THE PRESENT IS NOT ALWAYS THE KEY TO THE PAST

EXPLORING AND MODELING THE PALEOGENE INTERNALLY-DRAINED FLUVIAL SYSTEMS OF THE MIDDLE MAGDALENA VALLEY BASIN, COLOMBIA

Xavier Roca and Kurtis Wikel

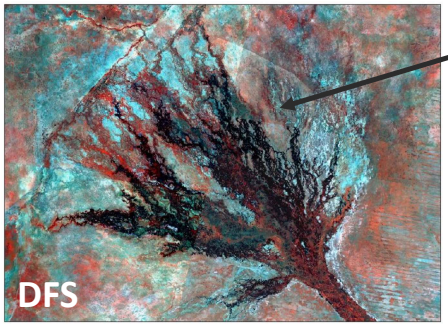
July 1st, 2022

PAREXRESOURCES.COM

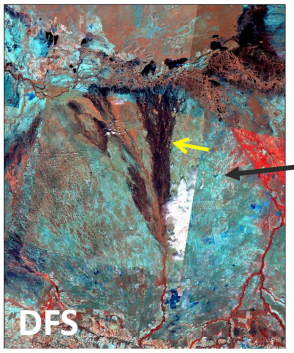
FLUVIAL SYSTEMS: TRIBUTIVE VS **DISTRIBUTIVE**

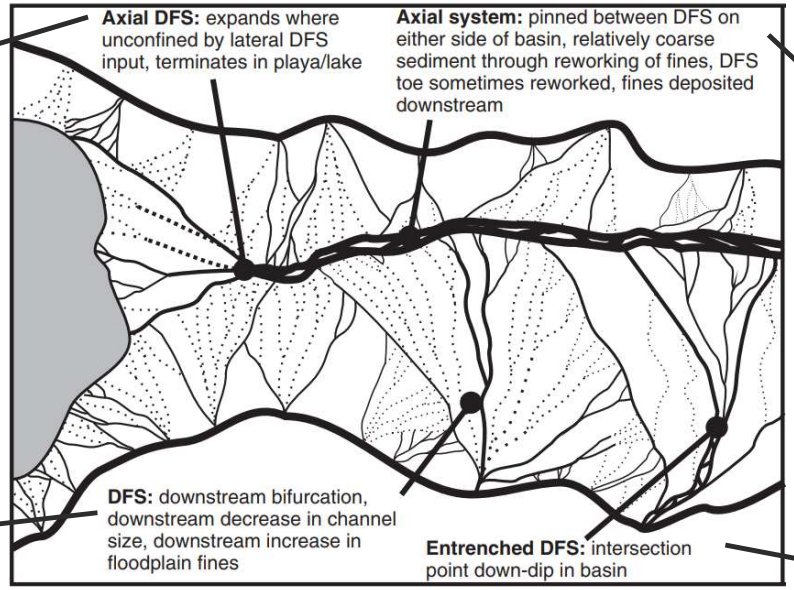
- Modern fluvial sedimentary basins are dominated by Distributive Fluvial Systems (aggradational)
- The importance of DFSs in the sedimentary record has probably been underappreciated
- Aspects of modern tributive (degradational) fluvial analogs may not be directly applicable to a part of the sedimentary record

Okavango River (Botswana)

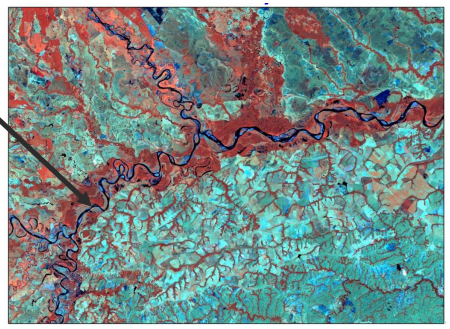


Taquari River (Brazil)

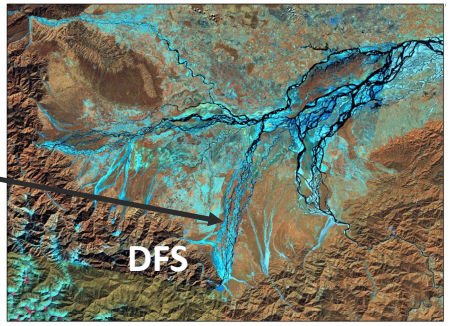




Rio Upia (Colombia)



Brahmaputra River (India)



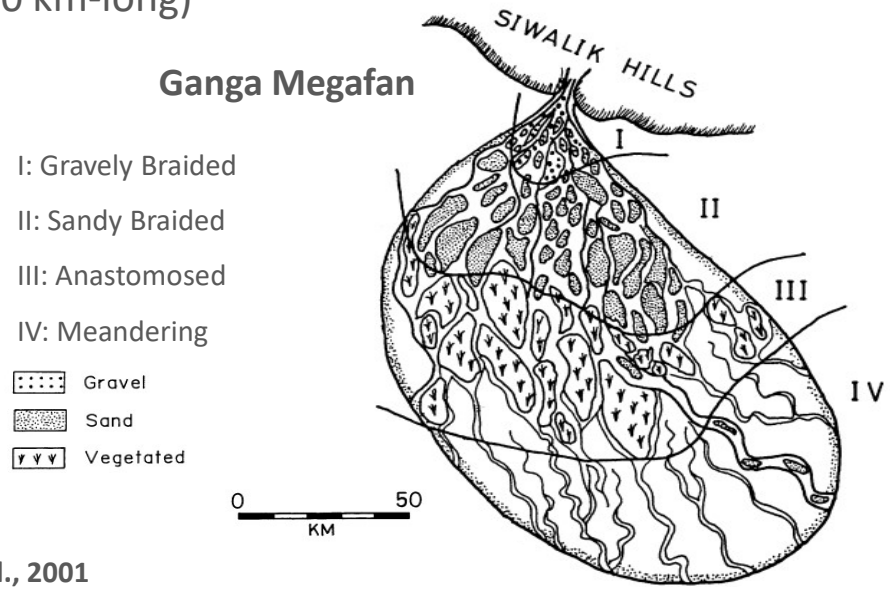
Percent Area Covered by Geomorphic Elements

Basin / Geomorphic Element	Himalayan Foreland	Andean Foreland (Chaco)	Andean Foreland (<250km)	Alaska Range Foreland	Okavango Rift
Total Distributive	92.8	97.99	99.80	94.43	94.52
Total Tributive	7.2	2.01	0.20	5.57	0.93

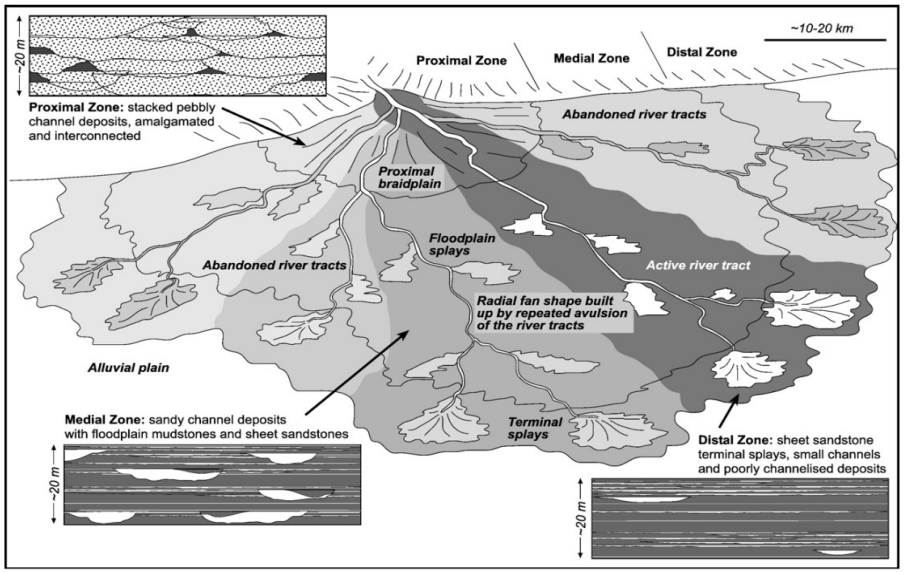
Modified from Weissmann et al, 2010 and 2014

CHARACTERISTICS OF DISTRIBUTIVE FLUVIAL SYSTEMS (DFS)

- Unconfined
  - Sediment entry point into a high- accommodation basin
- Aggradational nature
- Radial pattern from an updip apex
- From alluvial fans (<30 km-long) to fluvial megafans (~700 km-long)



Shukla et al., 2001

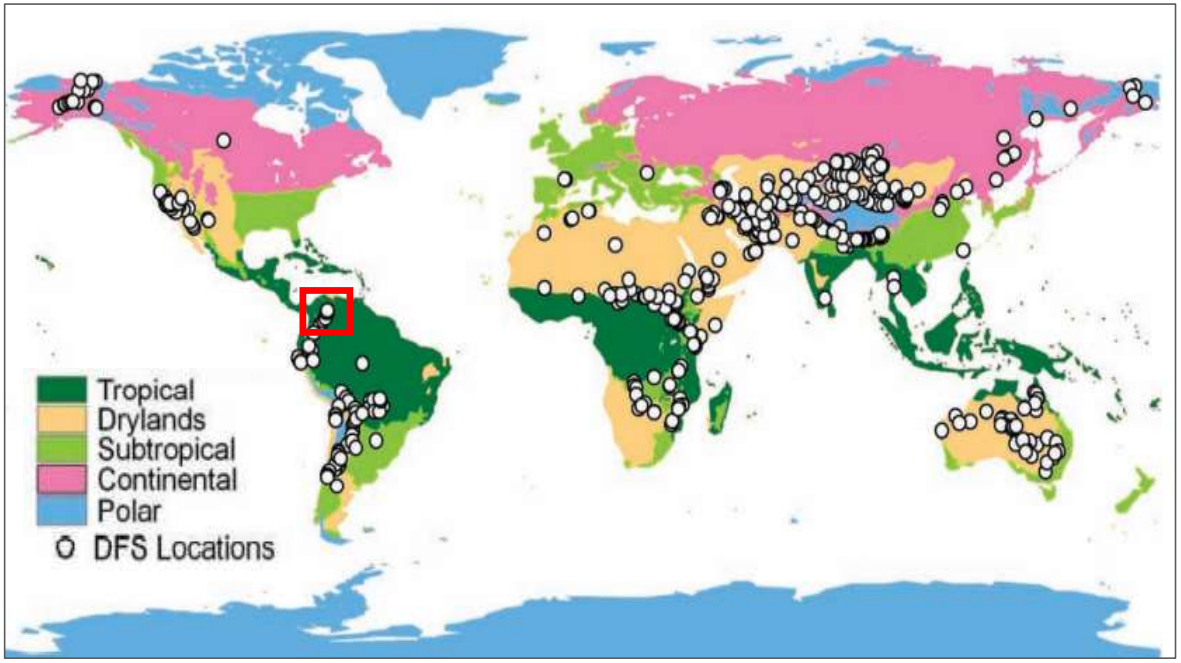


Nichols and Fisher, 2007

- Characteristic downslope depositional changes
  - Decrease in channel size, amalgamation, and NTG
  - Increase of fines and lateral continuity of sandstones (crevasse and terminal splays)
  - **Braided-anastomosed-meandering**

GLOBAL OCCURRENCE OF MODERN DFS

CLIMATES



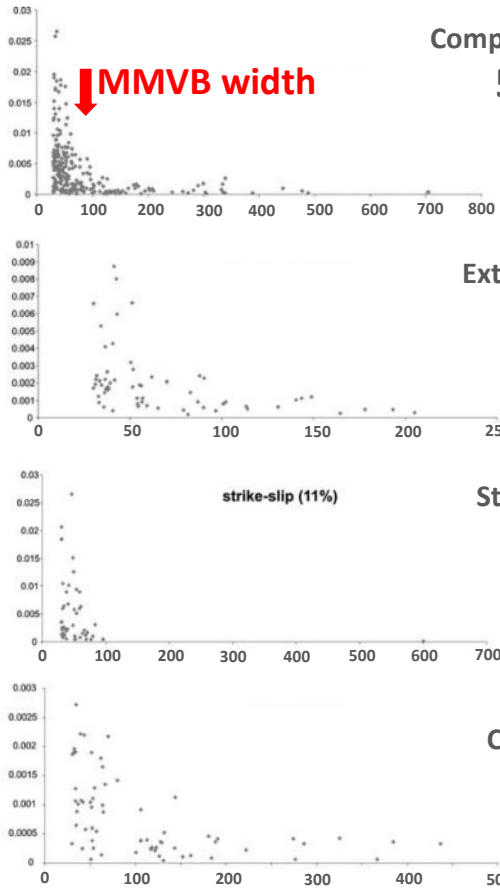
ENDORHEIC (internally drained) **vs** **EXORHEIC** (externally drained)

42% **58%**

of modern large DFSs

TECTONIC SETTINGS

(Gradient vs Length)



Compressional 57%

Extensional 13%

Strike-slip 11%

Cratonic 19%

Hartley et al, 2010

THE PALEOGENE OF THE MIDDLE MAGDALENA VALLEY BASIN

Middle – upper Eocene Esmeraldas Formation

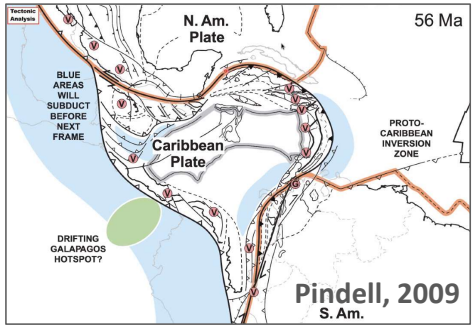
Lower Eocene La Paz Formation

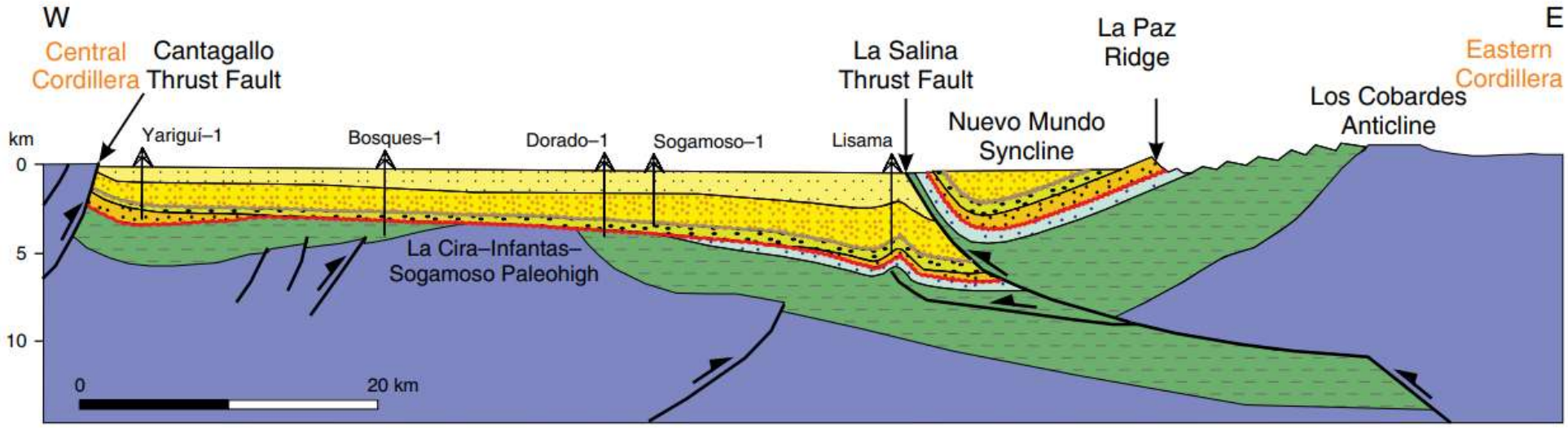
Paleocene Lisama Formation

Upper Miocene Real Formation

Lower Miocene Colorado Formation

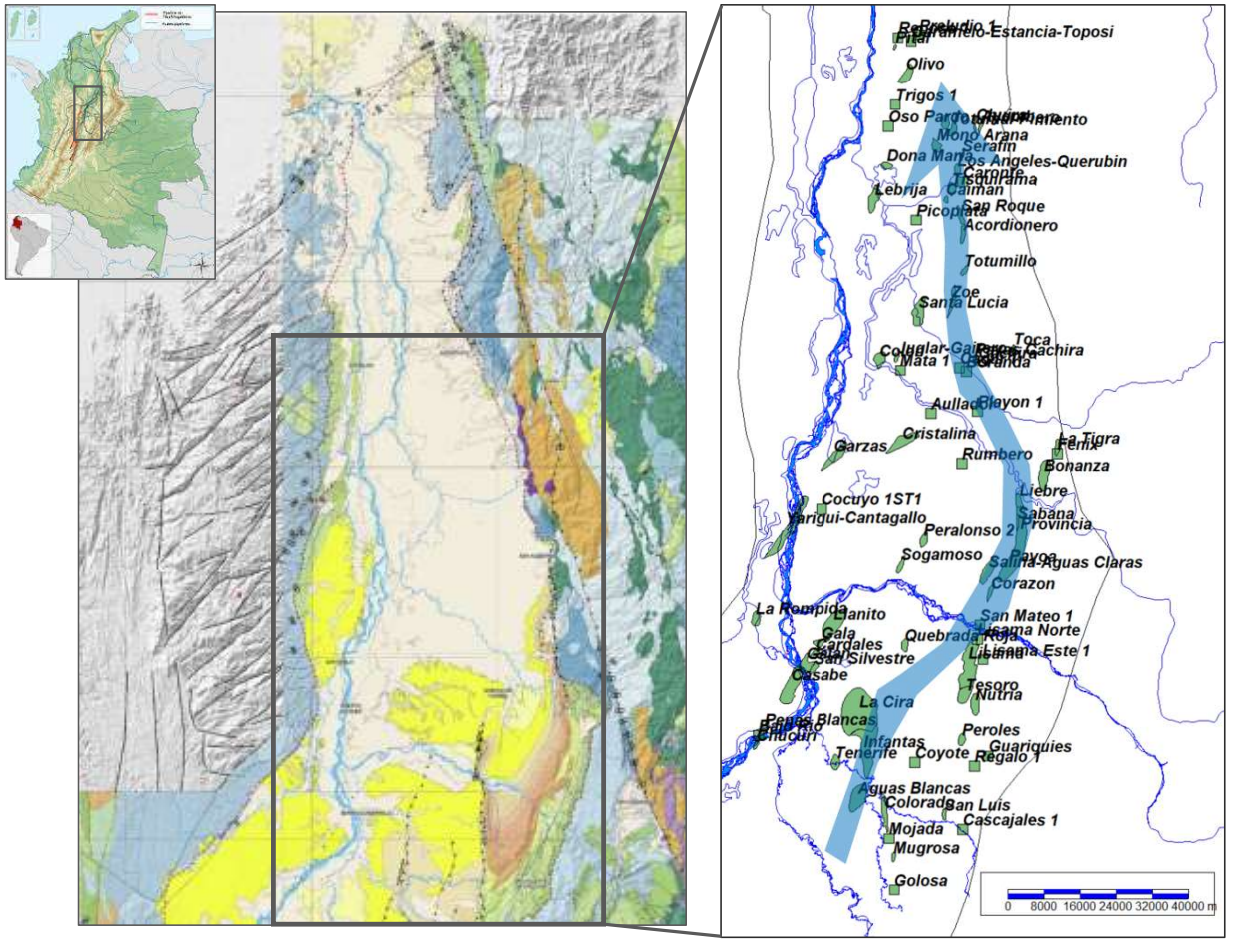
Oligocene Mugrosa Formation





Caballero et al., 2020

TRIBUTIVE OR DISTRIBUTIVE?



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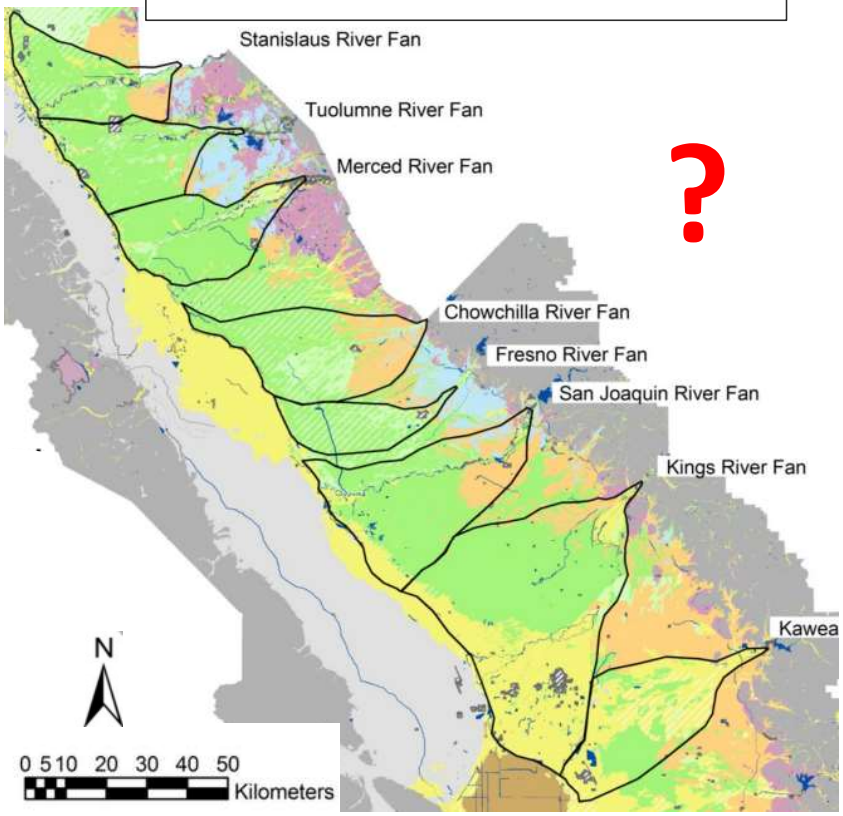
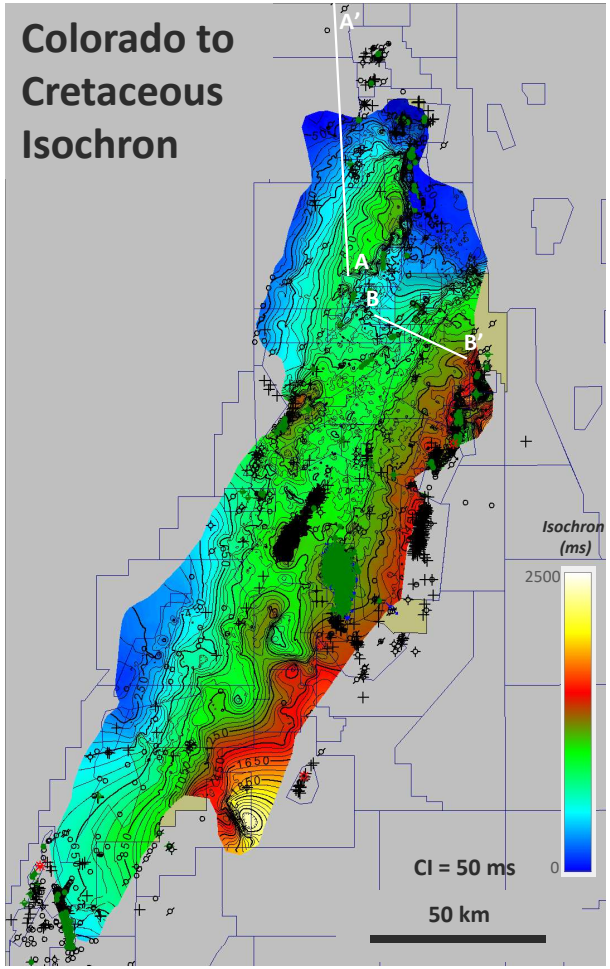
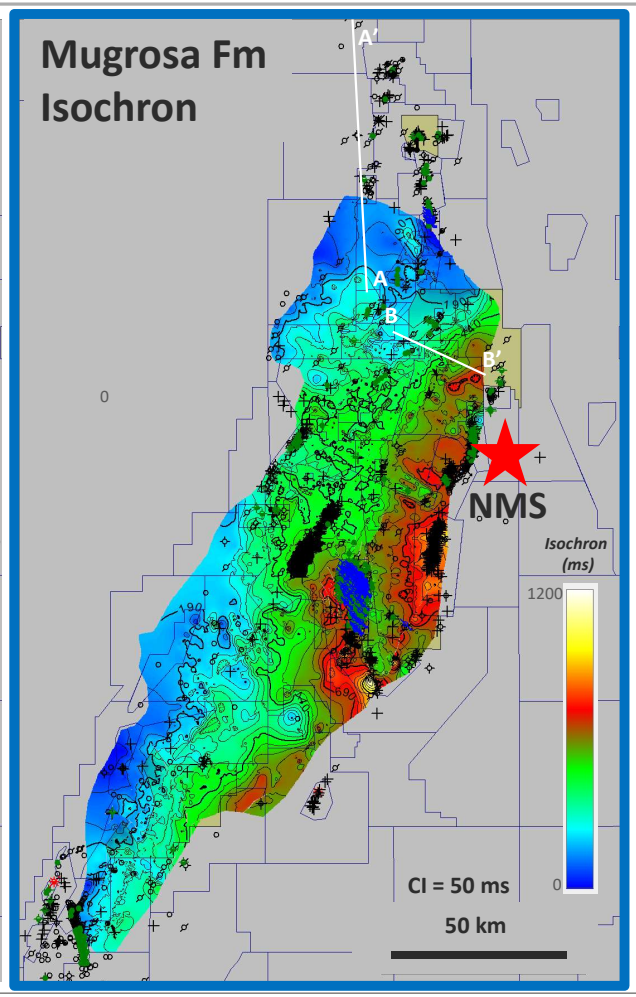
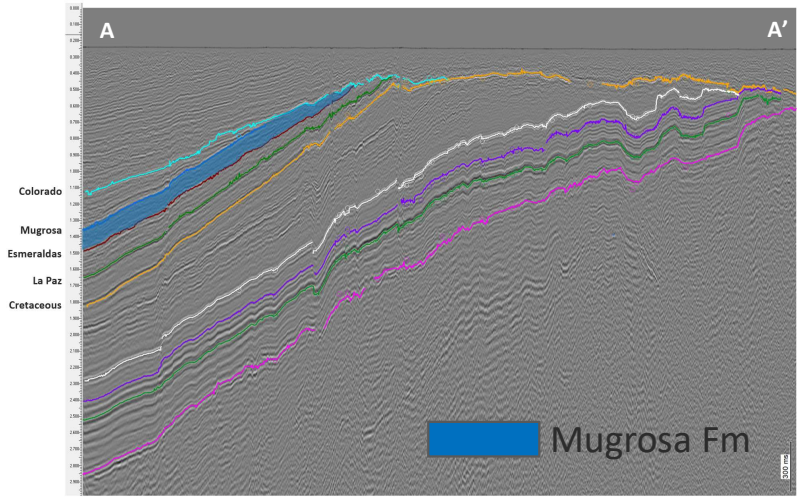


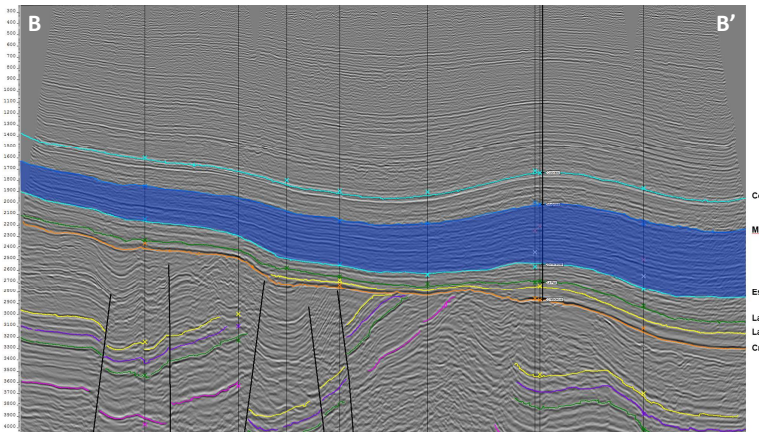
Weissmann et al., 2005

THE MUGROSA FM: FLUVIAL DEPOSITION IN AN ENDORHEIC BASIN

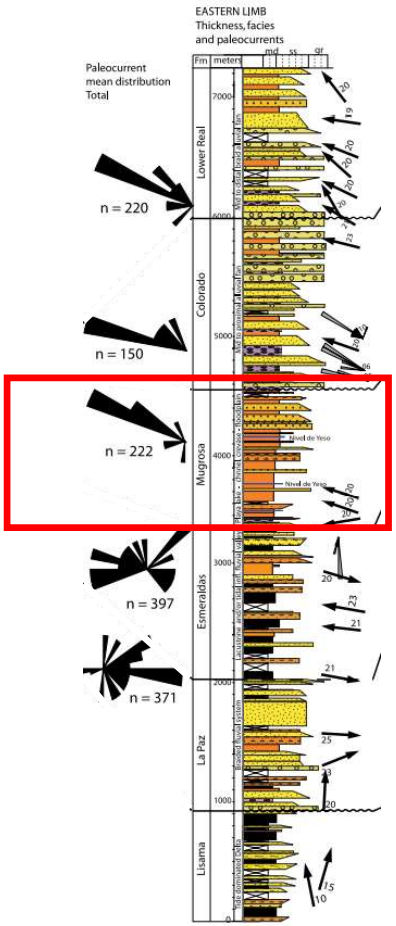


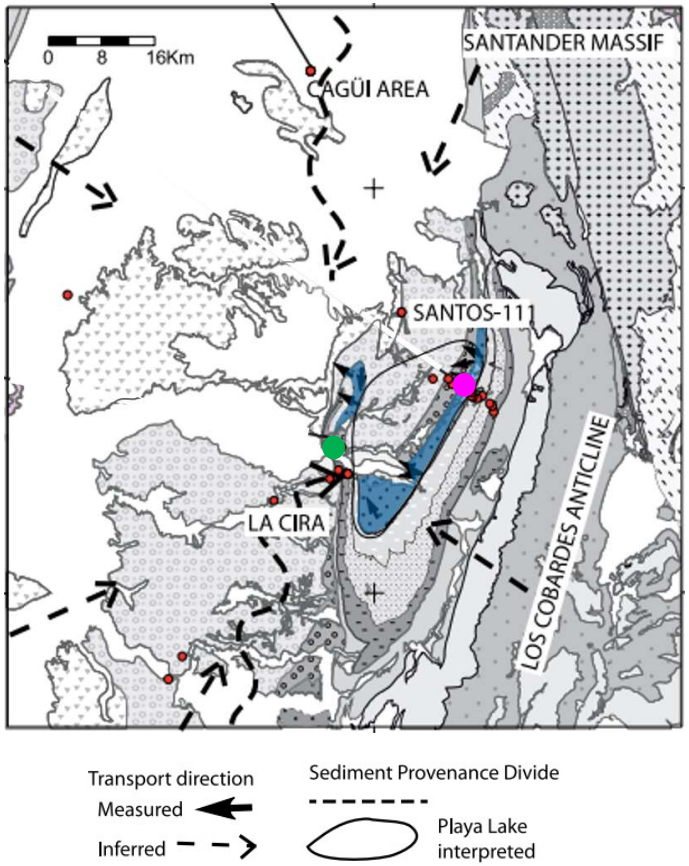






THE MUGROSA FM AT THE NUEVO MUNDO SYNCLINE

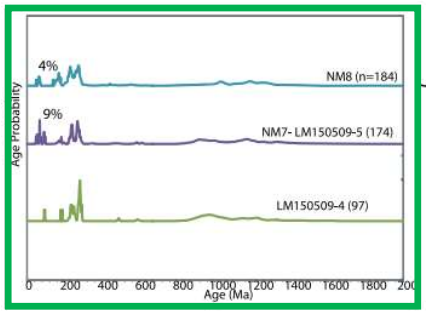




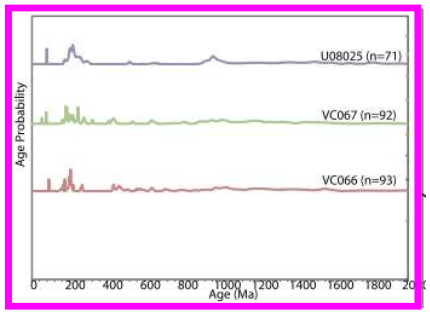
- 650m of westwards thinning in <15km
- Dominated by pedogenic mudstones interbedded with conglomeratic sandstones < 3.5m thick
- Exclusively derived from the Santander Massif and the Eastern Cordillera to the east
- SW to NW paleoflow directions
- **Interpreted as an alluvial fan prograding into a playa lake**

Detrital Zircons

Western Flank

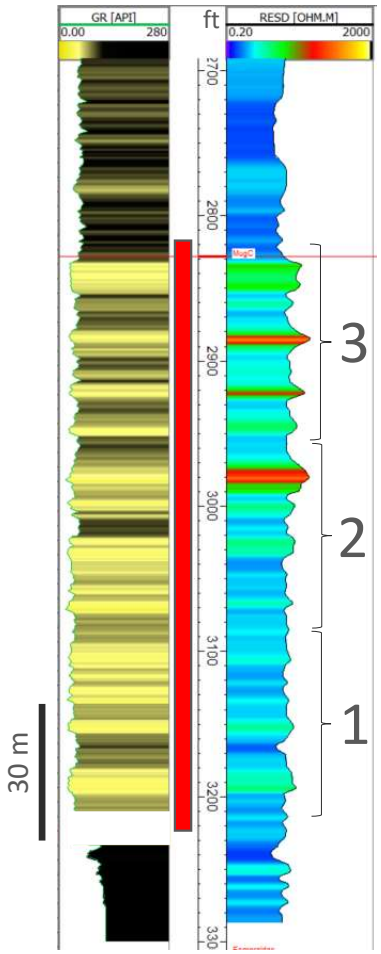


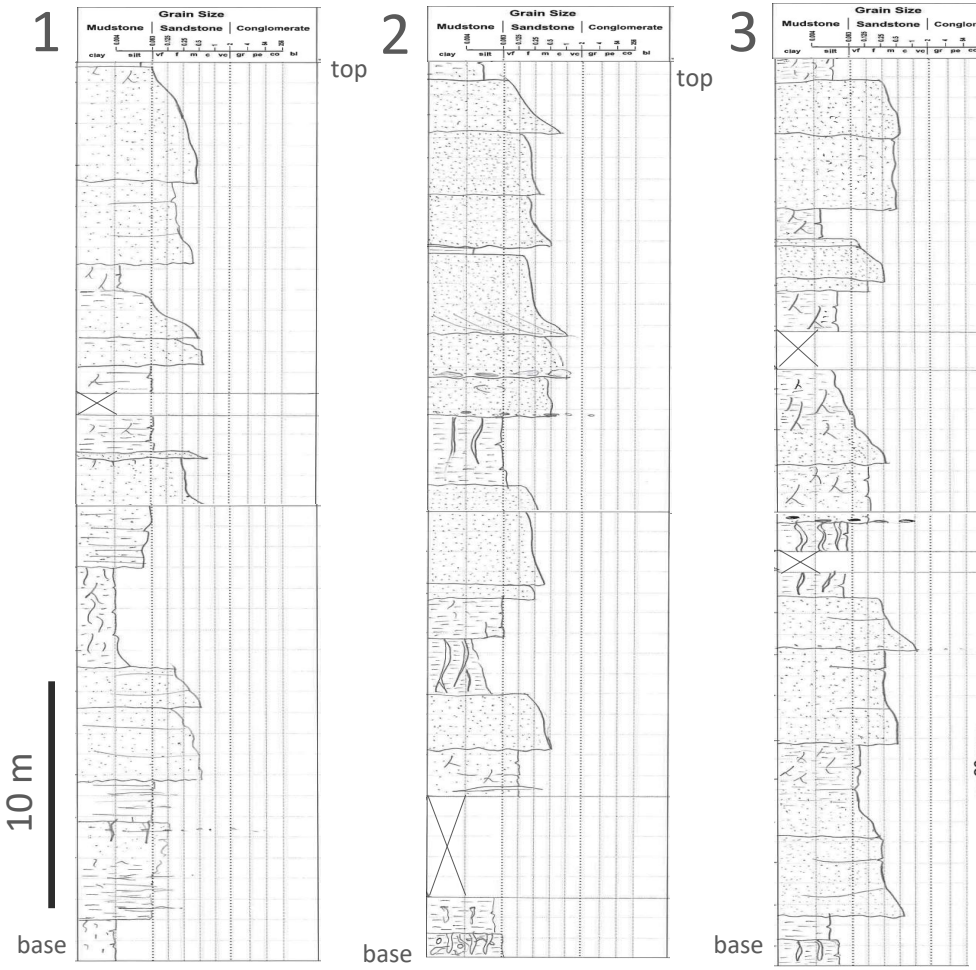
Eastern Flank

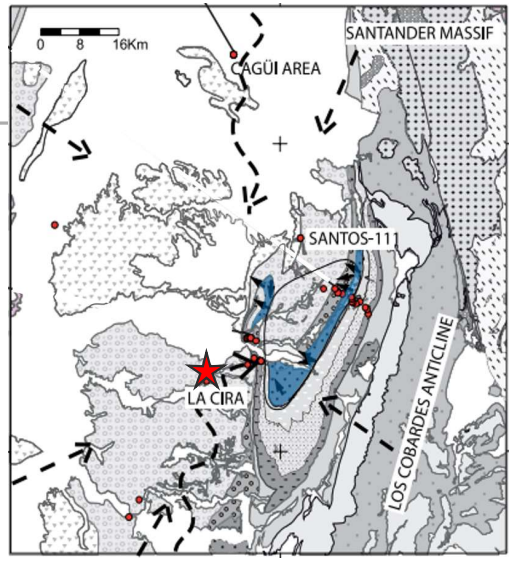


Caballero et al., 2013

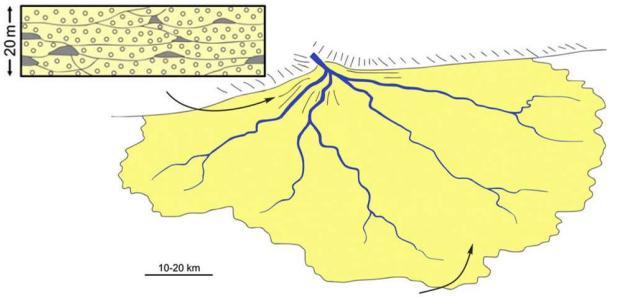
BASAL MUGROSA AT LA CIRA FIELD





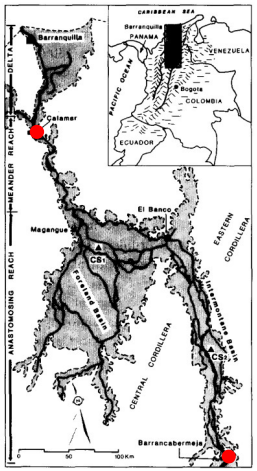


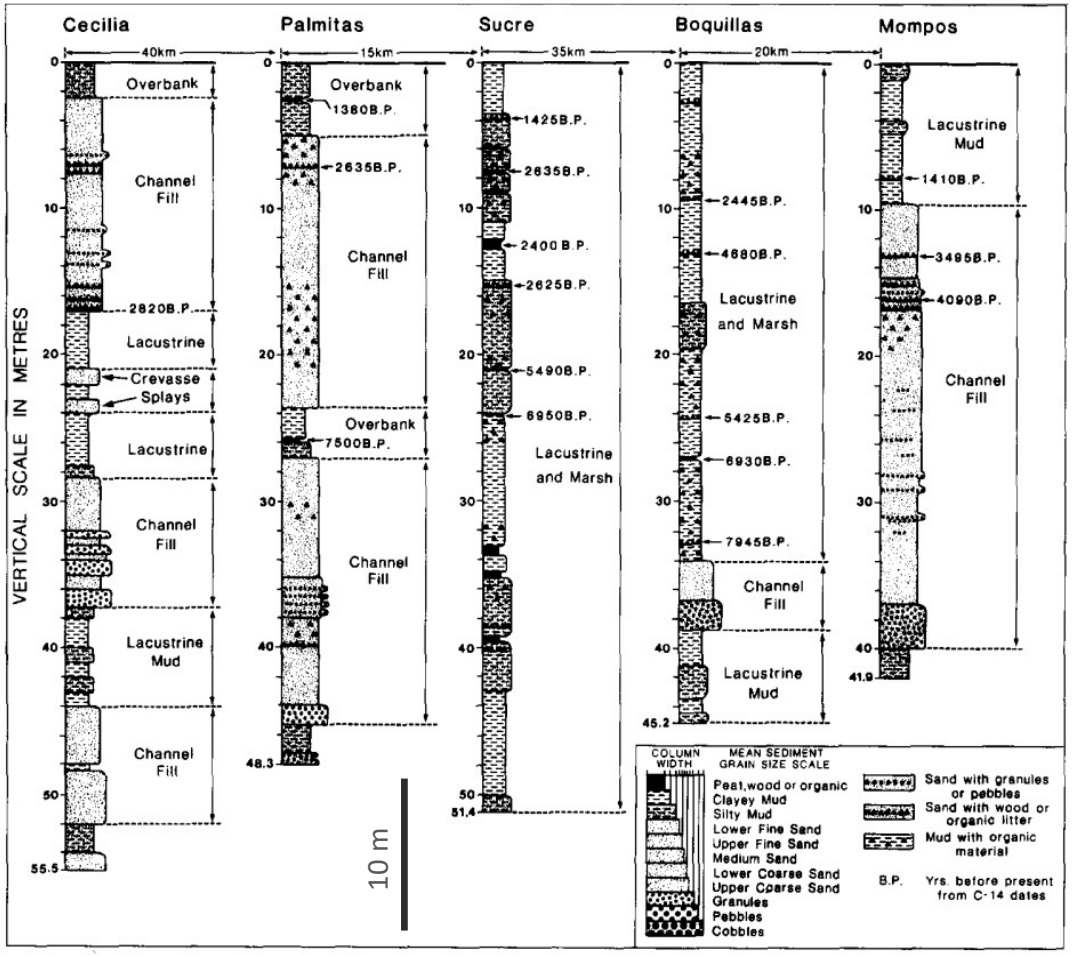
- Fine-grained facies are all pedoturbated
- Absence of intrachannel subaqueous deposits
- Proximal DFS facies or axial tributive fluvial deposits?



THE MODERN MAGDALENA RIVER

- Anastomosed fluvial system from Barrancabermeja to Calamar (520km)
- Sandy deposits reach thickness of 30m and 600m of channel widths
- **Channel levee, ephemeral lakes, and crevasse splay deposits represent 70 to 90% of the fluvial succession**

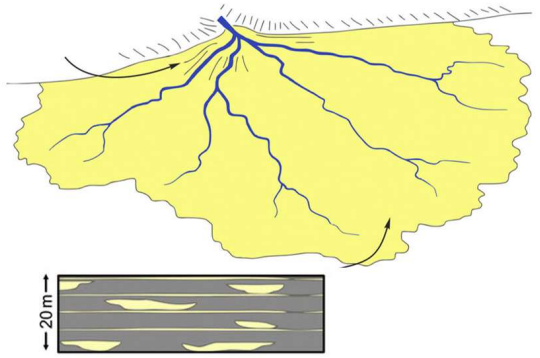


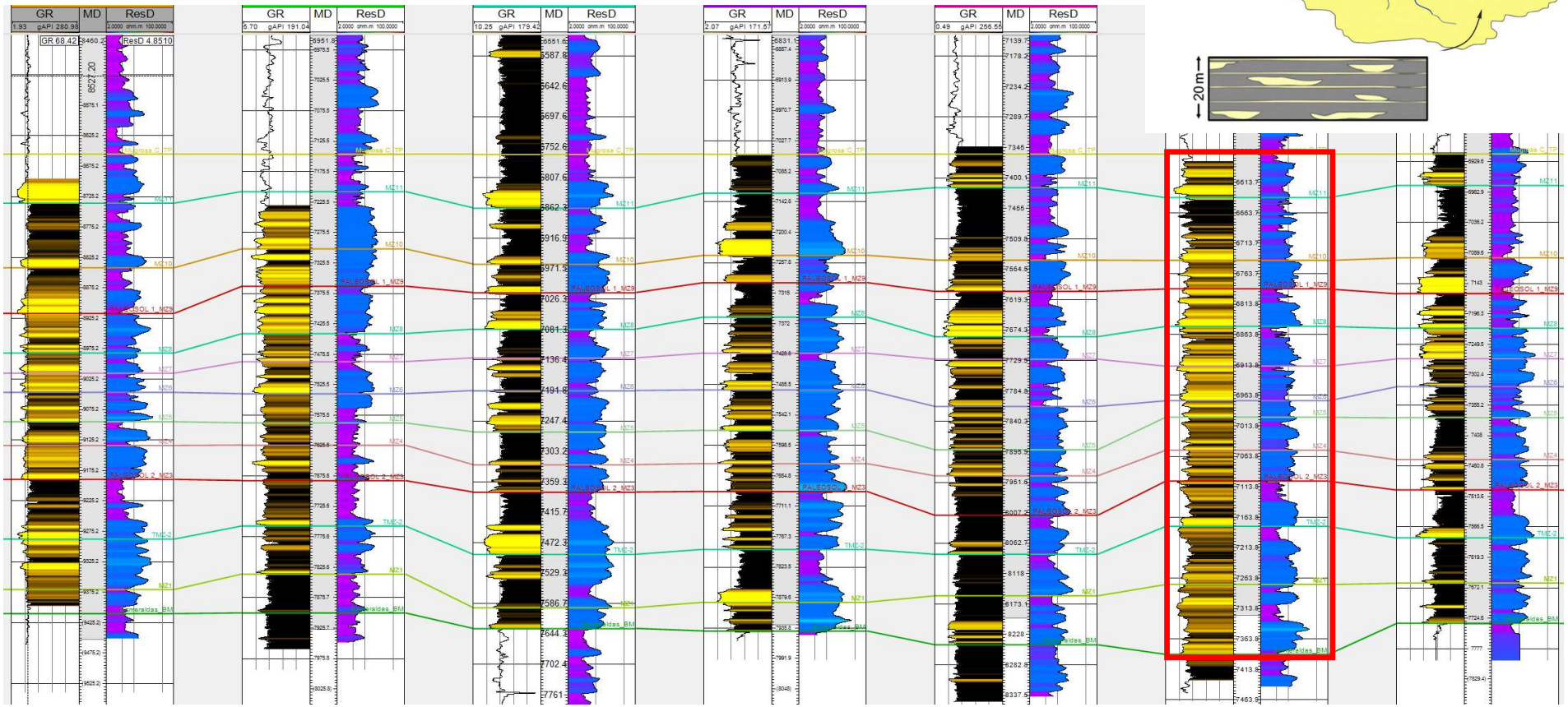


Smith, 1986

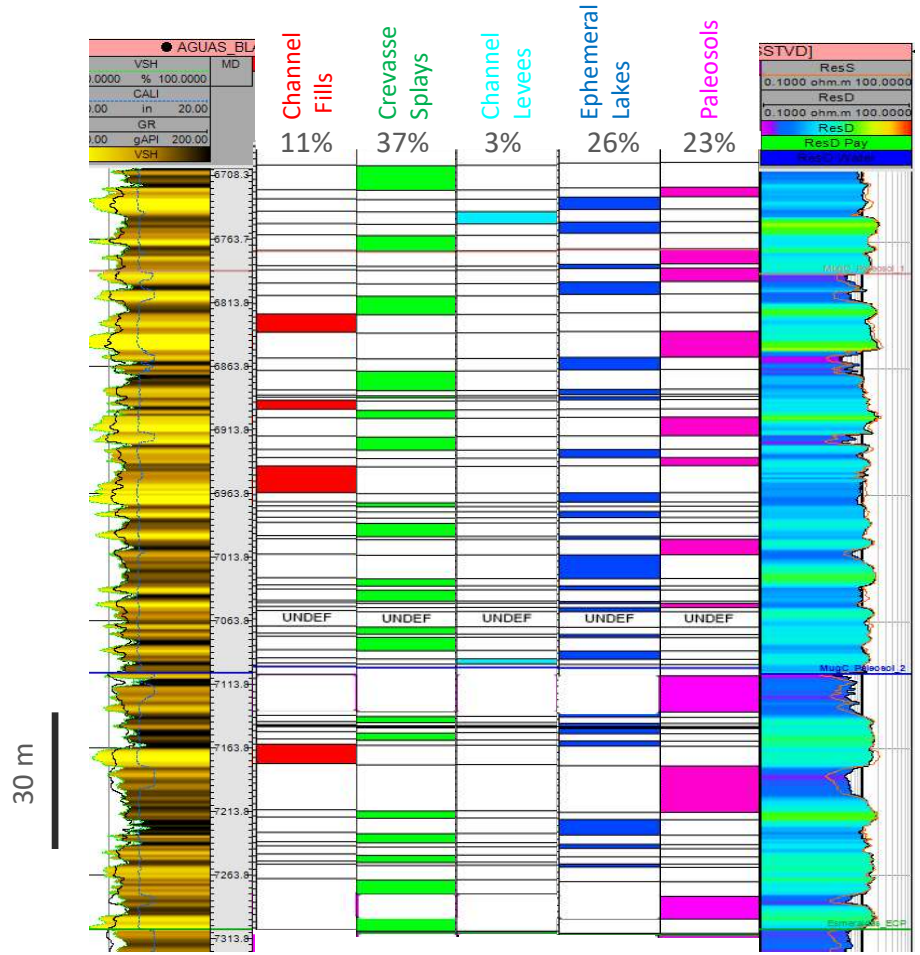
BASAL MUGROSA IN THE SUBSURFACE

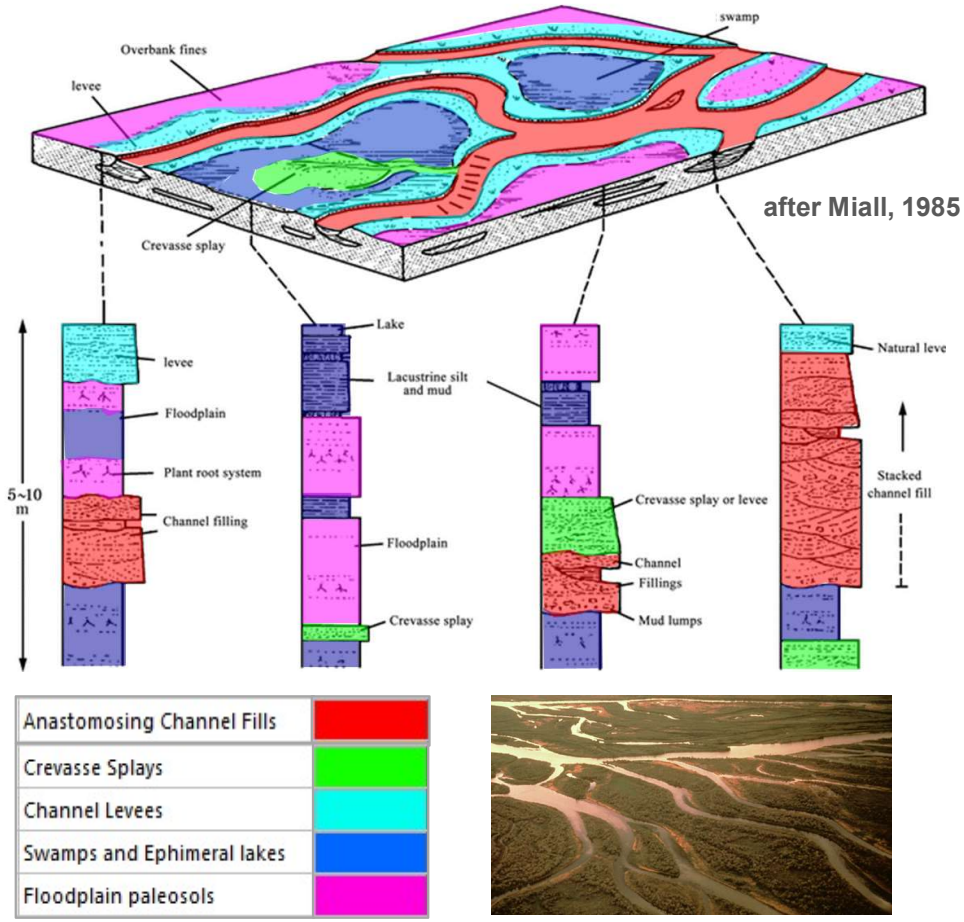
- Lateral continuity of paleosols assumed as a correlation approach





MUGROSA FACIES

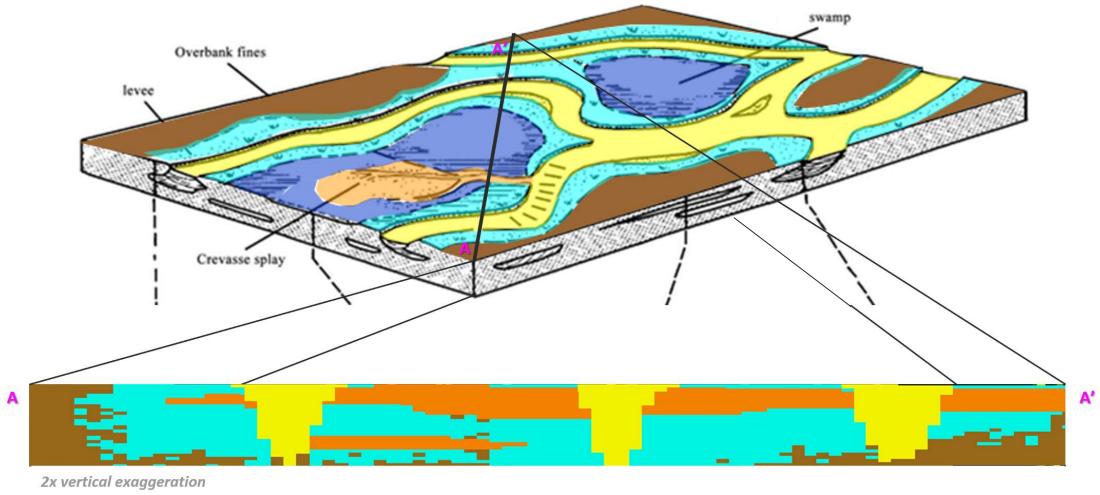


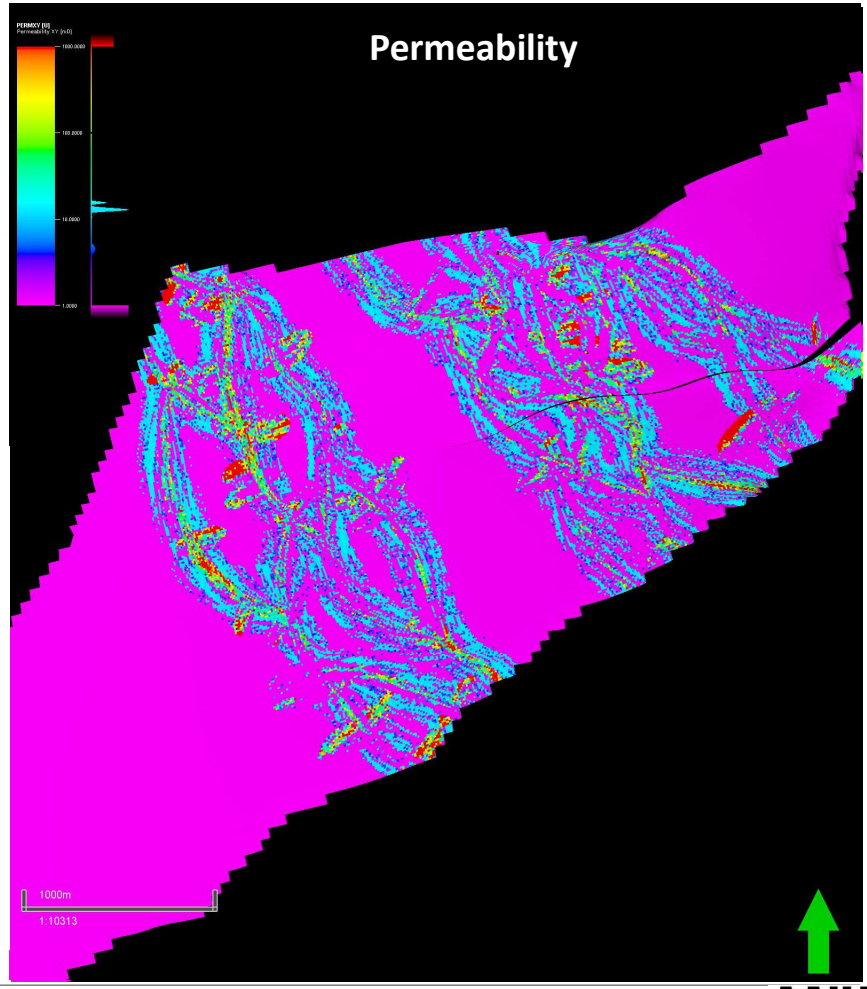


Anastomosing Channel Fills	
Crevasse Splays	
Channel Levees	
Swamps and Ephimeral lakes	
Floodplain paleosols	

SECTOR MODEL FOR FIELD APPRAISAL

1. Build a deterministic sector model
2. Constrain the channel style and orientation with polylines
3. Ensure a good fit with the interpreted regional context and production data
4. Use a global database to define channel widths
5. Build facies-based poro-perm distributions
6. Extrapolate simulation results to the full field reservoir



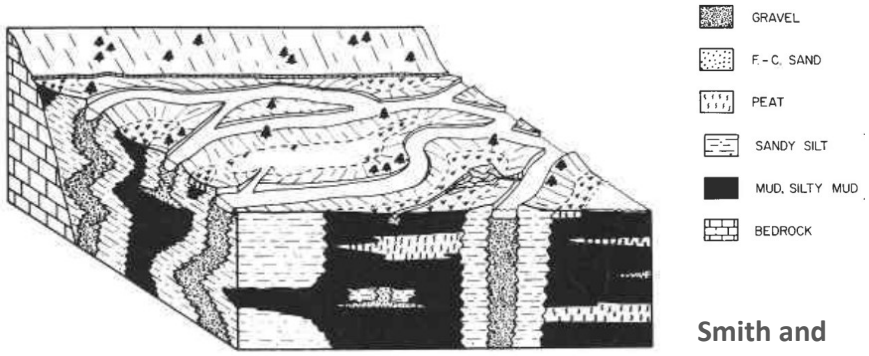


after Miall, 1985

OCURRENCE OF ANASTOMOSED FLUVIAL SYSTEMS

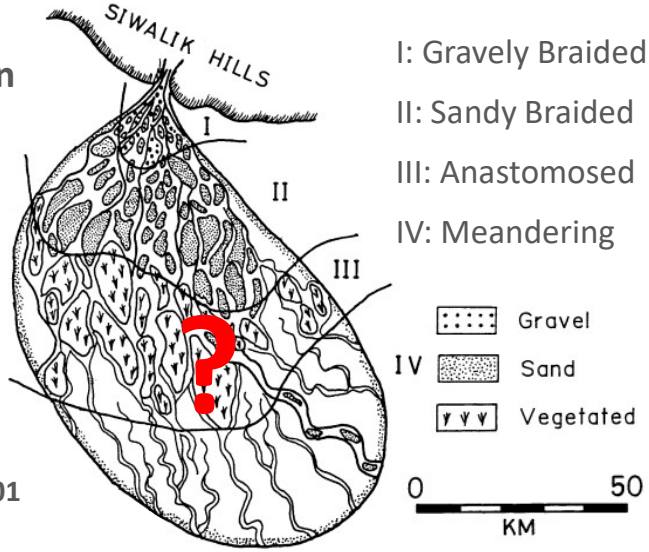
- Development of anastomosed fluvial systems requires high accommodation rates and enough fine-grained clastic fraction to stabilize the channels
- Rapidly subsiding fluvial foreland basins are the best settings for their accumulation
- Anastomosed fluvial deposits transition to braided channel systems upstream
- Are there high-quality reservoirs now involved in the structural traps along the eastern edge of the basin?

Alexandra River, Canada



Smith and Smith, 1980

Ganga Megafan (India)



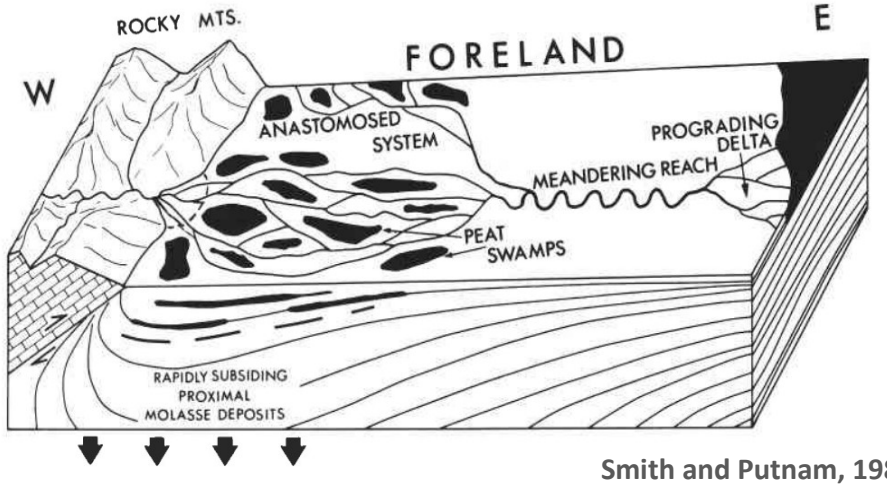
I: Gravely Braided

II: Sandy Braided

III: Anastomosed

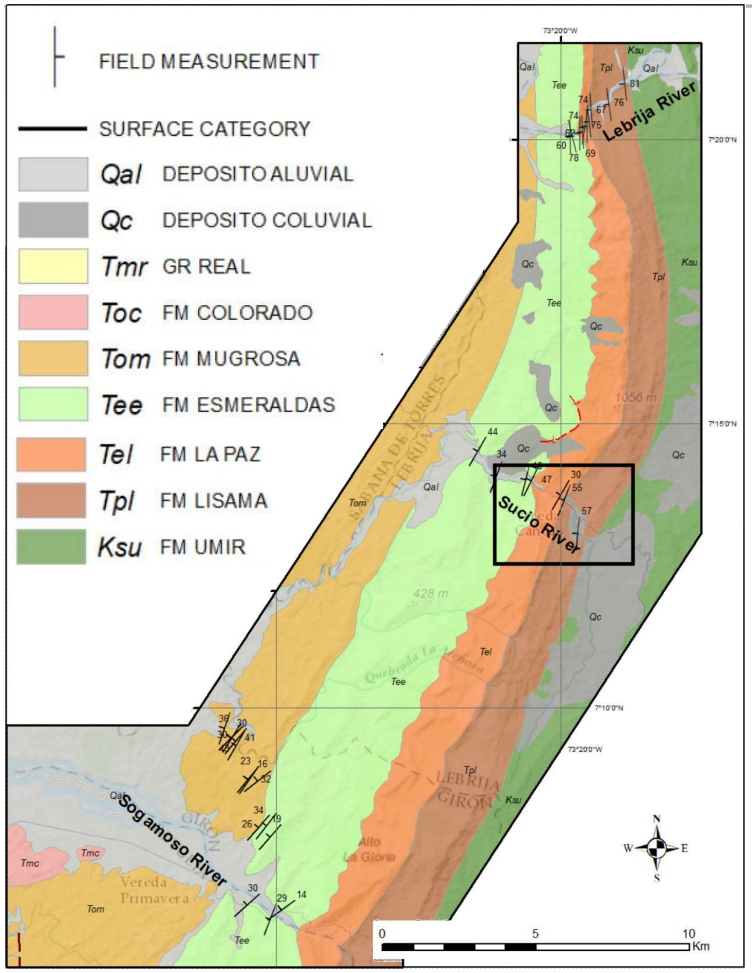
IV: Meandering

Shukla et al., 2001



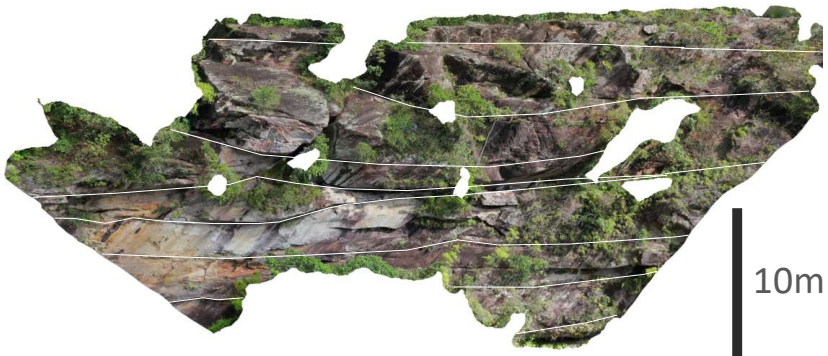
Smith and Putnam, 1980

ALLUVIAL CLASTICS PRESENT IN EASTERN BASIN MARGIN

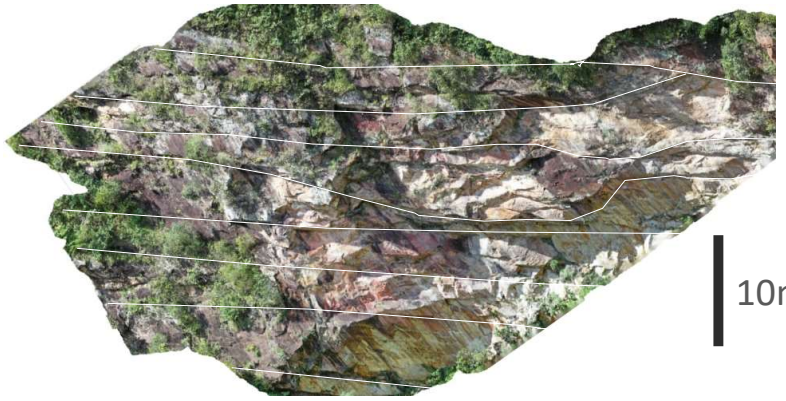


Restored Digital Outcrop models

LOWER ESMERALDAS FM



UPPER LA PAZ FM



Sucio River *Lebrija River*

CONCLUSIONS

- The global abundance of Distributive Fluvial Systems (DFS) in modern foreland basins suggests that a large portion of Paleogene fluvial deposits of the Middle Magdalena Valley Basin was distributive in nature.

- Several fluvial styles have been identified in the Mugrosa Formation, yet given its very high subsidence rates, anastomosed systems are likely to be the most abundant.

- Interpreting DFS deposits as an axial proto-Magdalena is highly likely to overestimate the dimensions, NTG and connectivity of producing reservoirs.

- The prediction of several eastern-derived DFSs implies the presence of coarse clastic deposits near the system's apex, involved in the basin edge deformation.

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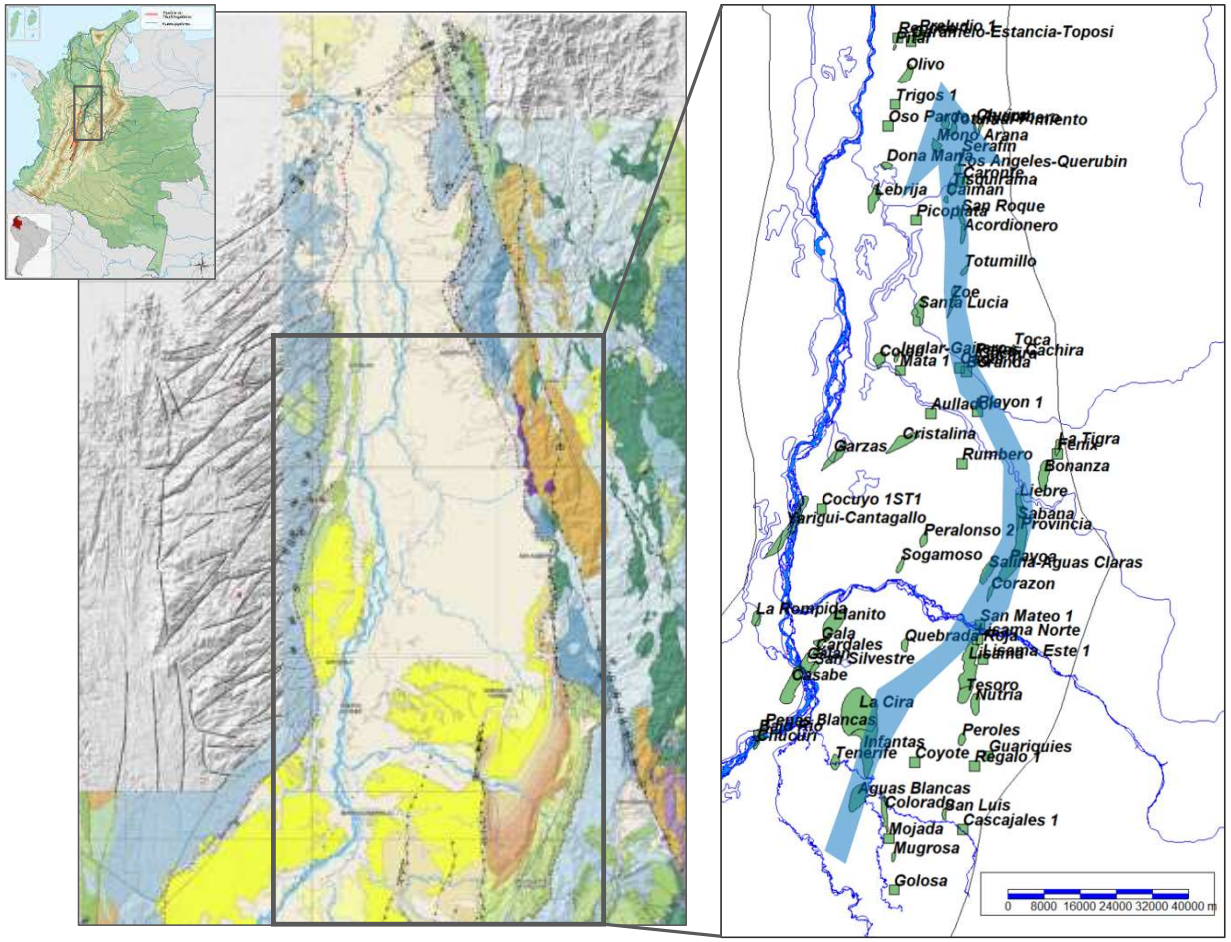
Claudia Guerrero and the Litoteca Team

THANK YOU

ANH
AGENCIA NACIONAL DE HIDROCARBUROS

TRIBUTIVE OR DISTRIBUTIVE?



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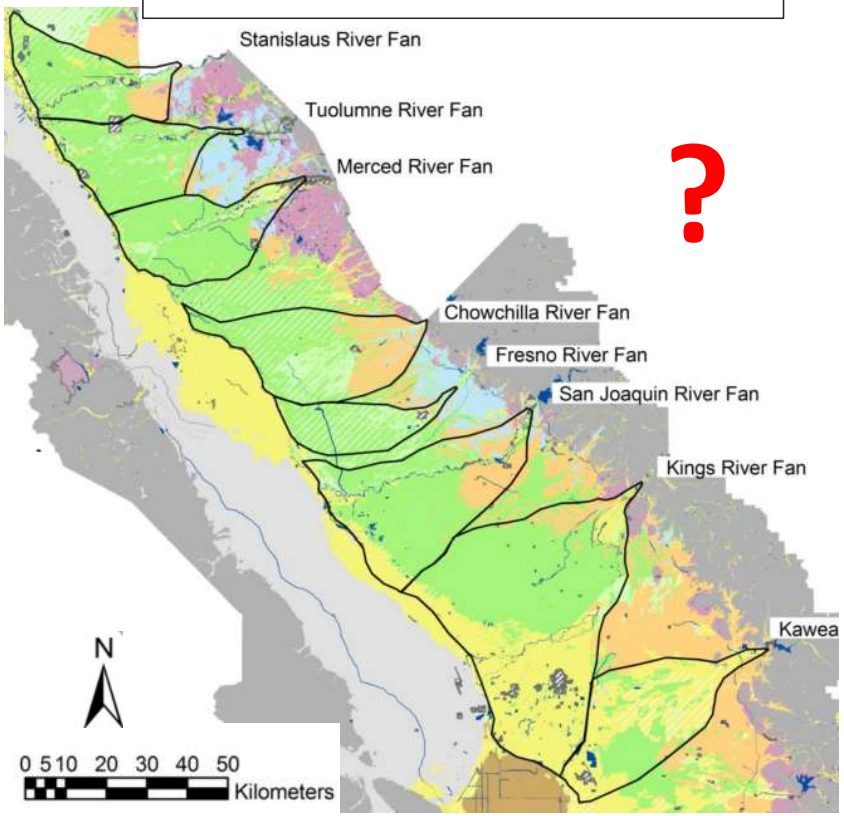

Weissmann et al., 2005