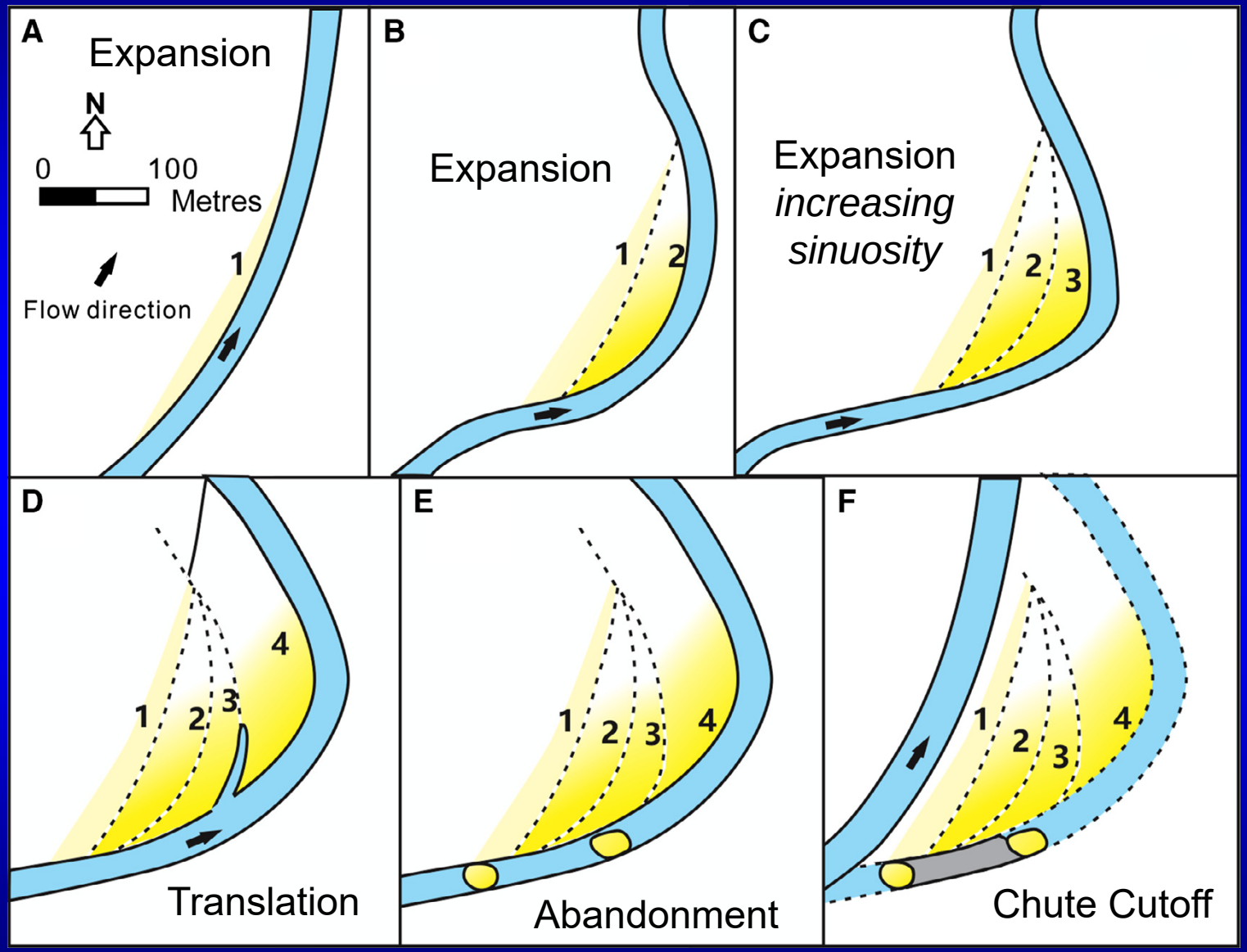
Wu et al., 2015

Cross Sections



Wu et al., 2015

Evolution of a meander loop



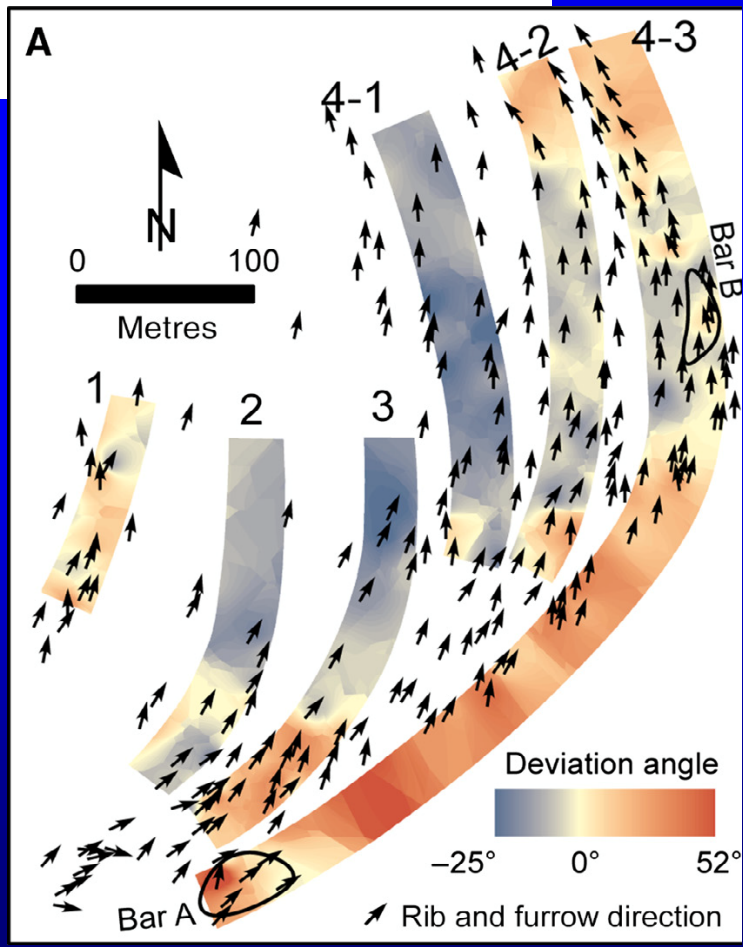
Wu et al., 2016

SEDIMENTOLOGY
the journal of the International Association of Sedimentologists
IAS
Sedimentology (2016) **63**, 1458–1473
doi: 10.1111/sed.12269

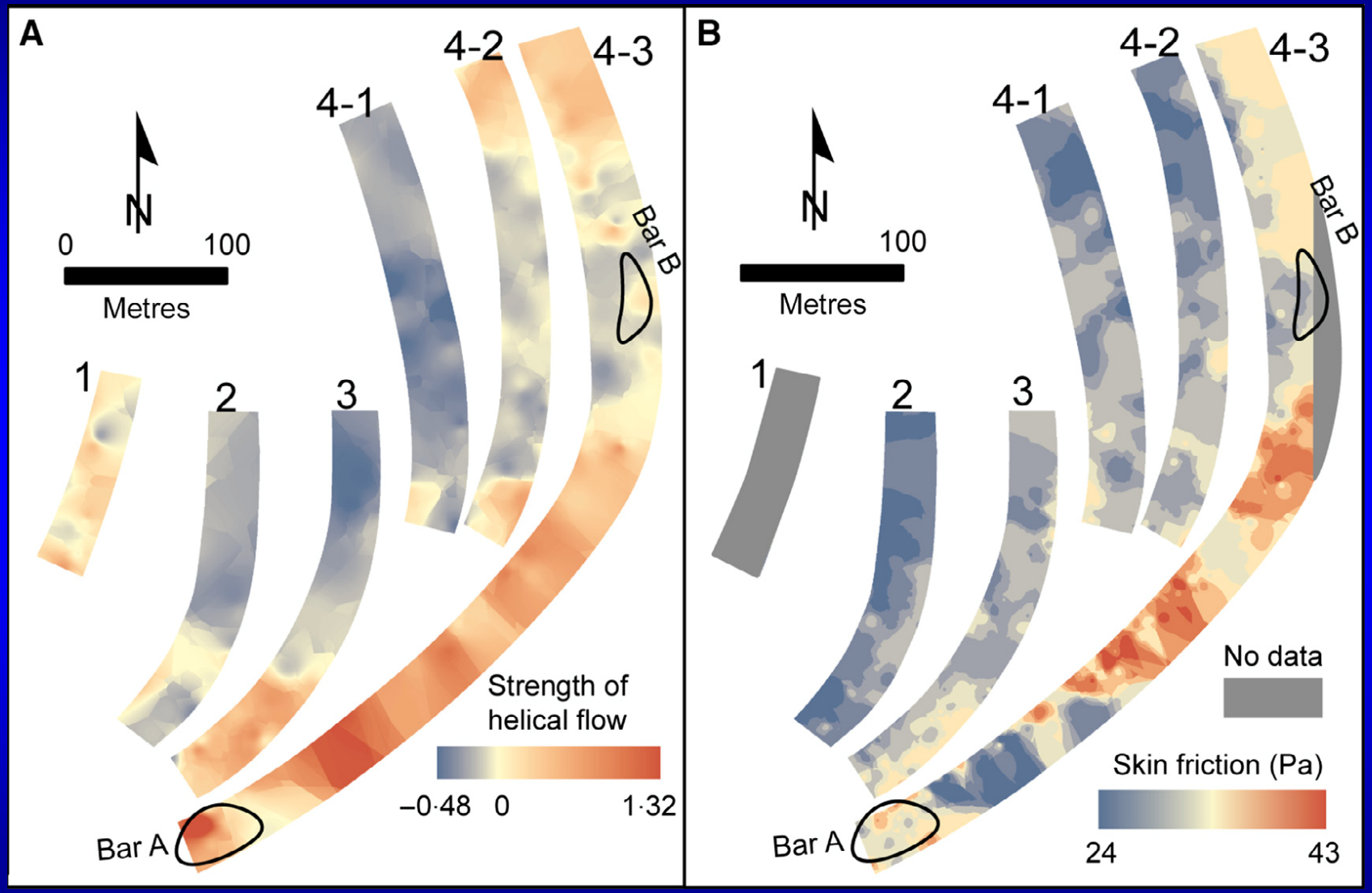
Formation of point bars through rising and falling flood stages: Evidence from bar morphology, sediment transport and bed shear stress

CHENLIANG WU*, MOHAMMAD S. ULLAH†, JIN LU‡ and JANOK P. BHATTACHARYA§

Paleoflow field versus bar migration direction and channel orientation

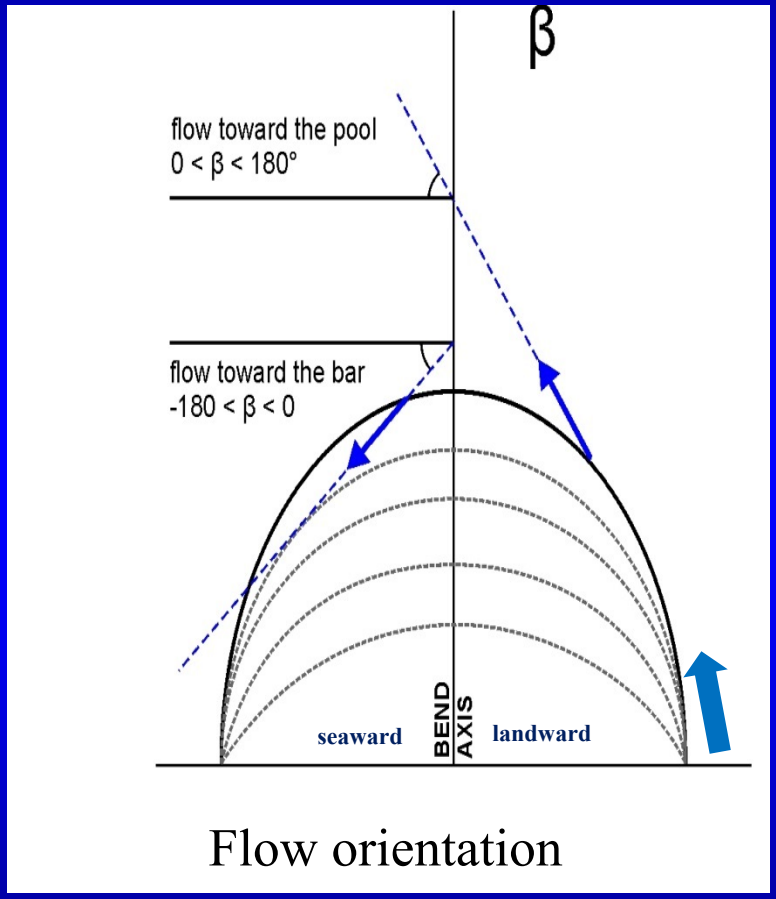


Flow Strength & Skin Friction



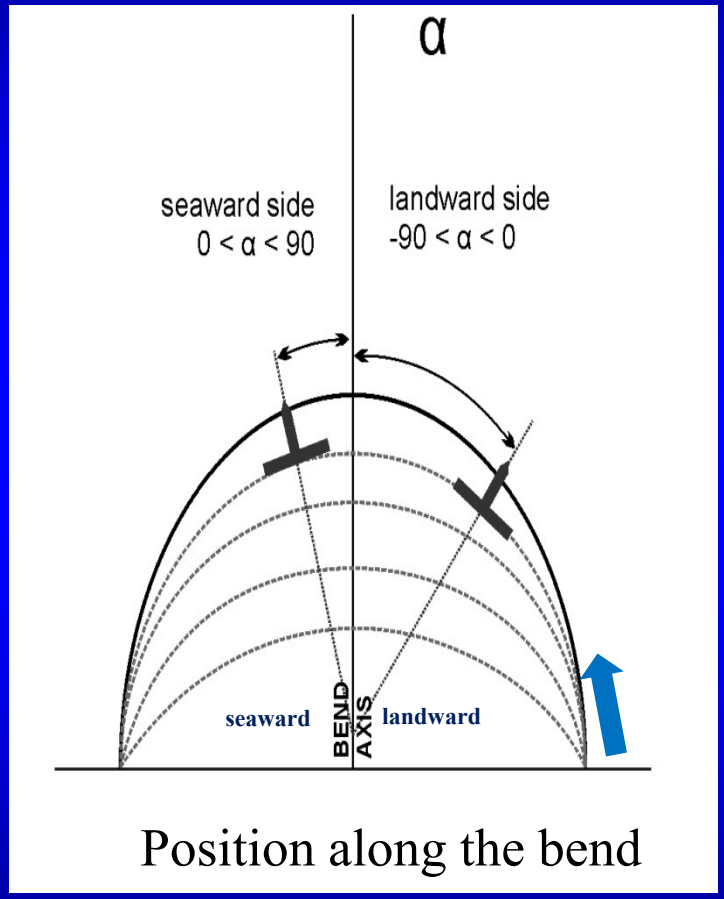
Wu et al., 2016

Paleocurrent variance from Channel Axis



Flow orientation

β >0 flow toward the belt margin
B<0 flow toward the belt axis



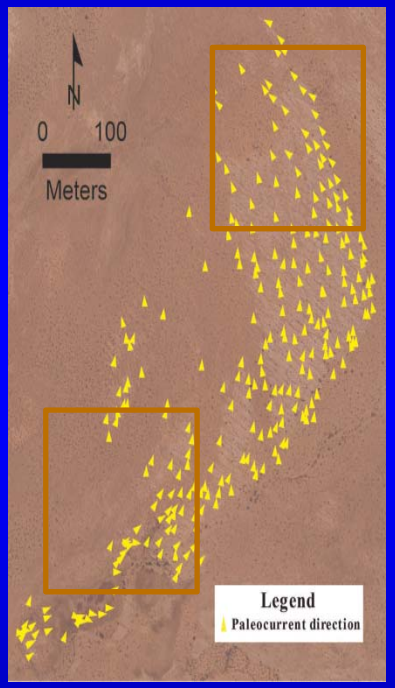
Position along the bend

α <0 landward side of the bar
α >0 seaward side of the bar

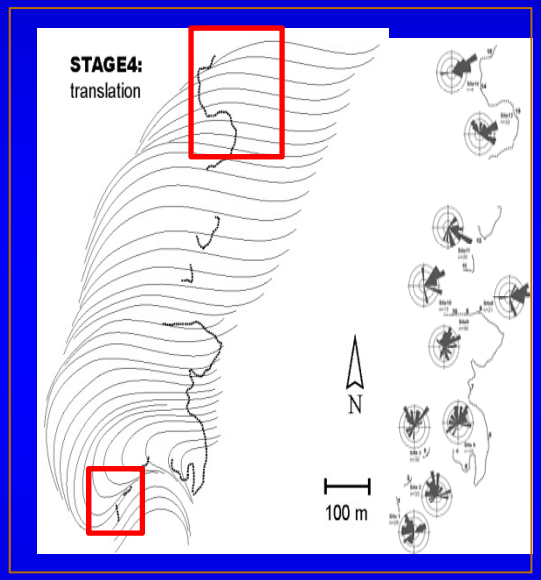
Slide courtesy of M. Ghinassi

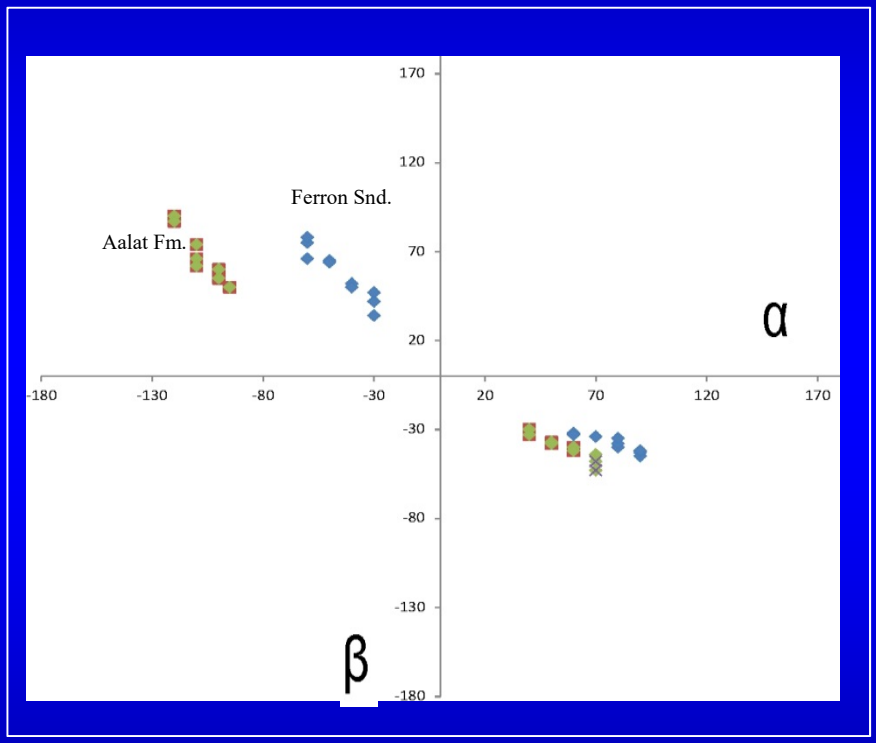
Paleocurrent distribution

Wu et al., 2015- JSR
Cretaceous Ferron Sandstone (Utha, USA)

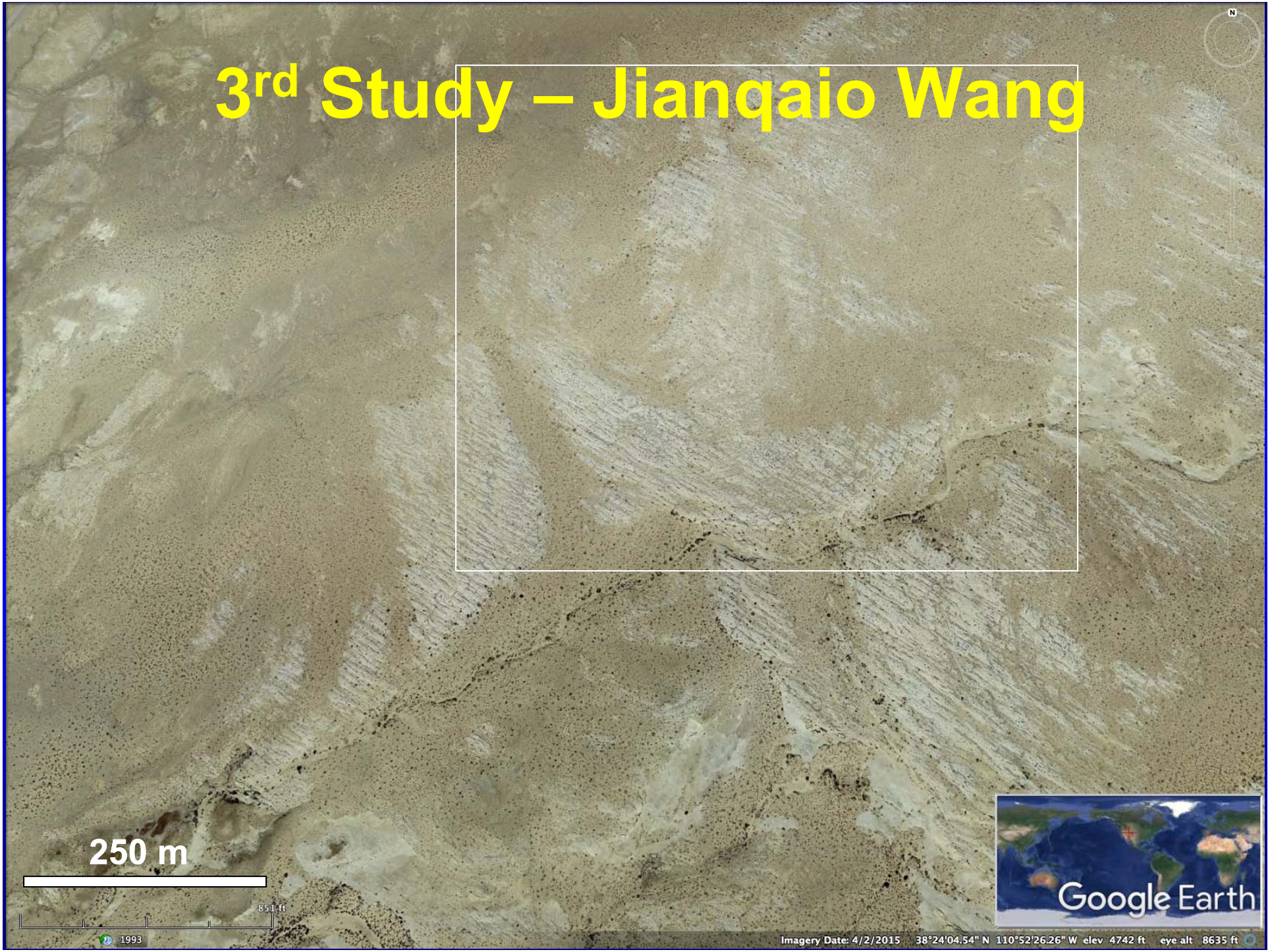


Ghinassi et al., 2013- JSR
Pleistocene Aalat Fm. (Eritrea)



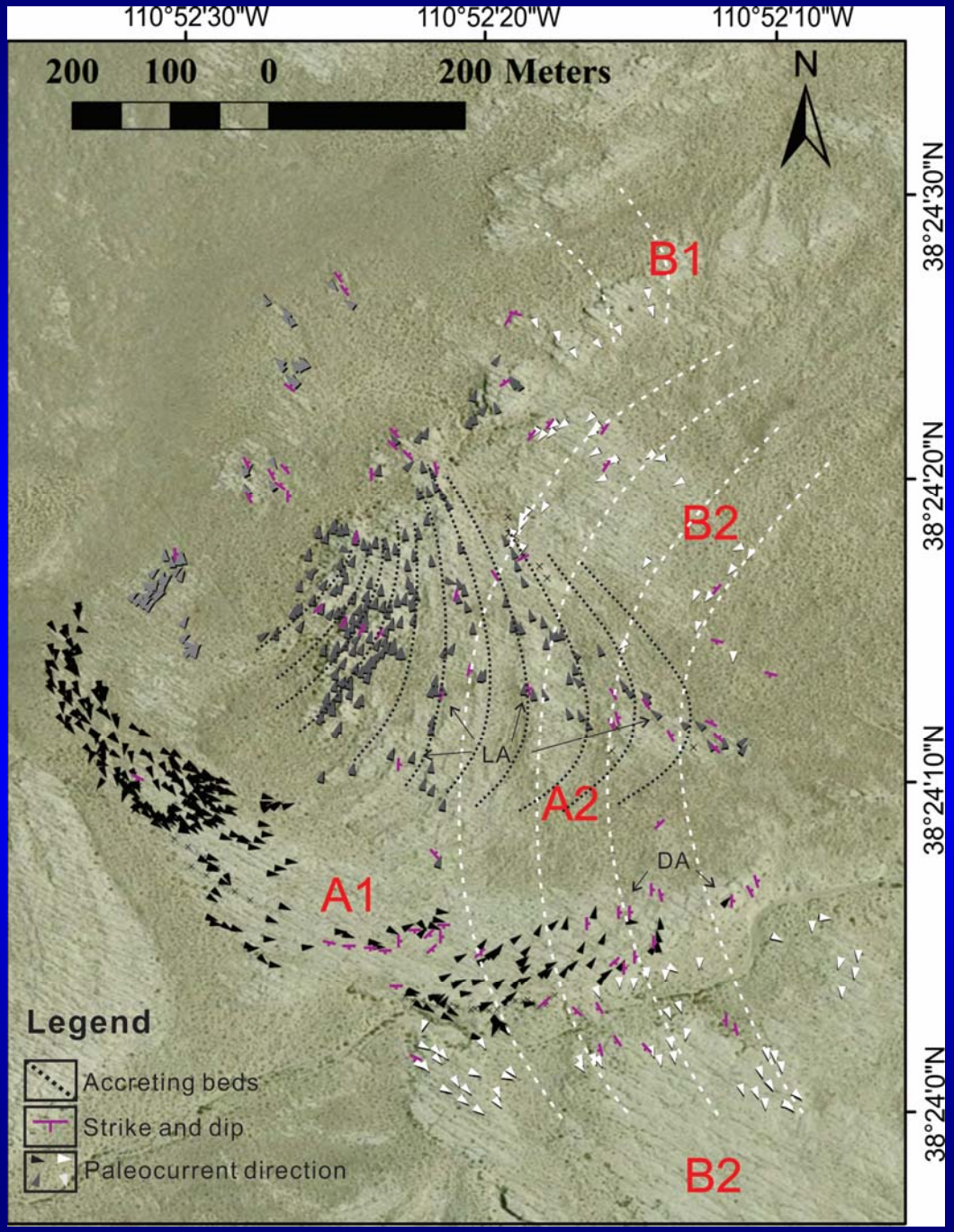


Slide courtesy of M. Ghinassi

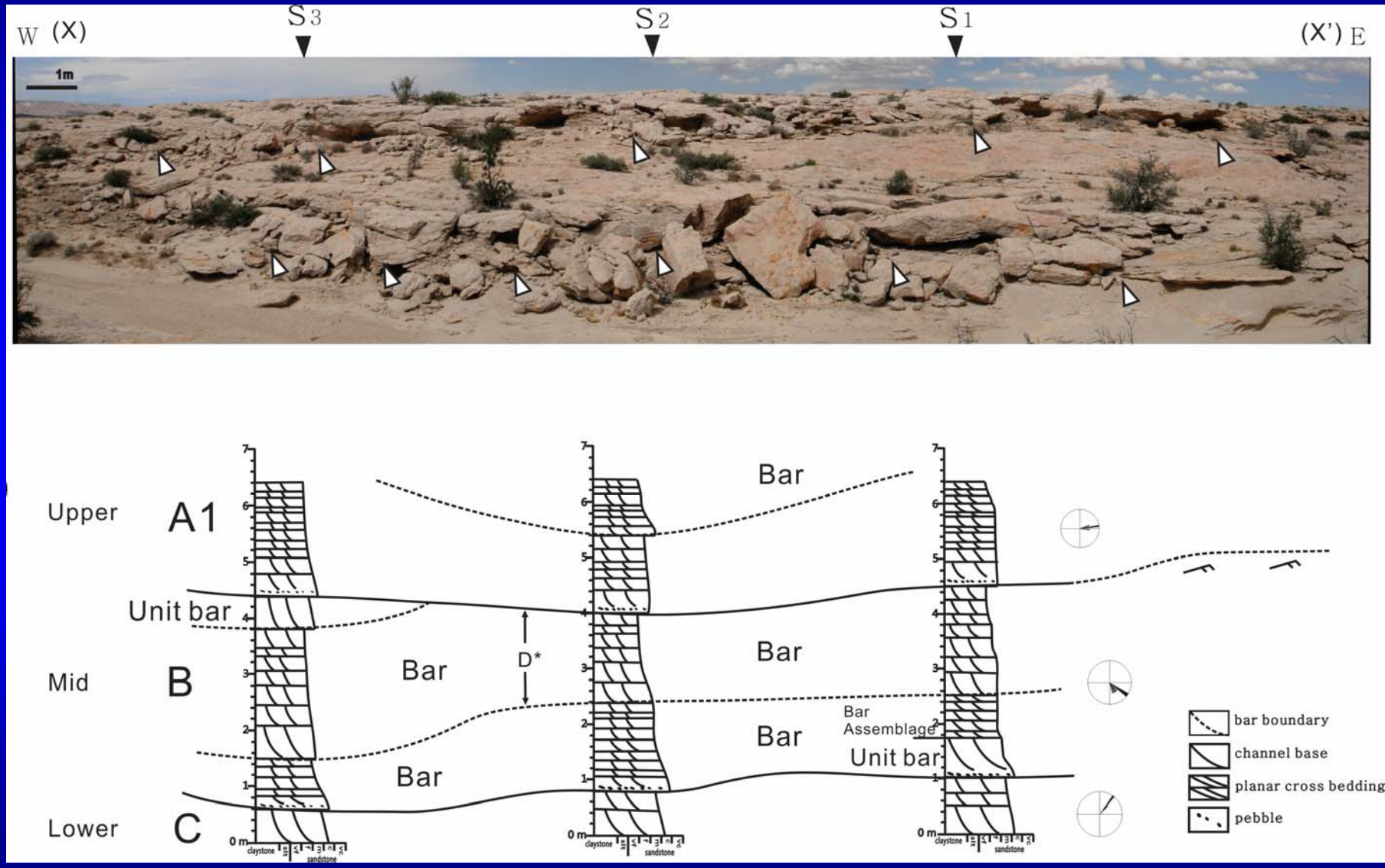

3rd Study – Jianqaio Wang
250 m
851 ft
1993
Google Earth
Imagery Date: 4/2/2015 38°24'04.54" N 110°52'26.26" W elev 4742 ft eye alt 8635 ft

Identification of channel belts

- Paleocurrent changes
- Grain size jumps
- Cross-cutting relationships

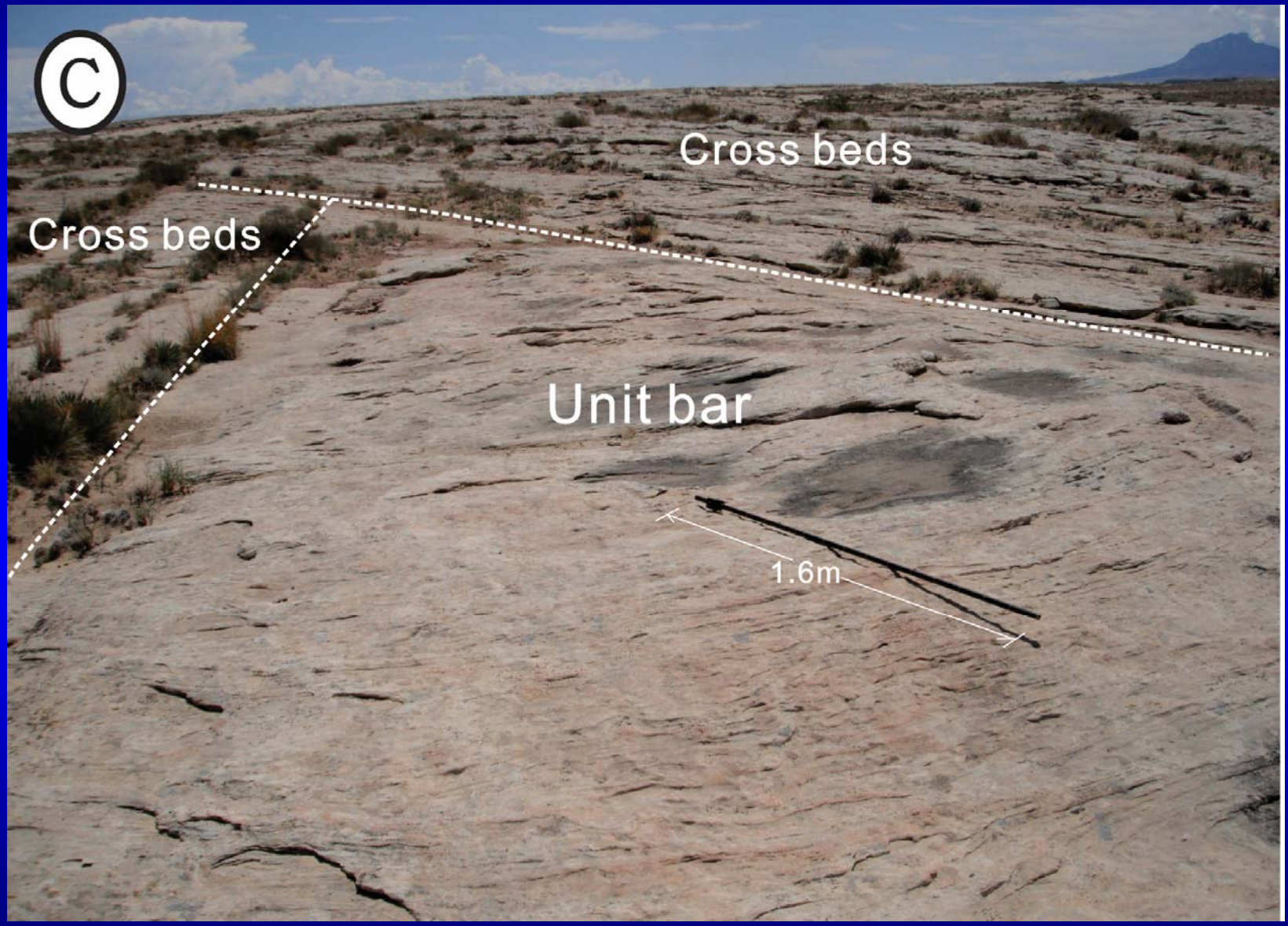


3 channel belts



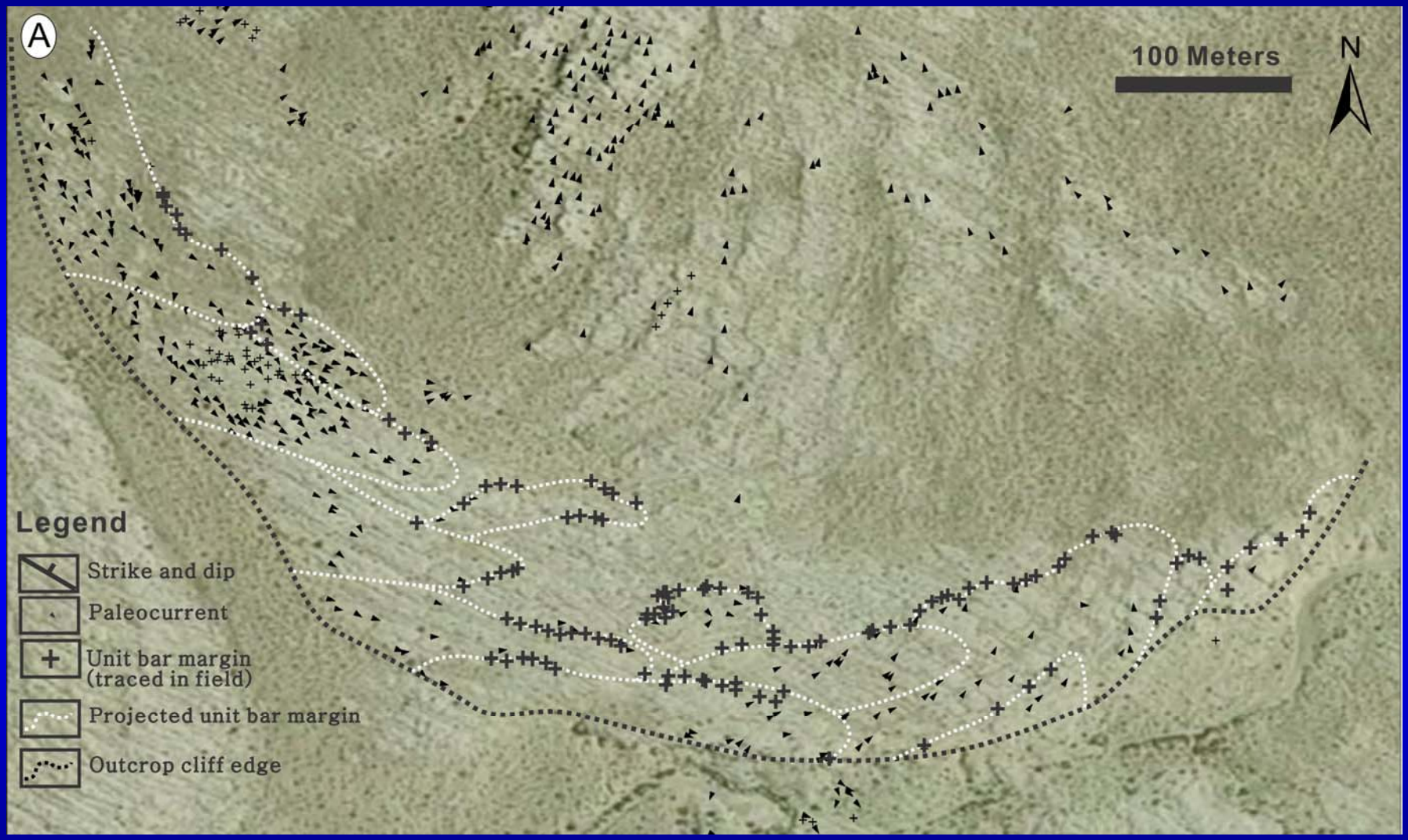
Jianqaio Wang, 2013

Identification of Unit Bars in Outcrop



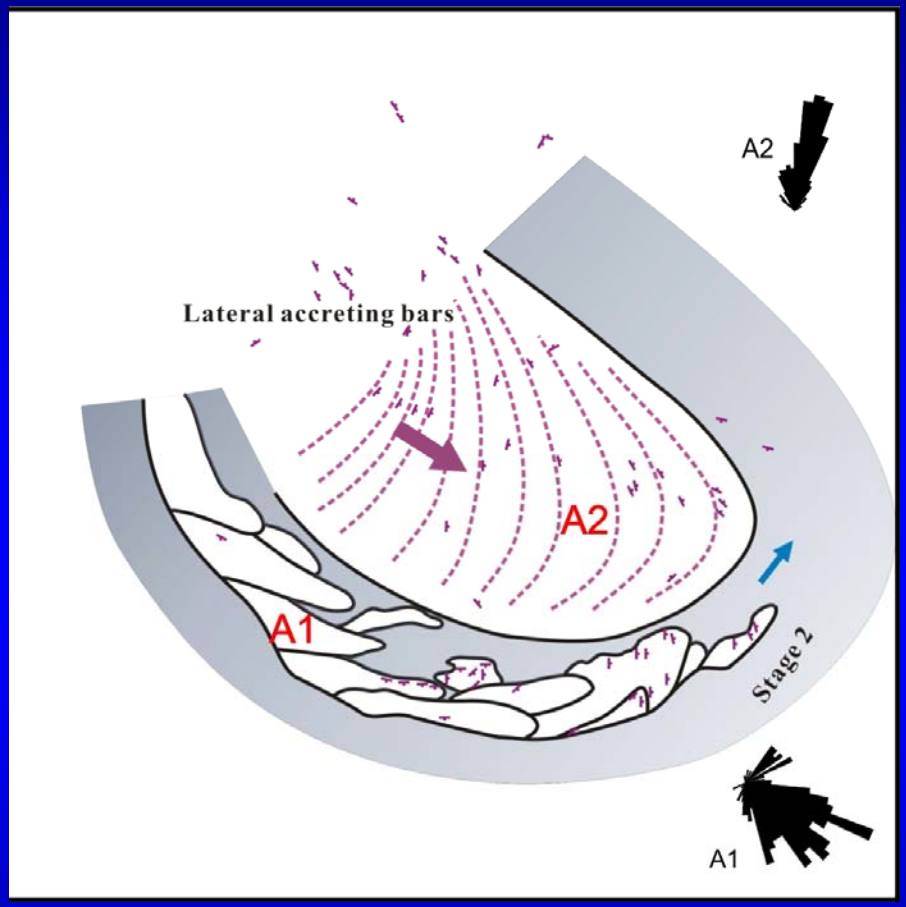
Meters-wide ribs, >0.5-meter thick foresets

Mapping Unit Bars



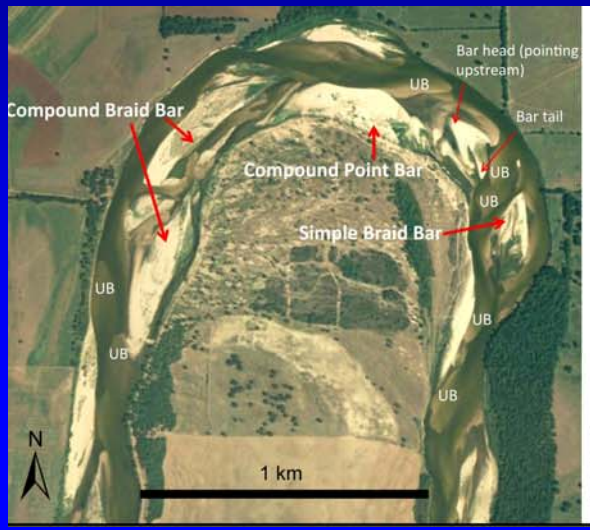
Wang & Bhattacharya, in revision, JSR

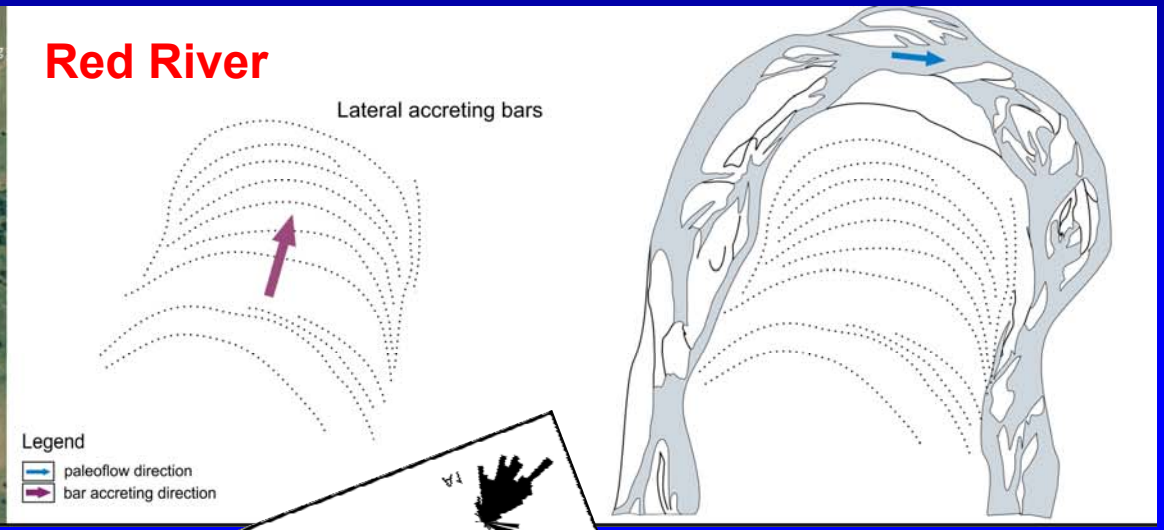
Paleochannel Reconstruction



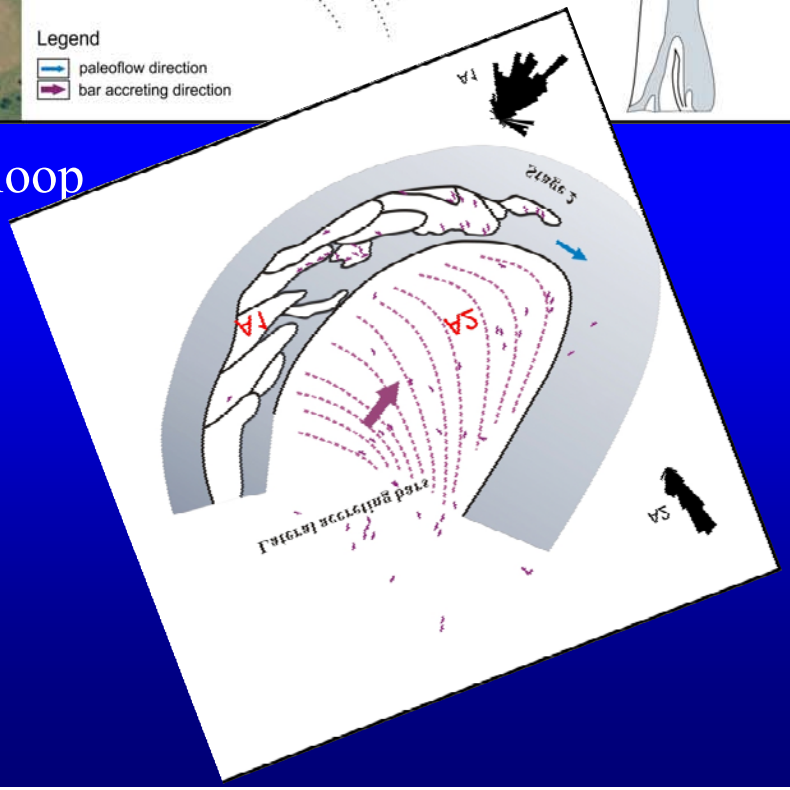
Unit bars are amalgamated and plastered onto the outside of the meander during late-stage filling Wang and Bhattacharya, *in revision*, JSR).

Comparison to Red River



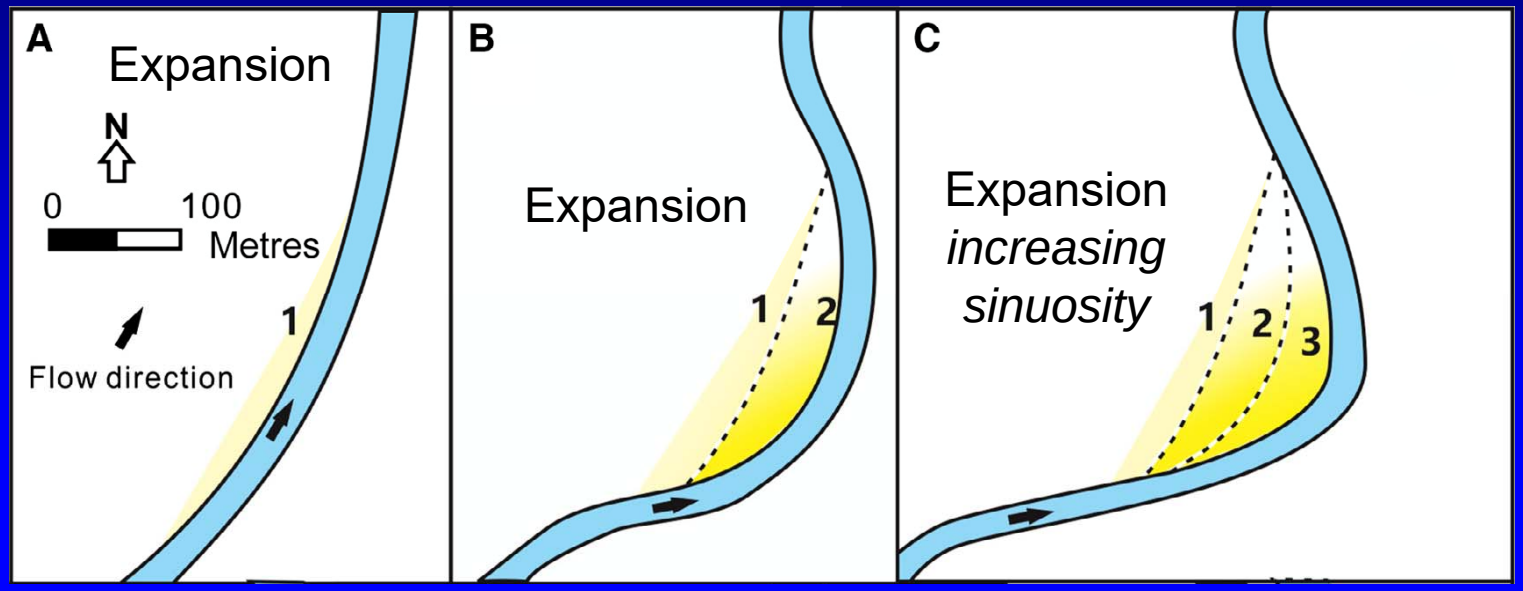


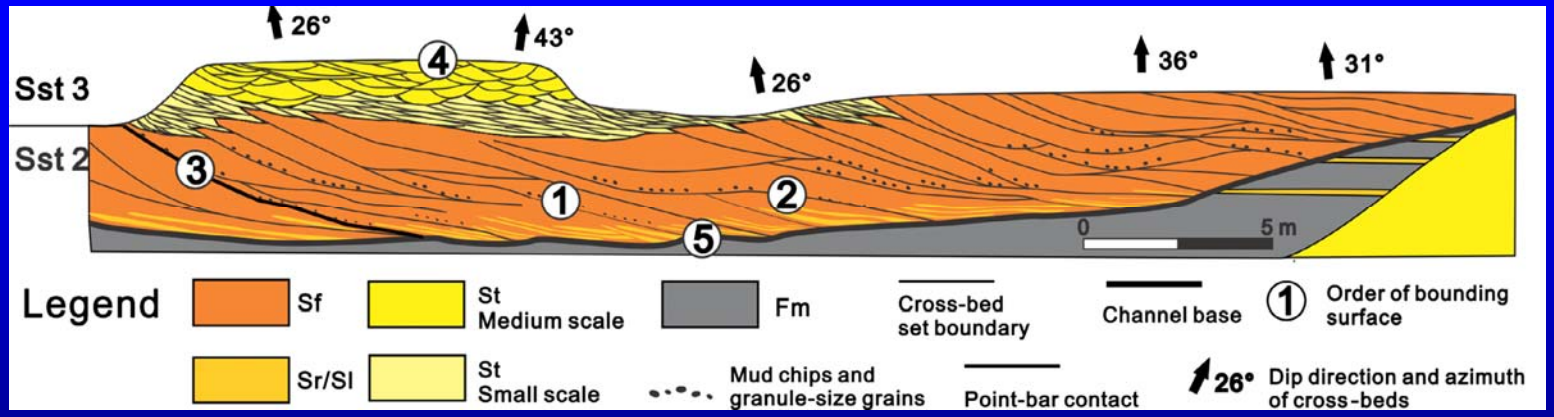
Braid bars in a meander loop



Wang & Bhattacharya, in revision, JSR

Paleohydraulics





Wu et al., 2016

Dimensions and Shapes

Table 1. Channel dimension parameters.

Channel bend	Channel depth (m)*	Channel width (m)*	Sinuosity†	Wavelength (m)†	Radius of curvature (m)†	Amplitude (m)†
1	ND	ND	1·04	830	351	103
2	1·7 to 2·9	23 to 59	1·14	820	205	201
3	2·0 to 3·4	35 to 89	1·19	940	216	267
4-1	2·0 to 3·4‡	32 to 81‡	1·20	1012	228	302
4-2			1·19	1149	263	329
4-3			1·22	1157	255	360

TABLE 2.—*Paleohydraulic parameters estimated from Method 1.*

Point Bar Number	Average Set Thickness (cm)	Average Dune Height (cm)	Channel Depth (m)	Channel Width (m)	Sinuosity
1	/	/	/	/	1.01
2	9.7	22–43	1.7–2.9	23–59	1.19
3	12.0	27–54	2.0–3.4	35–89	1.35
4	11.4	25–51	2.0–3.4	32–81	1.44

$Qw = 115 - 387 m^3/s$

CONCLUSIONS

- River type – low sinuosity highly amalgamated meanderbelts
- Small to moderate size (<5m deep, $Q_w \sim 10^2$ m^3/s)
- Moderate to steep gradient.
  - ongoing work on backwater effects.
- Provides a testing ground for river plan form models, grain size variability, and channel migration and belt amalgamation, in a sequence stratigraphic context and in an ancient example.