Quantitative Architectural Analysis and Depositional Model of an Asymmetric Conglomerate-Rich Submarine Channel Fill, Cerro Toro Formation, Sierra del Toro, Magallanes Basin, Chile*

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Abstract

Asymmetry is defined as both the cross-sectional profile of the channelform and the facies distribution within that form. Although a ubiquitous feature of sinuous fluvial channels, asymmetry of submarine channels is poorly documented and rarely incorporated in numerical, experimental, and reservoir models. With superb three-dimensional exposure, the conglomeratic axial channel-belt of the Upper Cretaceous Cerro Toro Formation, southern Chile, provides an excellent opportunity to study submarine channel asymmetry and its impacts on reservoir heterogeneity. Exposures of the channel belt at Sierra del Toro record a 3.5 km wide, 300 m thick channel complex here named the Wildcat complex.

The Wildcat complex has a low sinuosity (1.03) meandering planform and thus exhibits slight cross-sectional asymmetry. However, the fill of the channel complex is highly asymmetric. Twelve measured sections, bed tracing, and photopanel correlation demonstrate that grain size, bed thickness, amount of amalgamation, and margin architecture all vary drastically from outer to inner bend. The outer bend is characterized by thick-bedded, conglomeratic, amalgamated facies as well as a sandy overbank accumulation. The inner bend is notably different, where thin-bedded, sandy and muddy facies onlap a composite margin adjacent to a predominantly muddy overbank.

These observations have been incorporated into a predictive depositional model of asymmetric submarine channel evolution. This model predicts the cross-sectional profile, facies distribution, margin architecture, and planform shape of asymmetric channels as well as their respective overbank environments. The modern Monterey fan-channel, a great modern analog to this system in terms of grain size, channel width, channel depth, and facies asymmetry, is used to refine the channel asymmetry model. Results of this study are broadly applicable for outcrop, modern, subsurface, and flume experimental datasets and the corresponding quantitative data can be used to constrain numerical and reservoir models built for sinuous submarine channels.

References

Fildani, A. and A.M. Hessler, 2005, Stratigraphic record across a retroarc basin inversion; Rocas Verdes-Magellanes Basin, Patagonian Andes, Chile: GSA Bulletin, v. 117/11-12, p. 1596-1614.

Hubbard, D.K., R.B. Burke, I.P. Gill, W.R. Ramirez, and C.E. Sherman, 2008, Coral-reef geology; Puerto Rico and the US Virgin Islands, *in* B.M. Riegl and R.E. Dodge (eds.) Coral Reefs of the USA: Springer, v. 1, p. 263-302.

STRONG FACIES ASYMMETRY IN A CONGLOMERATIC SUBMARINE CHANNEL FILL, CERRO TORO FM, CHILE

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SPODDS
Stanford Project On Deepwater Depositional Systems

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Shell

HESS

BP

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Chevron

MARATHON

RAG

ConocoPhillips

AERA

Reliance Industries Limited

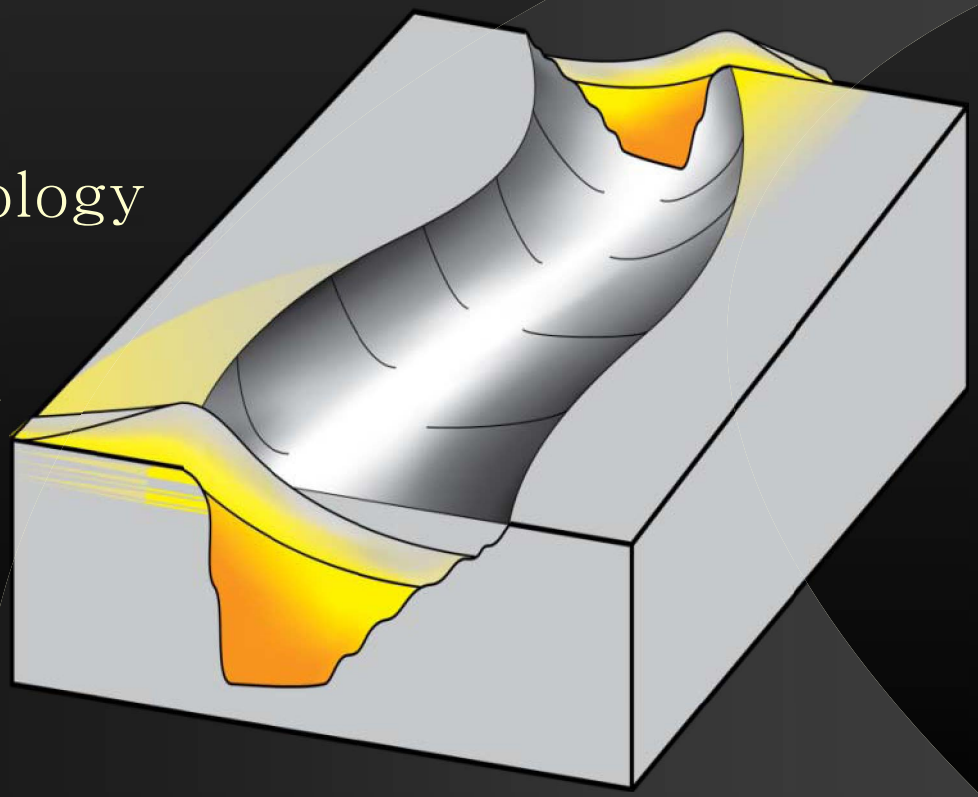
nexen

ExxonMobil

devon

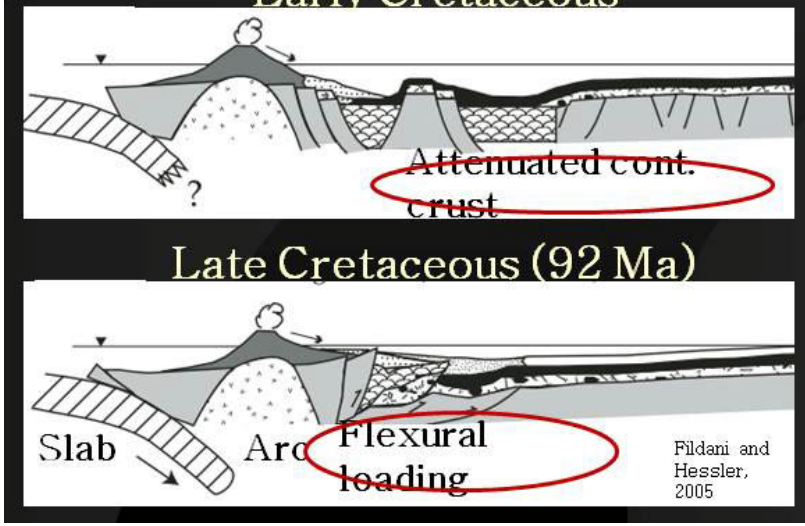
Chapter 1: Motivation and Conclusions

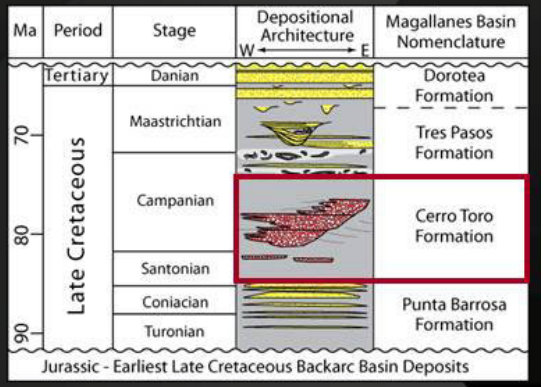
- Rare field-scale exposure
- Coarse grain size (boulders)
- Wildcat channel complex- 3.5 km wide x 300 m thick
- Asymmetry of Wildcat
  - Facies distribution/lithology
  - Cross sectional shape
  - Overbank accumulation
- Depositional model
  - Incorporates architecture
  - Quantitative model input



Magallanes basin, Chile

- Retro-arc basin inversion
- Deepwater for > 15 Ma = 5 km turbidites
- Evolution of stratigraphic architecture





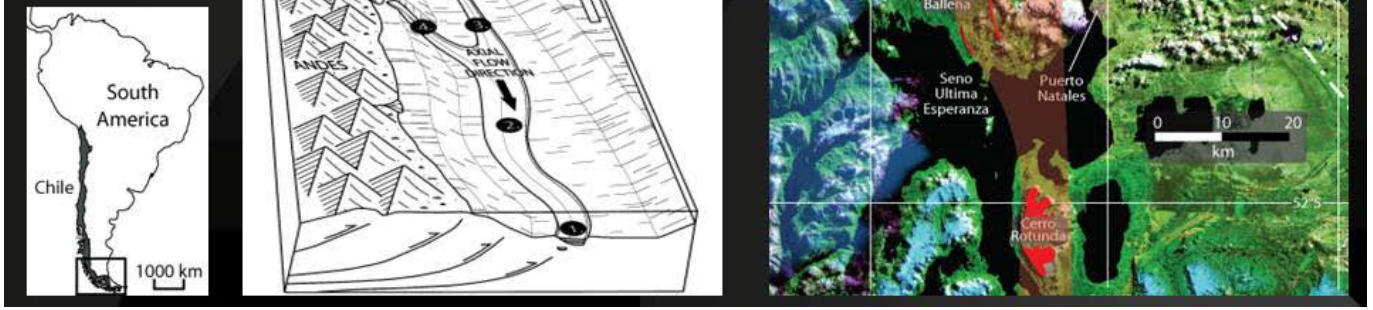
Notes by Presenter: Rift assembled with Gondwana breakup in late Jurassic ~ 150 Ma = Rocas Verdes Basin.

Inversion caused by onset of Andean compressional orogenesis and flexural loading at 92 Ma.

Subsidence high due to attenuated crust and thrust loading. Result is the Magallanes Basin, which shows distinct evolution of arch. But we will only focus on the large-scale channel belt located in the foredeep of the basin.

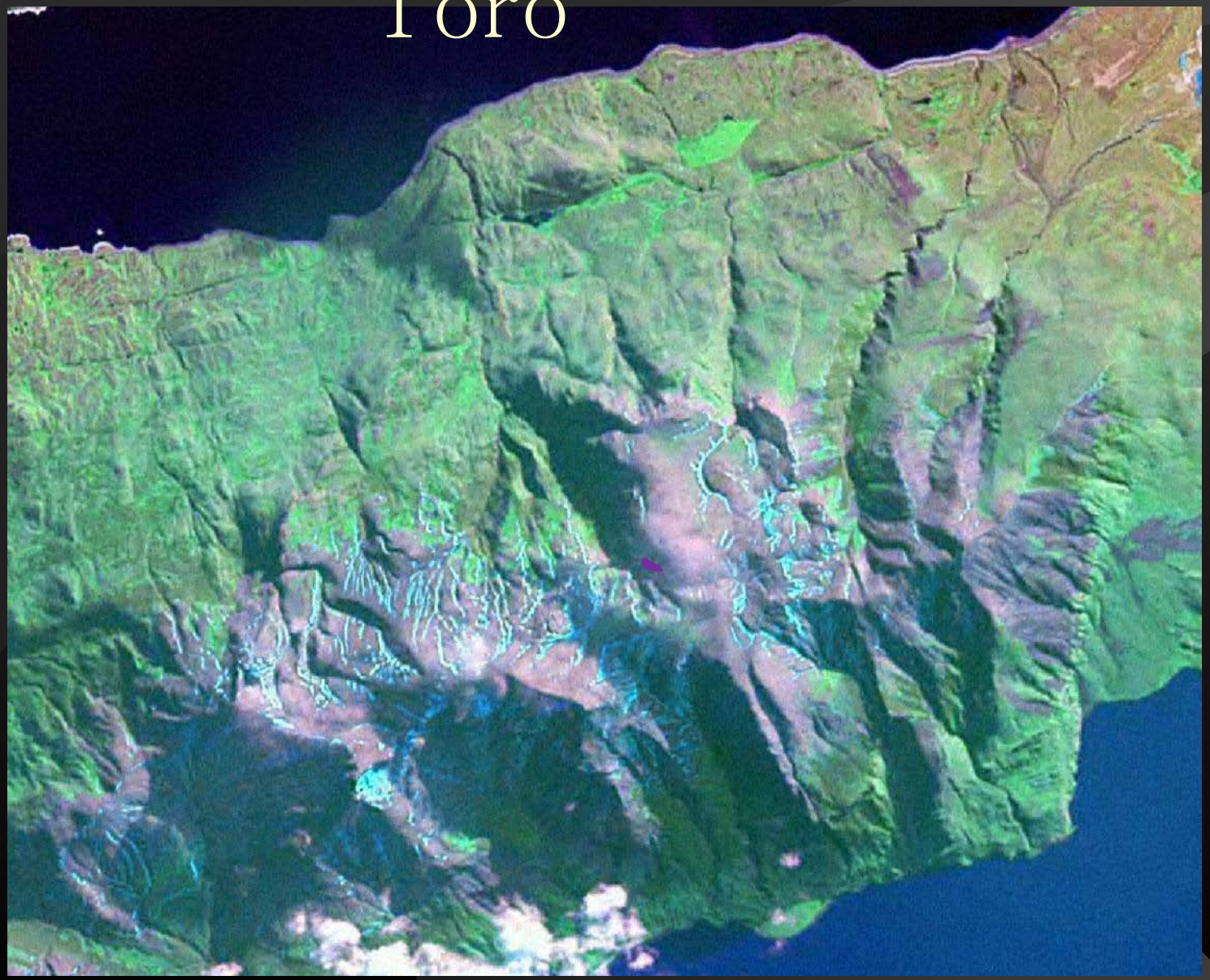
Cerro Toro Fm: axial channel belt

- Magallanes basin
- Arc-derived detritus
  - Tributaries
- Low sinuosity (1.06)
- South-flowing axial drainage



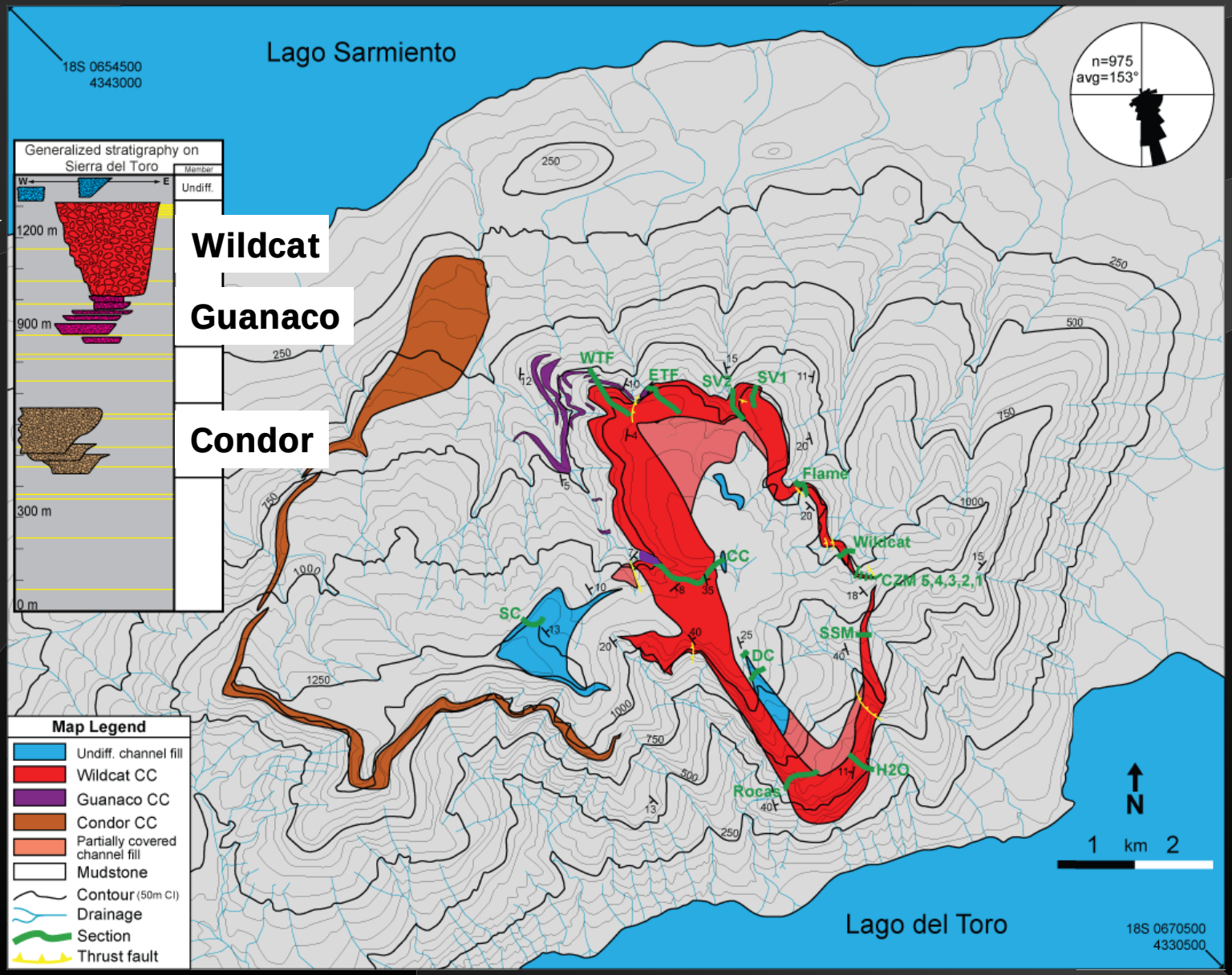
Notes by Presenter: Foredeep location = partial confinement. Transitional arc QFL domain. 1.06 sinuosity (cf other channel systems). Axial drainage.

Axial channel belt at Sierra del Toro



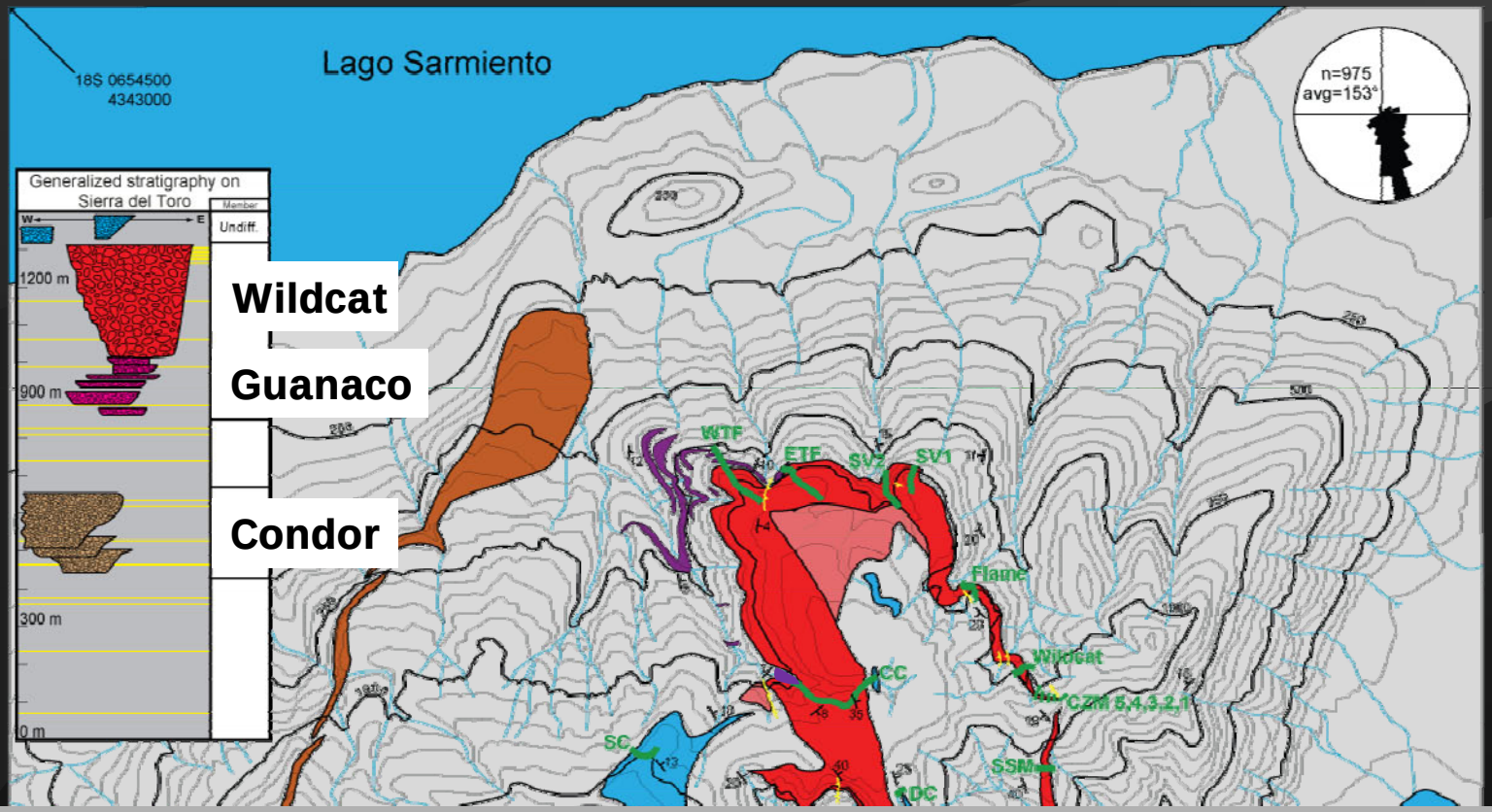
Axial channel belt at Sierra del Toro

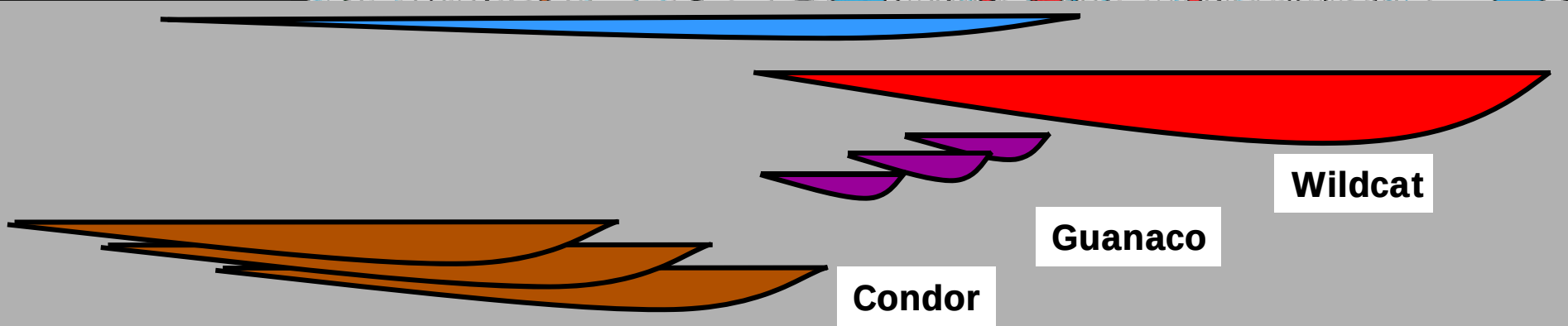
- Scale
- Methods
- Paleoflow



Axial channel belt at Sierra del Toro

- Scale
- Methods
- Paleoflow
- Stacking patterns
- Guanaco
- Remember!





Axial channel belt at Sierra del Toro

- Scale
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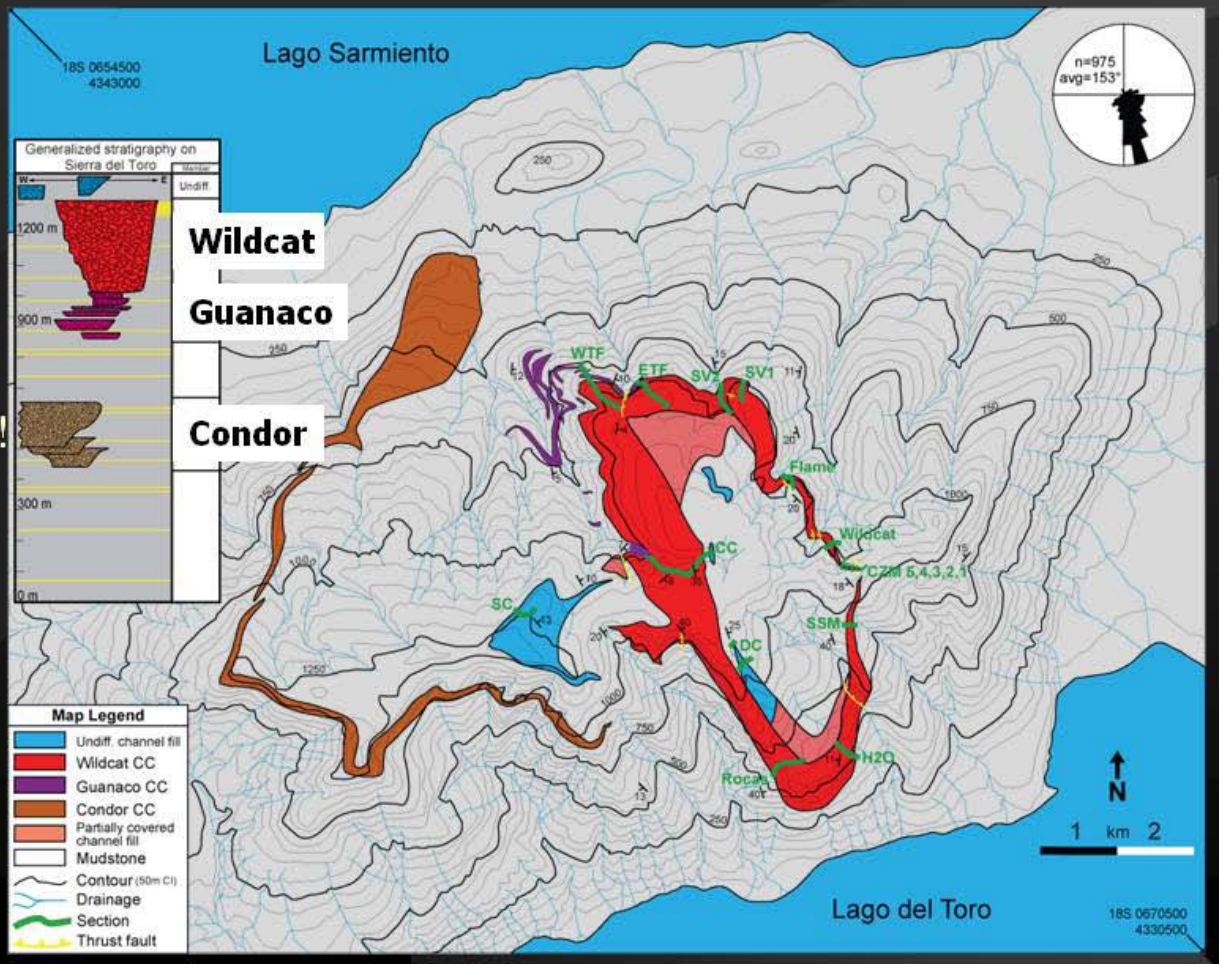
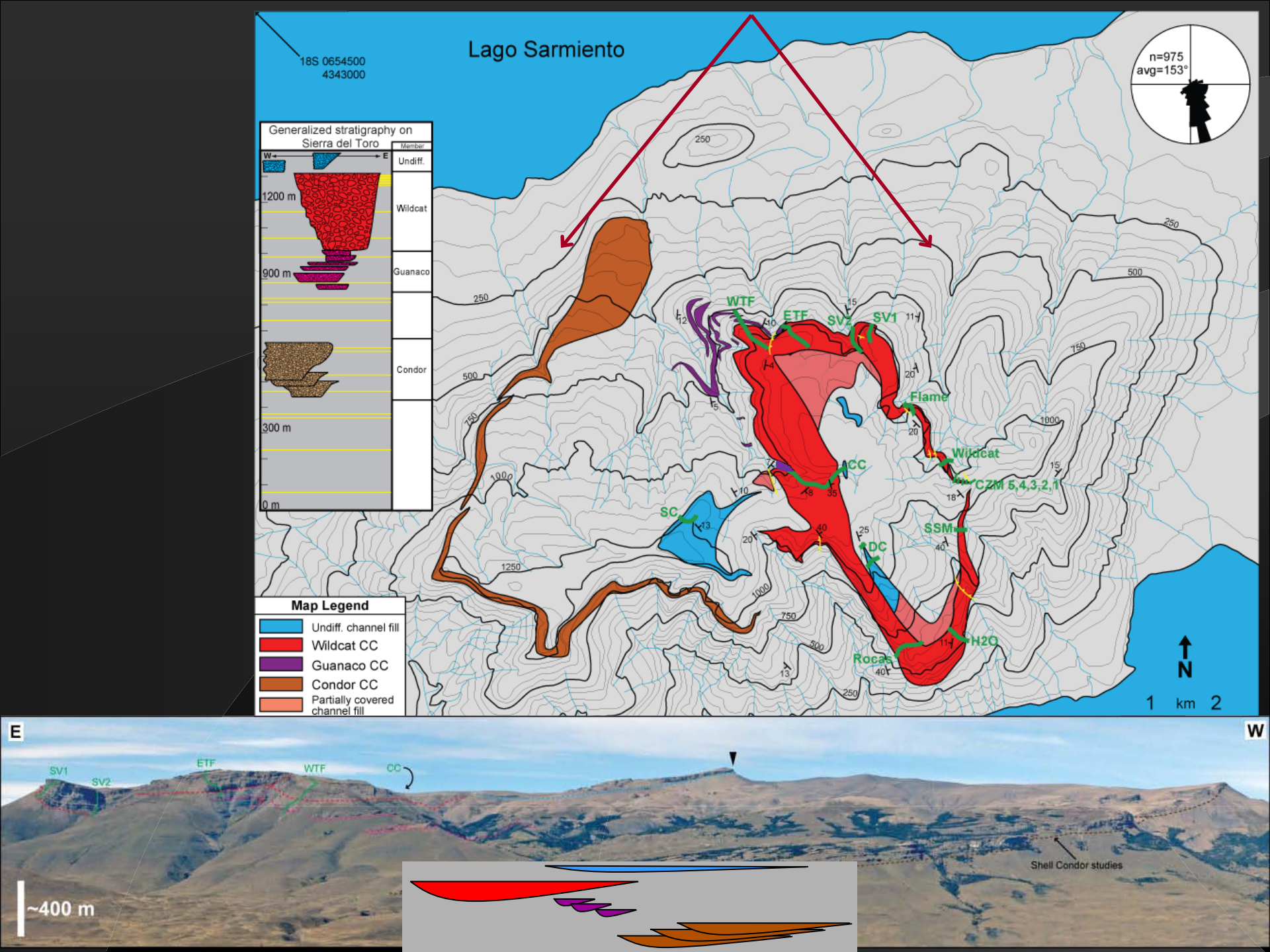
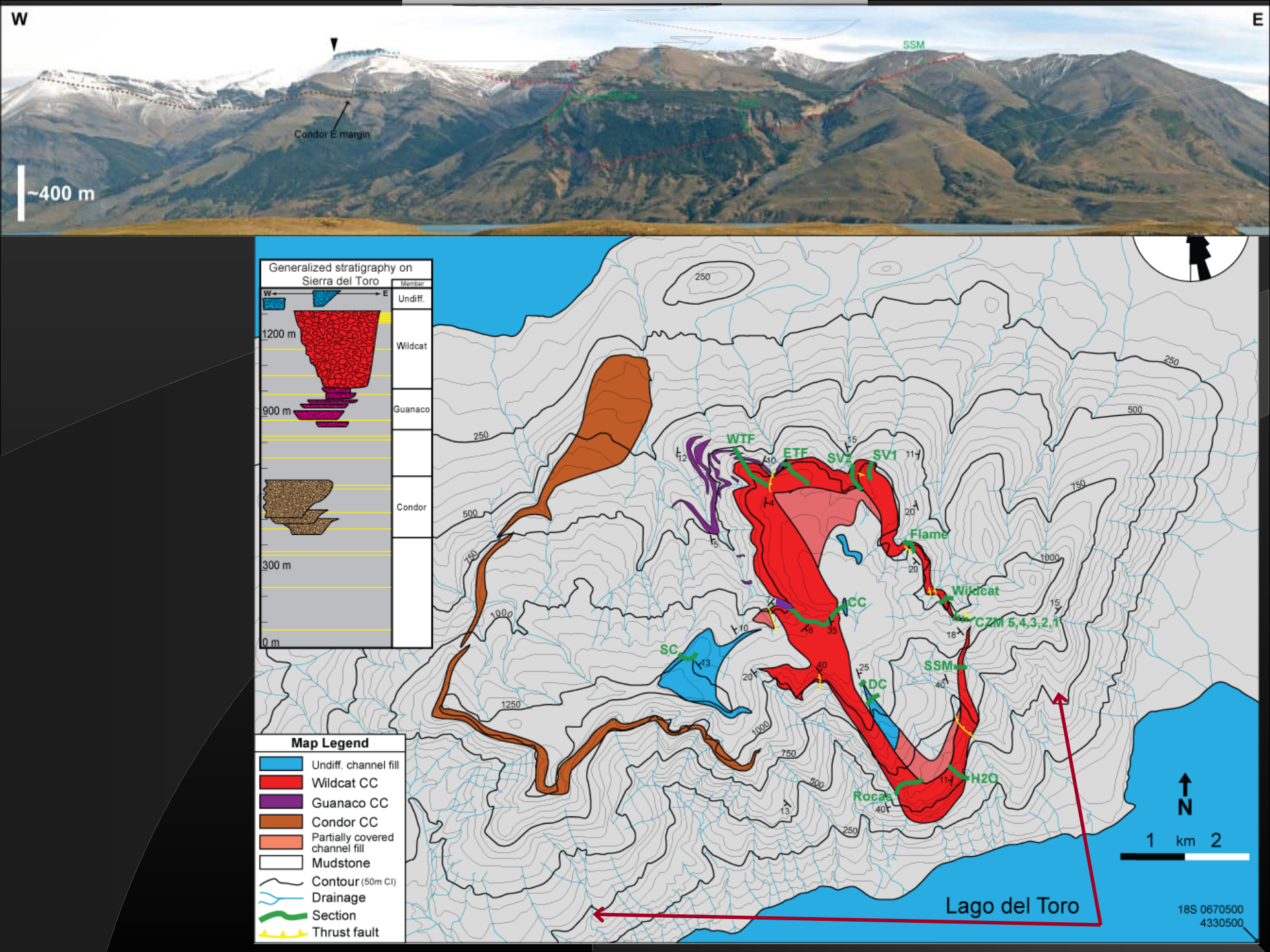
- Remember!



Notes by Presenter: Talk about big mountain.


18S 0654500
4343000
Lago Sarmiento
n=975
avg=153°
Generalized stratigraphy on
Sierra del Toro
Member
W
E
Undiff.
Wildcat
Guanaco
Condor
1200 m
900 m
300 m
0 m
WTF
ETF
SV2
SV1
Flame
Wildcat
CC
CZM 5,4,3,2,1
SC
SSM
DC
H2O
Rocas
Map Legend
Undiff. channel fill
Wildcat CC
Guanaco CC
Condor CC
Partially covered channel fill
N
1 km 2
E
W
SV1
SV2
ETF
WTF
CC
~400 m
Shell Condor studies


E
W
SV1
SV2
ETF
WTF
CC
~400 m
Condor E margin
Shell Condor studies


W
E
SSM
Condor E margin
~400 m
Generalized stratigraphy on Sierra del Toro
Member
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1200 m
900 m
300 m
0 m
Undiff.
Wildcat
Guanaco
Condor
WTF
ETF
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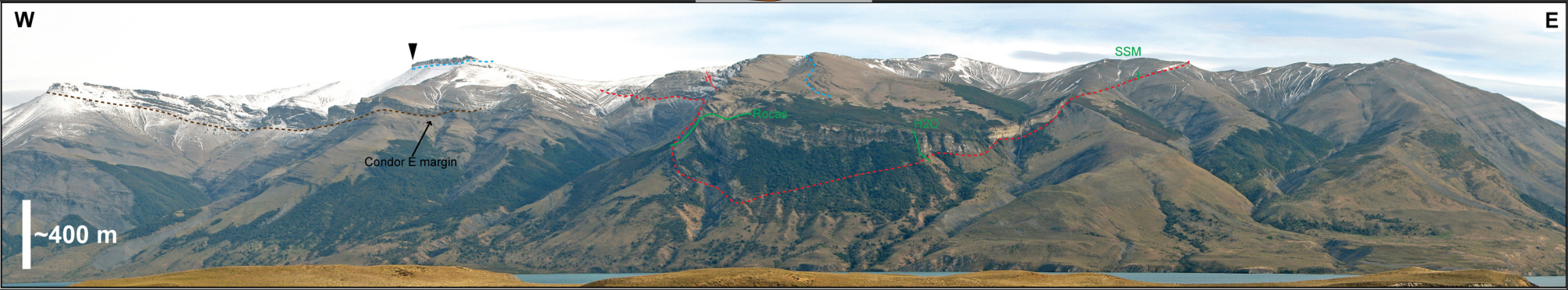
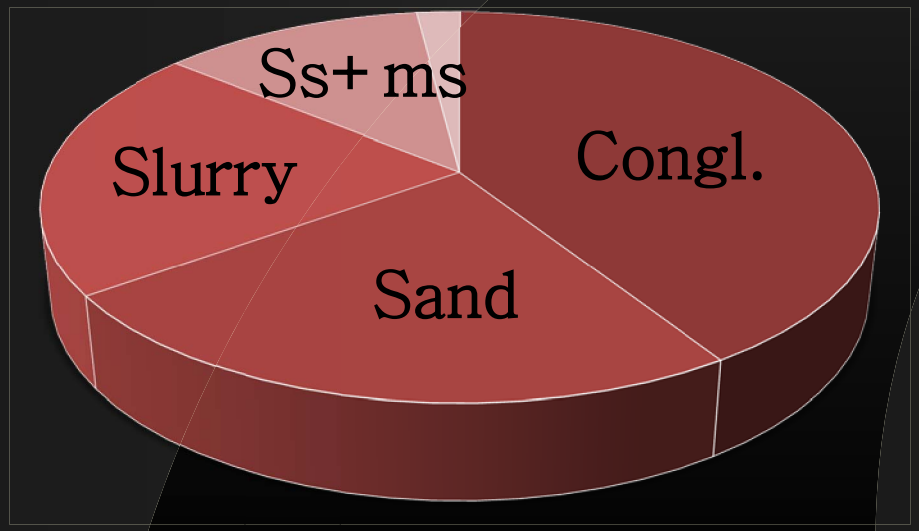
SV1
Flame
Wildcat
CC
CZM 5,4,3,2,1
SC
SSM
DC
H2O
Rocas
Lago del Toro
N
1 km 2
18S 0670500
4330500
Map Legend
Undiff. channel fill
Wildcat CC
Guanaco CC
Condor CC
Partially covered channel fill
Mudstone
Contour (50m CI)
Drainage
Section
Thrust fault

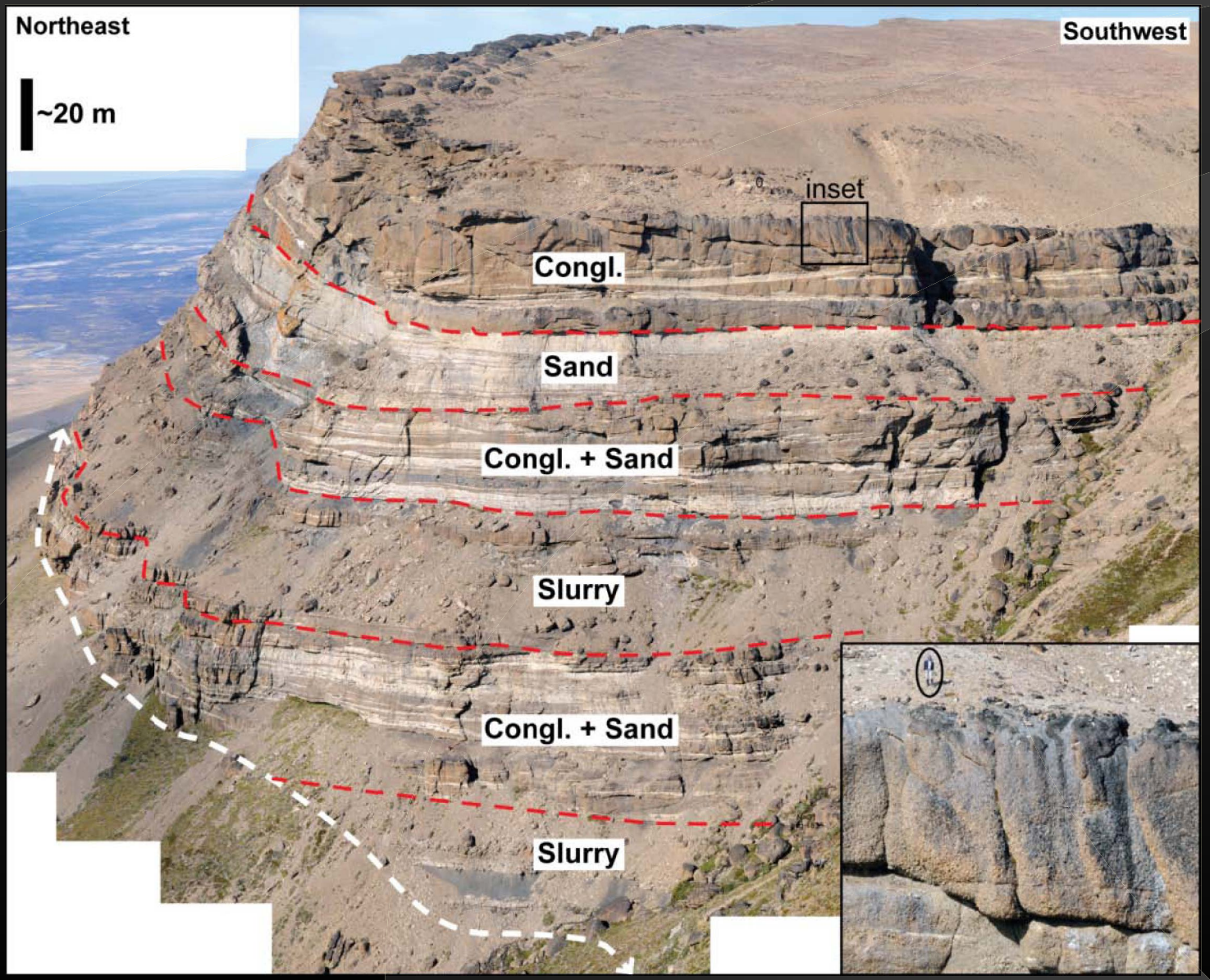

W
E
SSM
Rocas
HDO
Condor E margin
~400 m

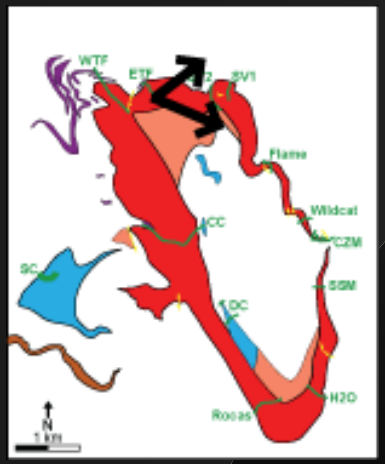
Channel fill lithofacies

- Conglomerate
- Sandstone
- Slurry flow
- Sandstone + mudstone
- Mudstone ± sandstone



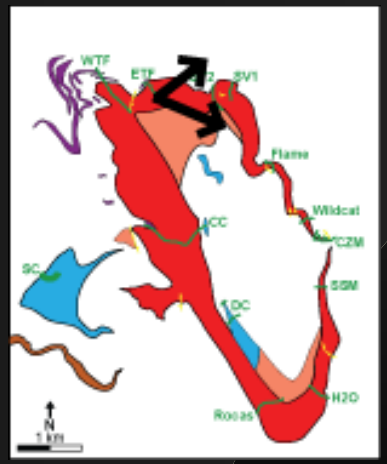
Wildcat channel fill: Large-scale architectural elements

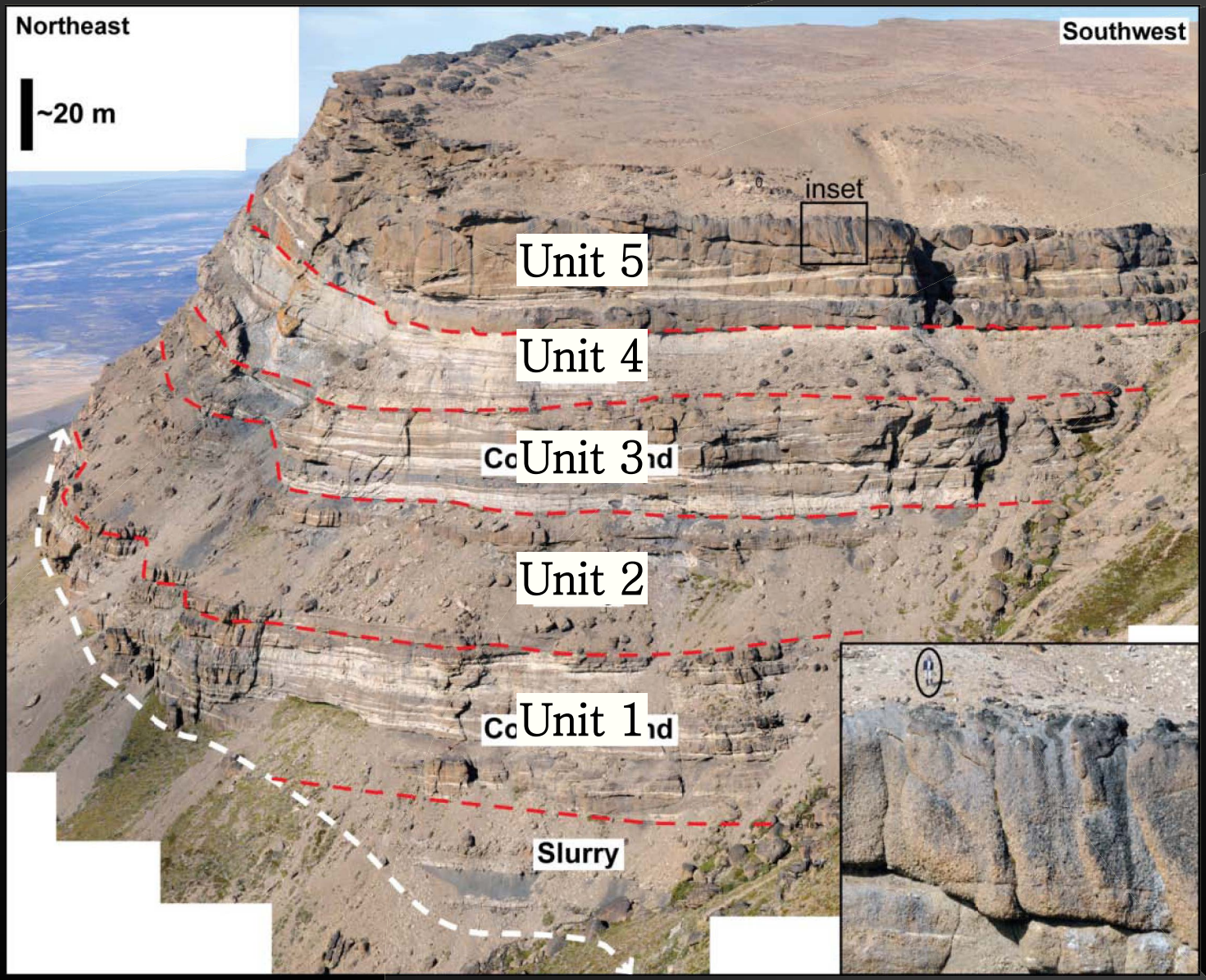




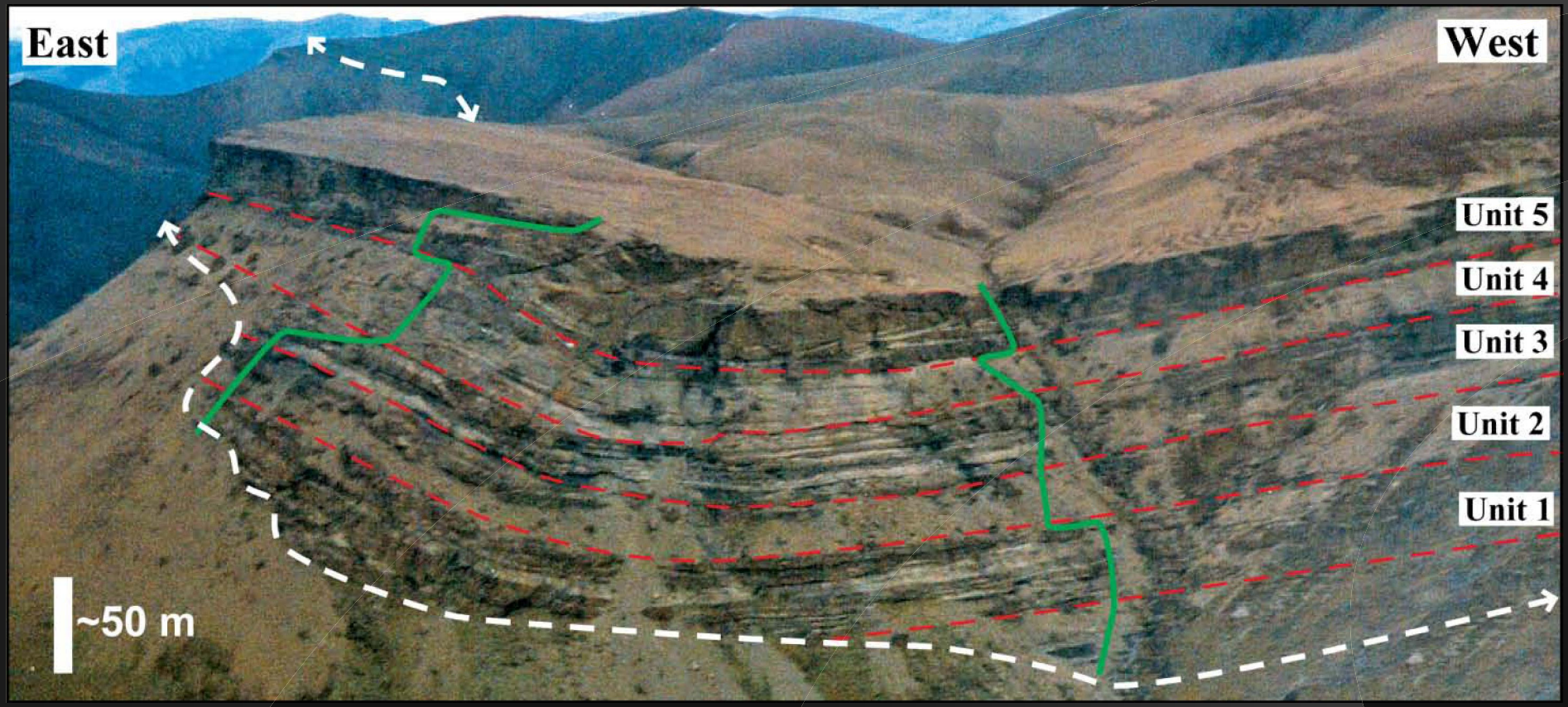
Wildcat channel fill: Large-scale architectural elements

- Lateral facies change in units 1-5

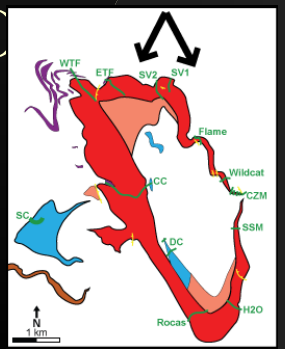




Eastern, amalgamated Wildcat

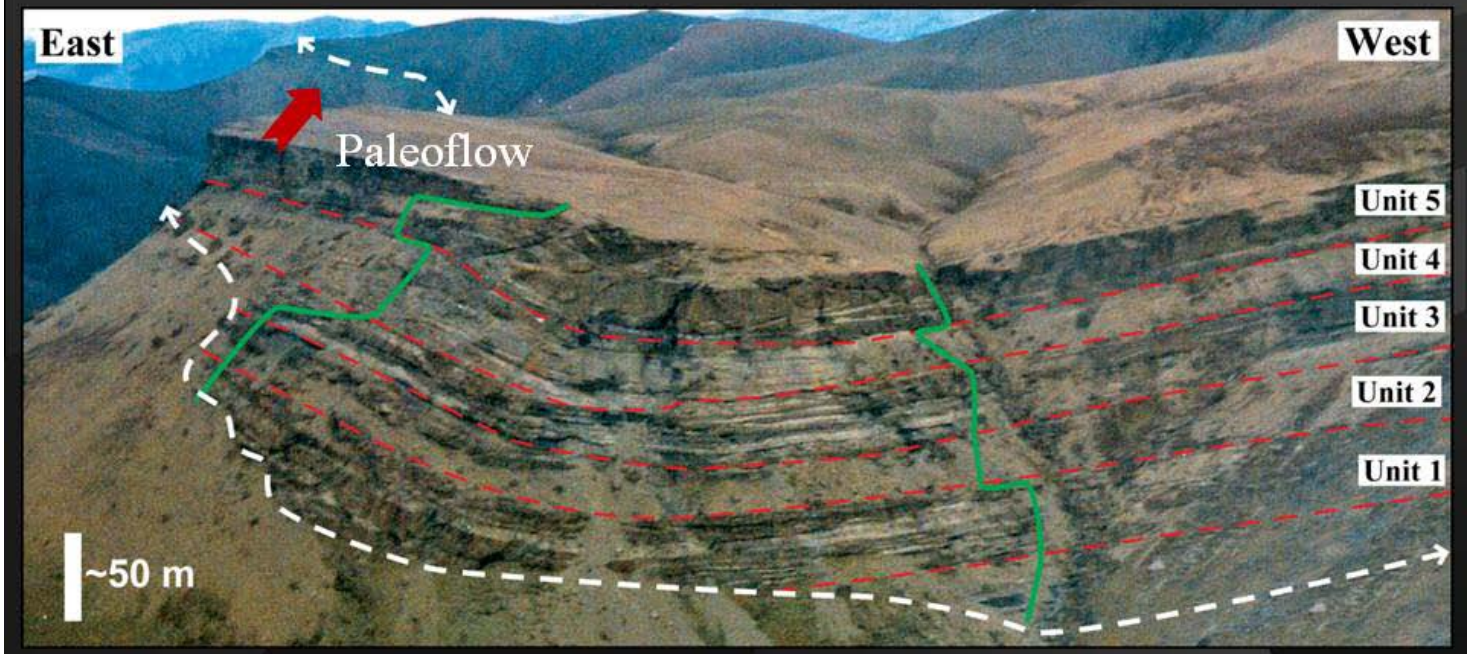


- z G G G
- Simple architecture
- Conglomeratic facies
- AR = 0.91

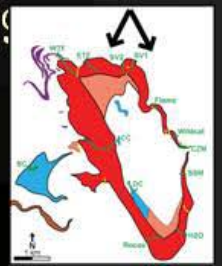


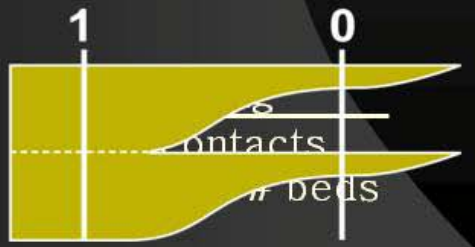
$$AR = \frac{\text{amalg contacts}}{\text{total \# beds}}$$

Eastern, amalgamated Wildcat



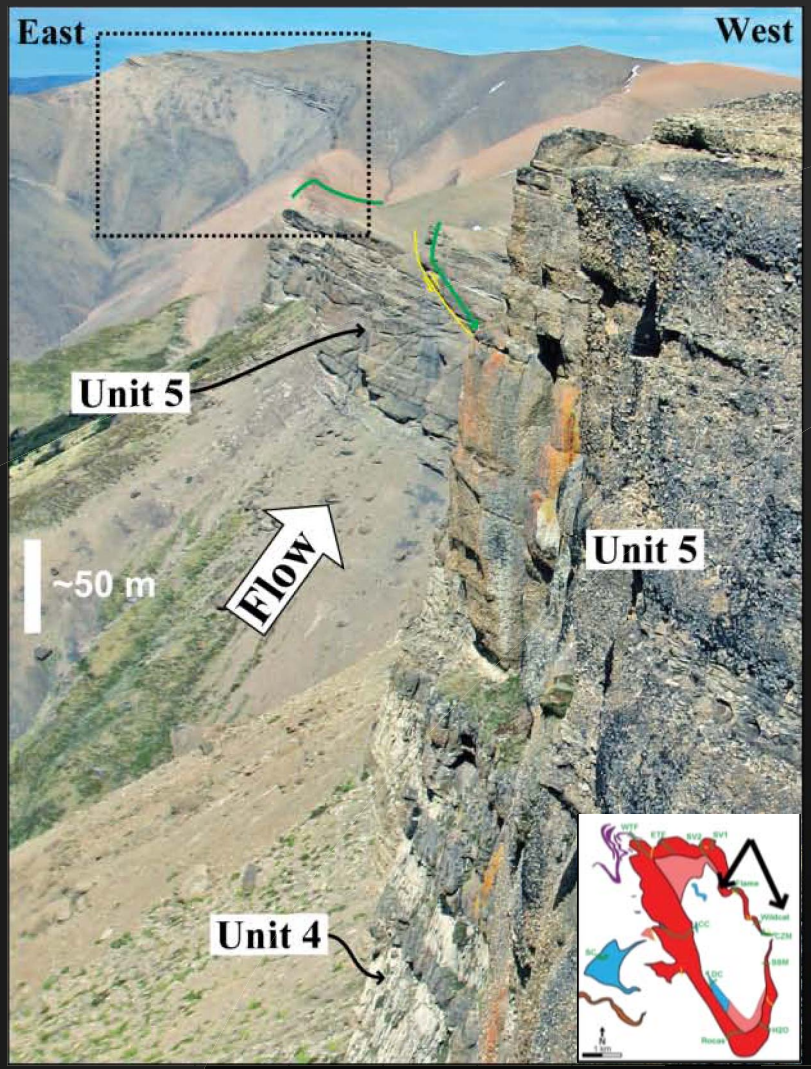
- Steep margin surface (S
- Simple architecture
- Conglomeratic facies
- AR = 0.91

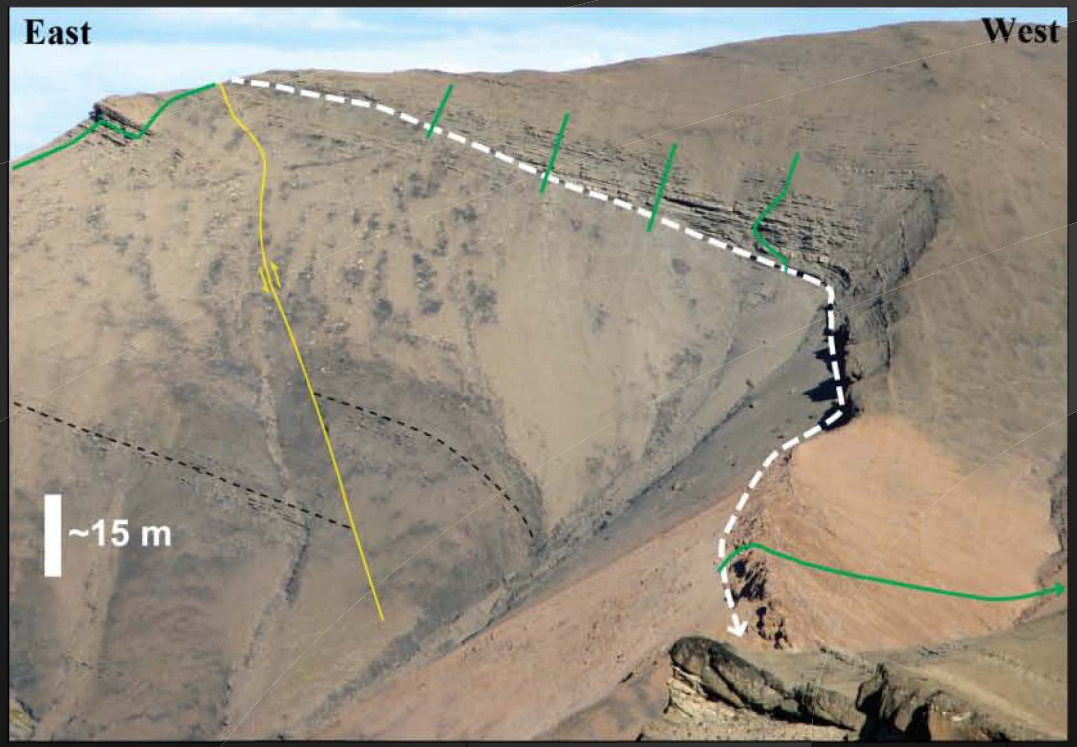




Notes by Presenter: Looking south (map). Amalgamated,etc.

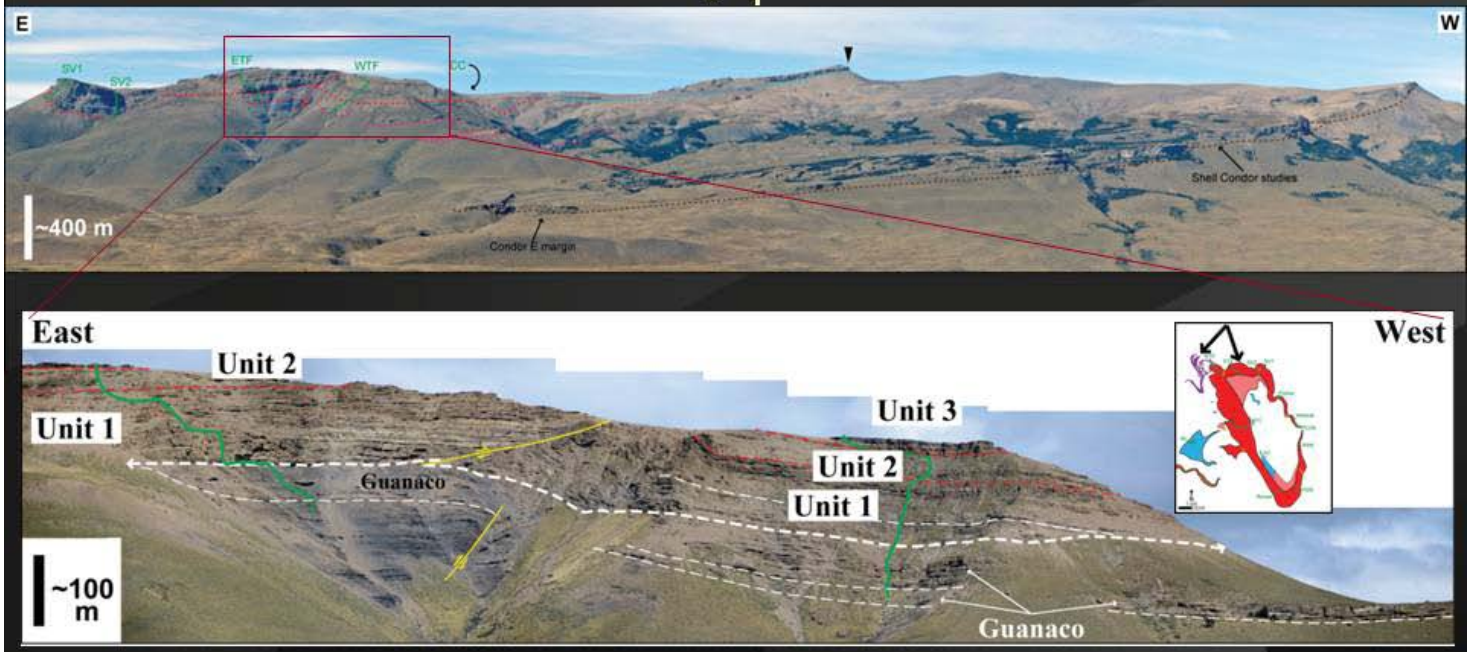
Eastern margin of the Wildcat





- Conglomeratic facies
- Complete pinchout exposed
- Overbank sand accumulation

Central, transitional zone – north



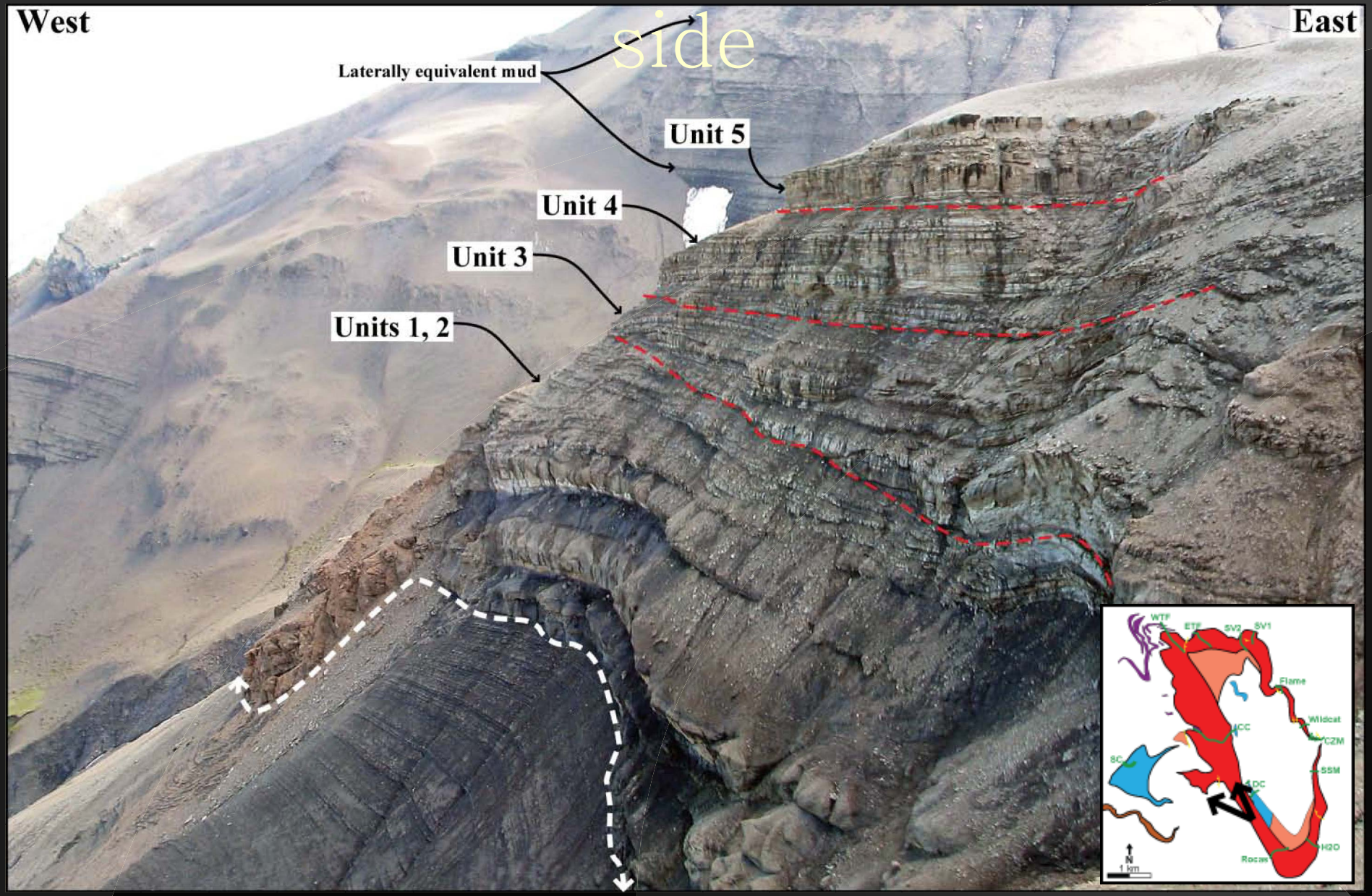
- Sand and congl. = 72%
- Mud = 2%
- AR = 0.80

→

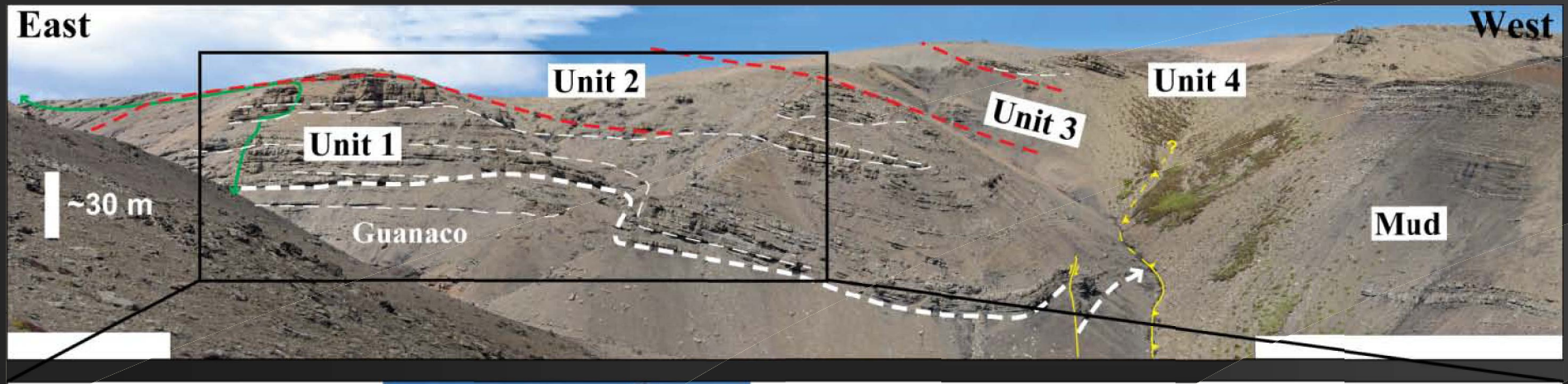
- Sand and congl. = 50%
- Mud = 35%
- AR = 0.62

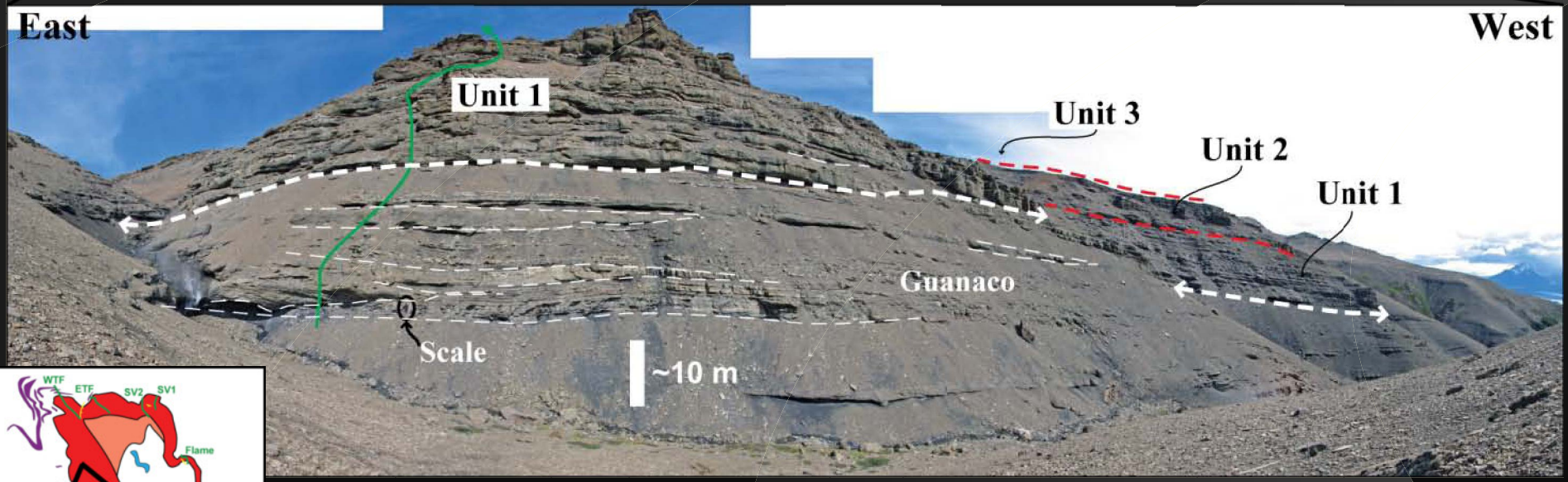
Notes by Presenter: Looking south (map).

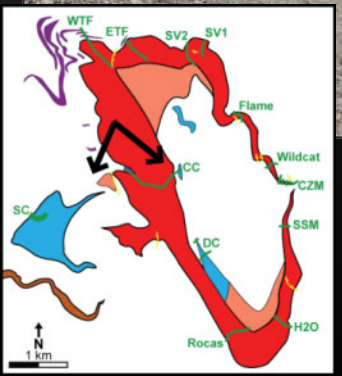
Central, transitional zone



Western margin north side

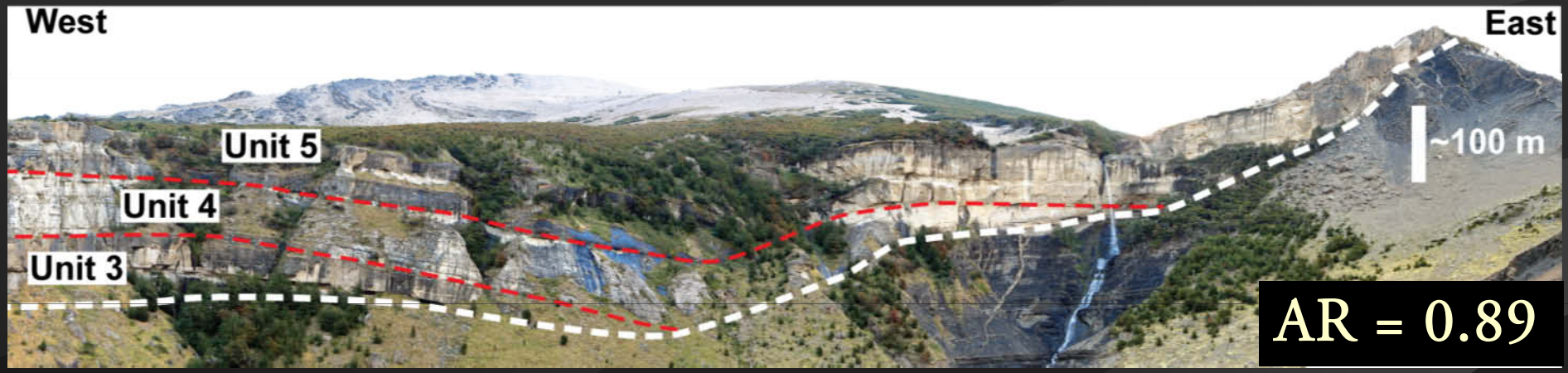


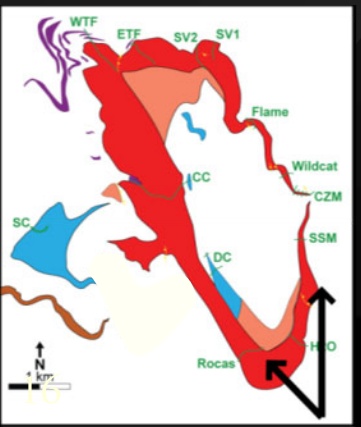




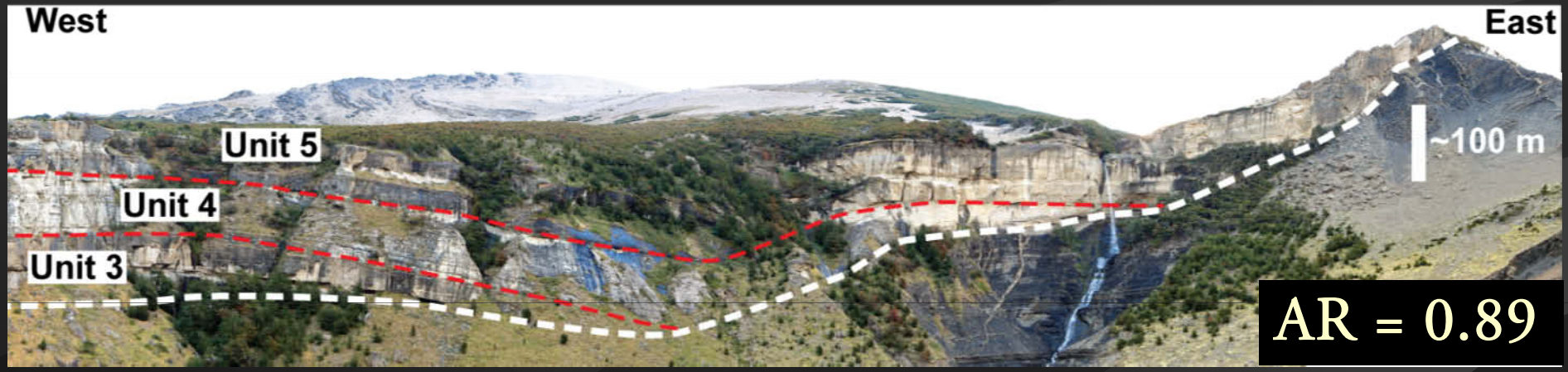
- z – G G GD P
- Complex, composite architecture
- Ss+ ms = 30%
- AR = 0.60

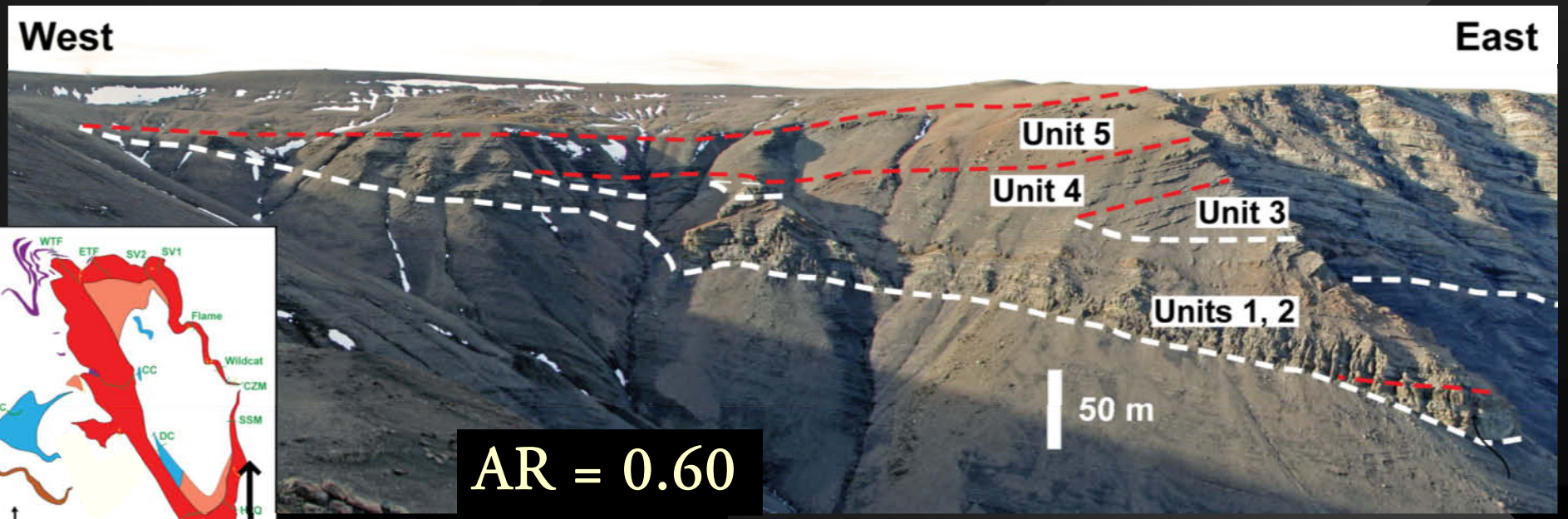
Wildcat margin architectures compared



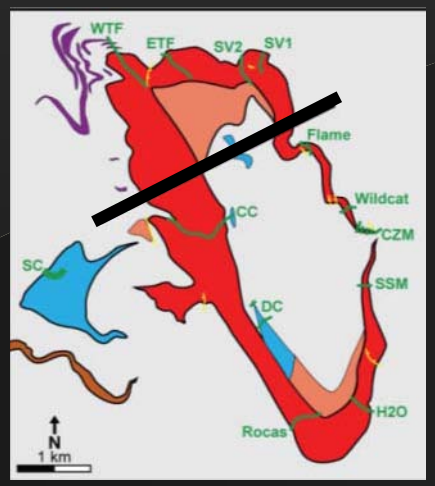


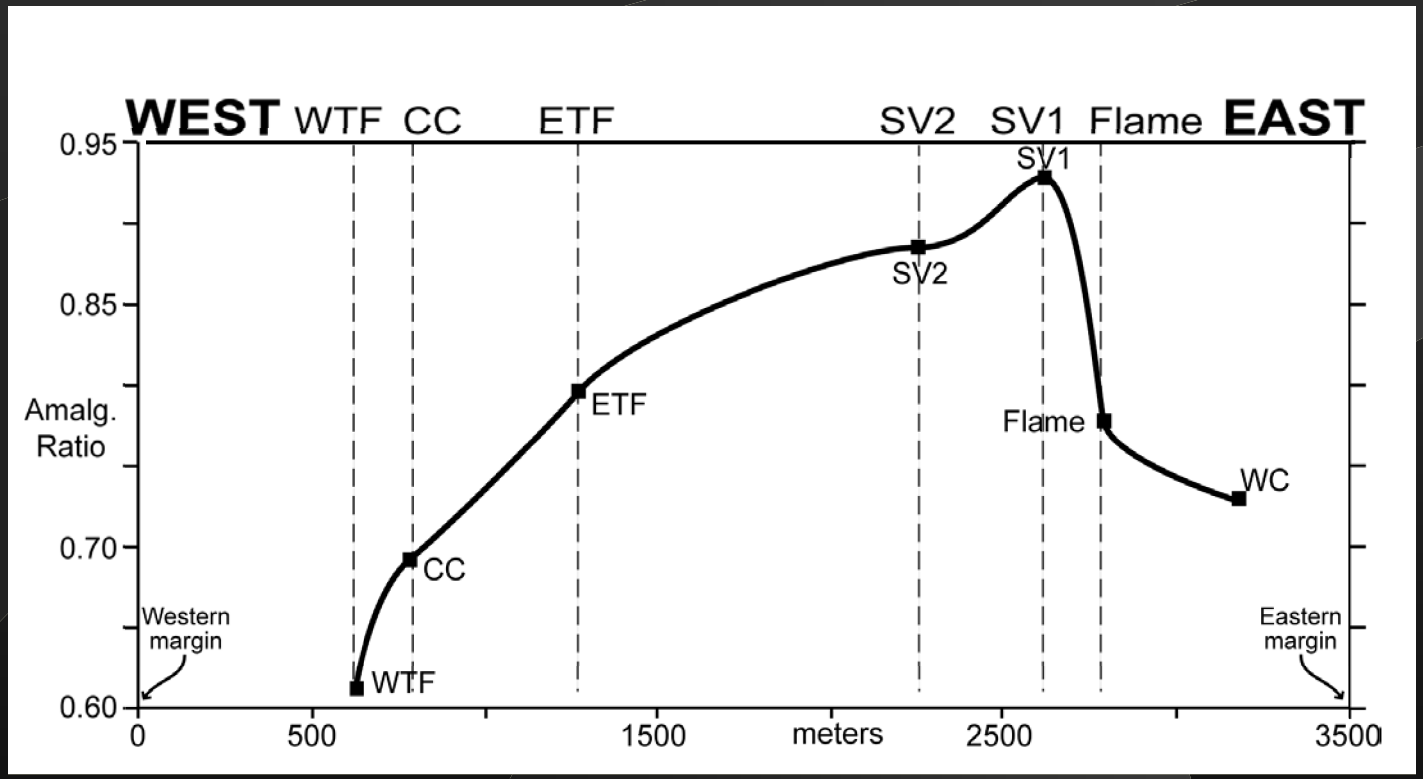
Wildcat margin architectures compared



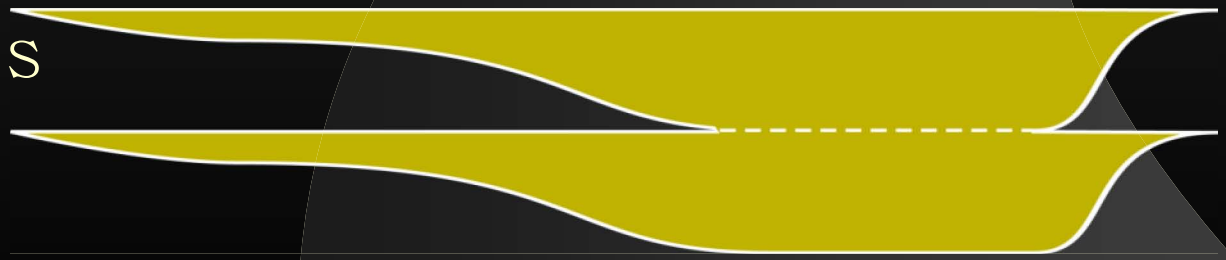


Quantitative facies distributions

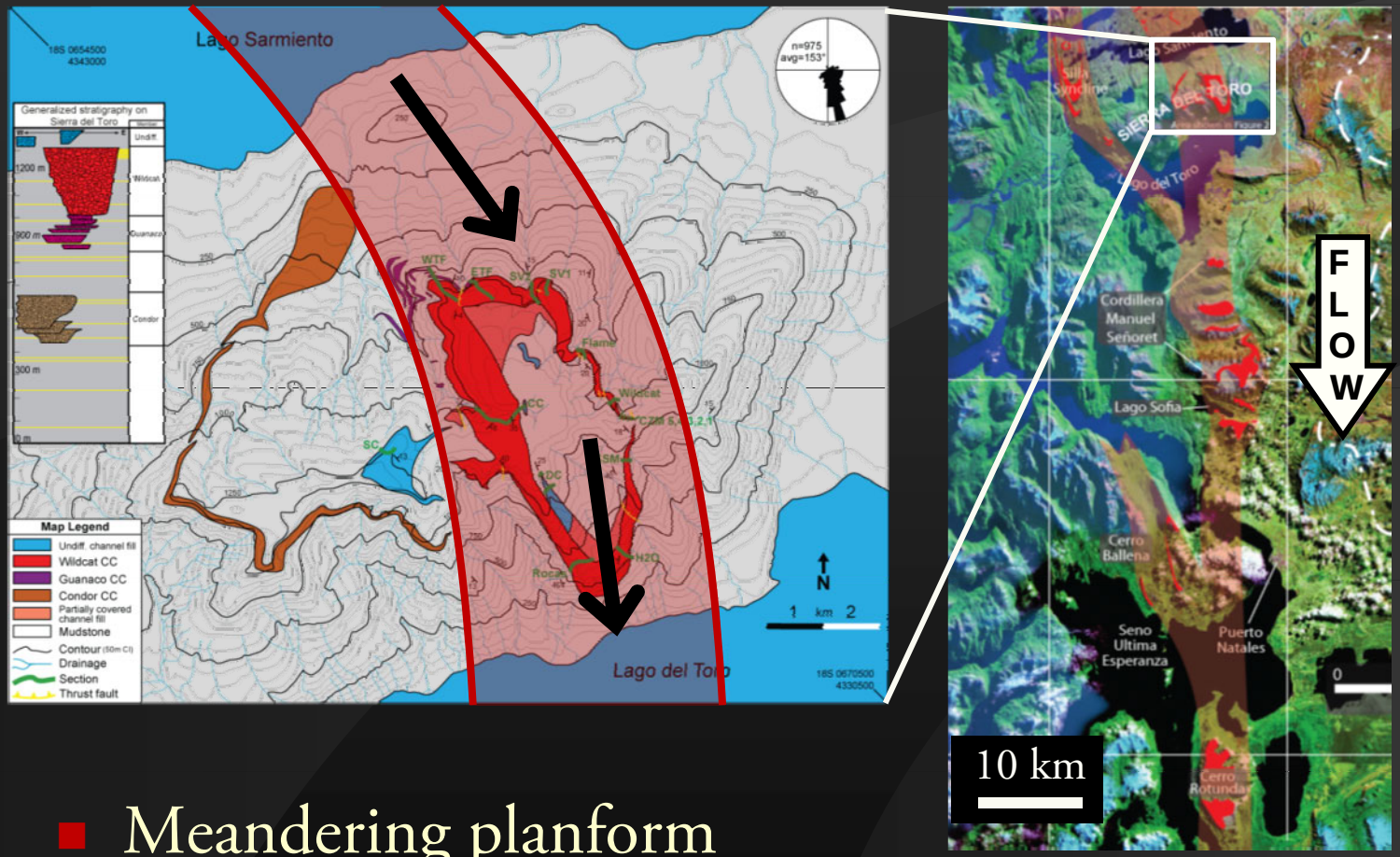




- Bed thickness
- Lithology proportions

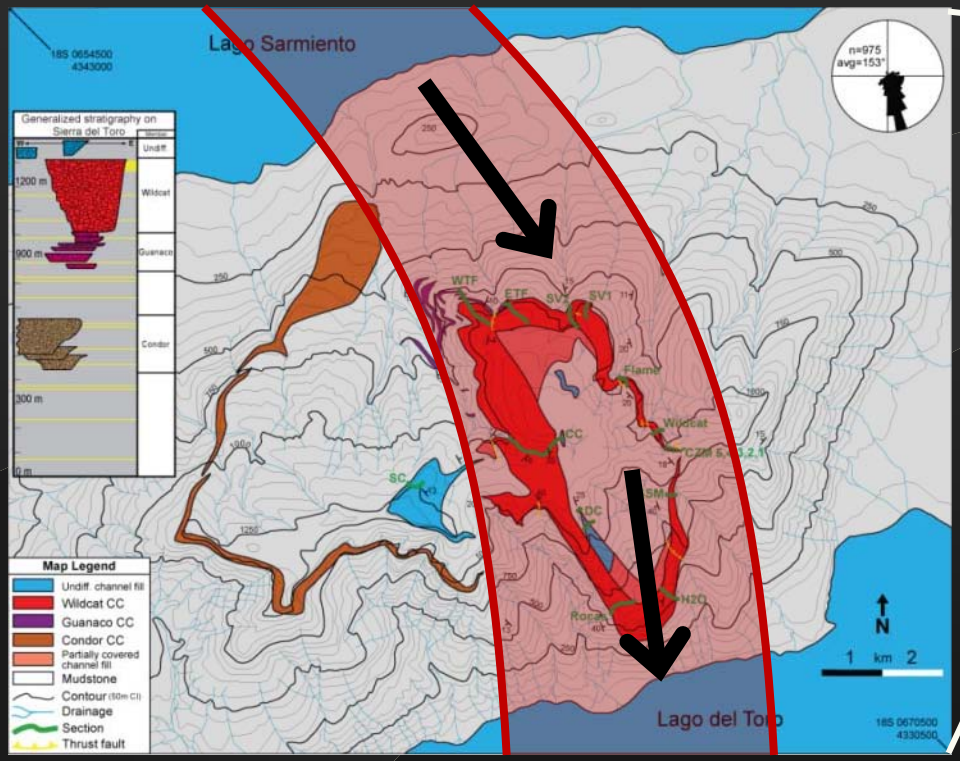


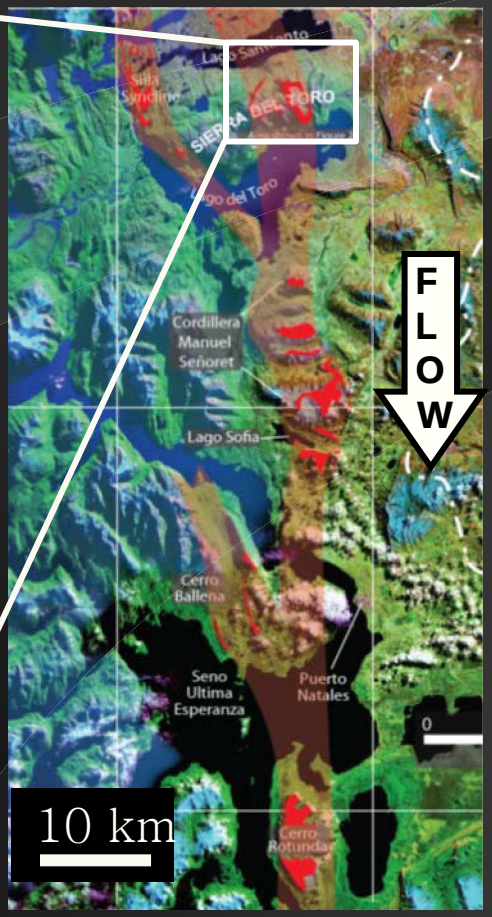
Low-sinuosity (1.06) meander bend

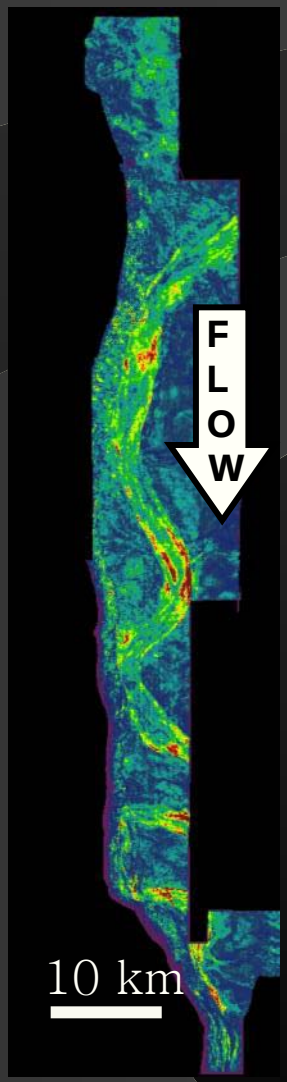


- Meandering planform
  - Paleoflow
  - Facies asymmetry (inner/outer beds)

Low-sinuosity (1.06) meander bend



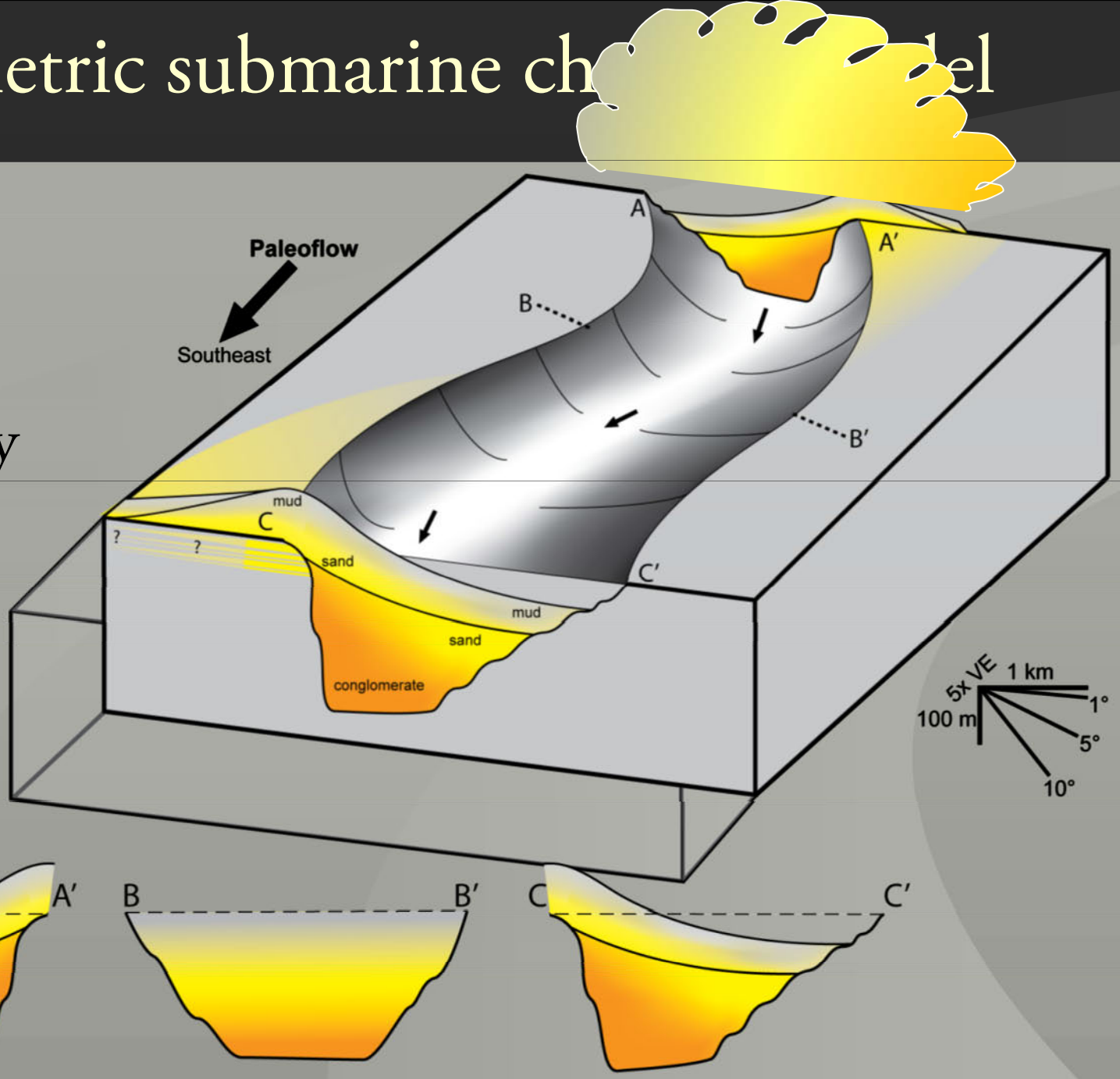




- Meandering planform
  - Paleoflow
  - Facies asymmetry (inner/outer beds)
- Puchkirchen Fm., Austria: subsurface analog

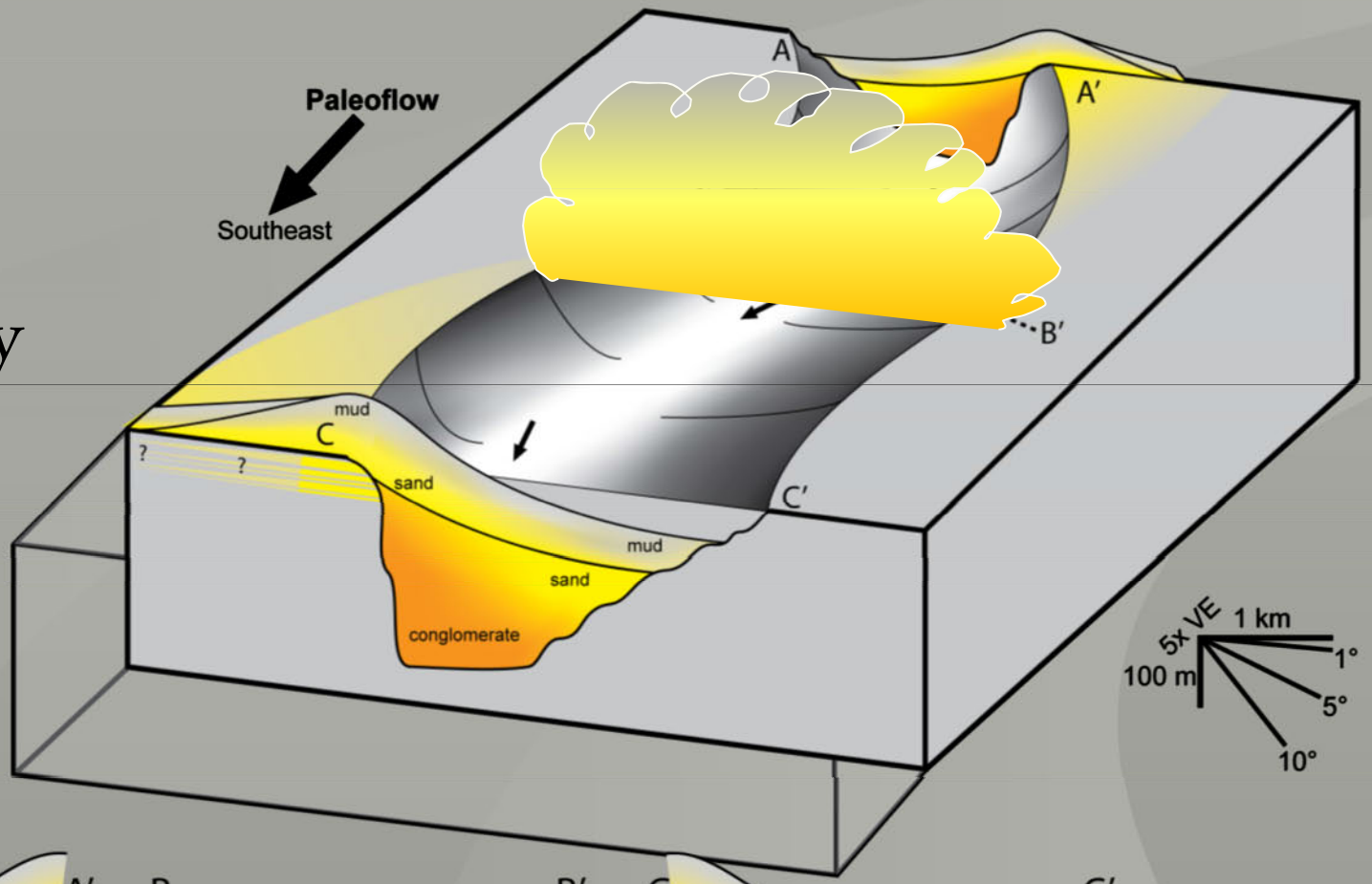
Asymmetric submarine ch el

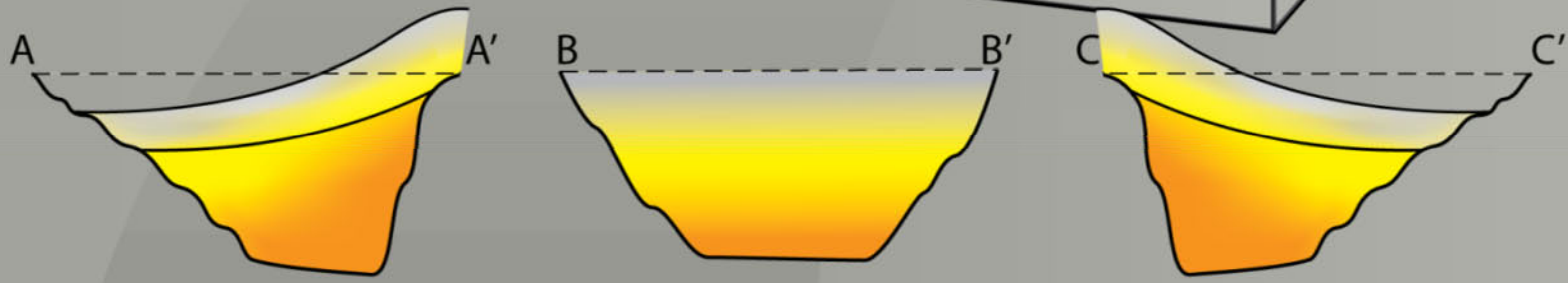
- Sinuosity
- Asymmetry
  - Facies
  - X-sec



Asymmetric submarine channel model

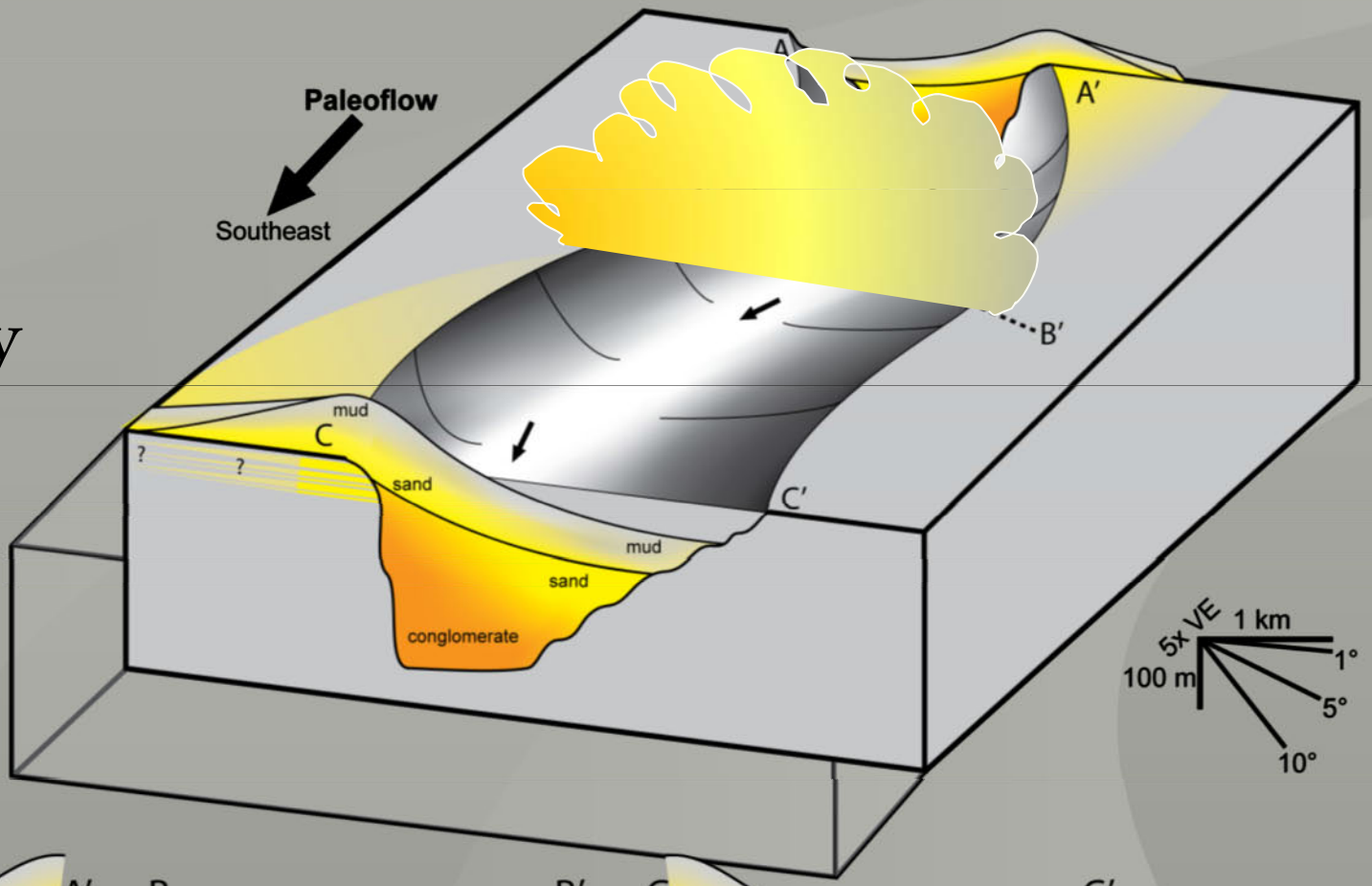
- Sinuosity
- Asymmetry
  - Facies
  - X-sec

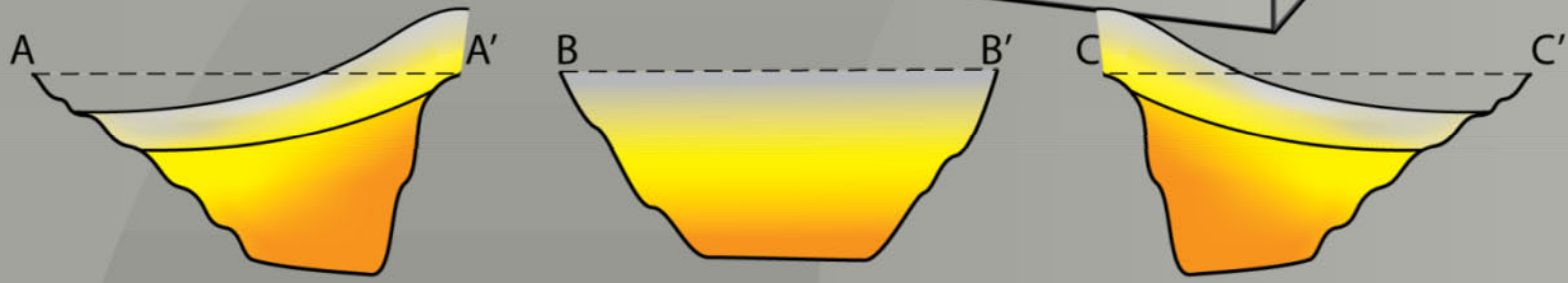




Asymmetric submarine channel model

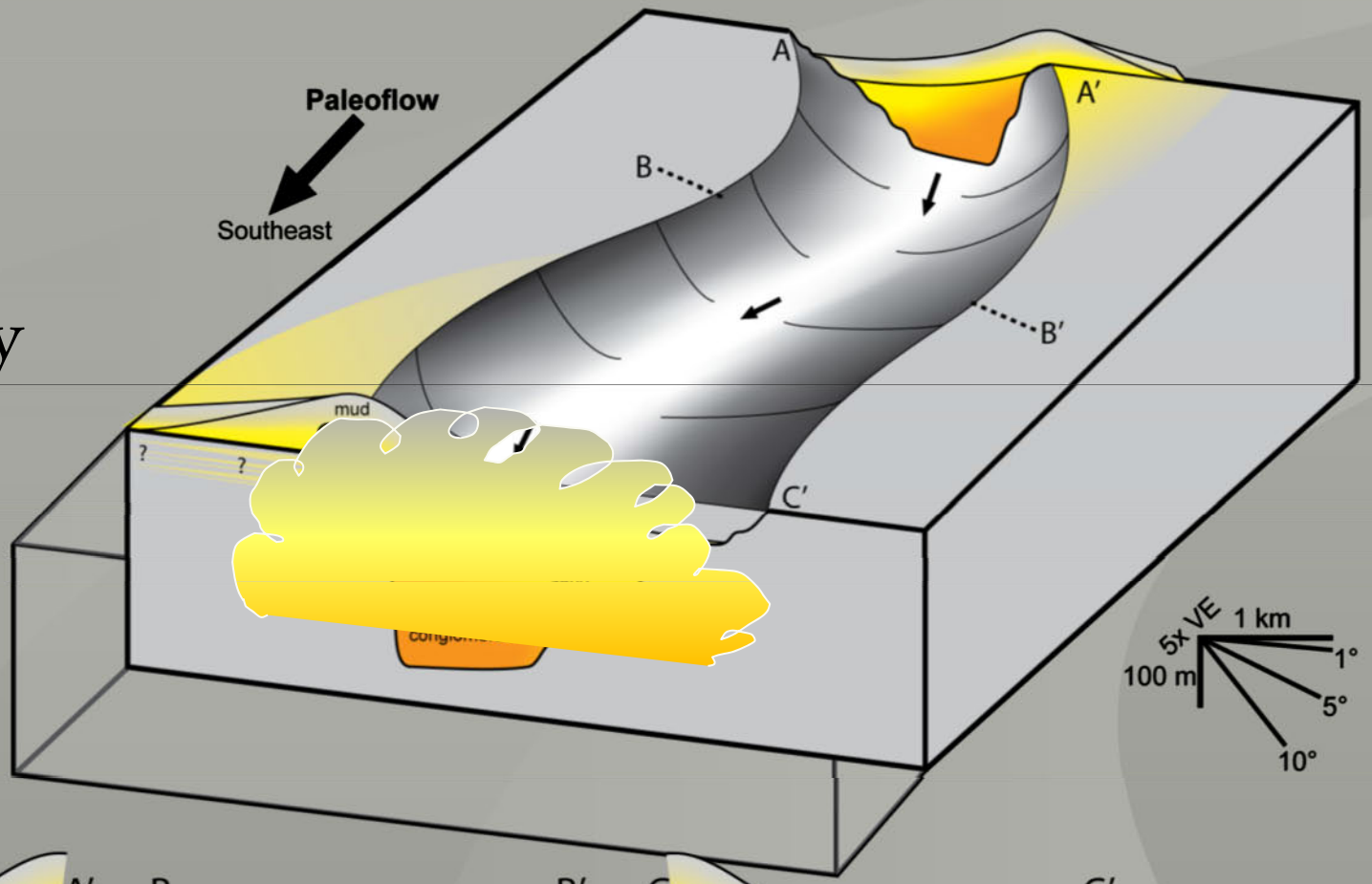
- Sinuosity
- Asymmetry
  - Facies
  - X-sec

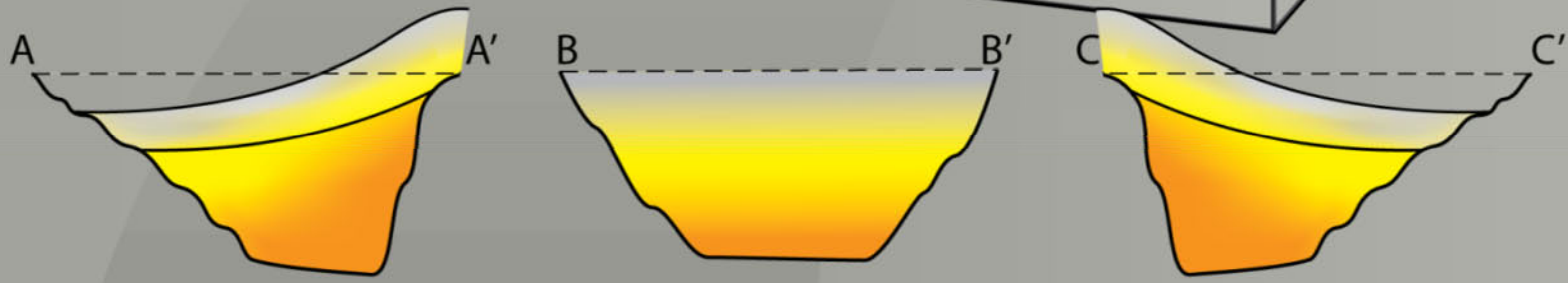




Asymmetric submarine channel model

- Sinuosity
- Asymmetry
  - Facies
  - X-sec





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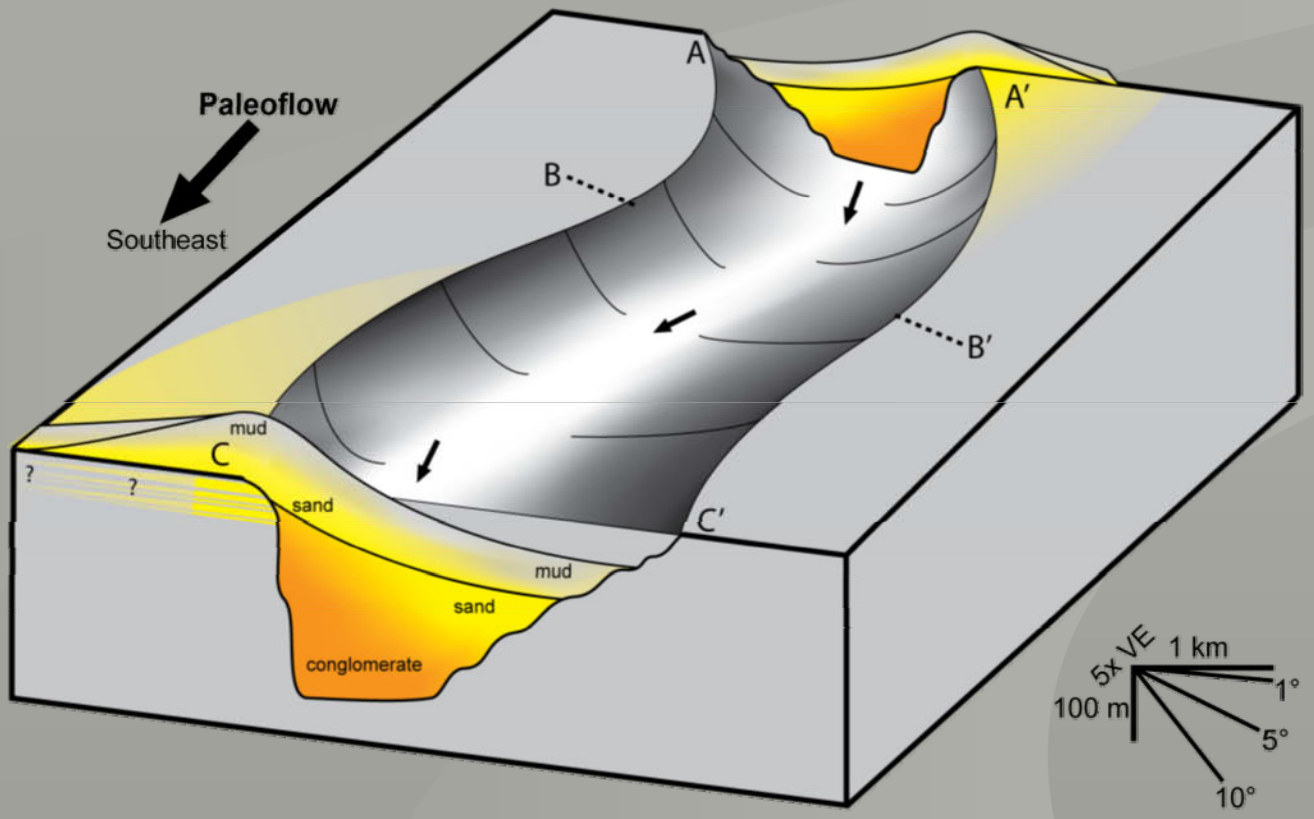
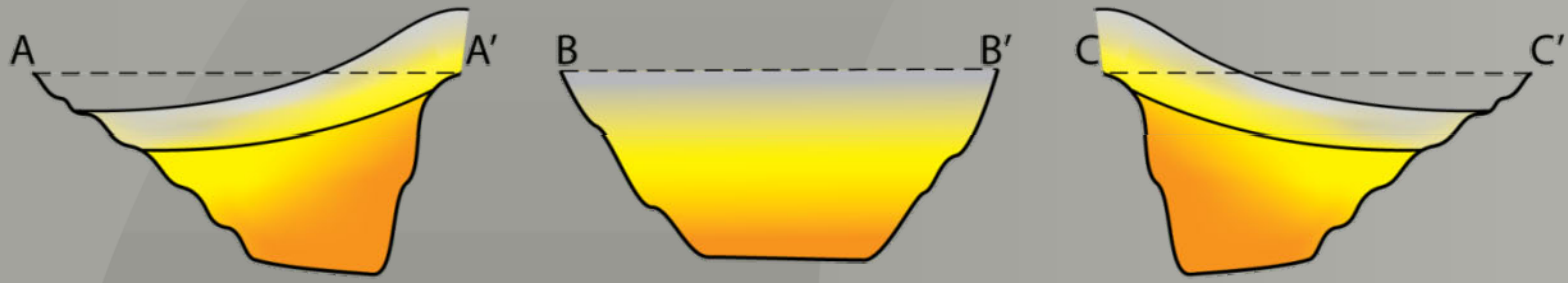
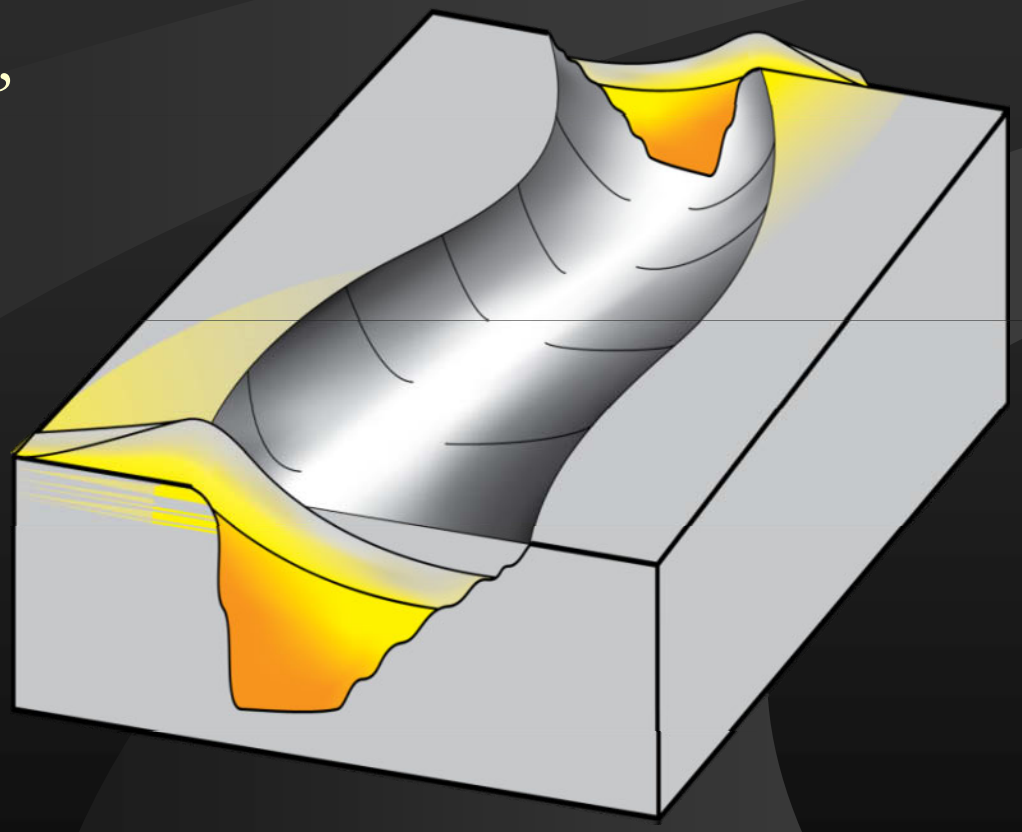




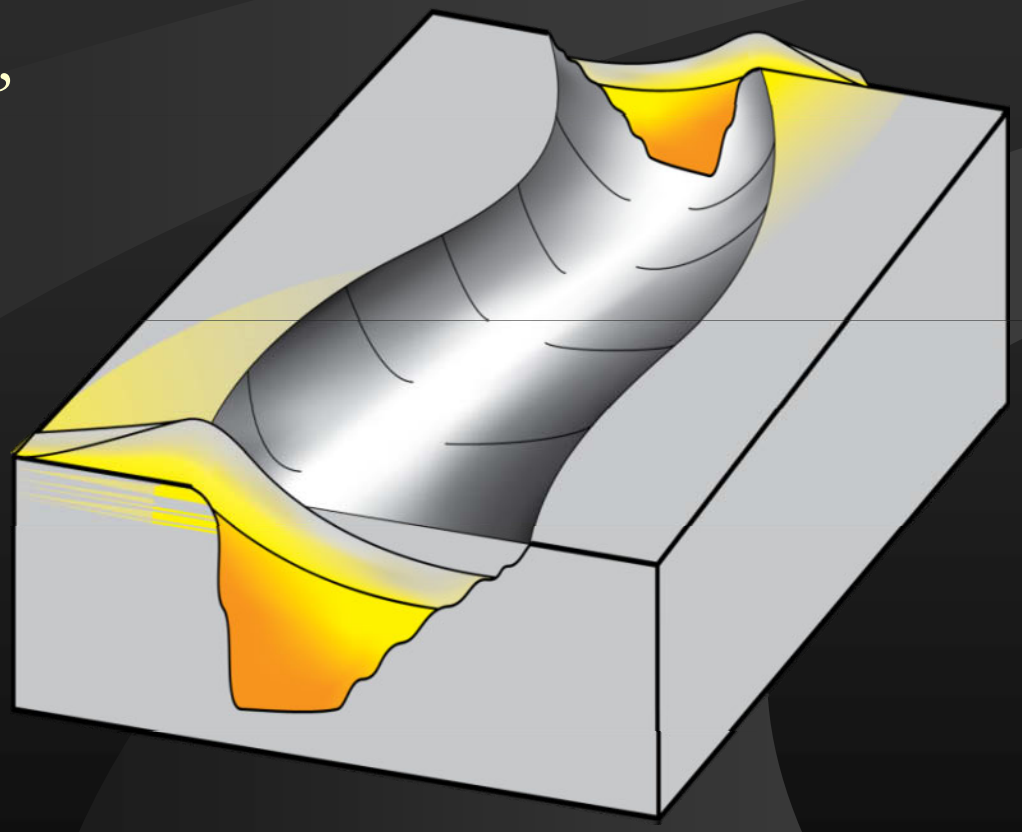
Conclusions

- Wildcat CC: 3.5 km wide, 300 m thick



Conclusions

- Wildcat CC: 3.5 km wide, 300 m thick
- Asymmetry of Wildcat
  - Facies distribution



Conclusions

- Wildcat CC: 3.5 km wide, 300 m thick
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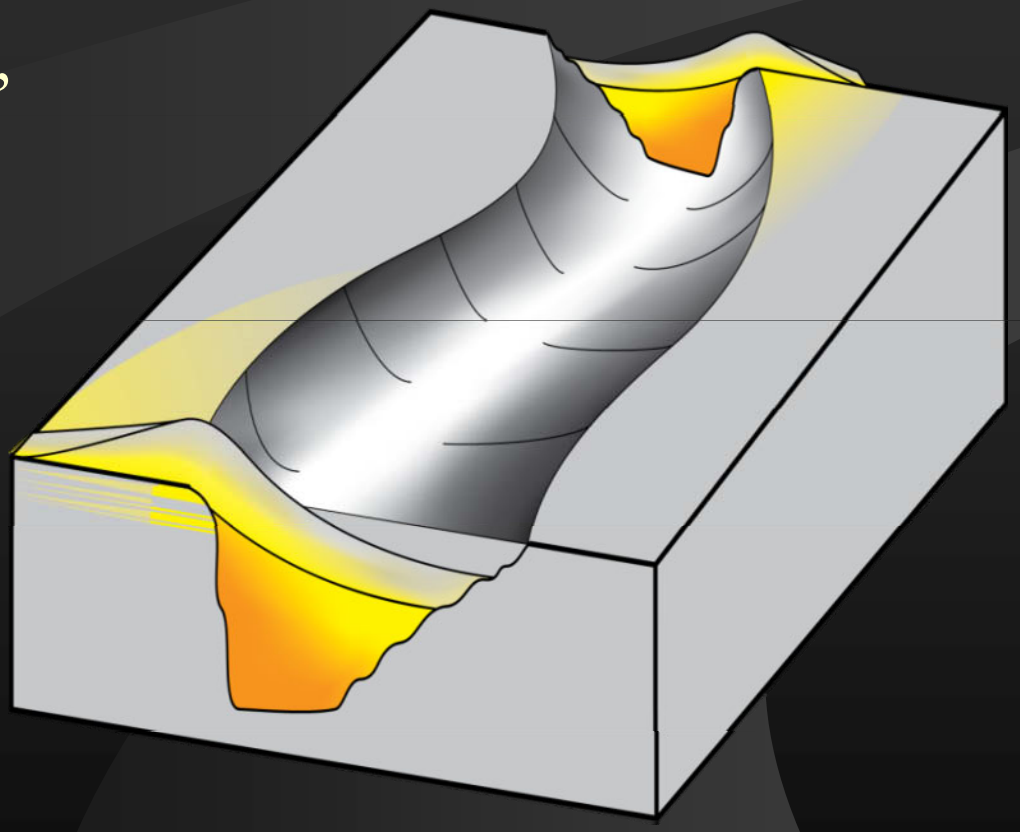
  - Overbank accumulation
  - Cross sectional shape
  - Meandering planform



Conclusions

- Wildcat CC: 3.5 km wide, 300 m thick
- Asymmetry of Wildcat
  - Facies distribution
  - Overbank accumulation
  - Cross sectional shape
  - Meandering planform
- Depositional model for asymmetric submarine channels
  - Incorporates sedimentary architecture
  - Provides quantitative input for models