Stratigraphic Stacking of Outcropping Slope Channels, Tres Pasos Formation, Chile: Insights into Turbidite Reservoir Distribution*

Ryan Macauley[1] and Steve Hubbard[1]

Search and Discovery Article #50478 (2011)
Posted September 26, 2011

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, USA, April 10-13, 2011

[1]University of Calgary, Calgary, AB, Canada (r_macauley@hotmail.com)

Abstract

Deep-water slope channel deposits have been proven to hold substantial hydrocarbon reserves making them attractive targets for exploration along continental margins. Advances in seismic imaging has resulted in vivid 3D perspectives of deep-water sedimentary systems in the subsurface. Despite these advances, sedimentological detail irresolvable in seismic data is crucial for understanding the connectivity within, and amongst, reservoir-scale sedimentary bodies. An outcrop belt, 130 m high and 2.5 km long, from the Cretaceous Tres Pasos Formation, Chile, represents an important means for acquiring this sedimentological data, allowing turbidite-channel development to be analyzed from the bed- to channel body-scale. This study attempts to capture the stratigraphic complexities of slope-channel strata, with a focus on internal channel-fill architecture and channel-stacking behavior.

The Tres Pasos Formation consists primarily of mudstone- and siltstone-dominated strata associated with a progradational, graded slope system characterized by > 800 m of relief. Architectural analysis was completed on coarse clastic lower- to base-of-slope deposits. Numerous gullies cross-cut the outcrop at high angles and provide excellent 2D and 3D exposures of channel geometries. The data collected consists of >1600 m of measured section, hundreds of paleoflow measurements, numerous photomosaics, and thousands of GPS waypoints used to map channel strata in 3D. At least three channel complexes characterize the stratigraphy, demarcated by bounding siltstone-dominated deposits and significant shifts in channel-stacking patterns. Channel complexes are composite features comprised of stacked channels, each of which is 6-15 m thick. The margins of channels are characterized by thinly interbedded sandstone and siltstone that were deposited within the confines of the conduit. Channel axes consist of sedimentation units 0.2-3 m thick, attributed to collapsing high-concentration turbidity currents.

Eighteen channel elements stack vertically, or slightly offset of one another, in the 130-m thick section. The overall aggradational stacking pattern is likely associated with confinement of the channel system; however a mechanism for this confinement is speculative because channel complex-scale outer levees have yet to be recognized in the outcrop belt. It is also plausible that structural confinement in the narrow Magallanes Basin foredeep influenced the architecture of slope channels.

References

Deptuck, M.E., Z. Sylvester, C. Pirmez, and C. O'Byrne, 2007, Migration-aggradation history and 3-D seismic geomorphology of submarine channels in the Pleistocene Benin-major Canyon, western Niger Delta slope: Marine and Petroleum Geology, v. 24/6-9, p. 406-433.

Hodgson, D.M., C.N. Di Celma, R.L. Brunt, and S.S. Flint, 2011, Submarine slope degradation and aggradation and the stratigraphic evolution of channel-levee systems: Journal of the Geological Society, v. 168/3, p. 625-628.

Hubbard, S.M., A. Fildani, B.W. Romans, J.A. Covault, and T.R. McHargue, 2010, High relief clinoform development: insights from outcrop, Magallanes Basin, Chile: JSR, v. 80, p. 357-375.

McHargue, T., M.J. Pyrcz, M.D. Sullivan, J. Clark, A. Fildani, B.W. Romans, J.A. M. Covault, M. Levy, H. Posamentier, and N. Drinkwater, 2011, Architecture of turbidite channel systems on the continental slope: Patterns and Predictions, *in* S.M. Hubbard, B.W. Romans, and A. Fildani (eds.) Thematic issue: Stratigraphic Evolution of Deep-Water Architecture: Marine and Petroleum Geology, v. 28/3, p. 728-743.

Nakajima, T., J., Peakall, W.D. McCaffrey, D.A. Paton, and P.J.P. Thompson, 2009, Outerbank bars: a new intra-channel architectural element within sinuous submarine slope channels: JSR, v. 79, p. 872-886.

Posamentier, H.W., 2003, Depositional elements associated with a basin floor channel-levee system: case study from the Gulf of Mexico: Marine and Petroleum Geology, v. 20, p. 677-690.

Posamentier, H.W., and V. Kolla, 2003, Seismic geomorphology and stratigraphy of depositional elements in deep-water settings: JSR, v. 73, p. 367-388.

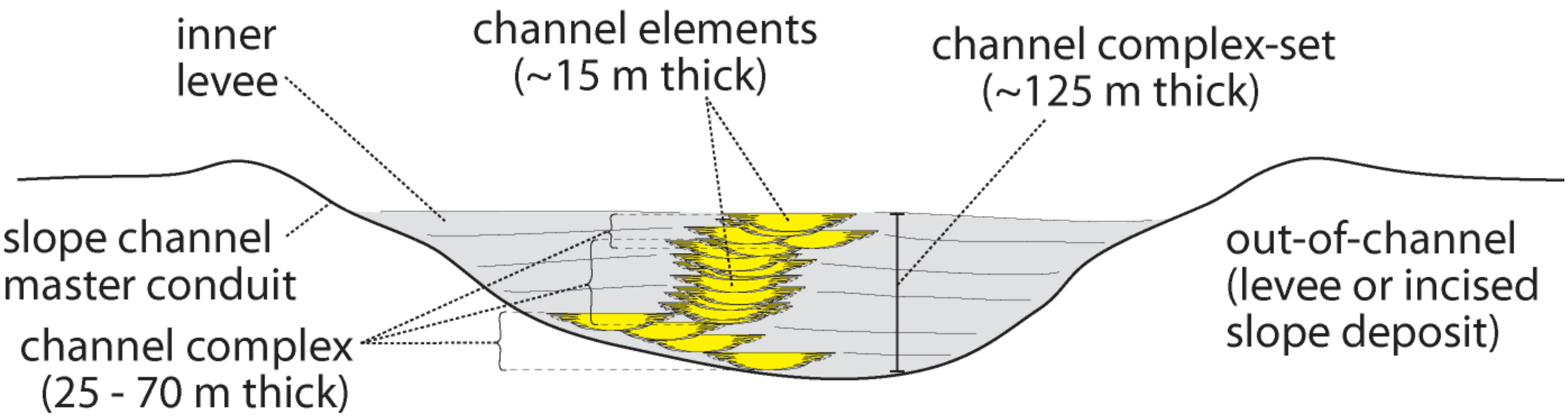
Romans, B.W., A. Fildani, S.M. Hubbard, J.A. Covault, J.C. Fosdick, and S.A. Graham, 2011, Evolution of Deep-Water Stratigraphic Architecture, Magallanes Basin, Chile: Marine and Petroleum Geology, v. 28, p. 612-628.

Samuel, A., B. Kneller, S. Ralan, A. Sharp, and C. Parsons, 2003, Prolific deep-marine slope channels of the Nile Delta, Egypt: AAPG Bulletin, v. 87/4, p. 541-560.

Sylvester, Z., C. Pirmez, and A. Cantelli, 2011, A model of submarine channel-levee evolution based on channel trajectories: Implications for stratigraphic architecture: Marine and Petroleum Geology, v. 28, p. 716-717.

Stratigraphic Stacking of Outcropping Slope Channels, Tres Pasos Formation, Chile: *Insights Into Turbidite Reservoir Distribution*

Ryan Macauley & Steve Hubbard



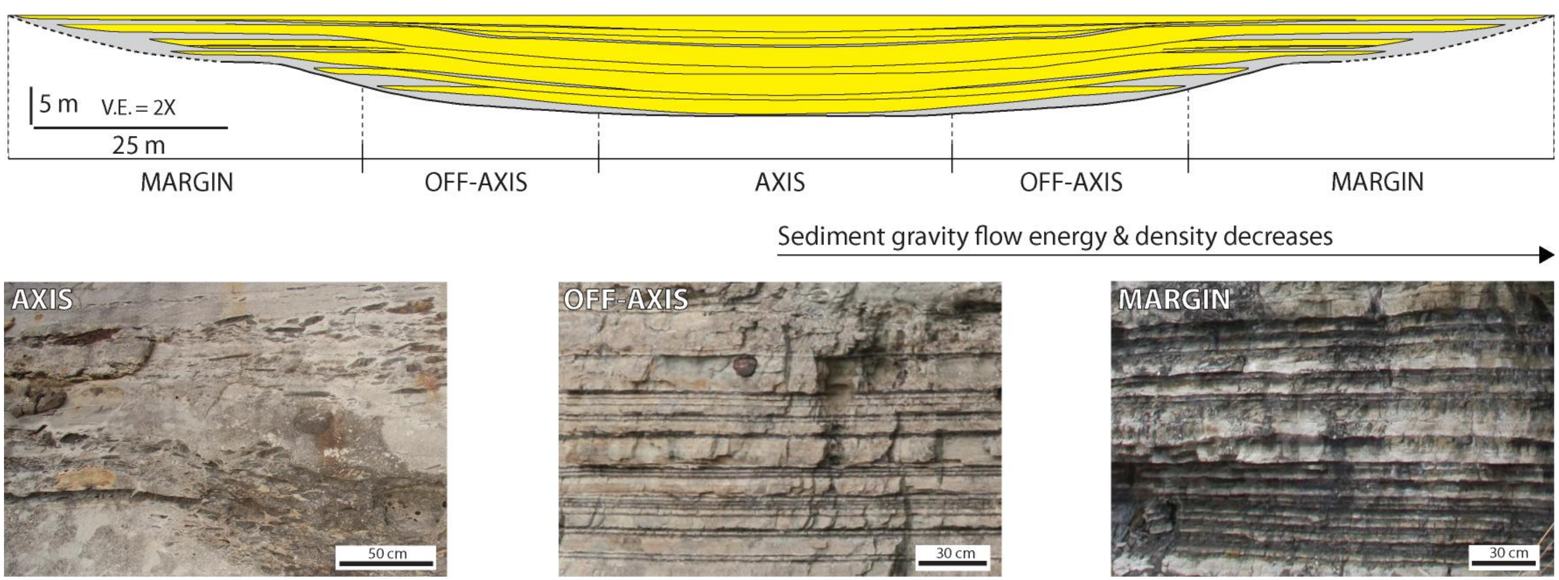
Presentation Objectives: Slope Channel Discussion

- capture the hierarchical stratigraphic complexities of slope-channel strata with a focus on internal channel-fill architecture and channel-stacking behavior

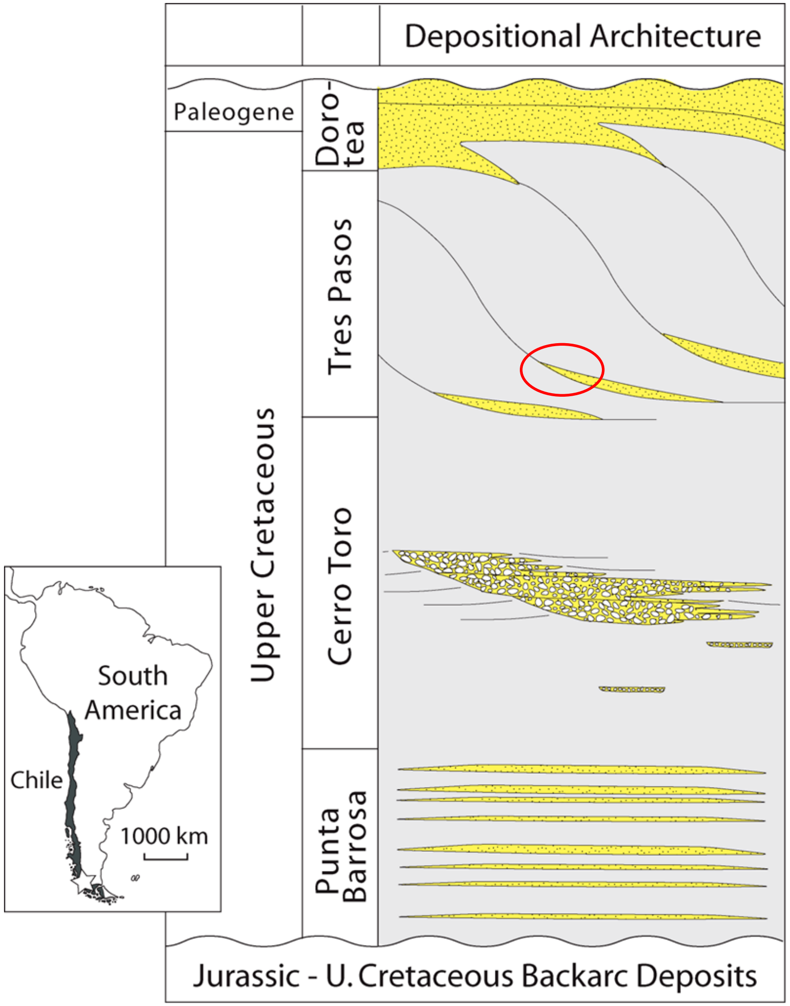
- demonstrate analogies between the outcropping channel complex-set in the Tres Pasos Formation and seismically imaged slope strata

- consider the implications of quantified outcrop observations for:

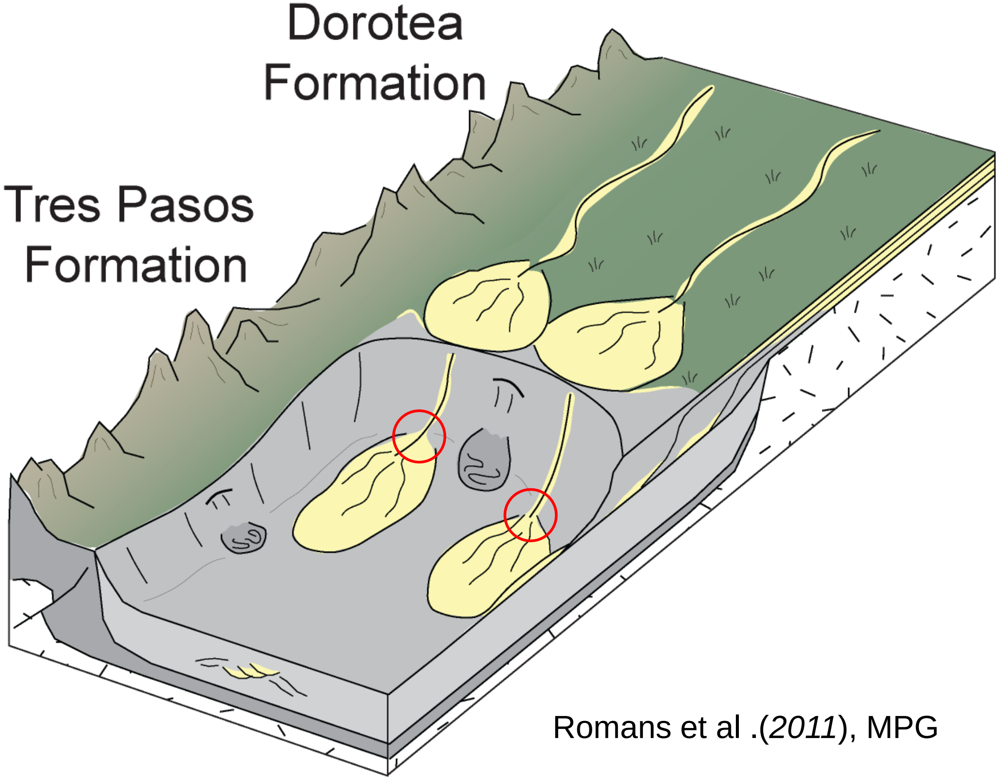
    - *slope-channel evolution*
    - *reservoir heterogeneity*



Paleogeographic Context: Magallanes Foreland Basin



Hubbard et al .(*2010*), JSR

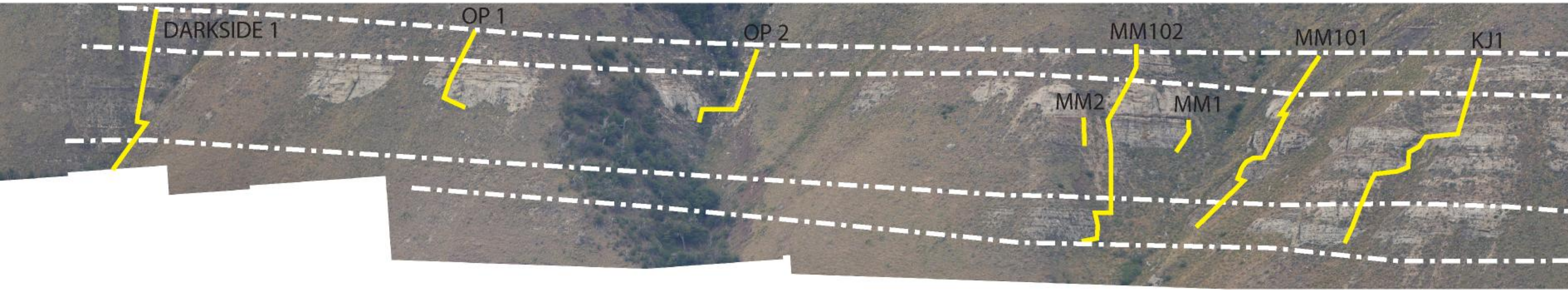


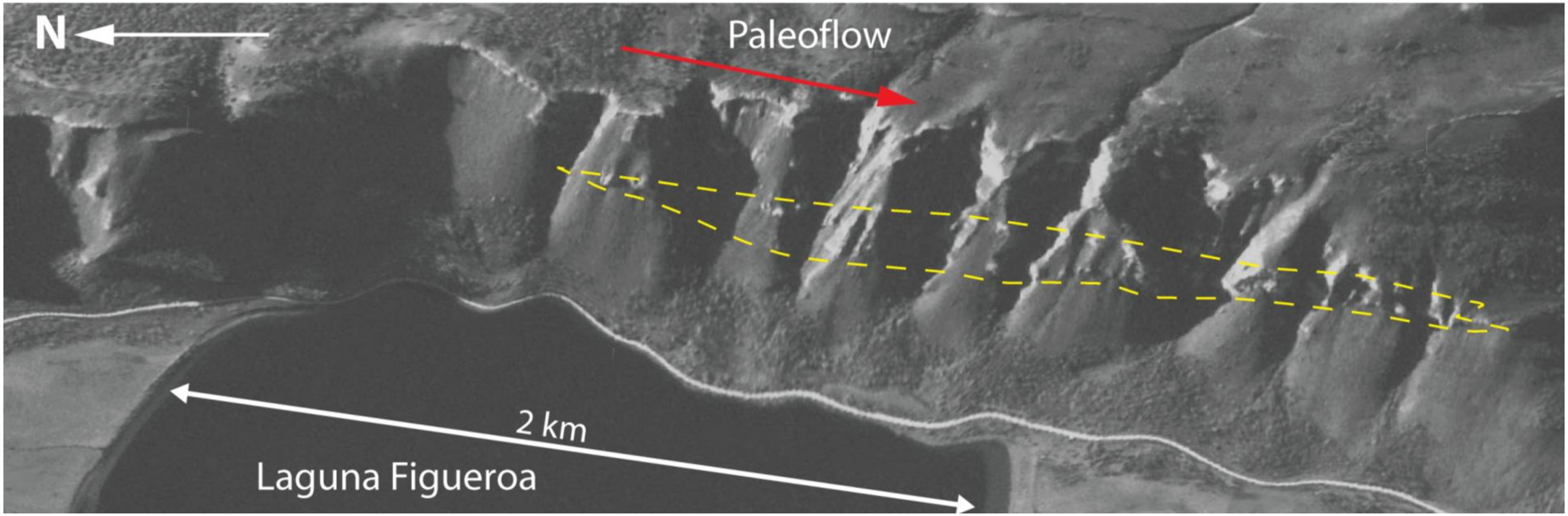
Romans et al .(*2011*), MPG

- Axially-filling Andean foreland
- Context: base of high-relief slope clinoform (800 m relief; 30 km long)

Dataset and Study Area

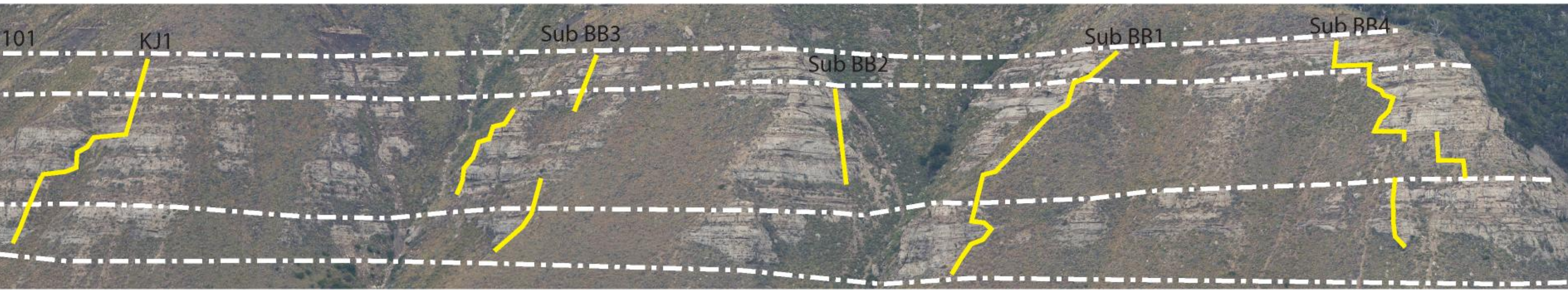
- channel strata obliquely exposed along an outcrop belt 2.5 km long X 130 m thick
- 2000 m of section; 183 channel element packages (18 channels); 3596 individual sedimentation units; and 100s of sole marks measured

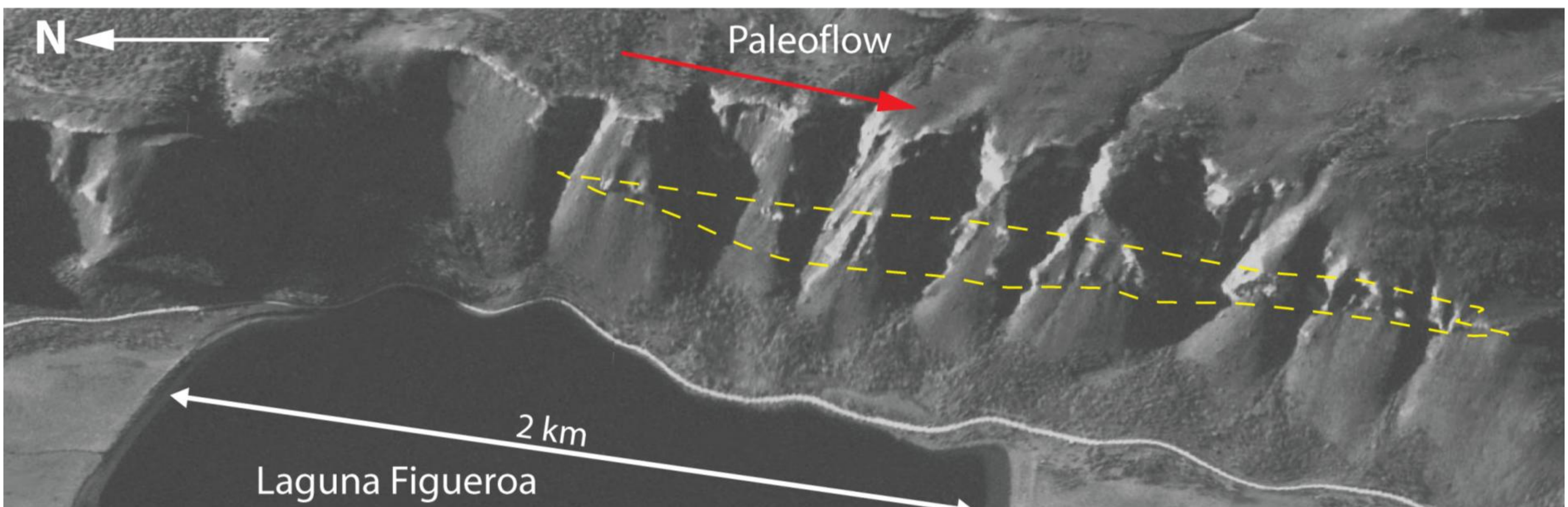




Dataset and Study Area

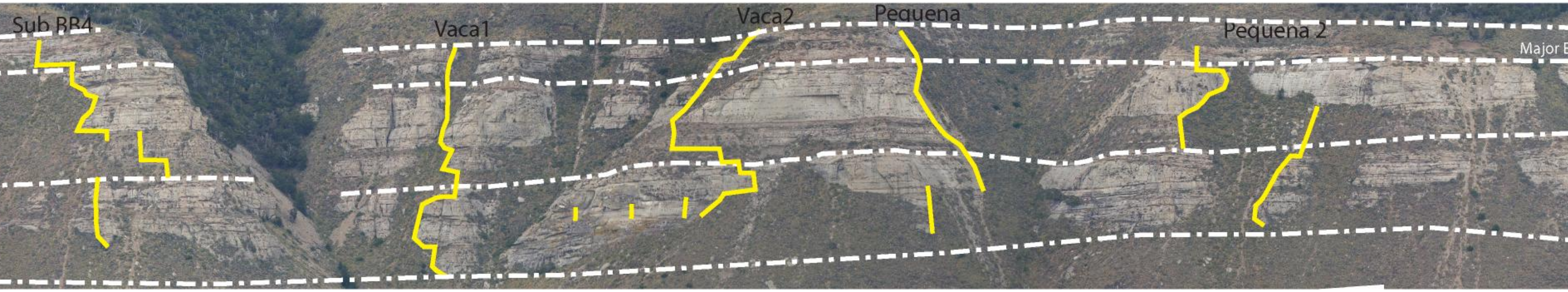
- channel strata obliquely exposed along an outcrop belt 2.5 km long X 130 m thick
- 2000 m of section; 183 channel element packages (18 channels); 3596 individual sedimentation units; and 100s of sole marks measured

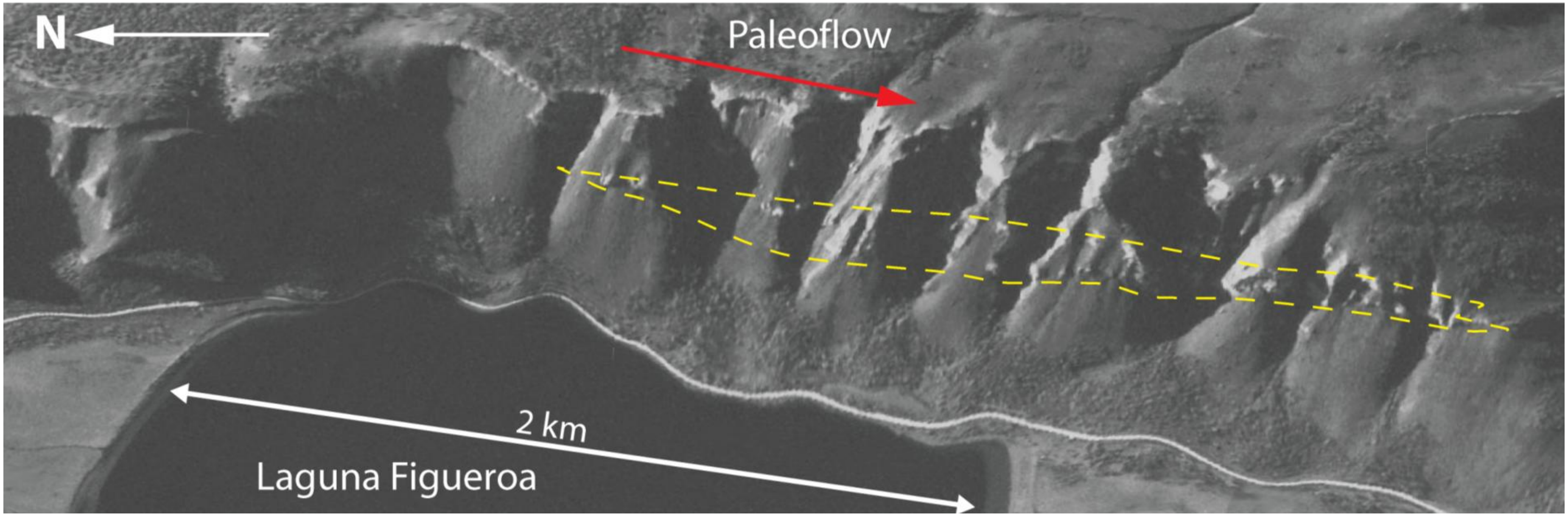




Dataset and Study Area

- channel strata obliquely exposed along an outcrop belt 2.5 km long X 130 m thick
- 2000 m of section; 183 channel element packages (18 channels); 3596 individual sedimentation units; and 100s of sole marks measured

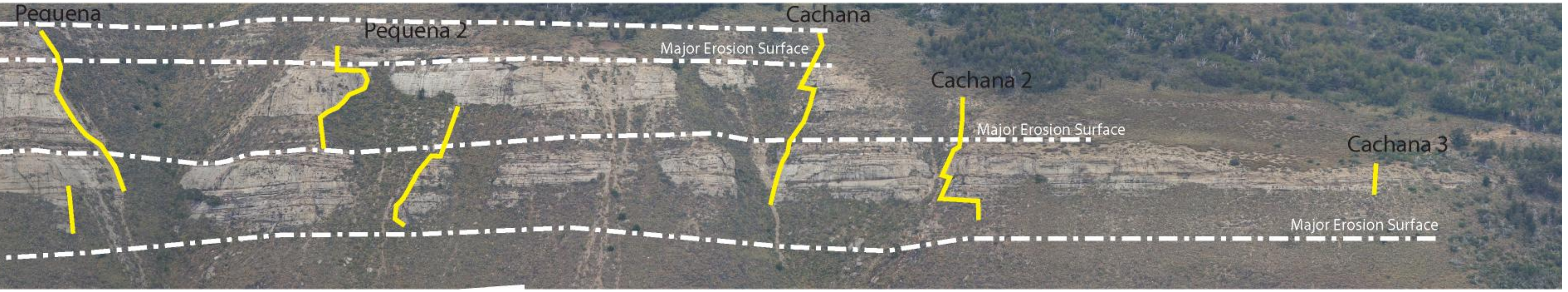


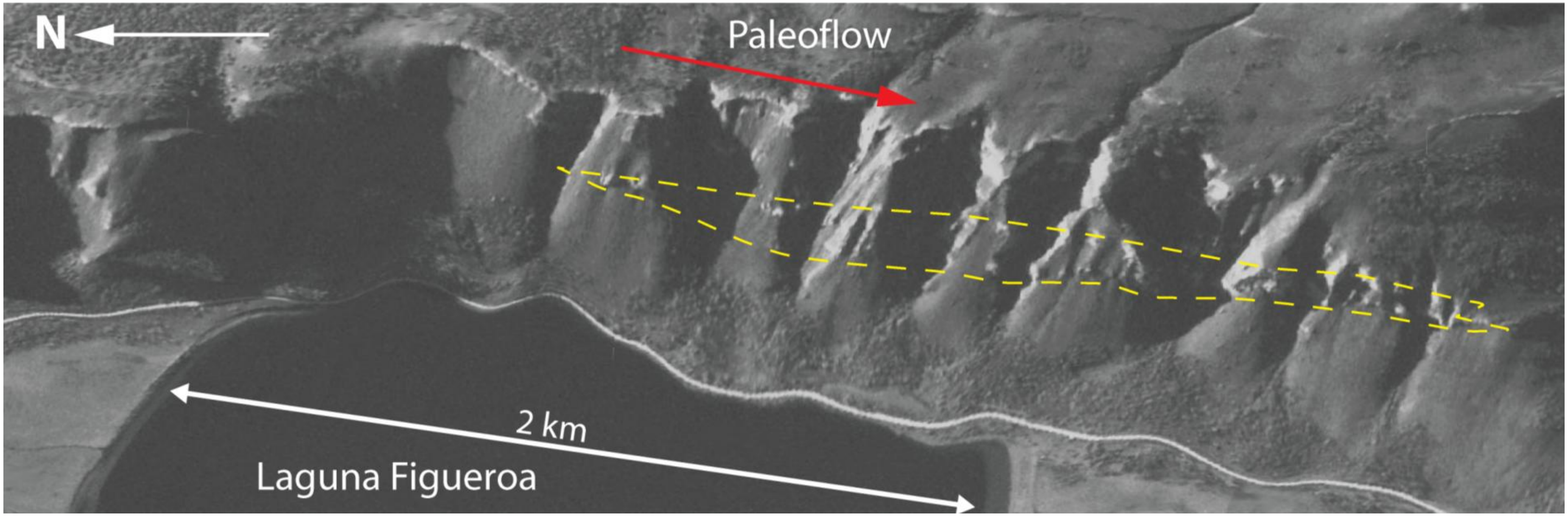


Dataset and Study Area

• channel strata obliquely exposed along an outcrop belt 2.5 km long X 130 m thick

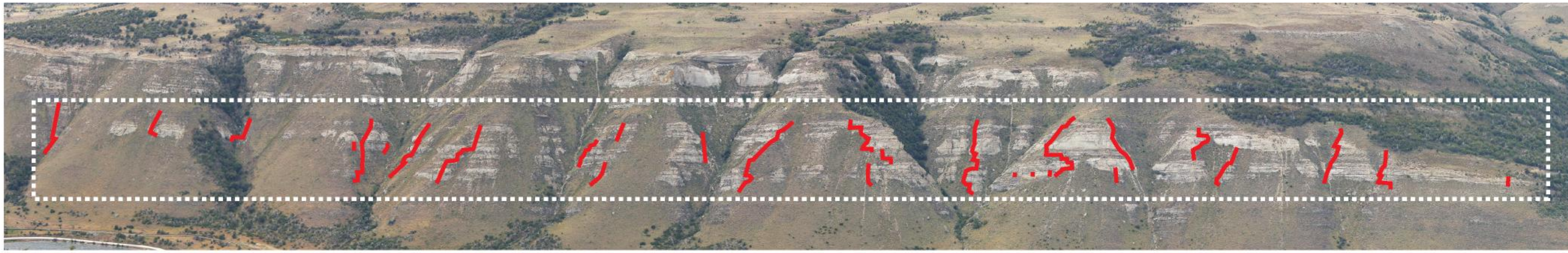
• 2000 m of section; 183 channel element packages (18 channels); 3596 individual sedimentation units; and 100s of sole marks measured

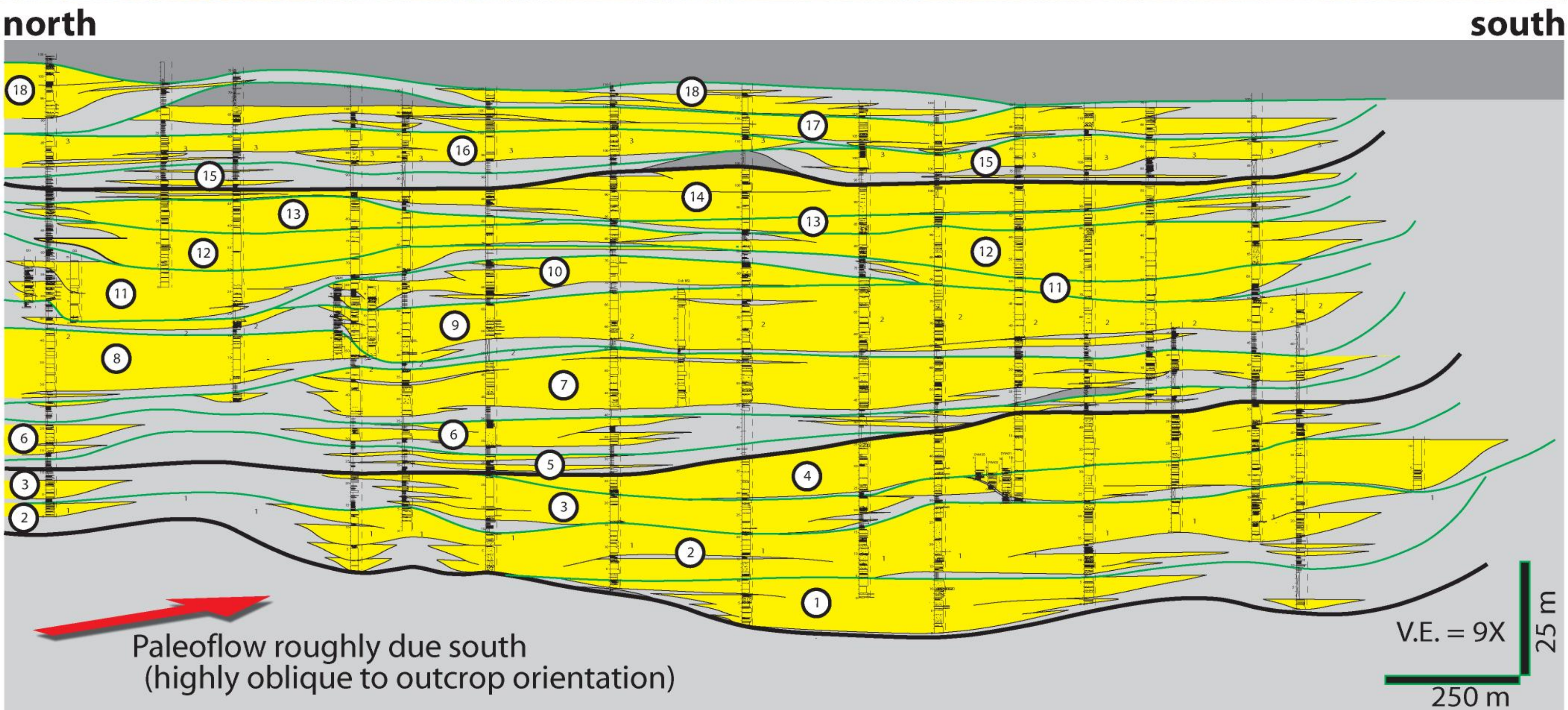




Element Stacking: Tres Pasos Channel Complexes

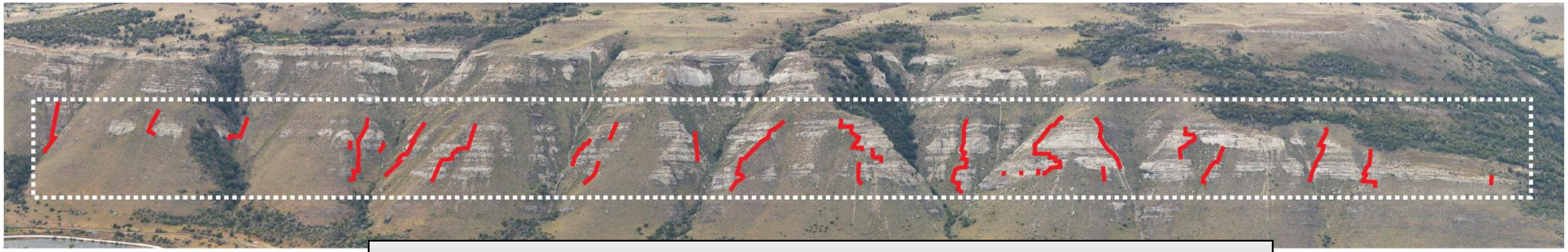
- 18 channels identified and correlated across outcrop
- channels intersect outcrop obliquely

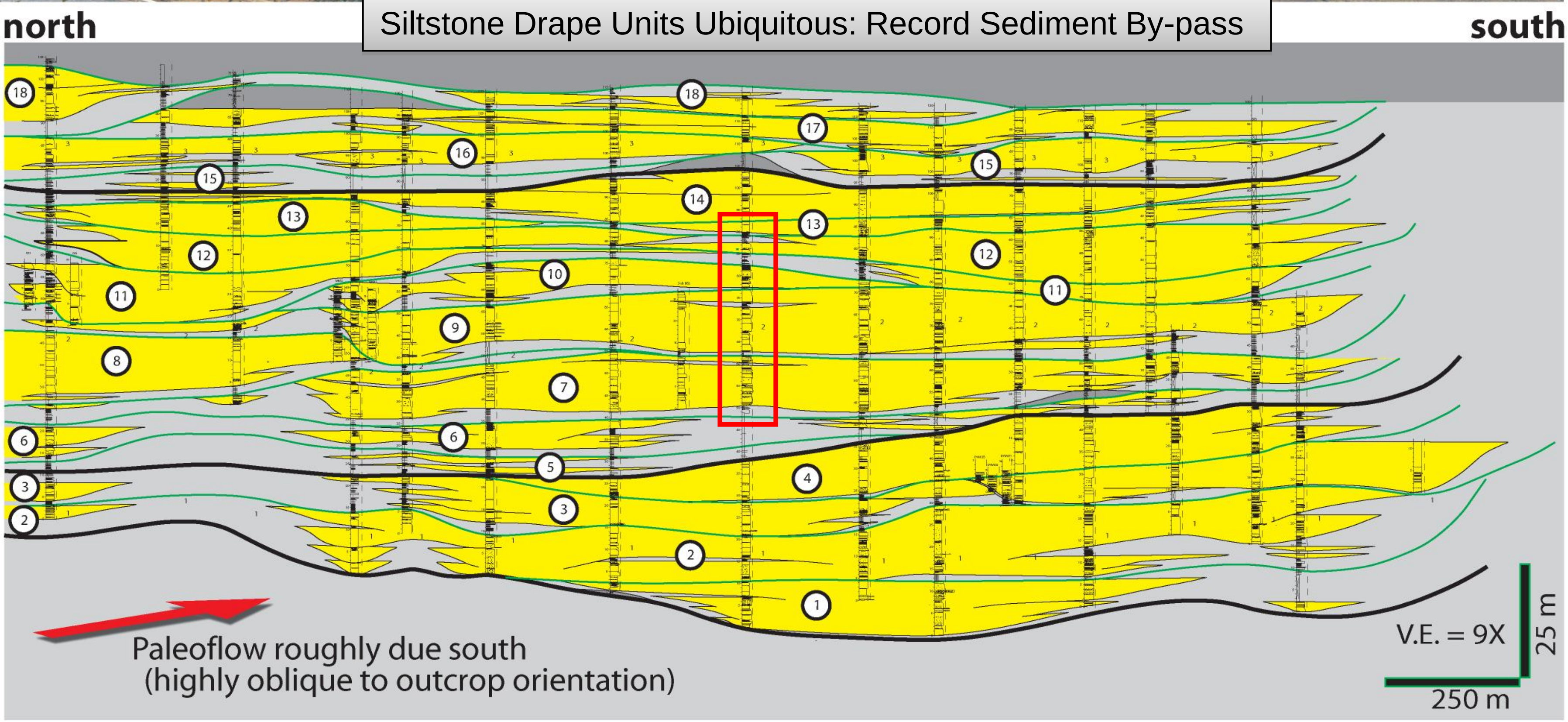




Element Stacking: Tres Pasos Channel Complexes

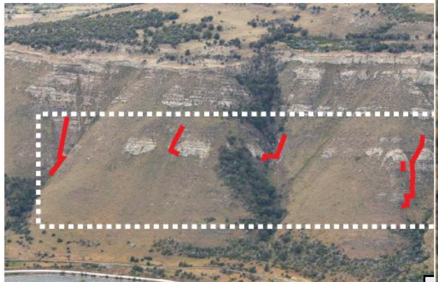
- 18 channels identified and correlated across outcrop
- channels characterized by widespread basal siltstone drapes

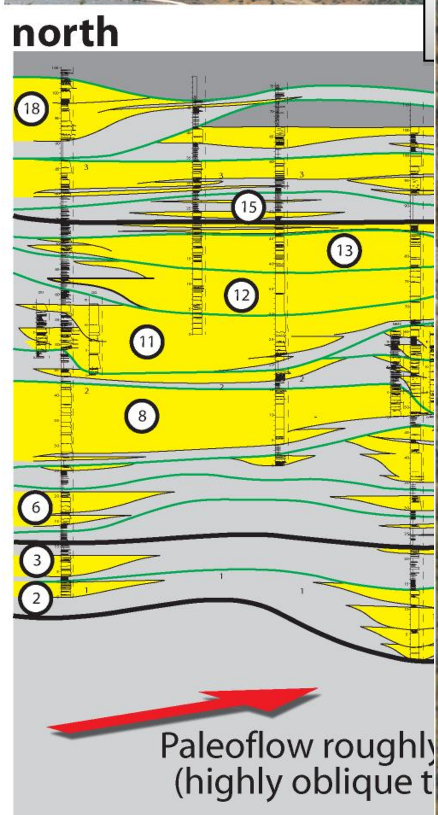


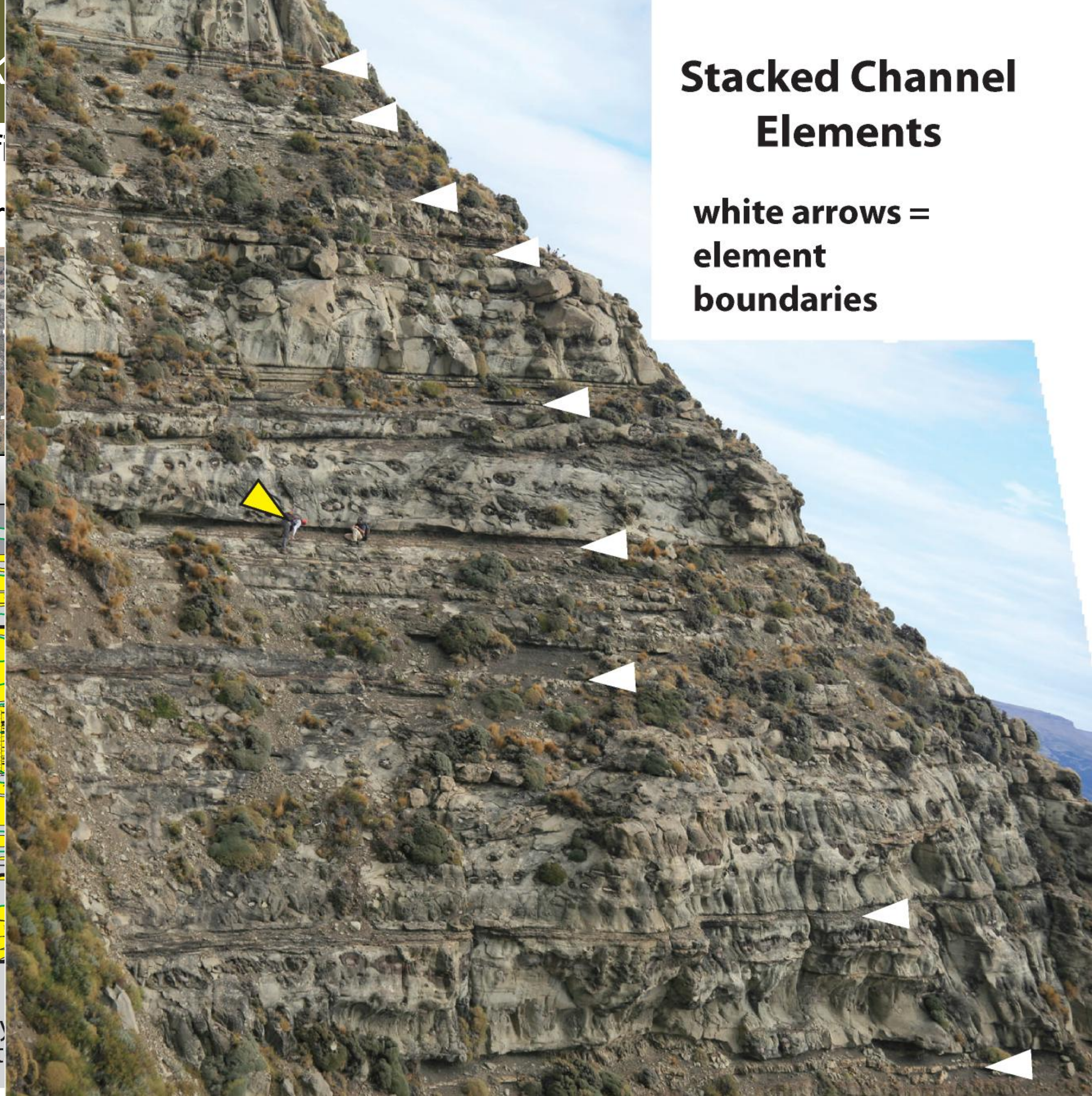


Element Stack

- 18 channels identifi
- channels character

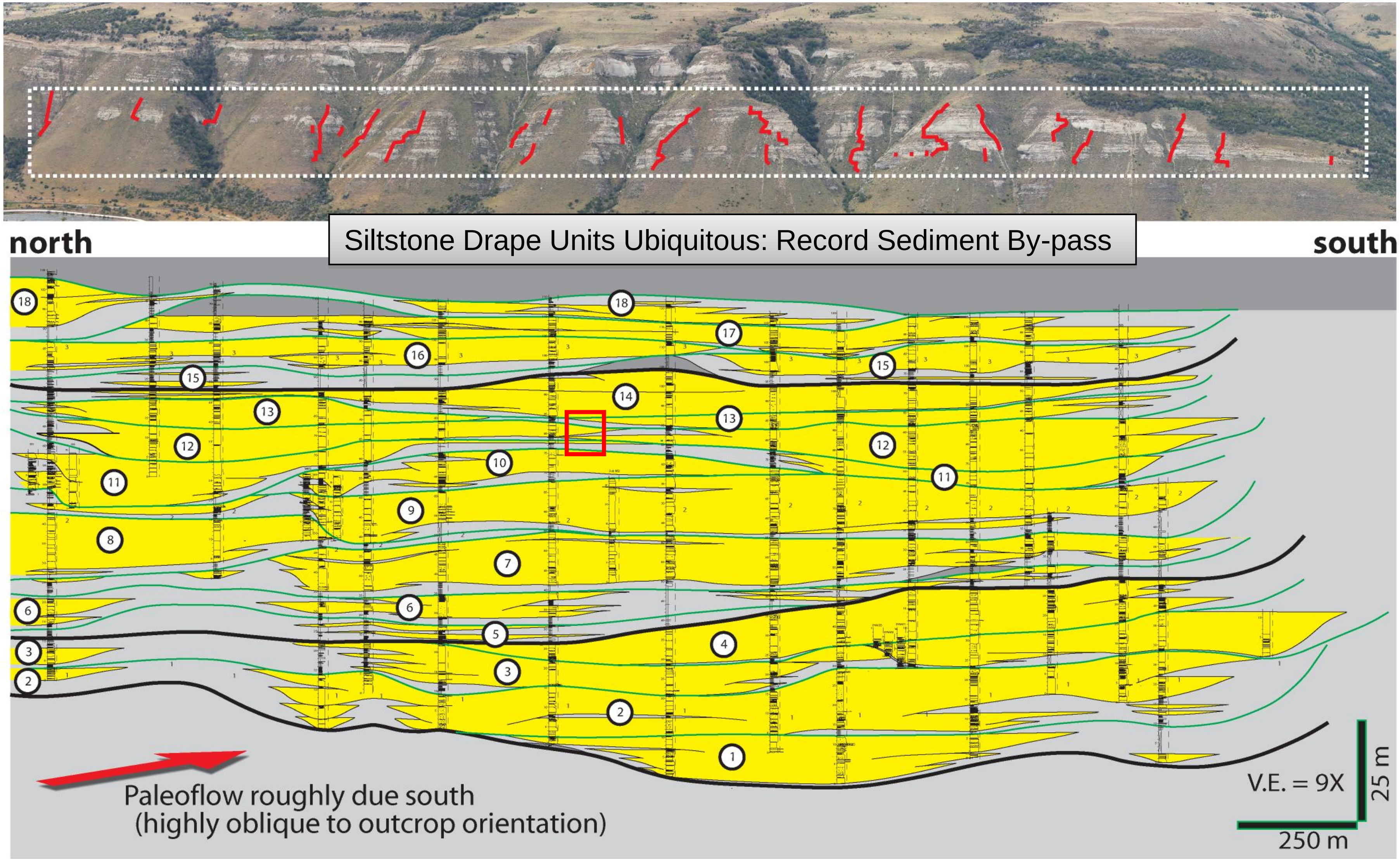






Element Stacking: Tres Pasos Channel Complexes

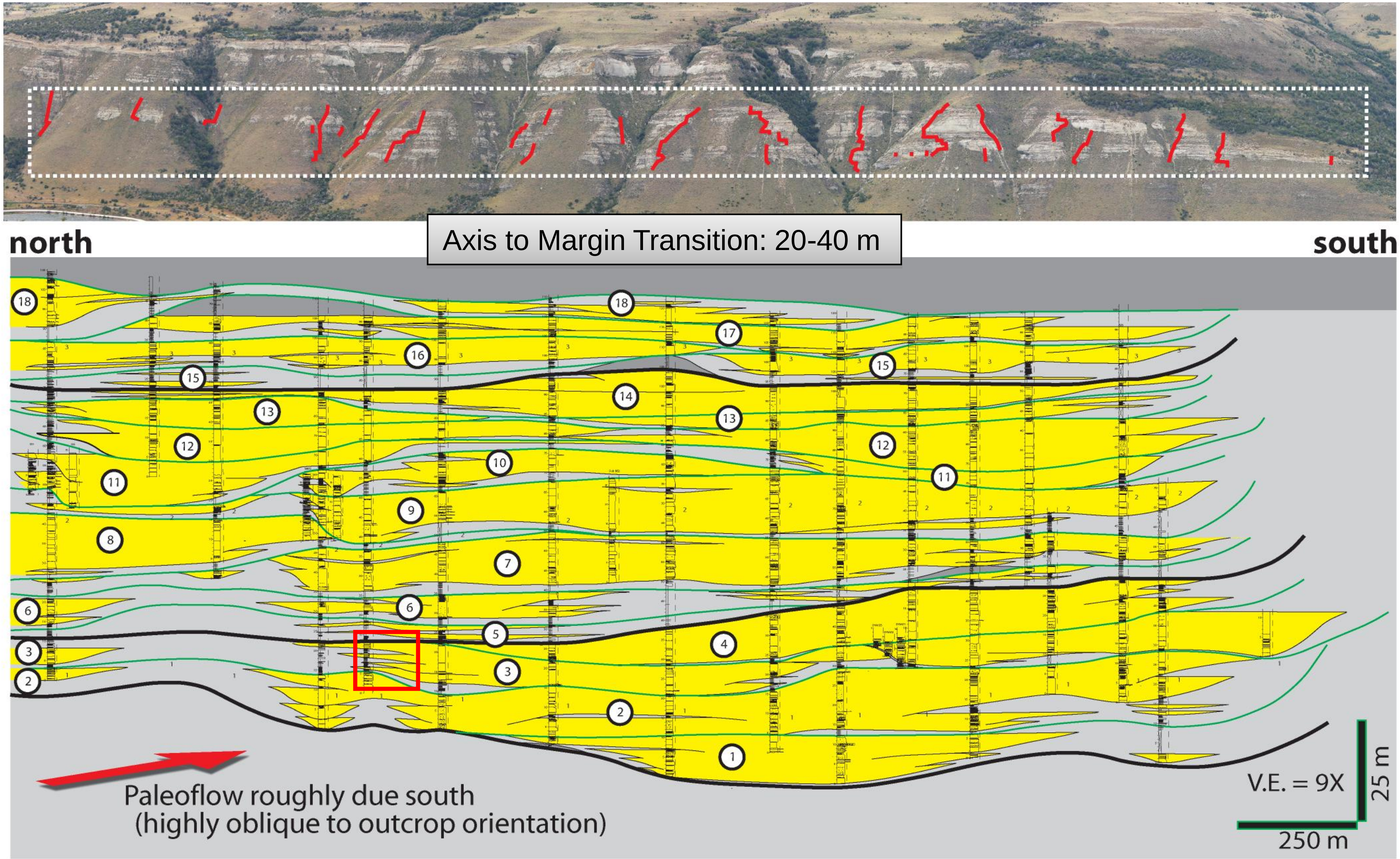
- 18 channels identified and correlated across outcrop
- drape units significant in off-axis and margin areas; commonly eroded in axes



Element Stacking: Tres Pasos Channel Complexes

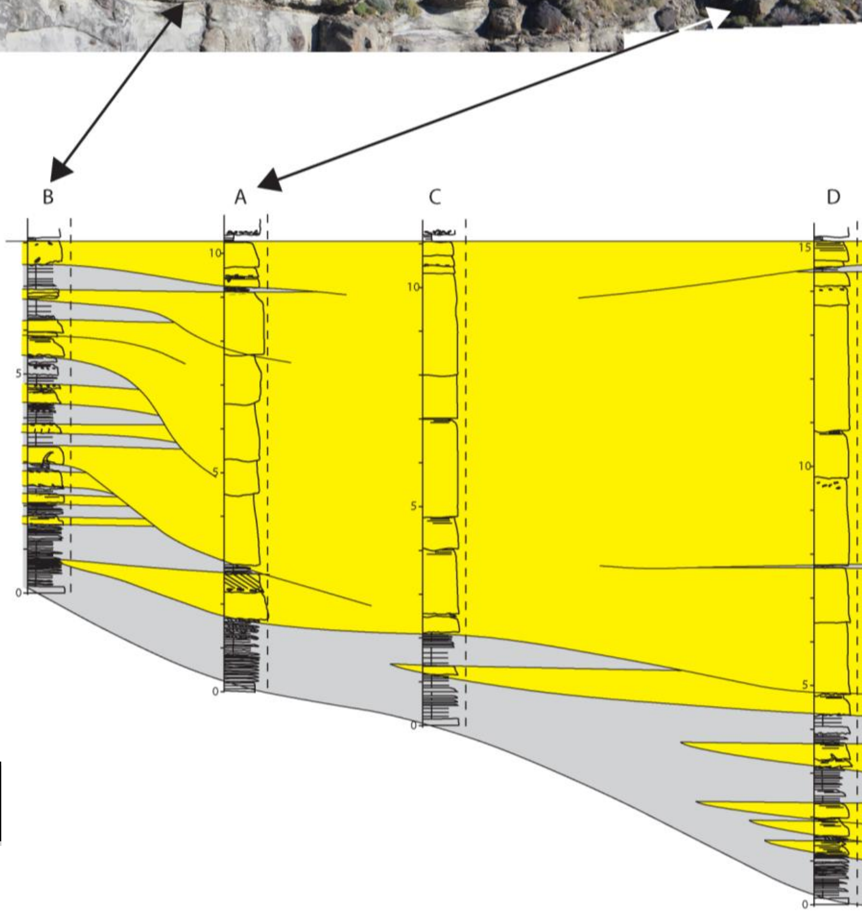
Element Stacking: Tres Pasos Channel Complexes

- 18 channels identified and correlated across outcrop
- the transition from axis to margin is rapid, characterized by a significant shift in rock quality



Eleme

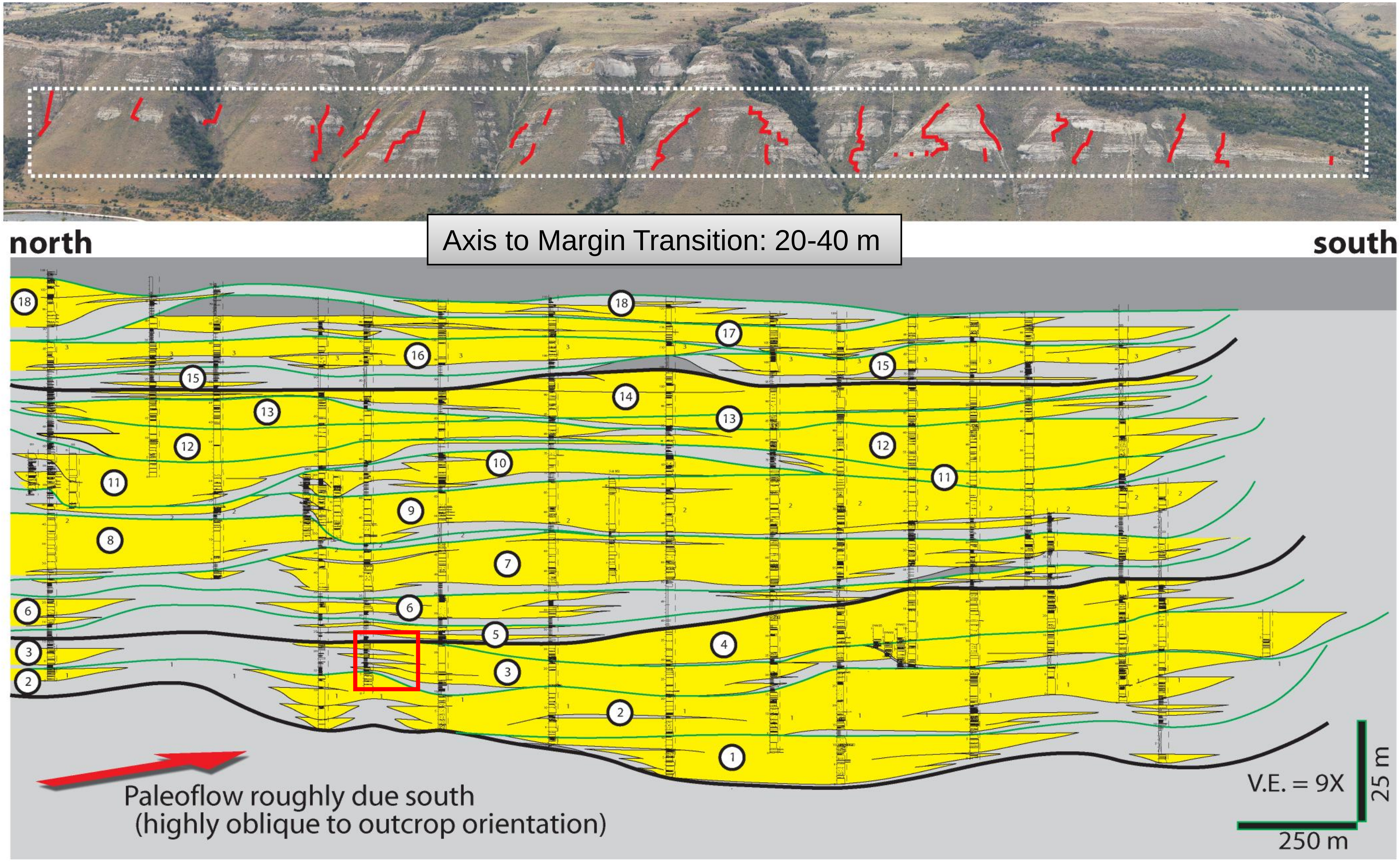
- 18 char
- the trans

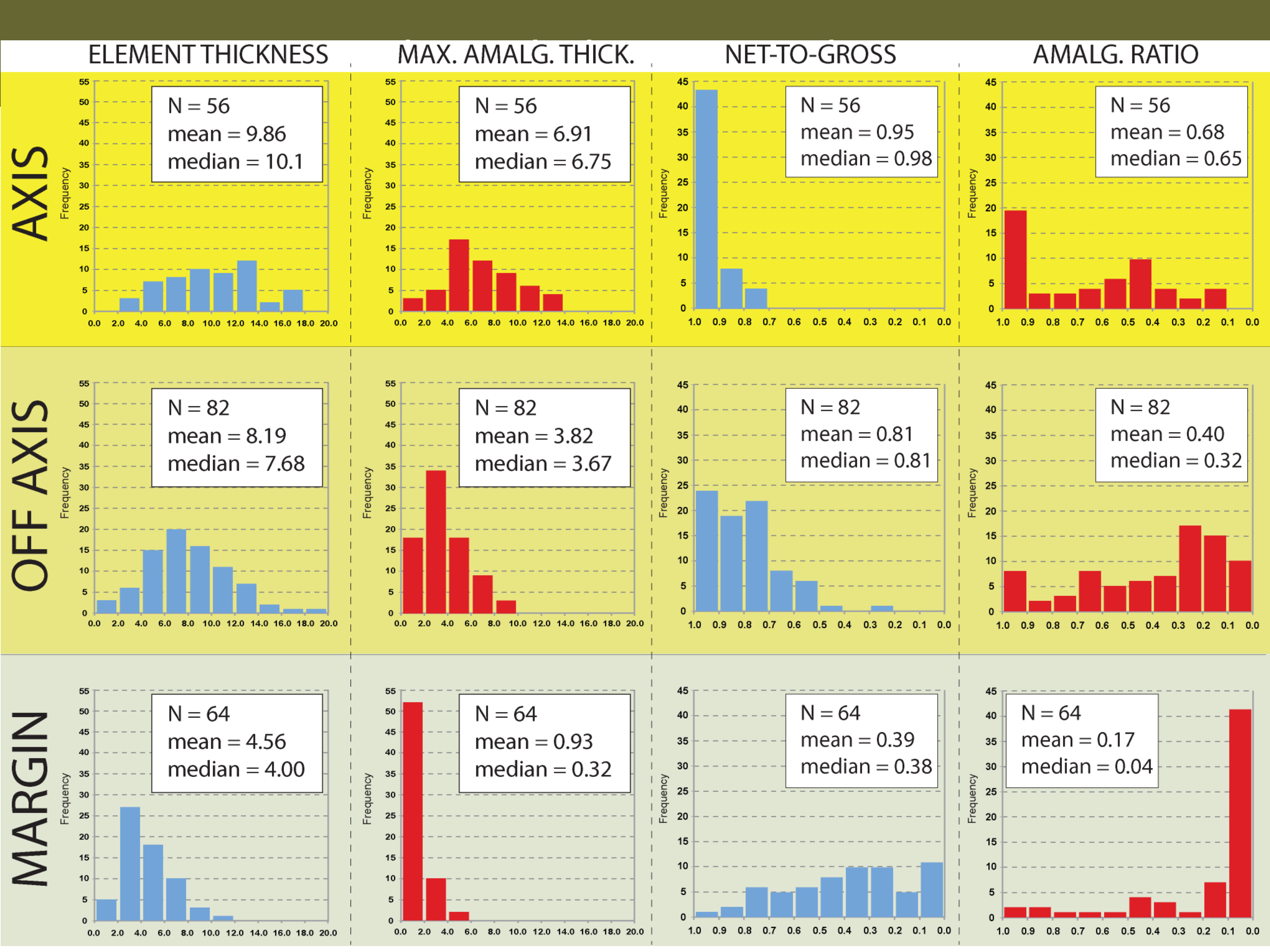


Axis to Margin Transition: 20-40 m

Tres Pasos Fm. Channel Element Metrics

- 18 channels identified and correlated across outcrop
- the transition from axis to margin is rapid, characterized by a significant shift in rock quality

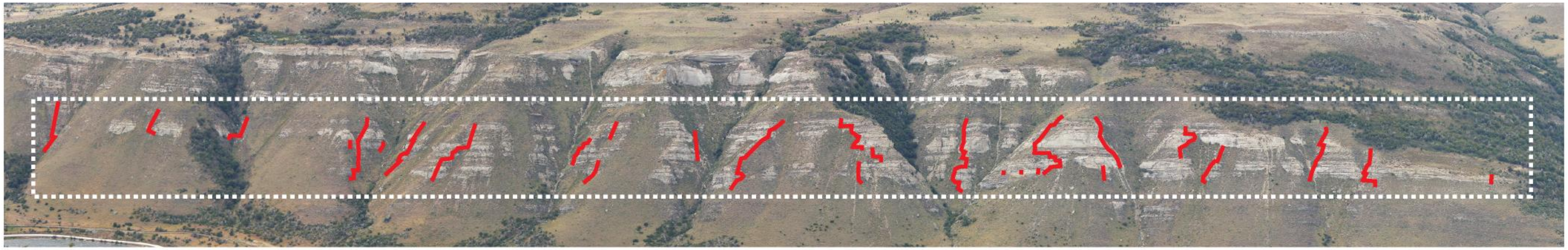


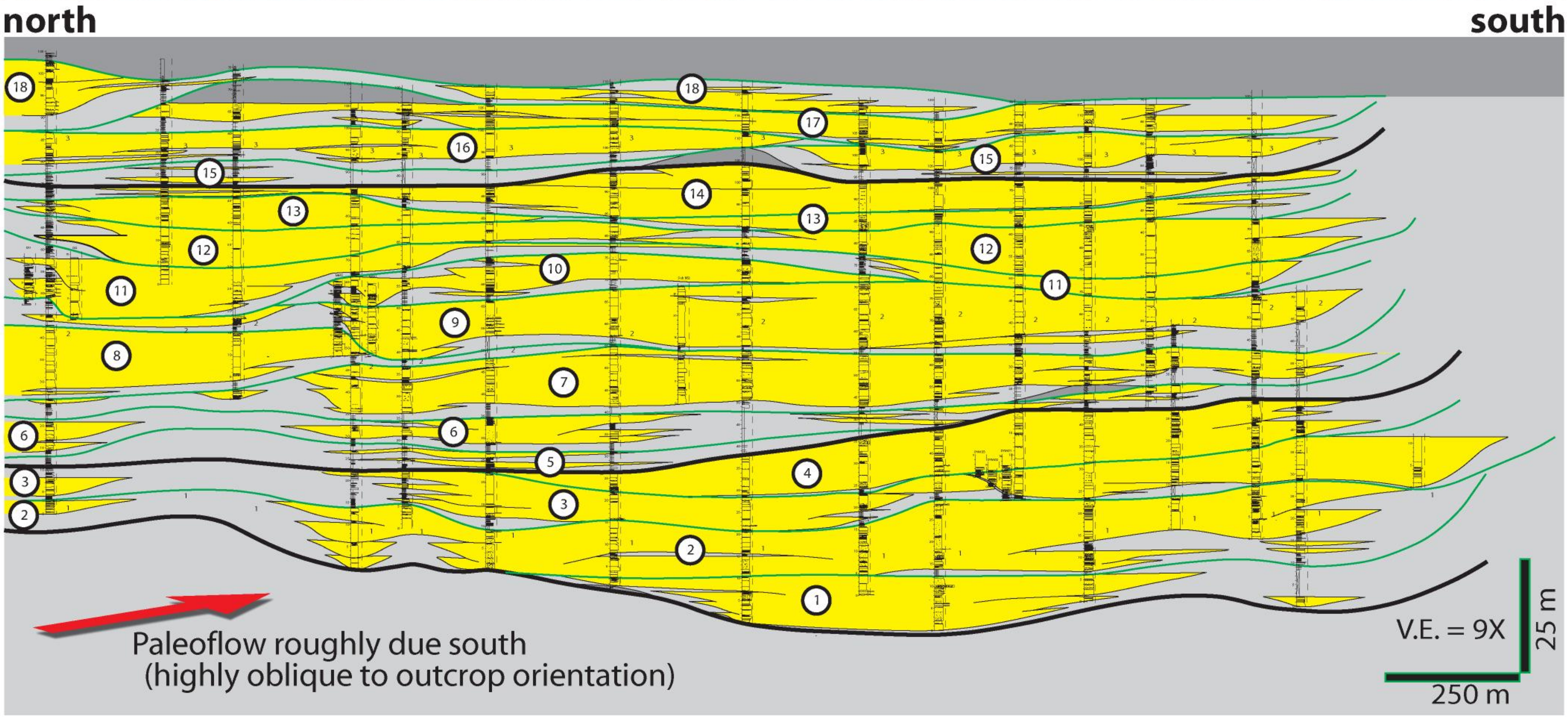


ELEMENT THICKNESS
MAX. AMALG. THICK.
NET-TO-GROSS
AMALG. RATIO
AXIS
OFF AXIS
MARGIN
Frequency
N = 56
mean = 9.86
median = 10.1
N = 56
mean = 6.91
median = 6.75
N = 56
mean = 0.95
median = 0.98
N = 56
mean = 0.68
median = 0.65
N = 82
mean = 8.19
median = 7.68
N = 82
mean = 3.82
median = 3.67
N = 82
mean = 0.81
median = 0.81
N = 82
mean = 0.40
median = 0.32
N = 64
mean = 4.56
median = 4.00
N = 64
mean = 0.93
median = 0.32
N = 64
mean = 0.39
median = 0.38
N = 64
mean = 0.17
median = 0.04

Element Stacking: Tres Pasos Channel Complexes

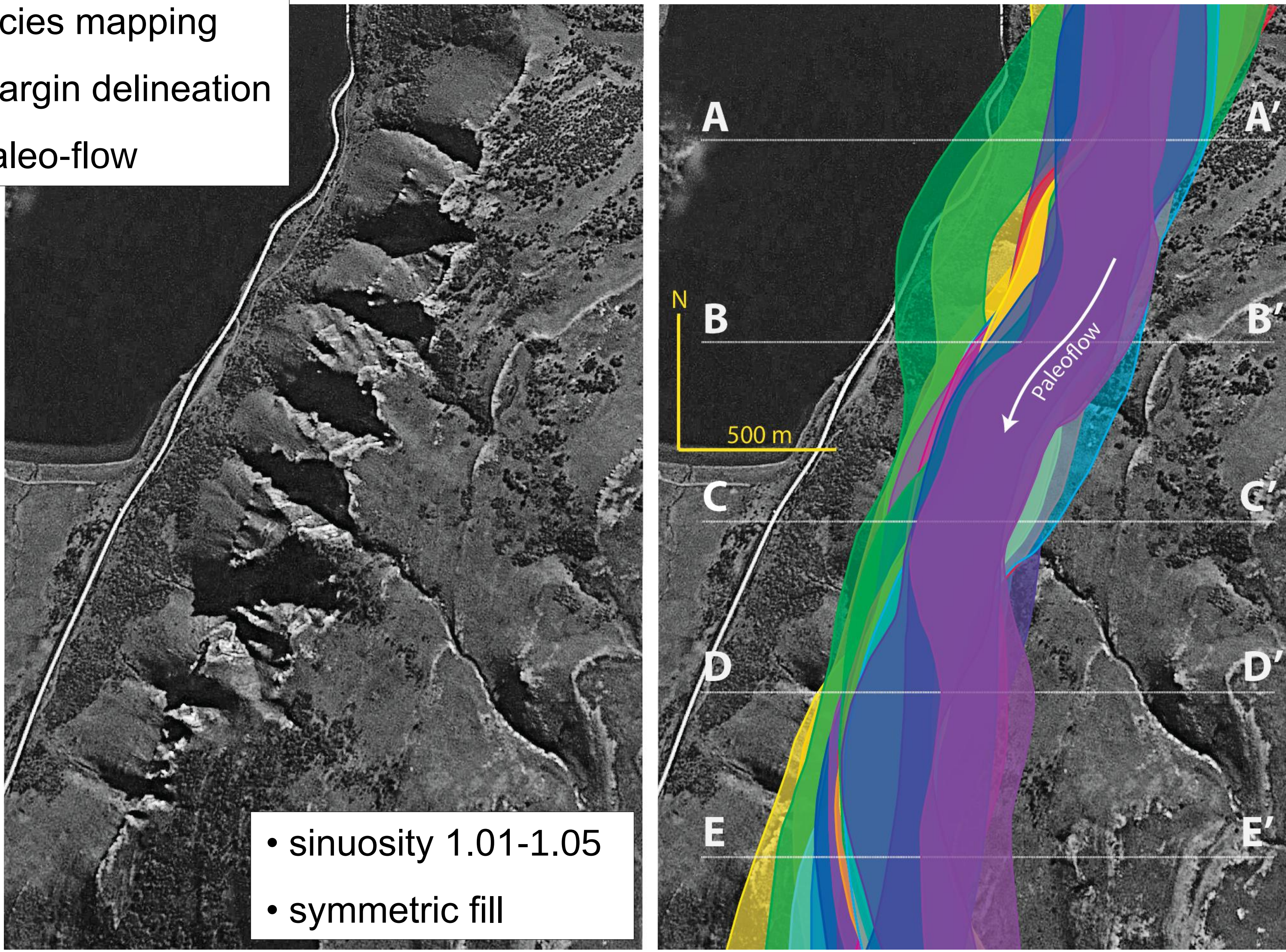
- constructing strike perspectives of channels from oblique outcrop
- facies mapping
- margin delineation
- paleo-flow





Element Stacking: Tres Pasos Channel Complexes

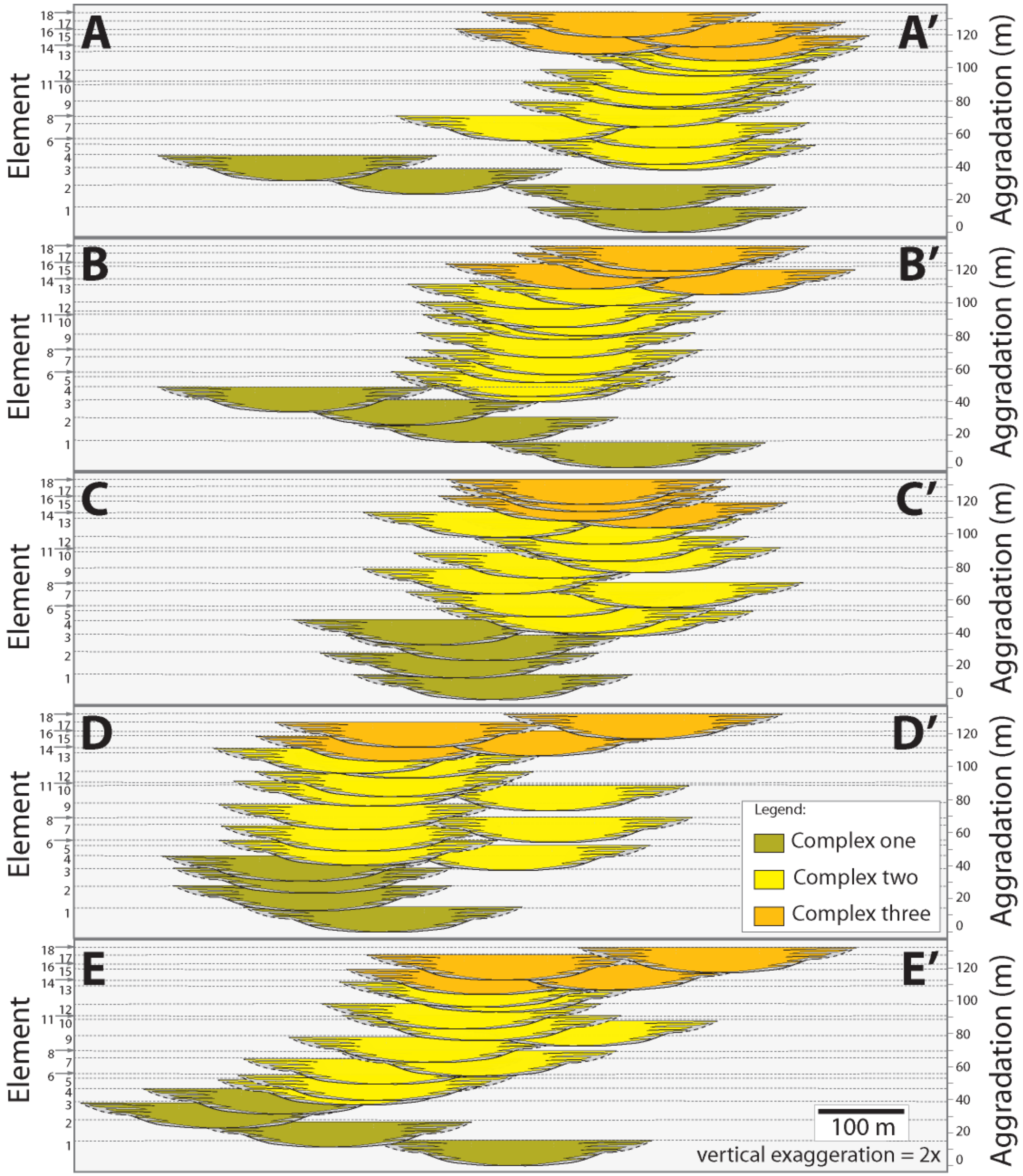
- facies mapping
- margin delineation
- paleo-flow



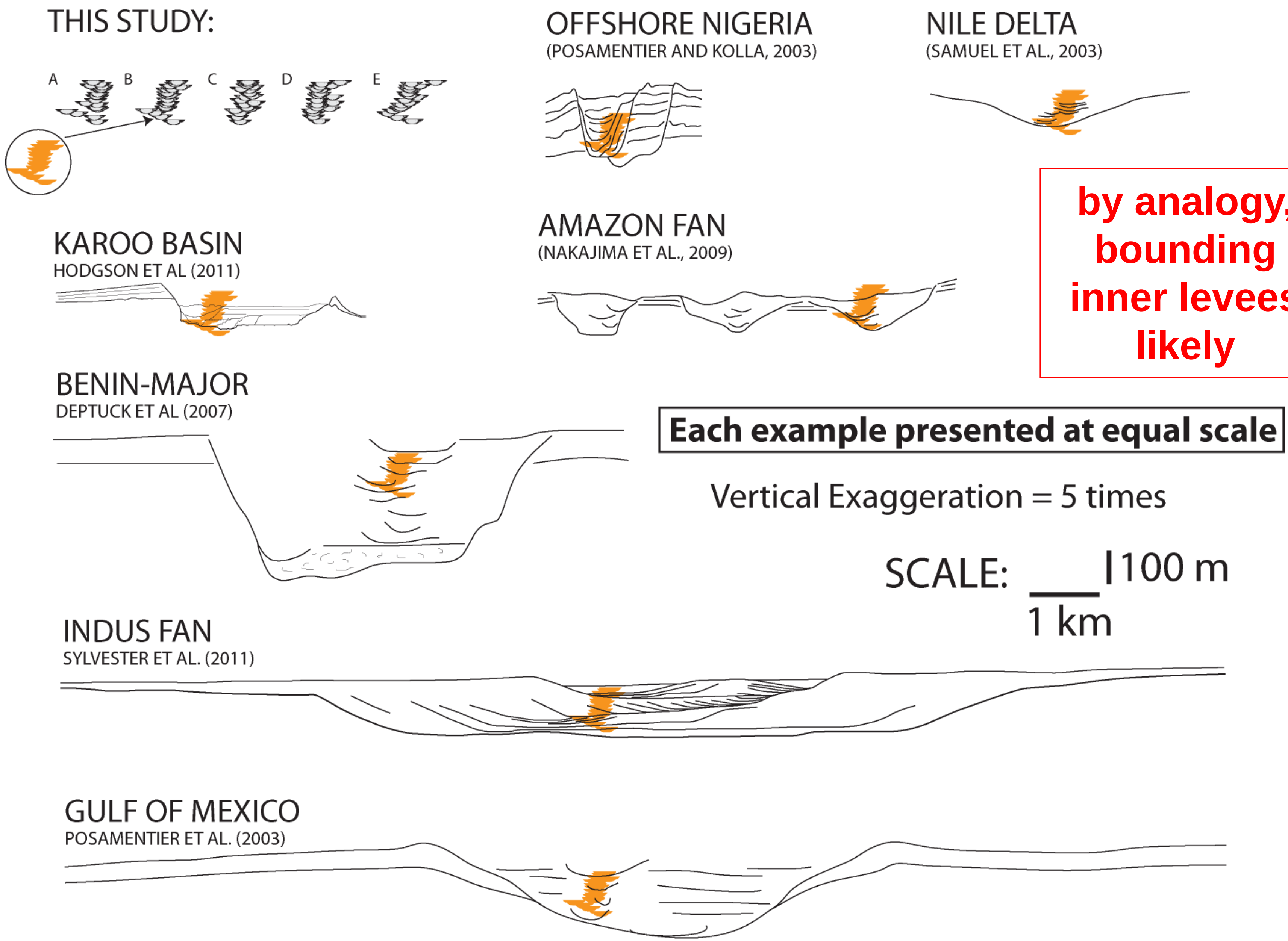
- sinuosity 1.01-1.05
- symmetric fill

Element Stacking: Tres Pasos Channel Complexes

- 18 stacked channel elements mapped
- 3 channel complexes
- 1 channel complex-set
- channel elements focused/confined
- aggradation considerable**
- what facies are lateral to the channel elements?



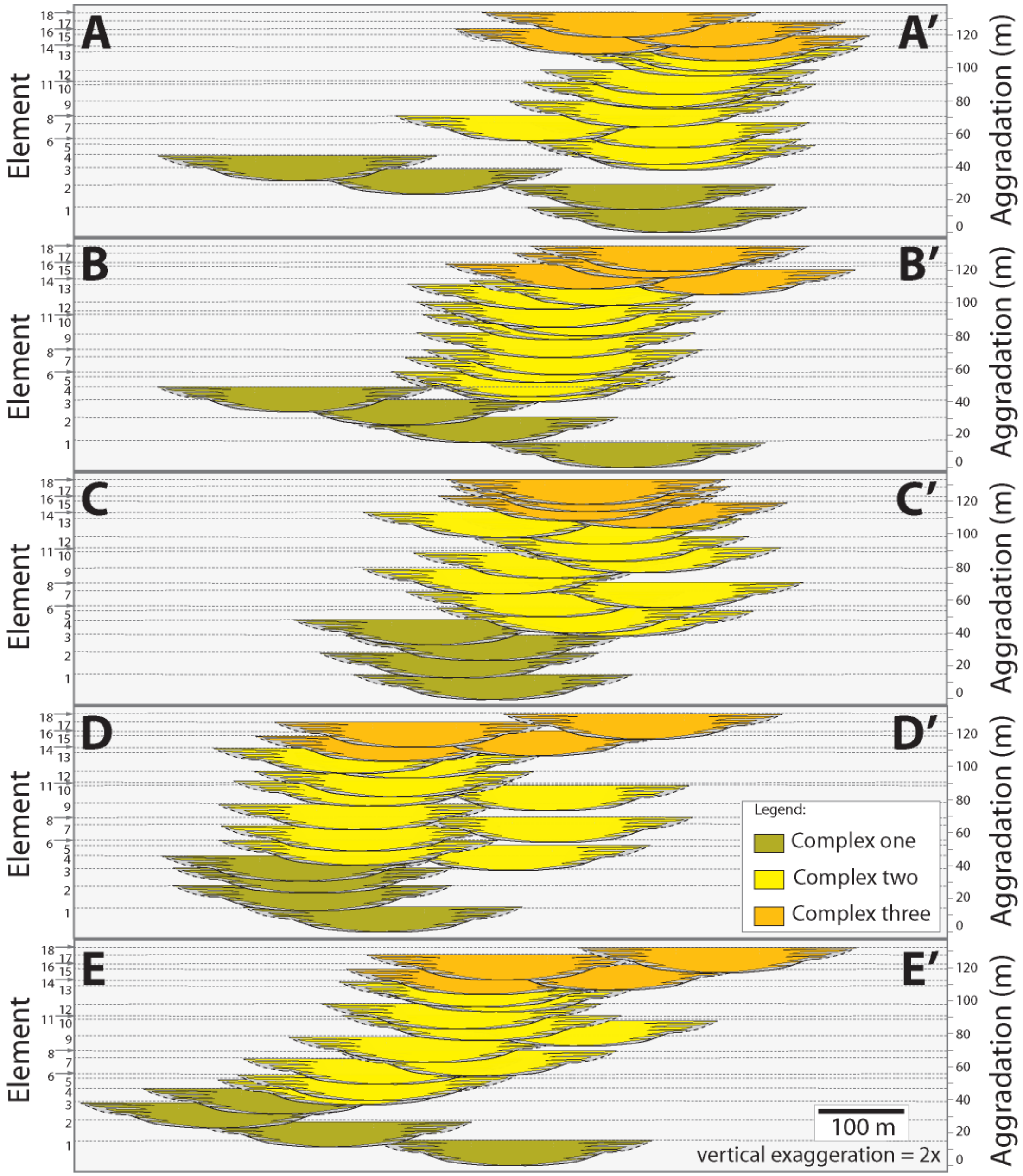
Tres Pasos Channel Complexes: Architectural Analogies



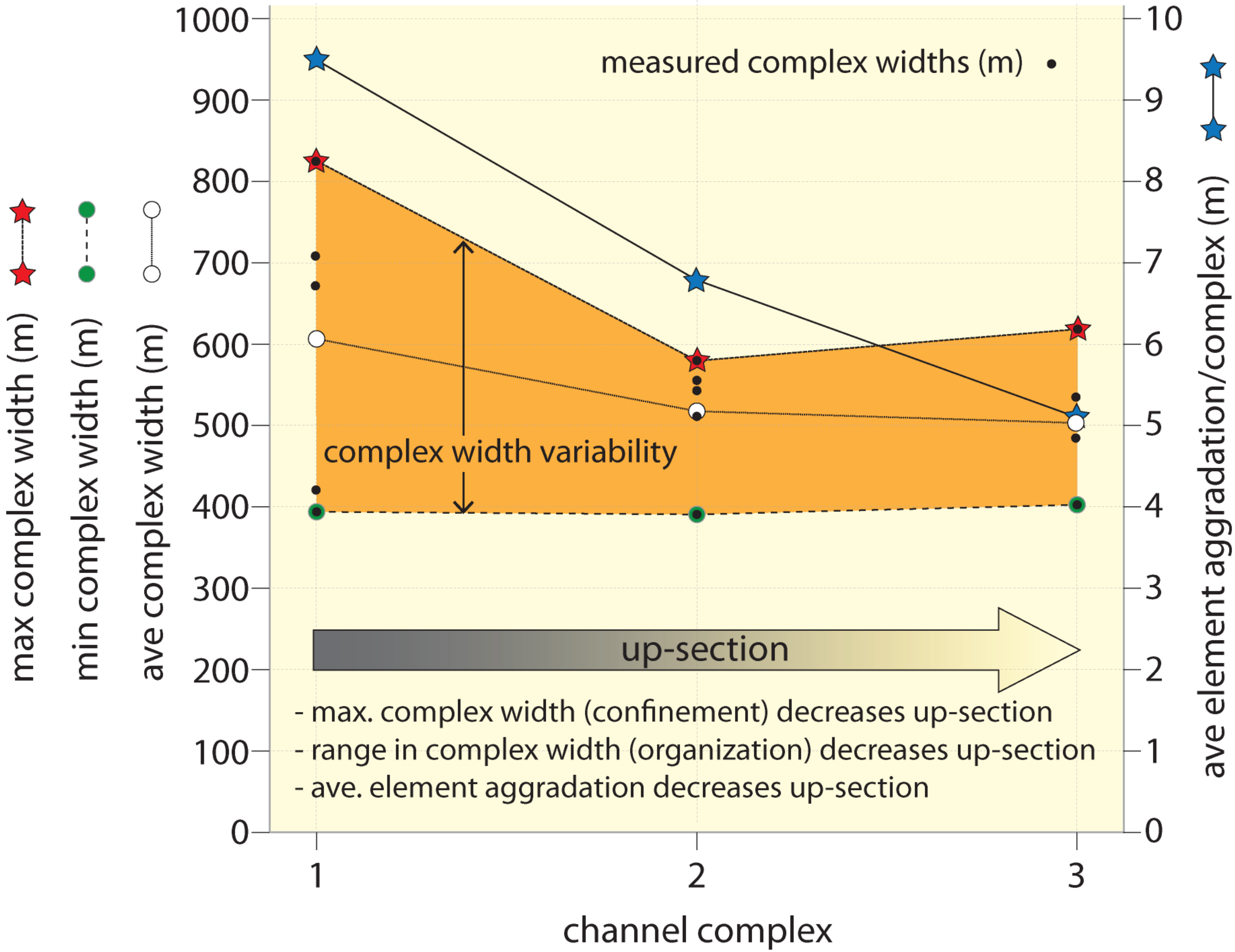
by analogy, bounding inner levees likely

Complex Stacking: Tres Pasos Channel Complex-Set

- quantification of channel complex architecture

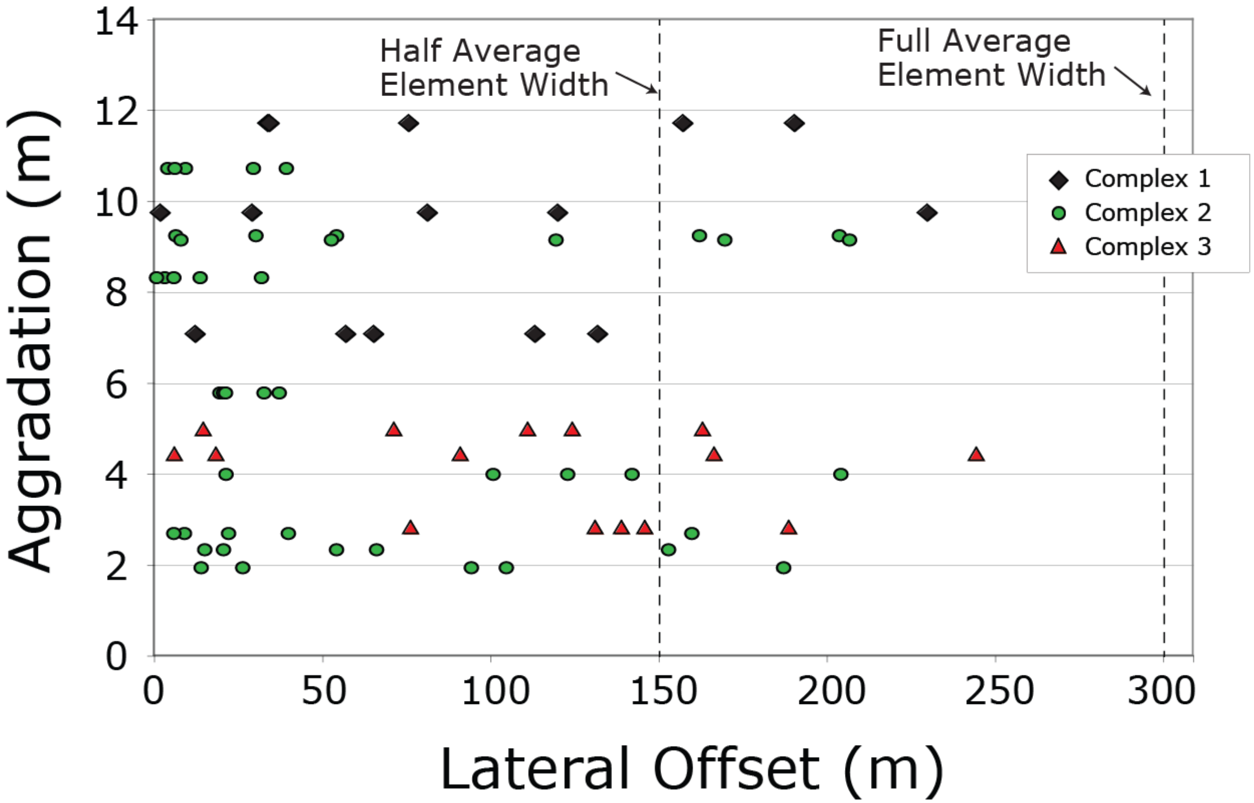


Complex Stacking: Tres Pasos Channel Complex-Set

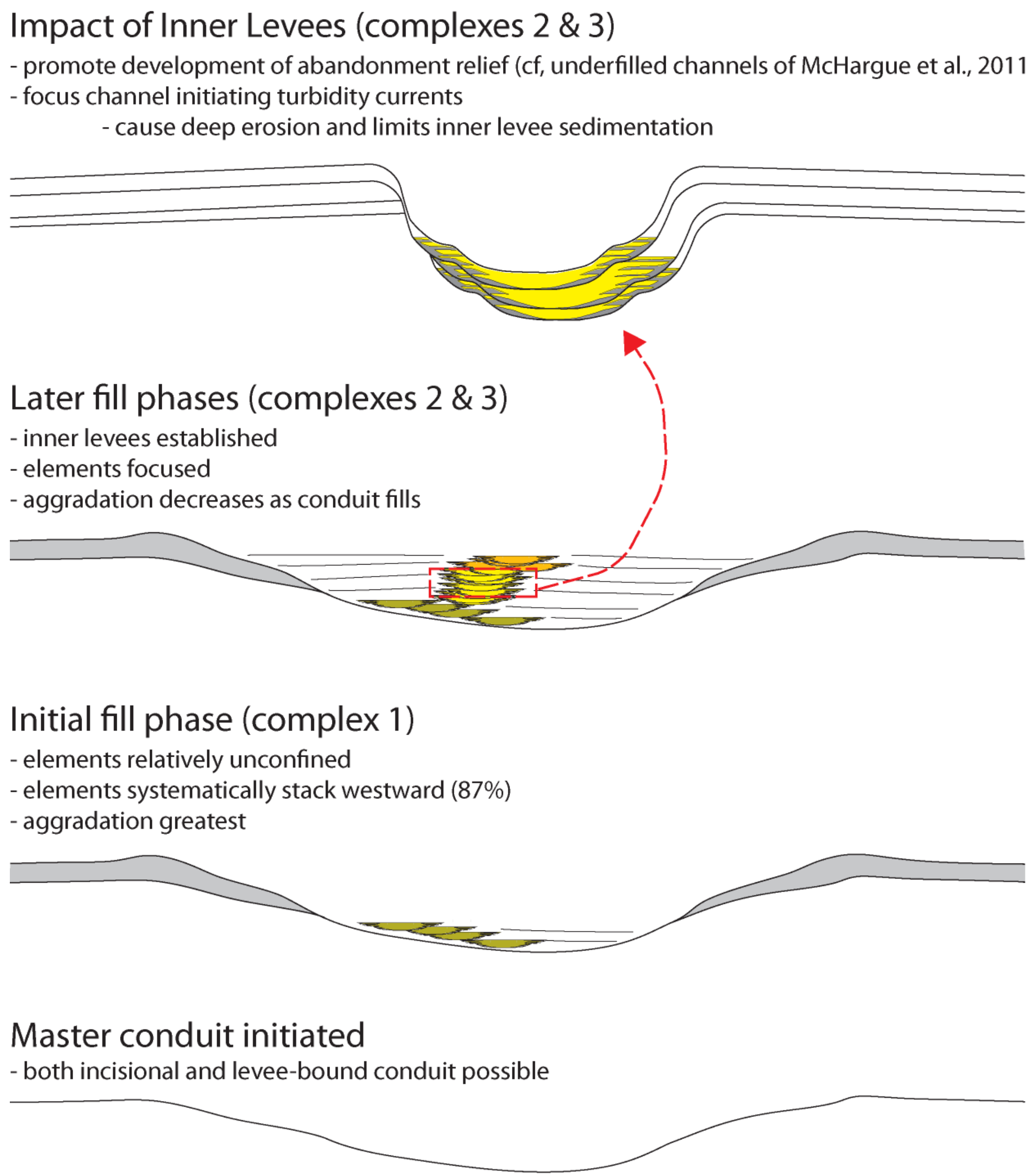


Element Stacking: Lateral Offset vs. Aggradation

- overall, lateral offset is minimal with > 80% of channels offset < half a channel width
- under-filled channels and impact of abandonment relief (cf., McHargue et al., 2011)



Element Stacking: Interpretations and Conclusions



IMPLICATIONS:

- mature, late-stage fill of the channel complex-set is laterally constrained but more highly amalgamated (increase in channel-element connectivity)

Acknowledgements

- research sponsors:

Chevron
MARATHON
ConocoPhillips
TALISMAN ENERGY
NSERC CRSNG

- collaborators and field assistants:

Andrea Fildani, Brian Romans, Jake Covault, Julian Clark, Kirt Campion, Rodrigo Bastida,
Matt McCullough, Sean Fletcher, Dustin Bauer, Erin Pemberton, Brett Miles, Kerrie Bann