Fluvial Channel Reservoirs
20 years diagnosing their reservoir engineering attributes

Patrick Corbett

BG Group Professor Carbonate Petroleum Geoengineering

Institute of Petroleum Engineering

School of Energy, Geoscience, Infrastructure and Society

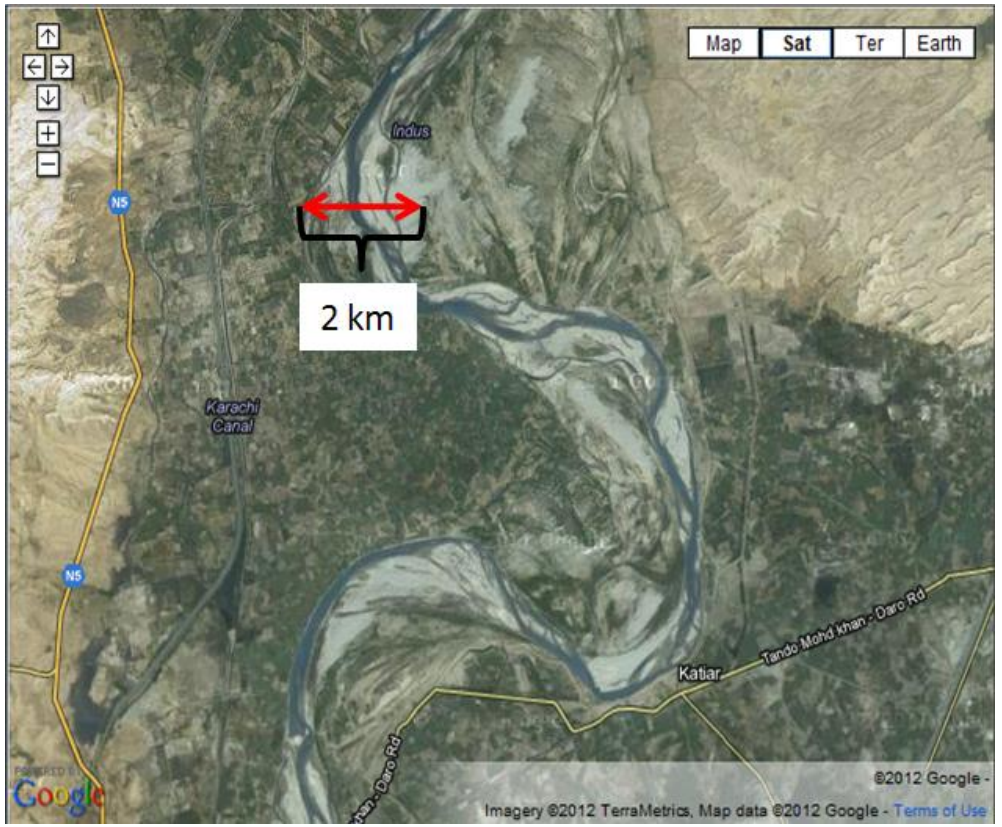
Heriot-Watt University, Edinburgh

RRR Talk, 29th September; EGS Talk 12th October 2016

Difference between a canal and a channel

- Canal

Channel(s)



Difference between a canal and a channel

- Canal

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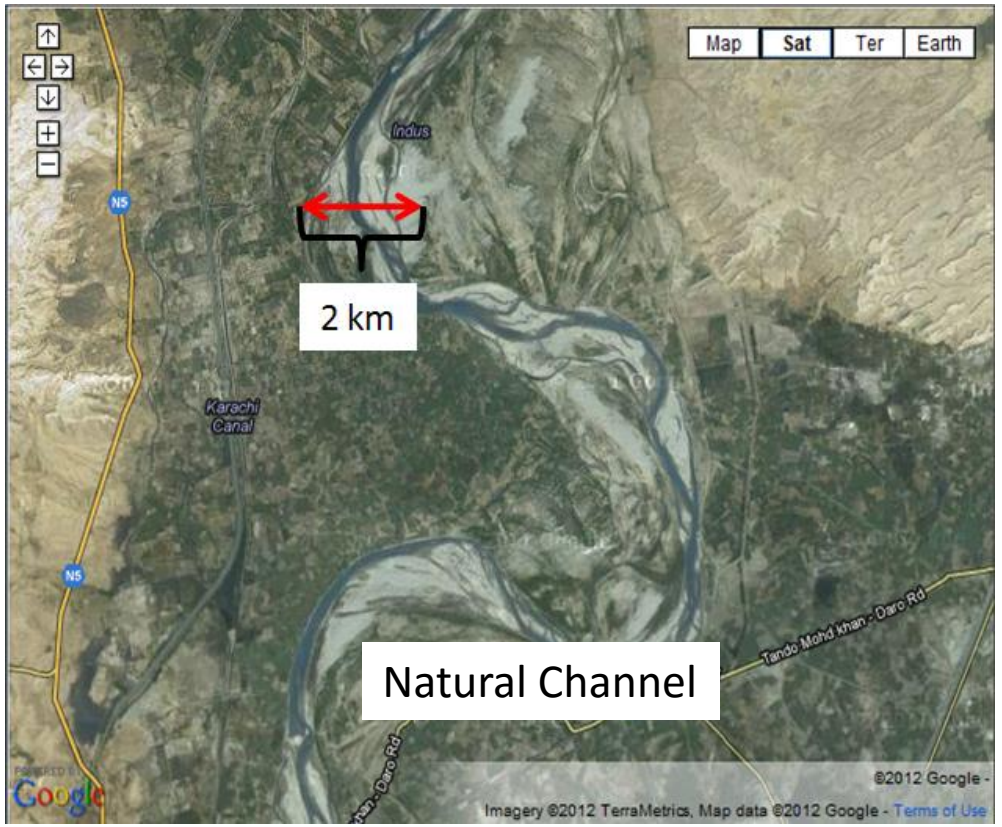

Difference between a canal and a channel

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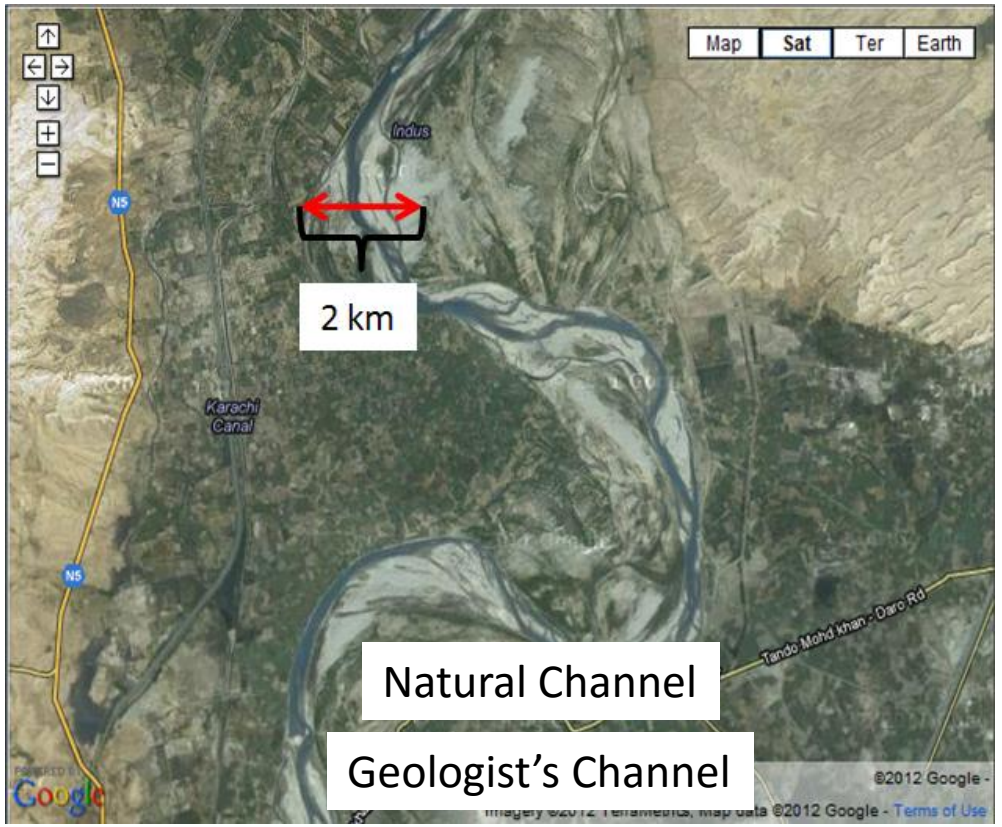


Talk format

- Well testing background
- Three fluvial well testing examples
- Incorporate training images from Google Earth
- New words – Geoskin, Geochoke, Georamp,….
- Summary
- Discussion

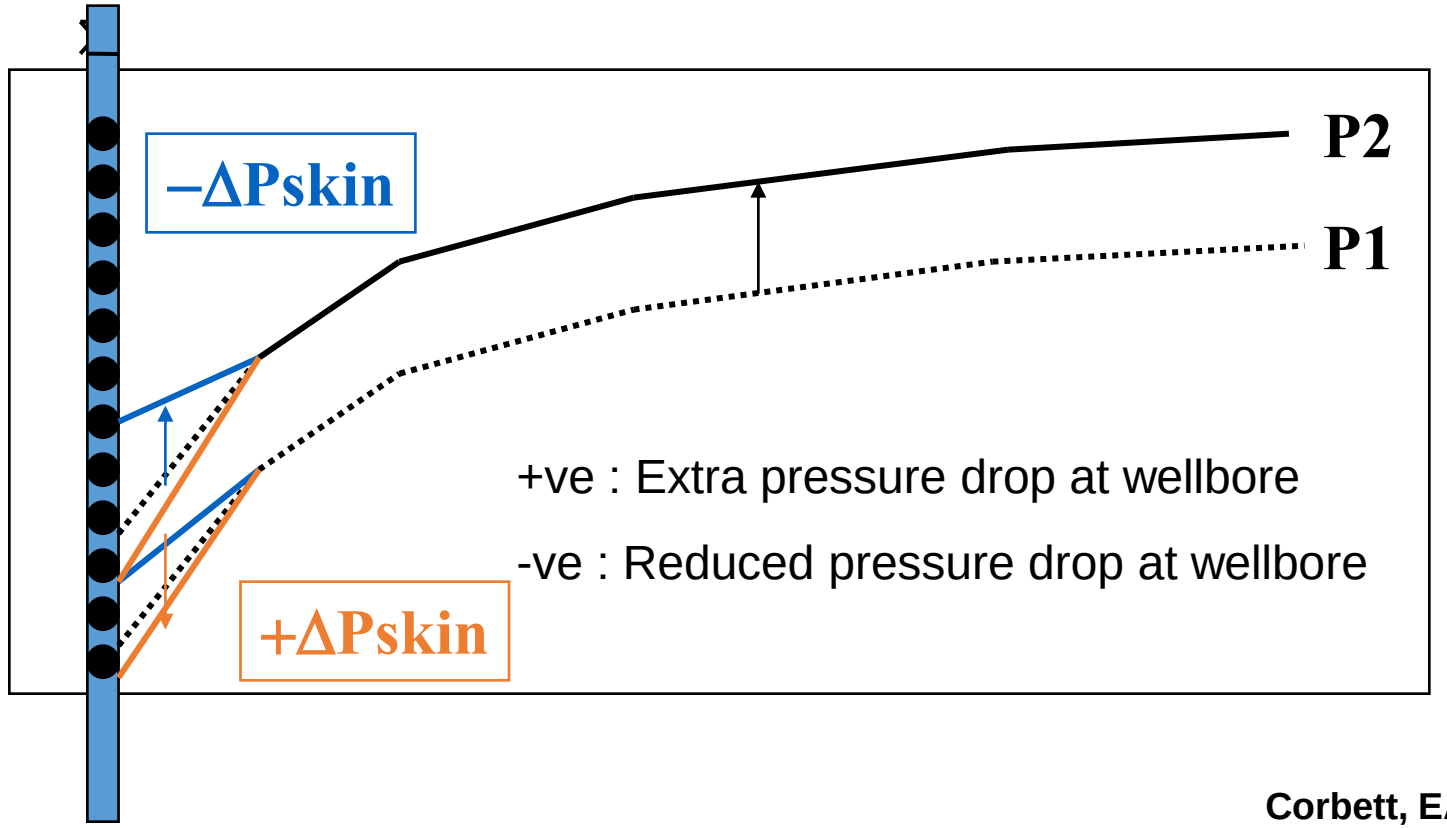
Basic transient well testing

Solution to the diffusivity equation for the following assumptions:

- Line source solution
- **Homogeneous and isotropic medium**
- Pressure independent rock/fluid properties
- Small Pressure gradients
- **Radial flow**
- Applicability of Darcy's Law
- Negligible Gravity
- Infinite acting reservoir

Skin

- Difference between pressure at shut-in and after 1hr (on the Horner straight line) (Bourdarot,1998)



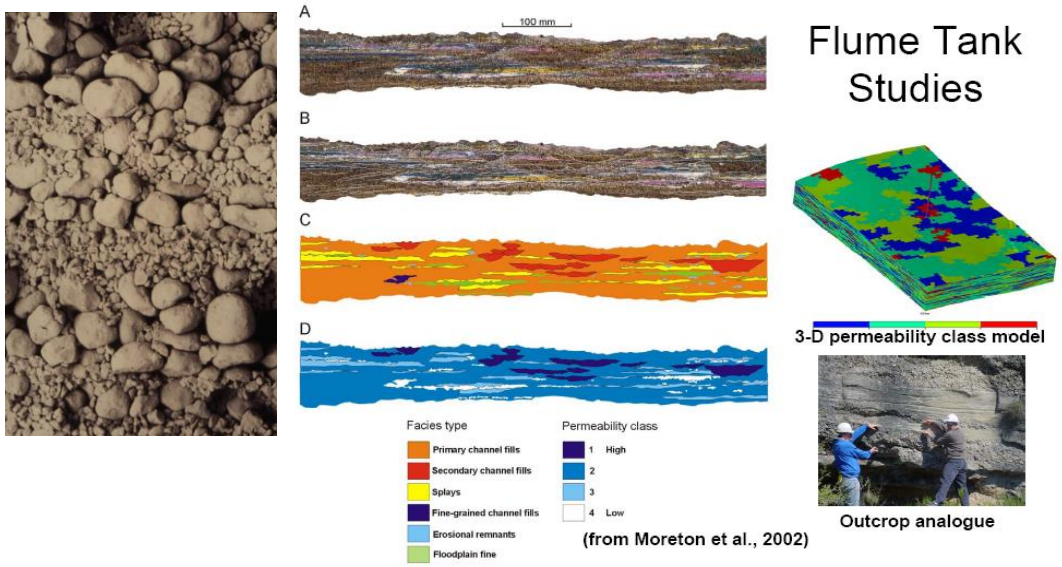
Corbett, EAGE/SEG DISC 2009

Skin

- Measure of damage or enhancement

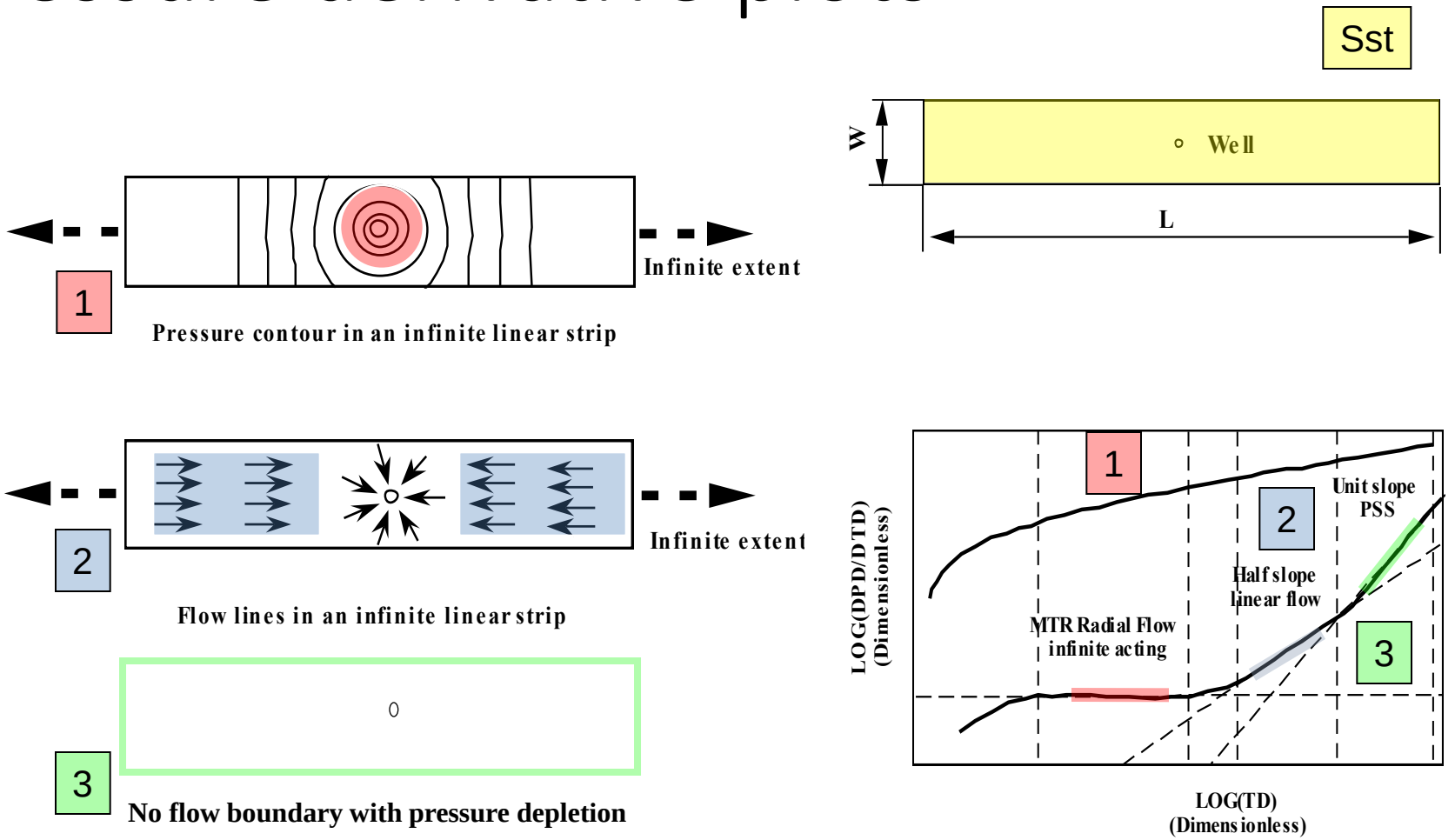
- Mechanical skin
  - **Partial perforations (+)**
  - **Dipping beds (-)**
  - **Drilling solids damage (+)**
  - **Turbulent flow in gas wells - Non-Darcy skin (+)**

- Geological skin (Geoskin)
  - **Natural fractures (-)**
  - **Rapid thickness changes - faults or sandbody (+)**
  - **Cemented nodules (+)**
  - **High perm. pseudo-fractures (-)**



Corbett, EAGE/SEG DISC 2009

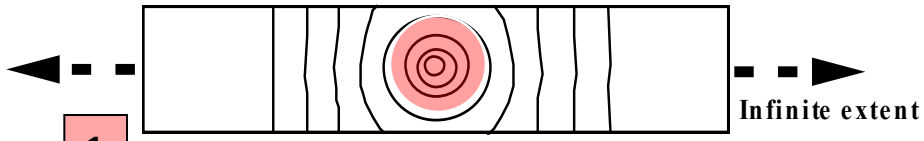
Pressure derivative plots



Flow regimes

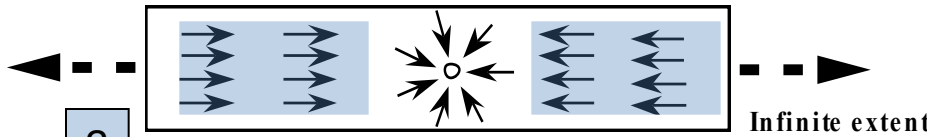
Corbett, EAGE/SEG DISC 2009

Pressure derivative plots



1

Pressure contour in an infinite linear strip



2

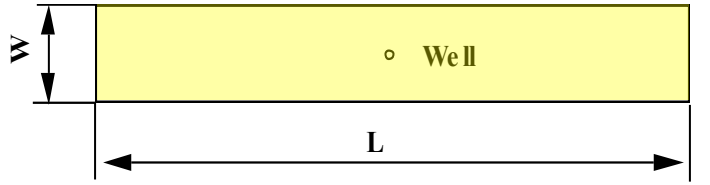
Flow lines in an infinite linear strip

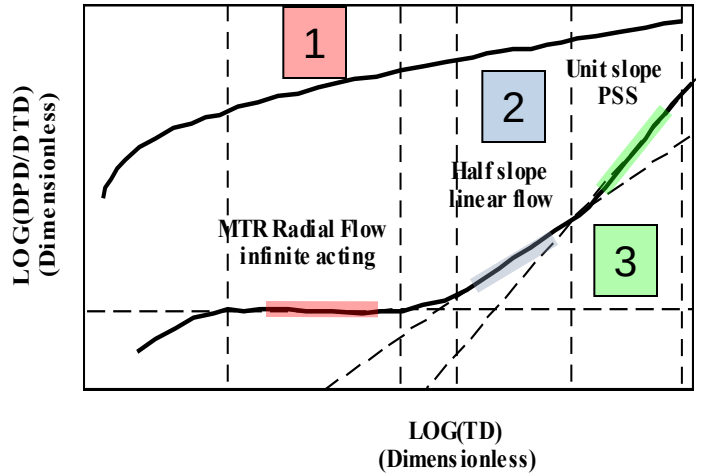
3

No flow boundary with pressure depletion

"Canal flow"

Sst

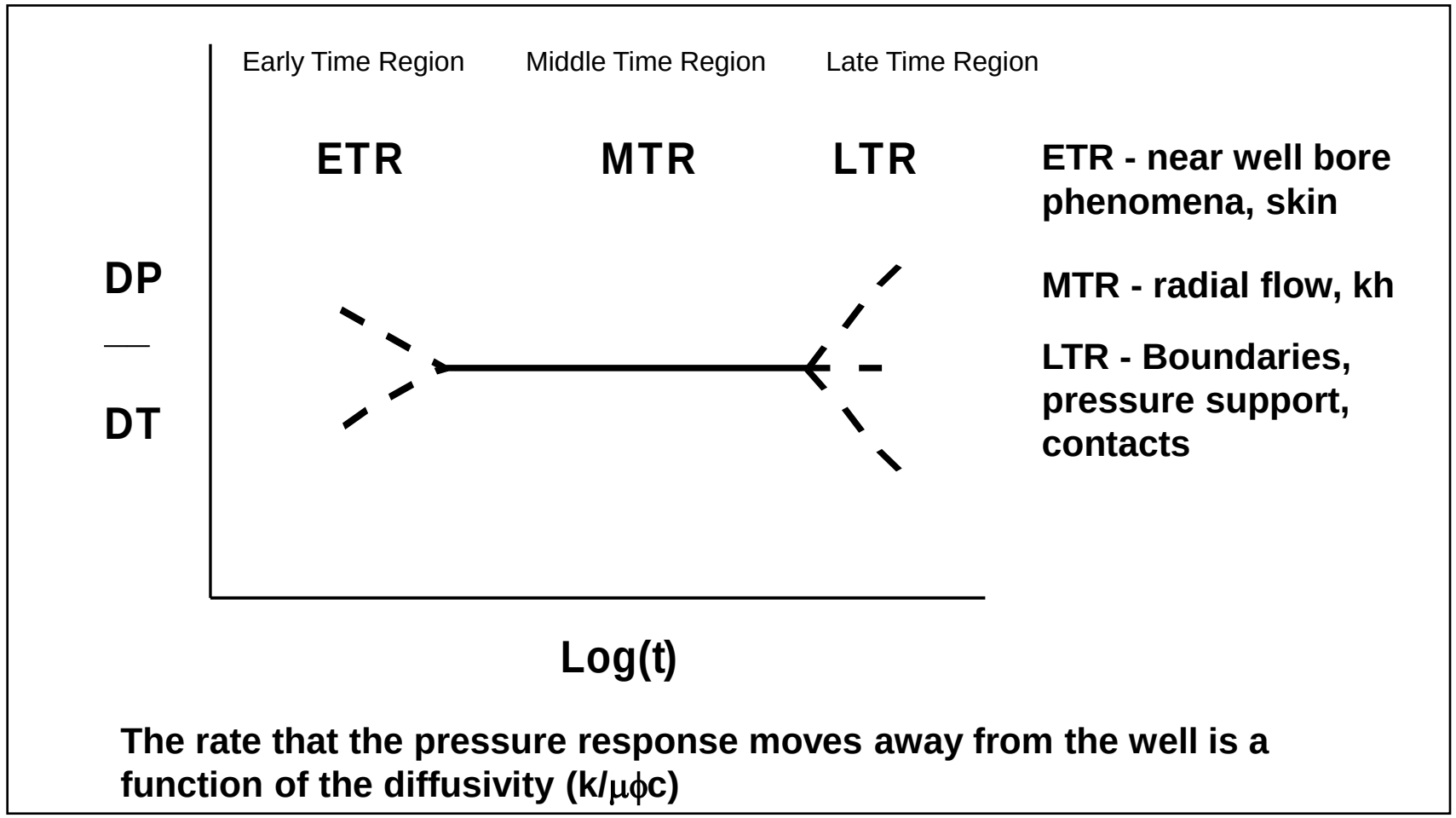




Flow regimes

Corbett, EAGE/SEG DISC 2009

Well testing

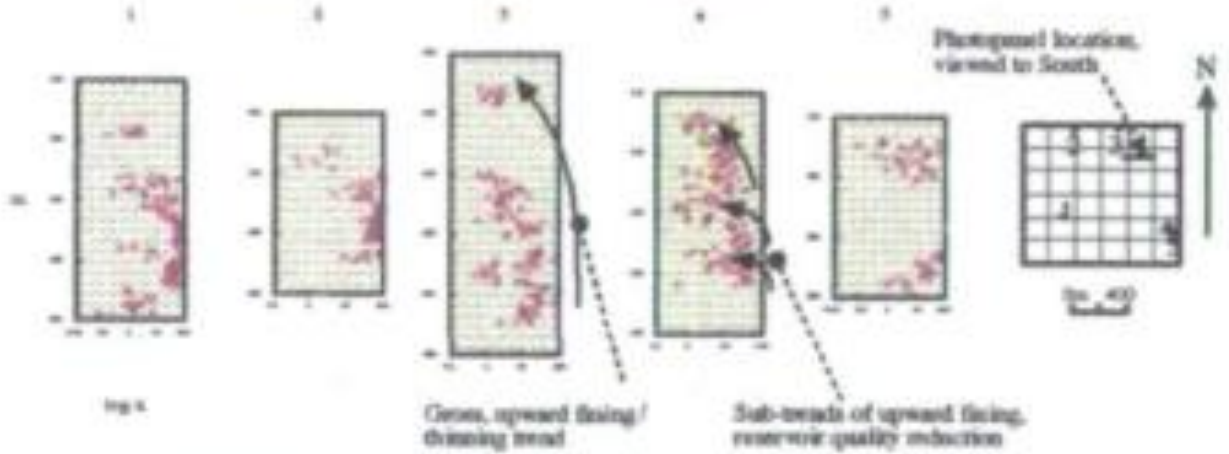


Corbett, EAGE/SEG DISC 2009

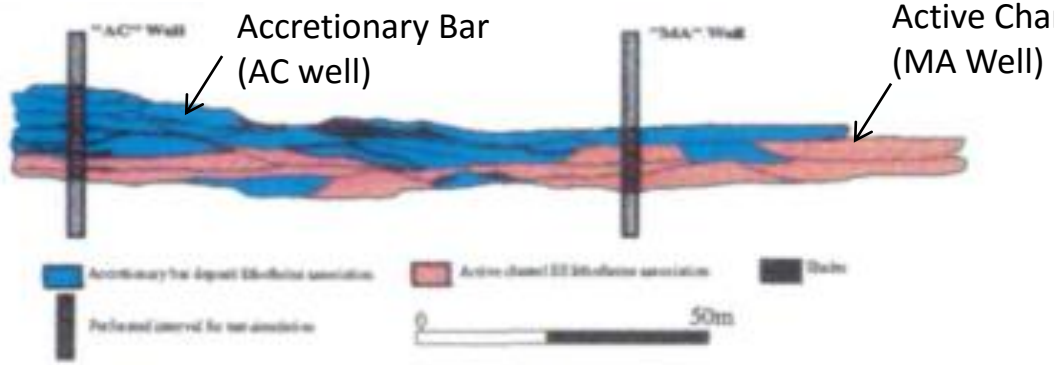
20 Years ago – Dalmellington Quarry, Ayrshire

Photomontage of analogue outcrop (working face)

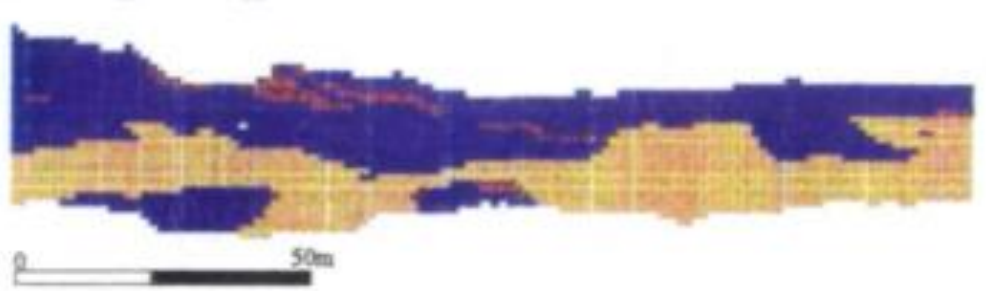
Permeability profiles and borehole locations from analogue site



Lithofacies associations recognised in worked face with well placement and perforated intervals

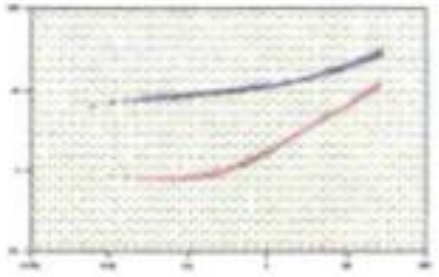
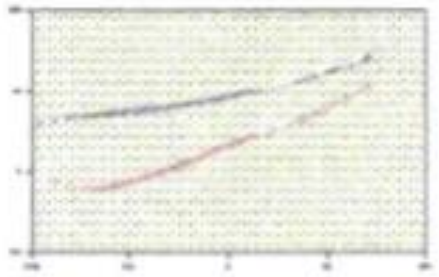


Simulation grid from Lith (5x vertical exagg.)



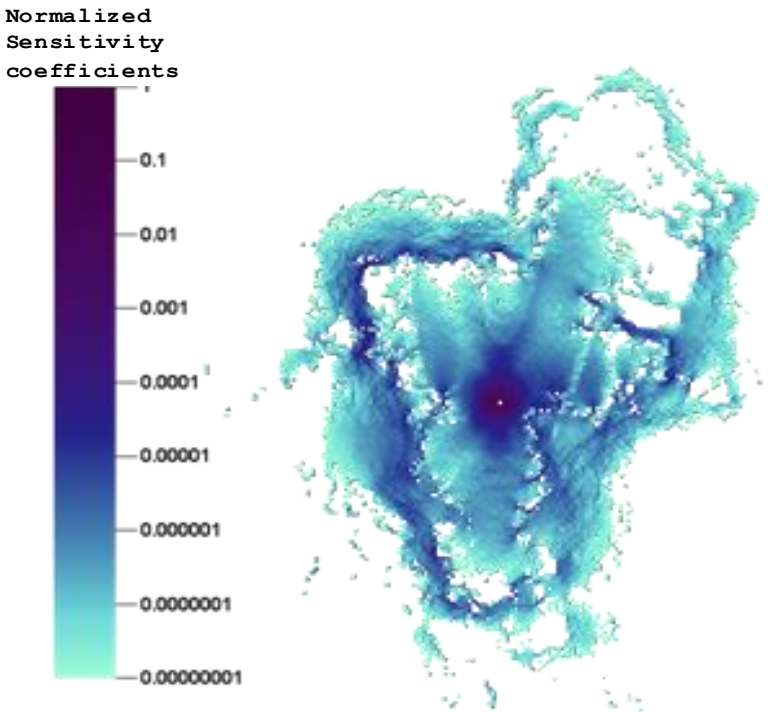
Dunlop and Corbett, 1996

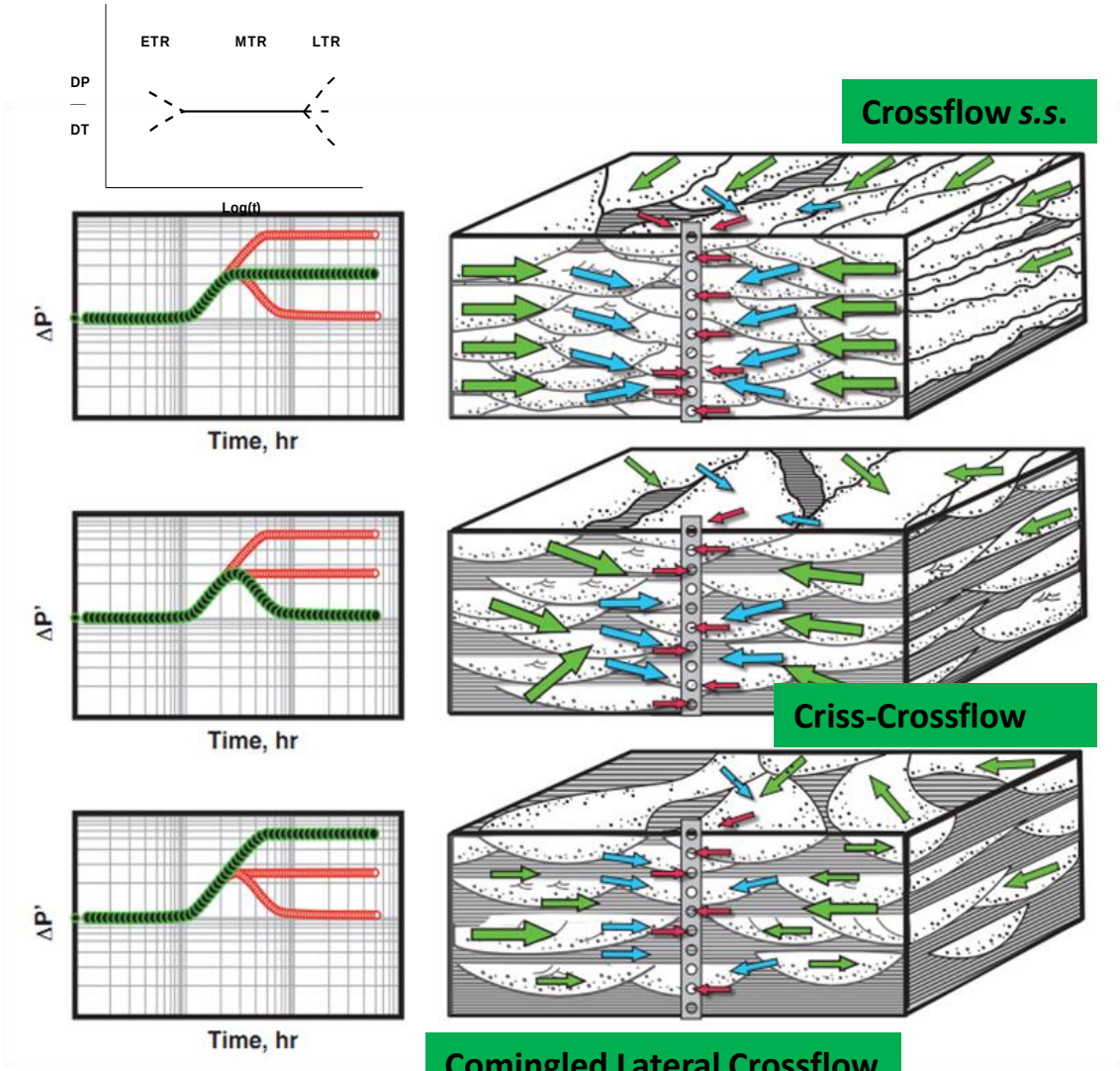
First numerical well test results

Well Placement (Figure 3 refers)	Permeability Contrast (Body Permeability)	Simulated Test Results K (mD)	K.h (mD.ft)	S	Log-Log Plot (2nd Drawdown)	Predicted Results Kar	Kgeo	K.h
AC (dominated by accretionary bar deposit association)	1 : 10 (5 ; 50 mD)	12.3	616	-0.4		13.4	6.73	676
MA (active channel fill dominates)	1 : 10 (5 ; 50 mD)	23	785	-2.0		37	26	1268

Dunlop and Corbett, 1996

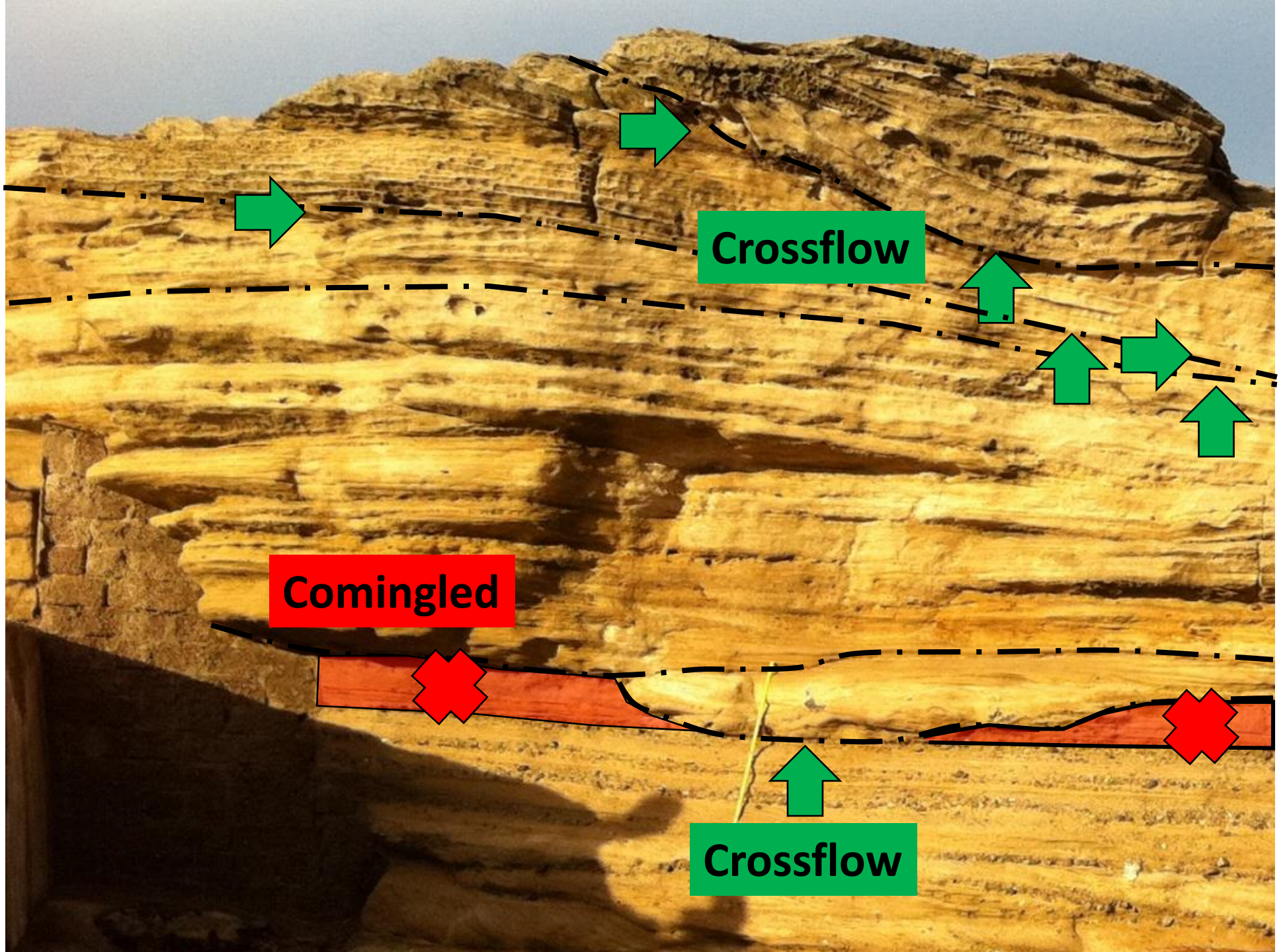
New Braided Fluvial Models



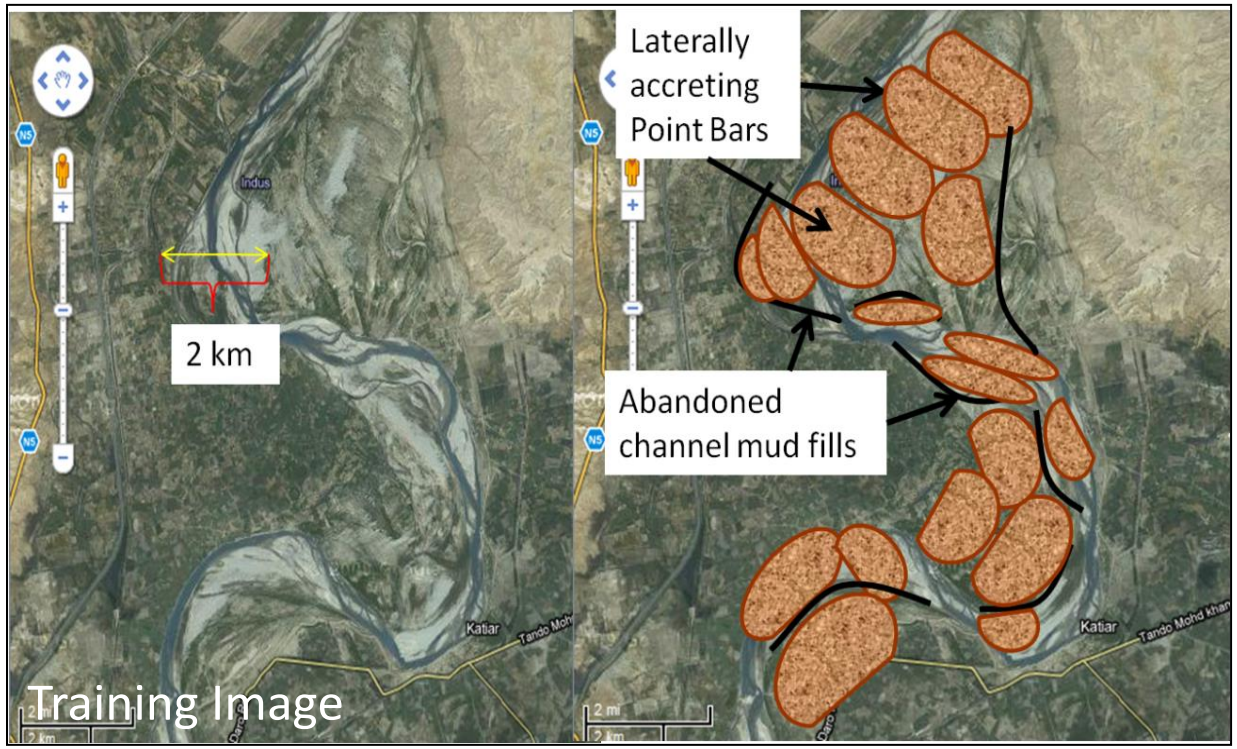


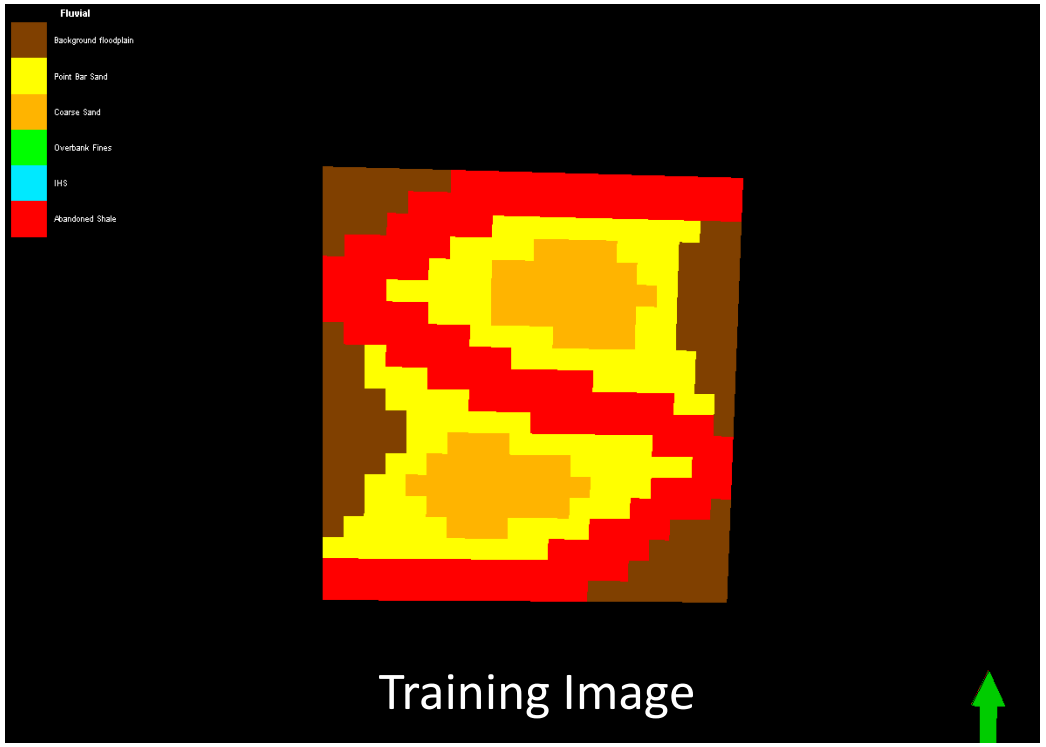
Corbett et al., 2012

Triassic Fluvial Sandstones
Scotland


Crossflow
Comingled
Crossflow

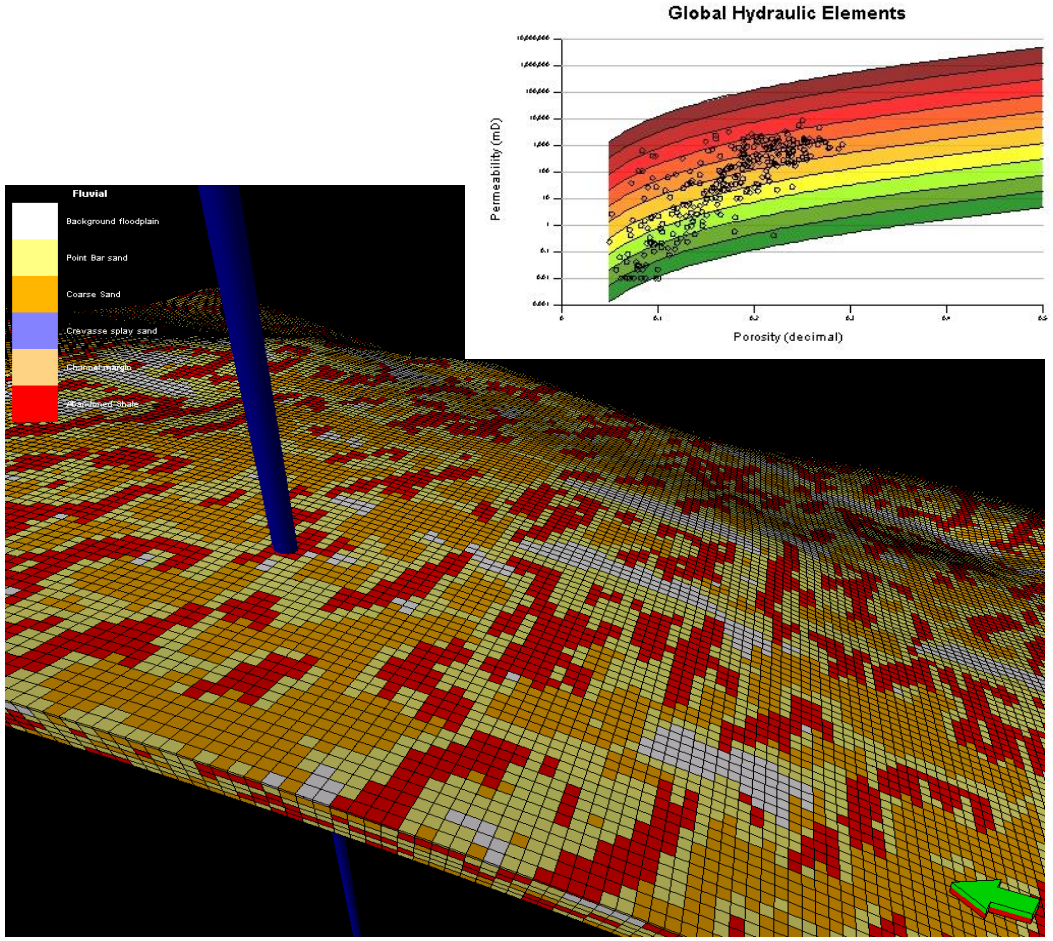
Case Study 1: Indian Example

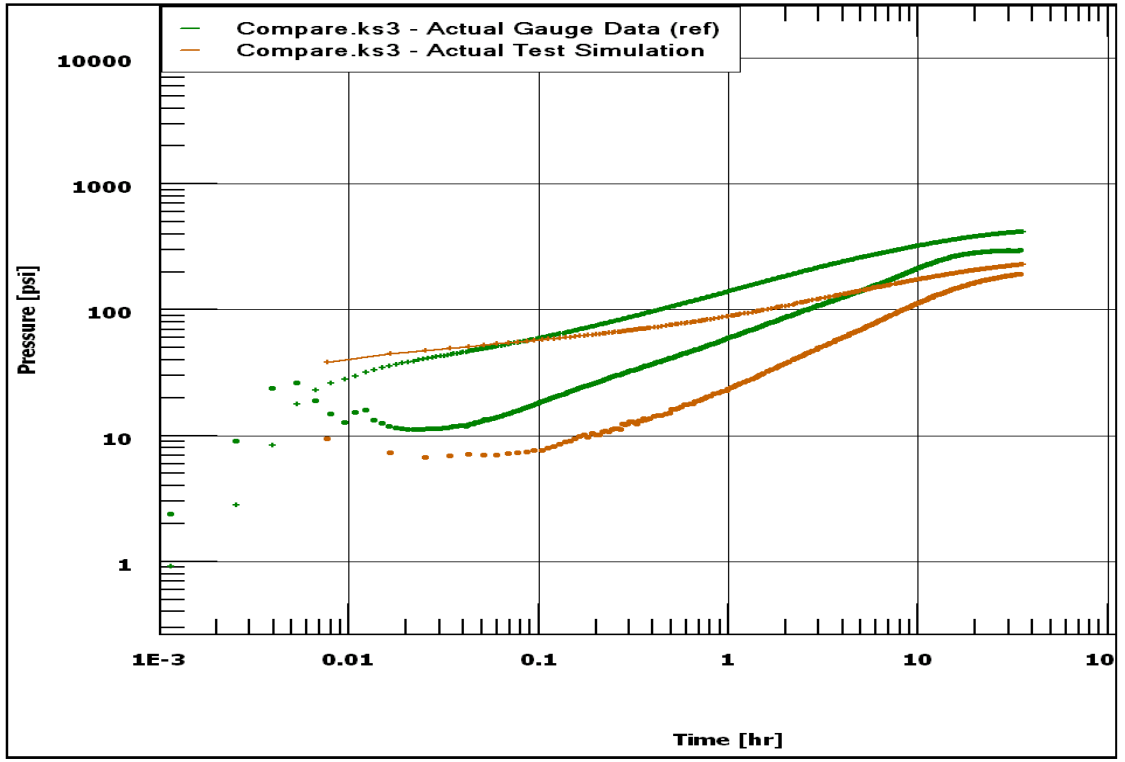




Corbett et al., 2012

Simulation Model





Corbett et al., 2012

Case Study 2: Colombian Example

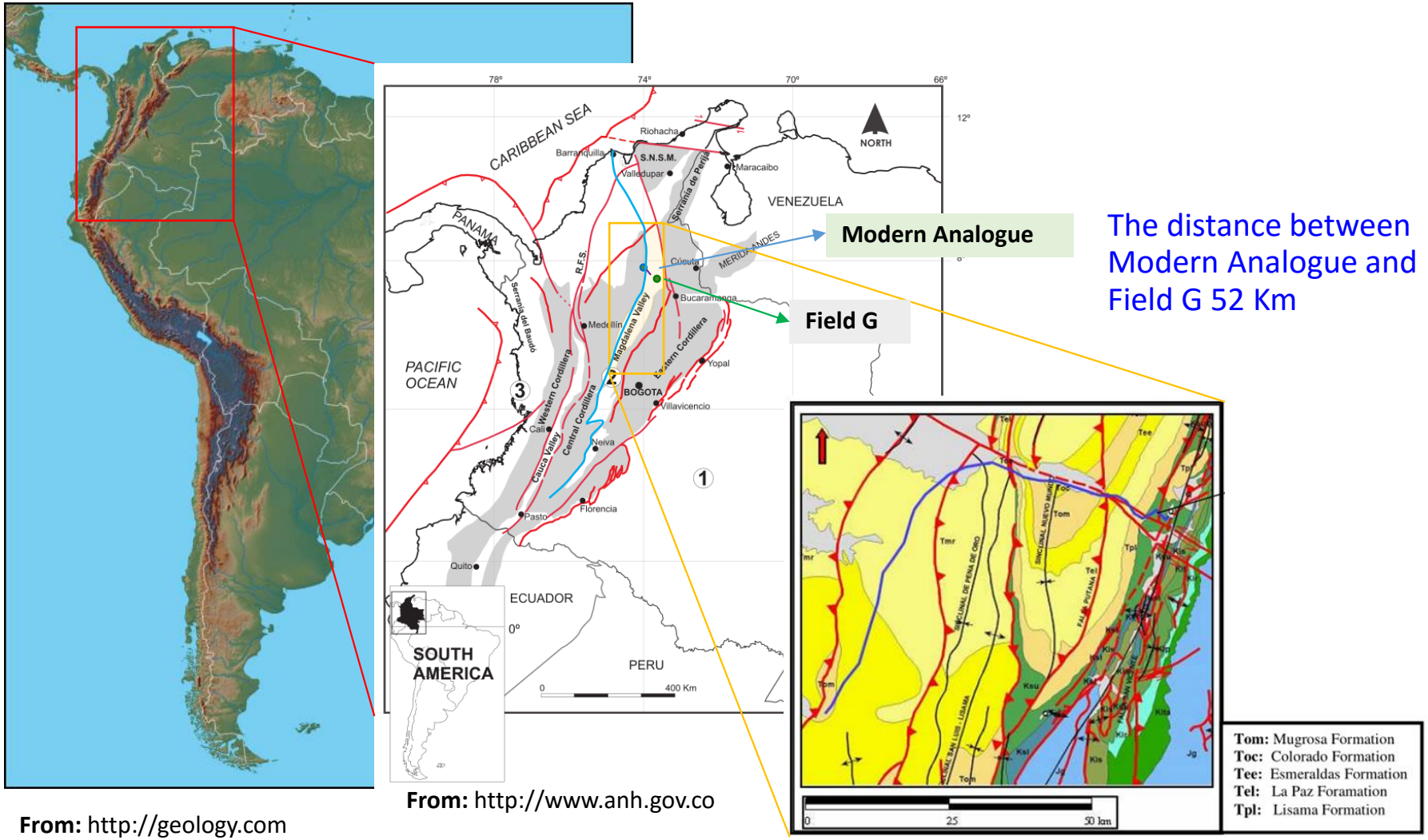
- Field G located in Middle Magdalena Valley Basin
- Well G1 (2012), Initial Production 300 BOPD
- Well G2 & G2 ST (2014), Initial Production 980 BOPD
- Hydrocarbon: 24 o API
- Shaly Sandstone Formation

From: Satellite Image - Google Earth

Unpubl., HWU MSc Thesis, 2015
Gleyden Lucila Duarte Benitez

Corbett and Benitez, In review

Geological Map of Colombia



From: http://geology.com

From: http://www.anh.gov.co

From: Gomez et al. SPE 122234
Nuevo Mundo Syncline

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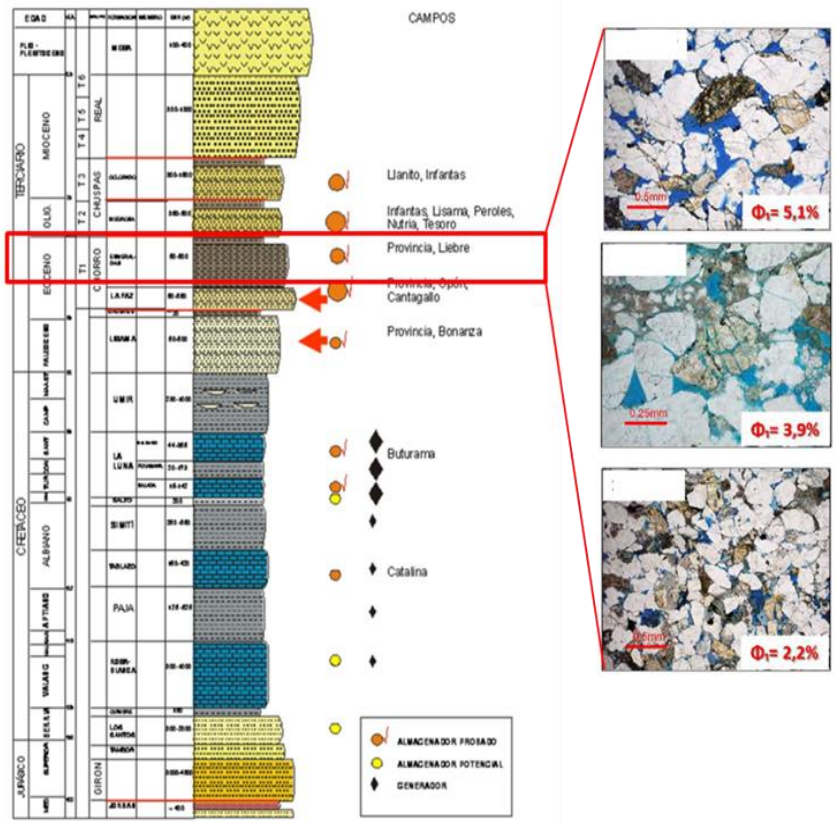
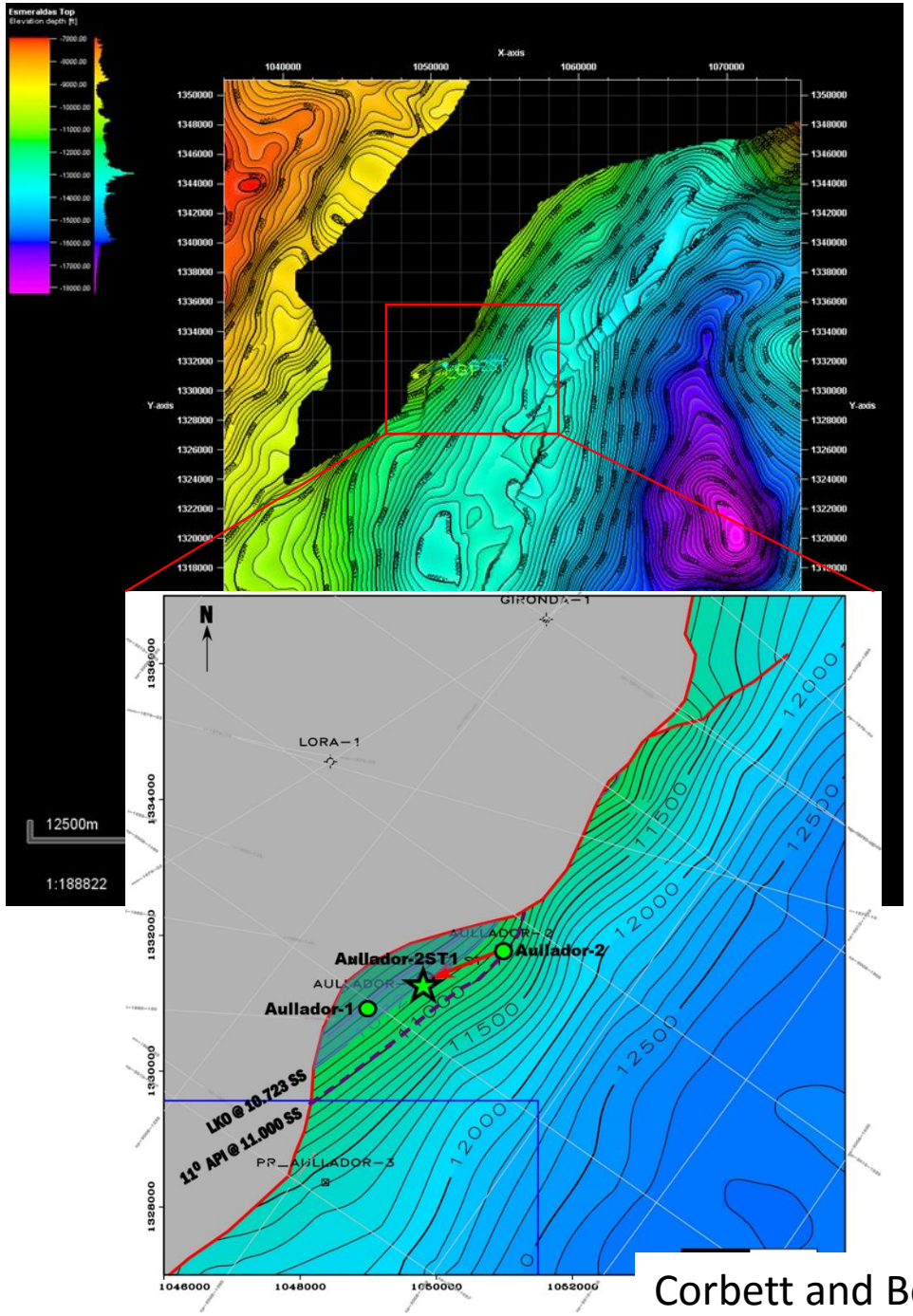
Reservoir Geology



Source: Unpublished Ecopetrol Report



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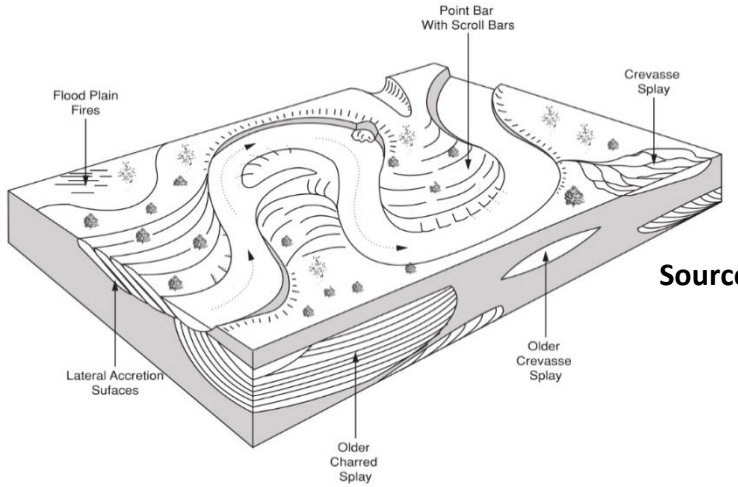
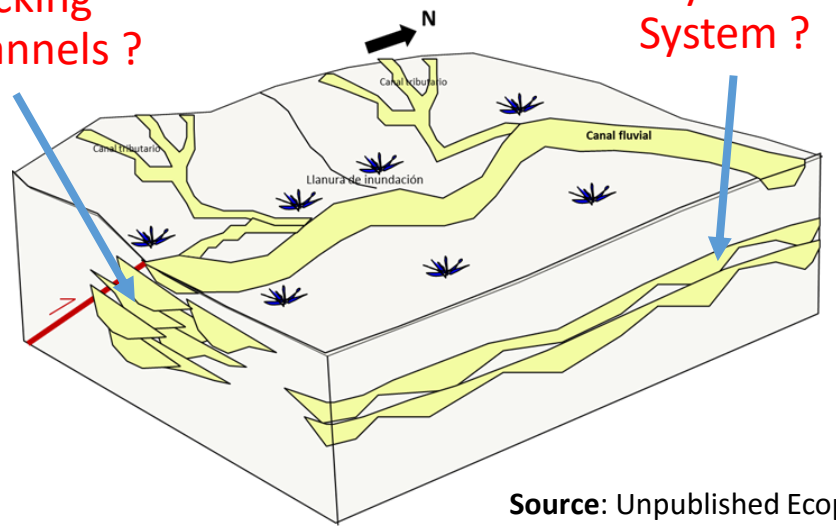
Depositional Environment



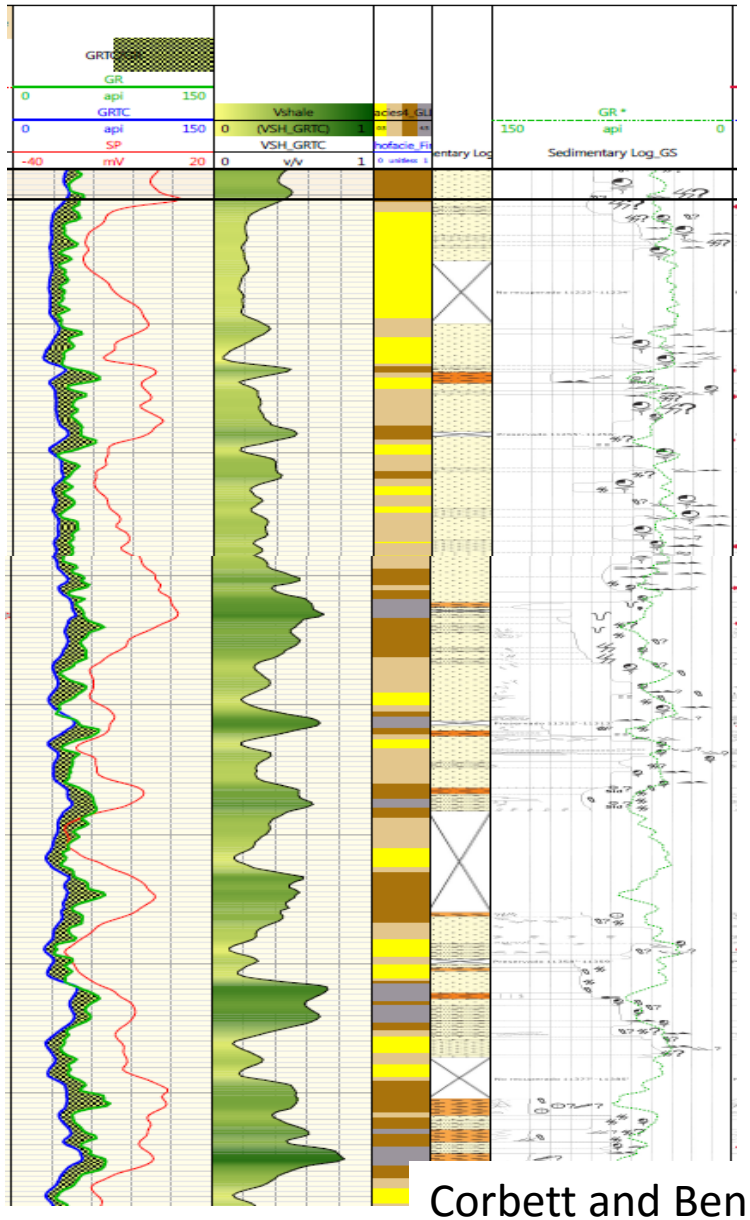
Source: Reservoir Sedimentology Course Notes

Stacking Channels ?

Layered System ?



Source: Unpublished Ecopetrol Report



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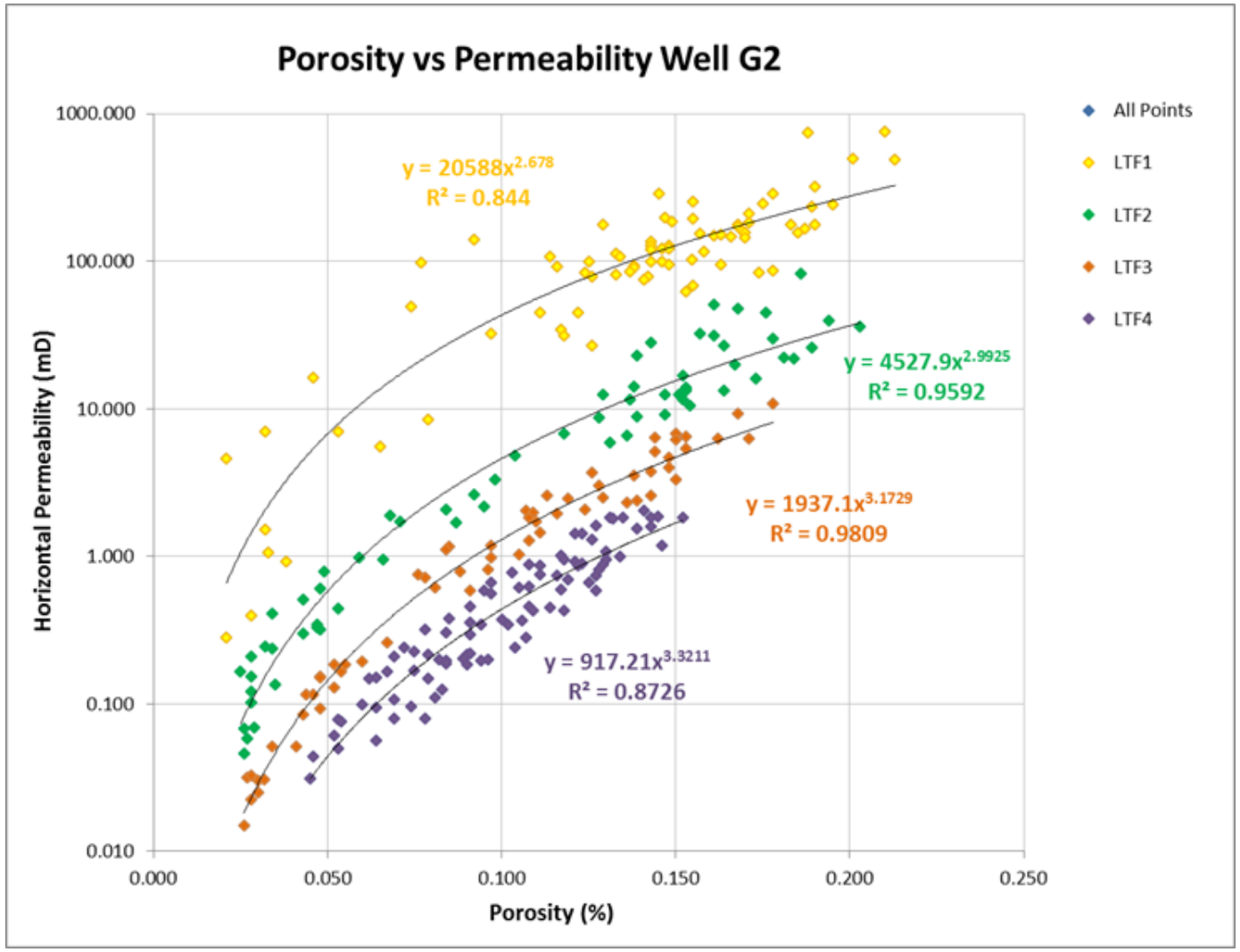
Lithofacies and poroperms



Corbett and Benitez, In review

Modern River Analogue

Corbett and Benitez, In review

Training Images

Training Image 1

Sand Accumulation away from the main channel

Training Image 2

Sand deposition within the main channel

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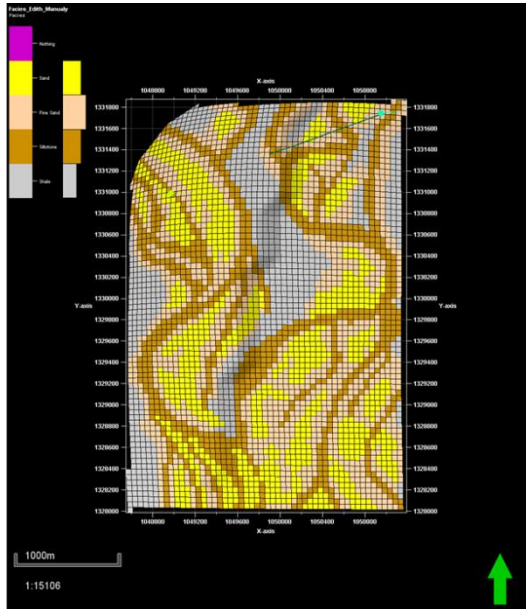
Reservoir Static Model



Training Image 1

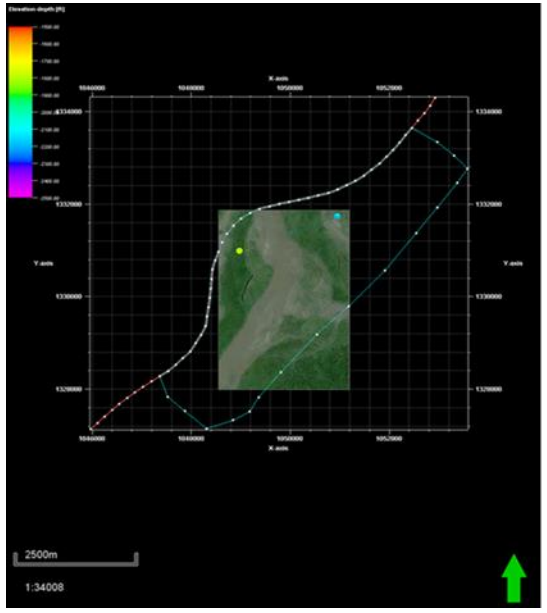
Sand Accumulation away of the main channel

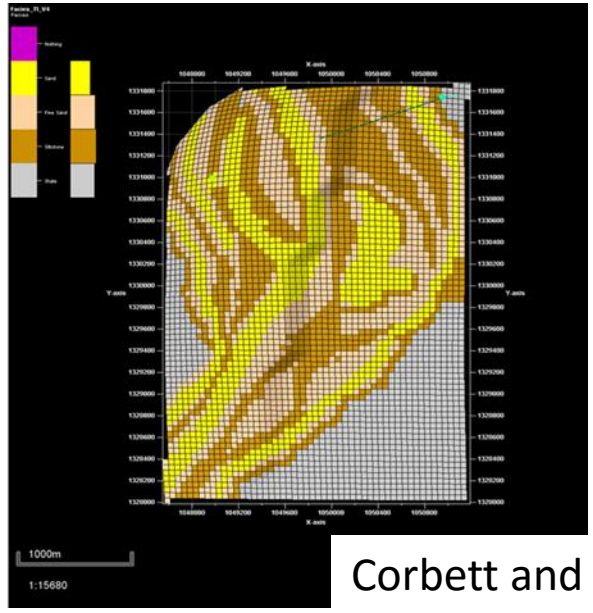
50 x 50 x 0.5 m

Training Image 2

Sand deposition within the main channel

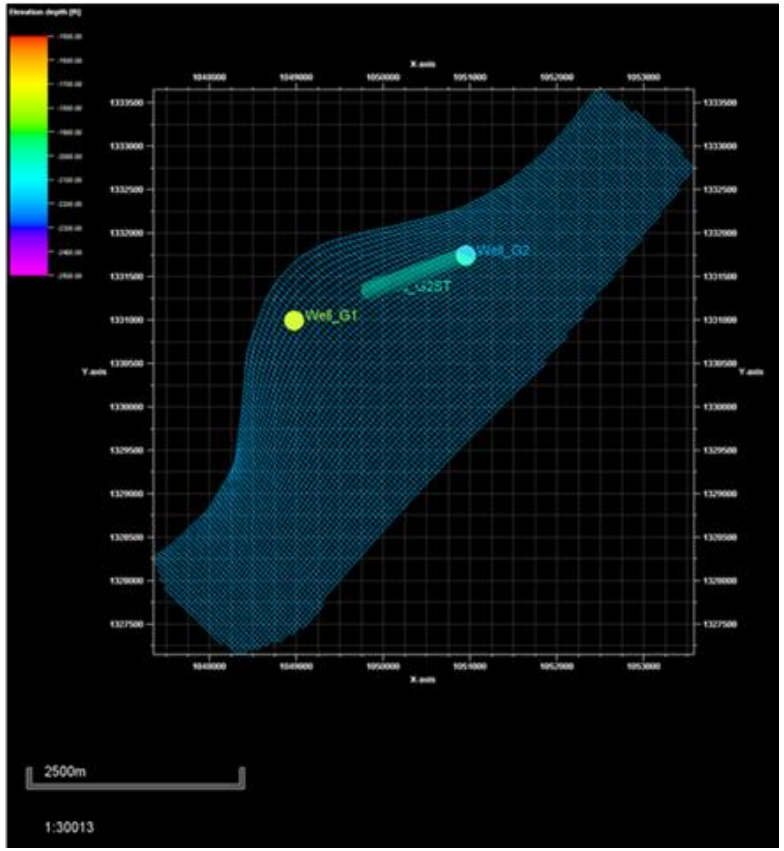
50 x 50 x 0.5

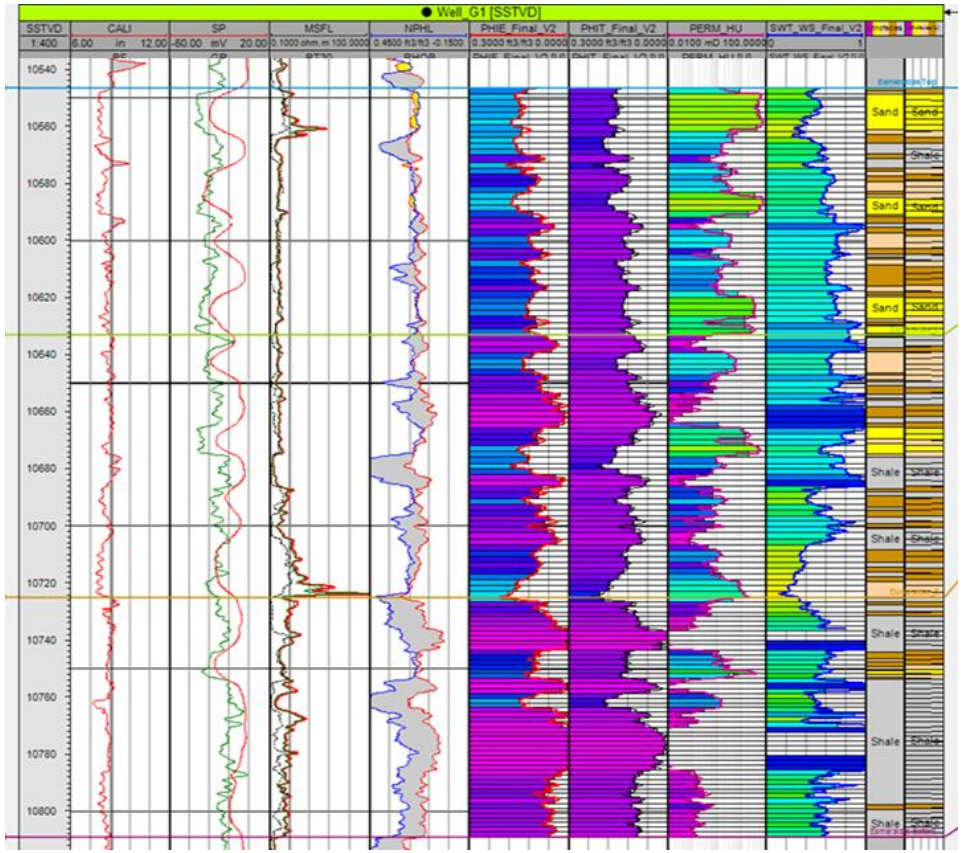




Corbett and Benitez, In review

Reservoir Static Model





Fine Model 50 x 50 x 0.5 m

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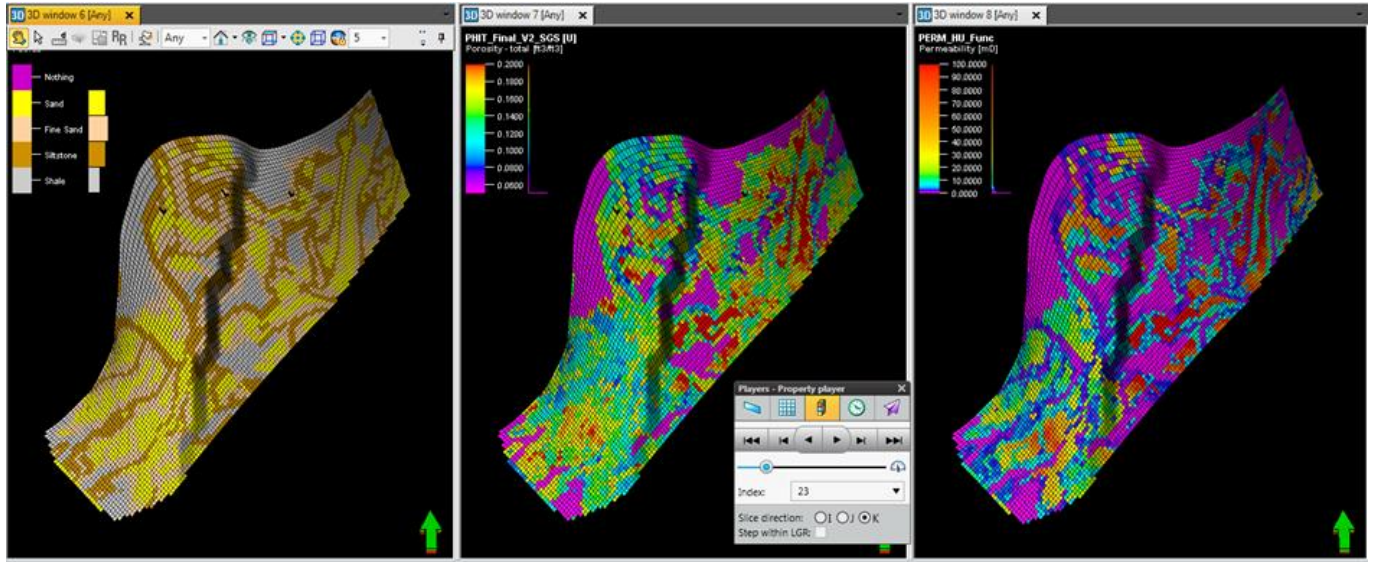
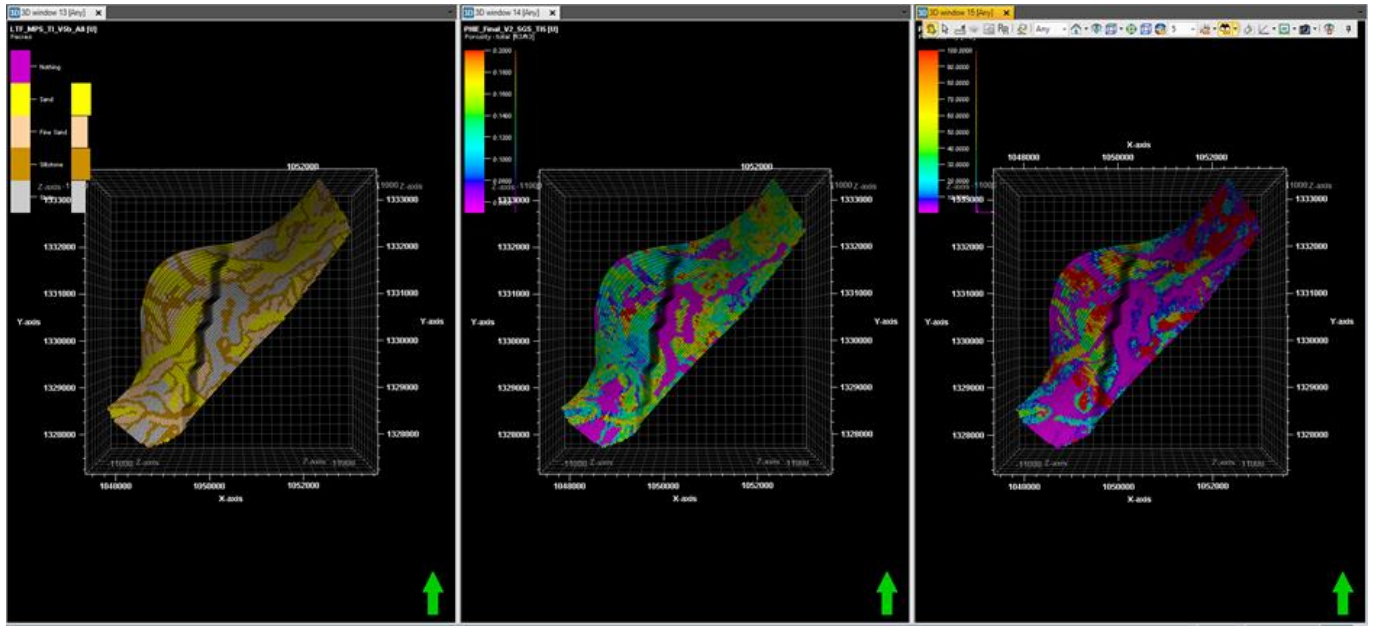
Reservoir Static Model



GeoModel 1
(Training Image 1)



GeoModel 2
(Training Image 2)

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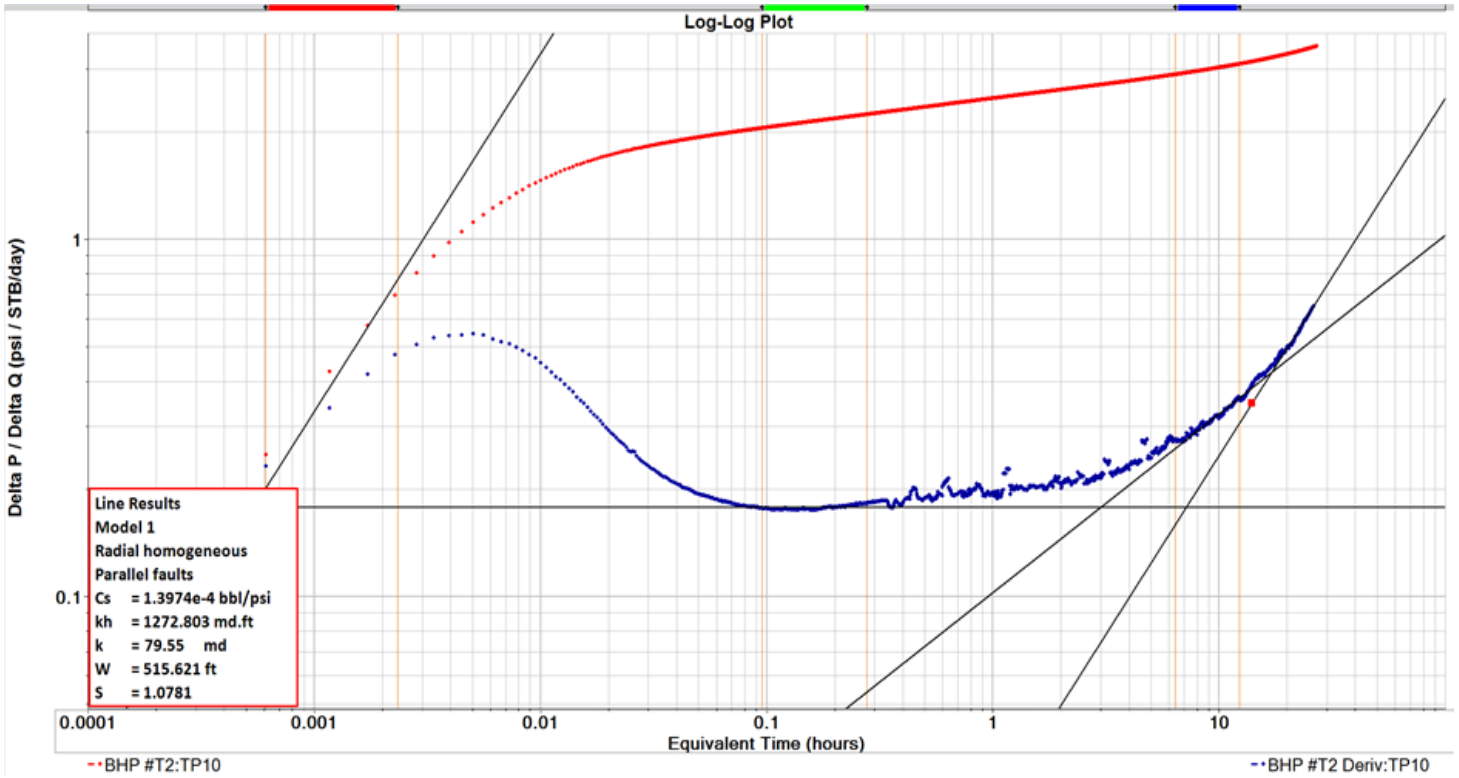
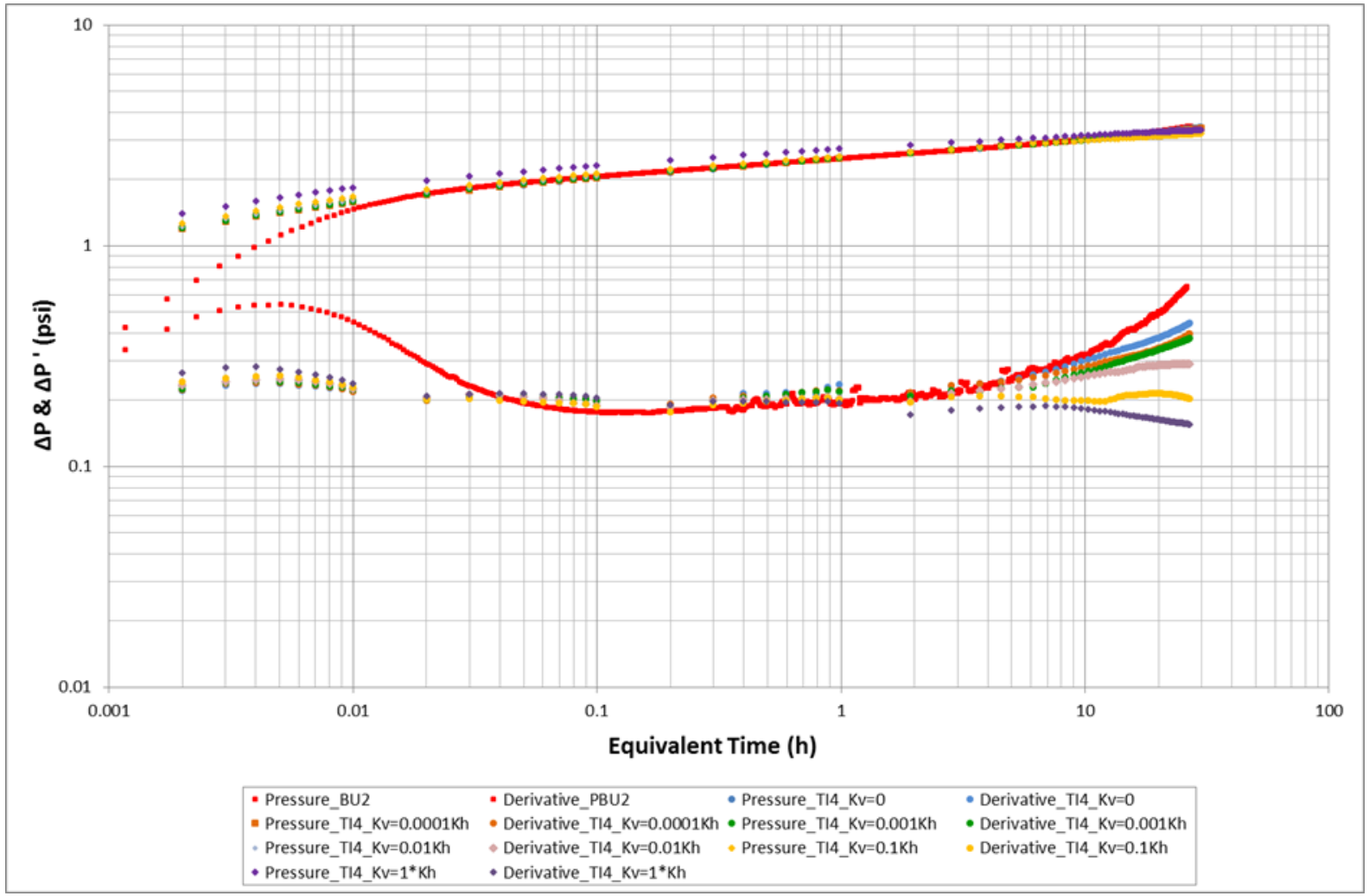
Analytical Well Testing Interpretation



Corbett and Benitez, In review

Results



Kv/Kh Sensitivity

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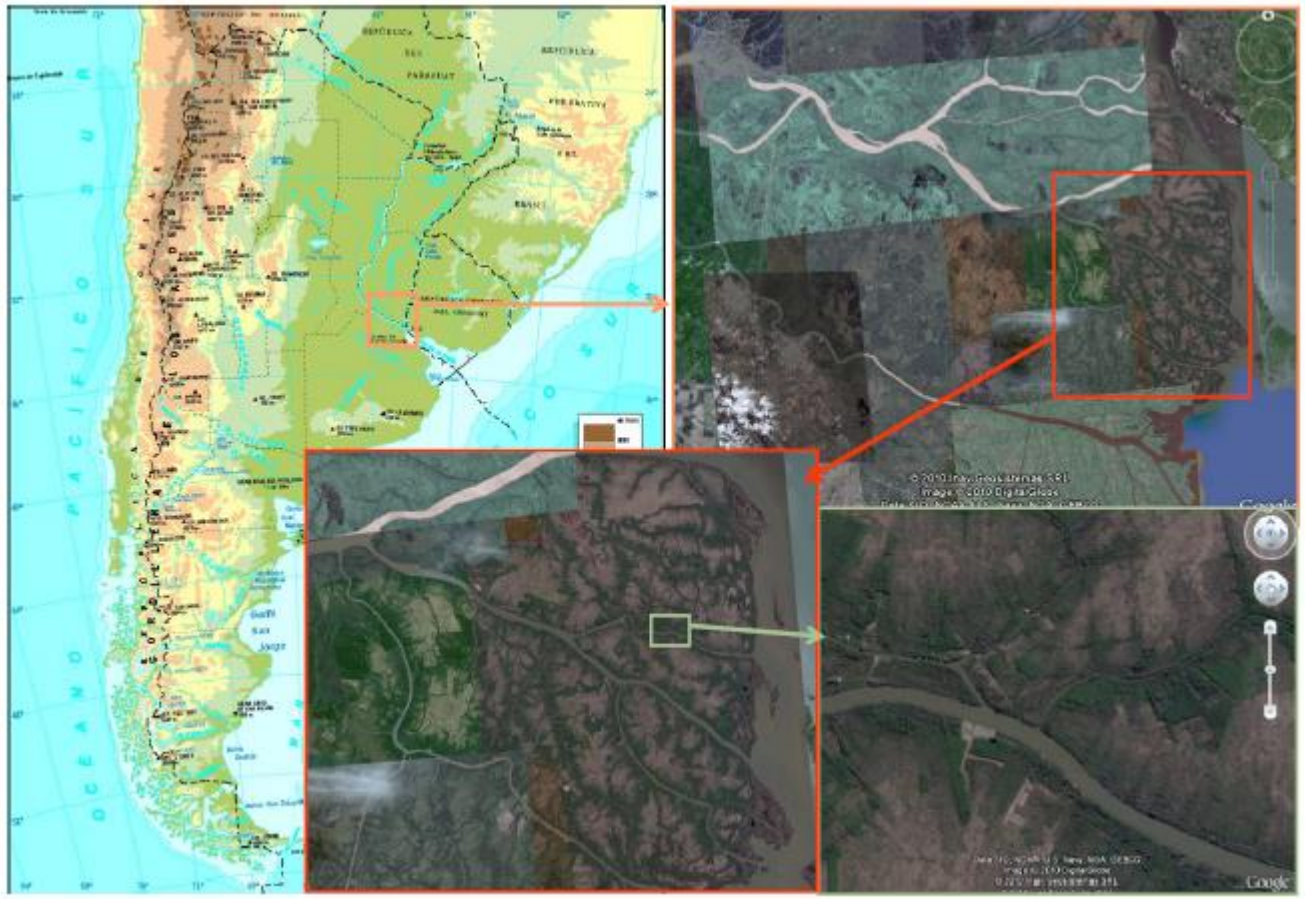
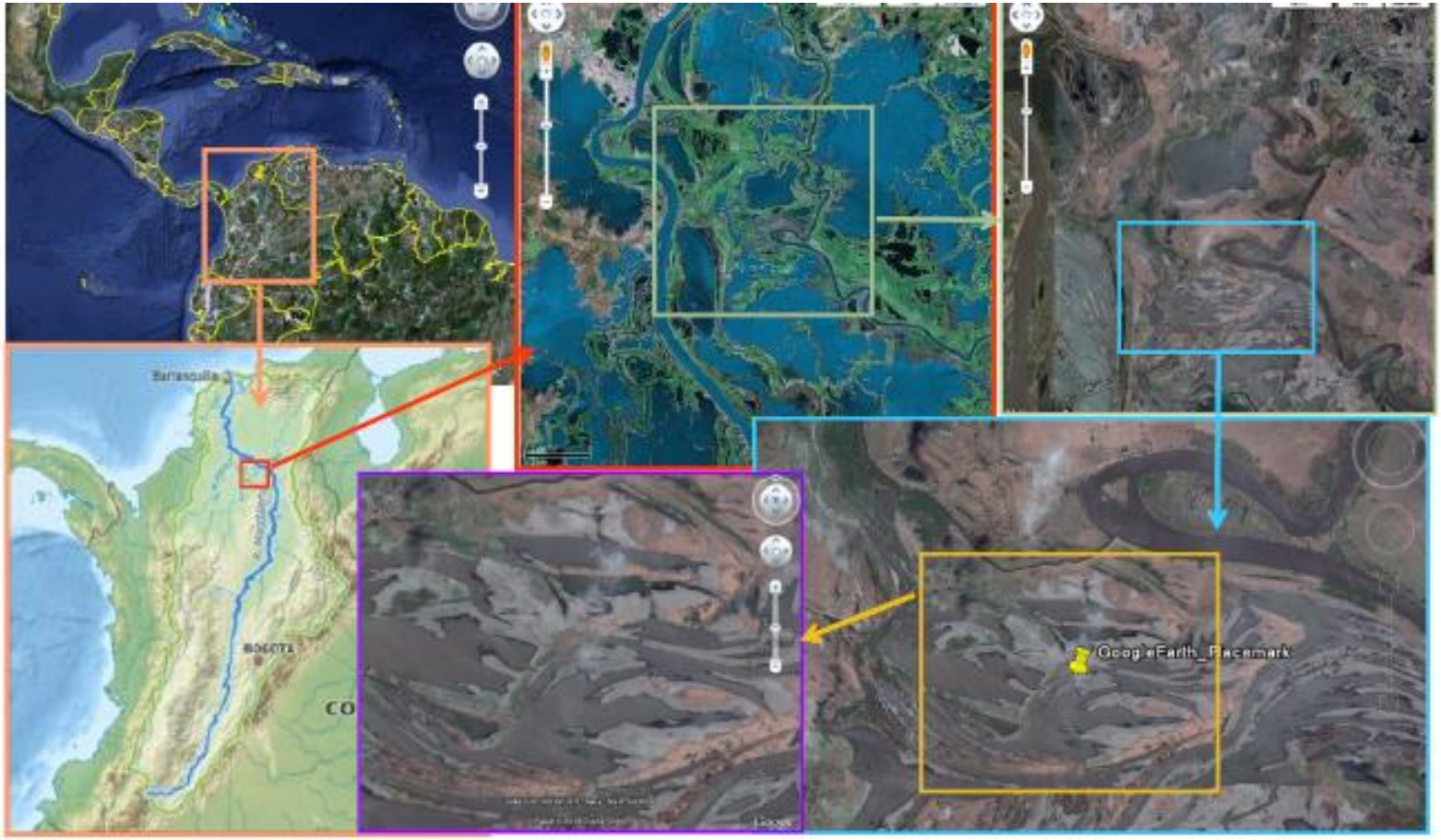
Case study 3: Unknown field example



Hamdi et al., 2014

Example of a modern Fluvial System (Parana River, S America)

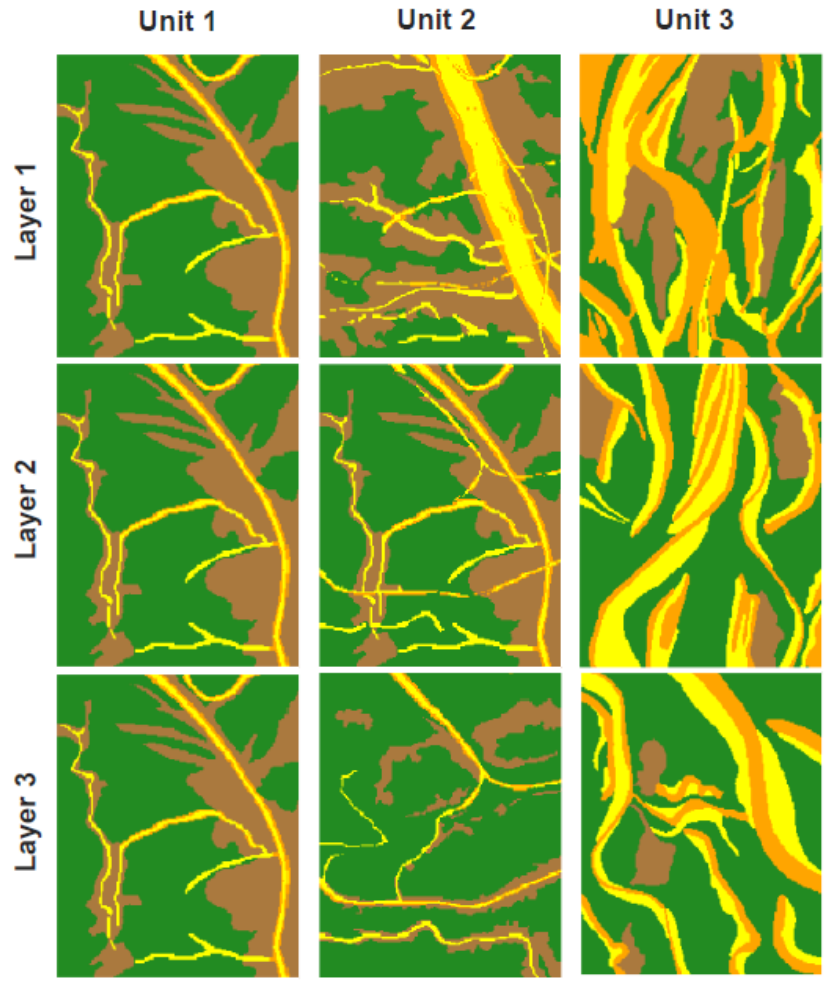
Importance of good analogues



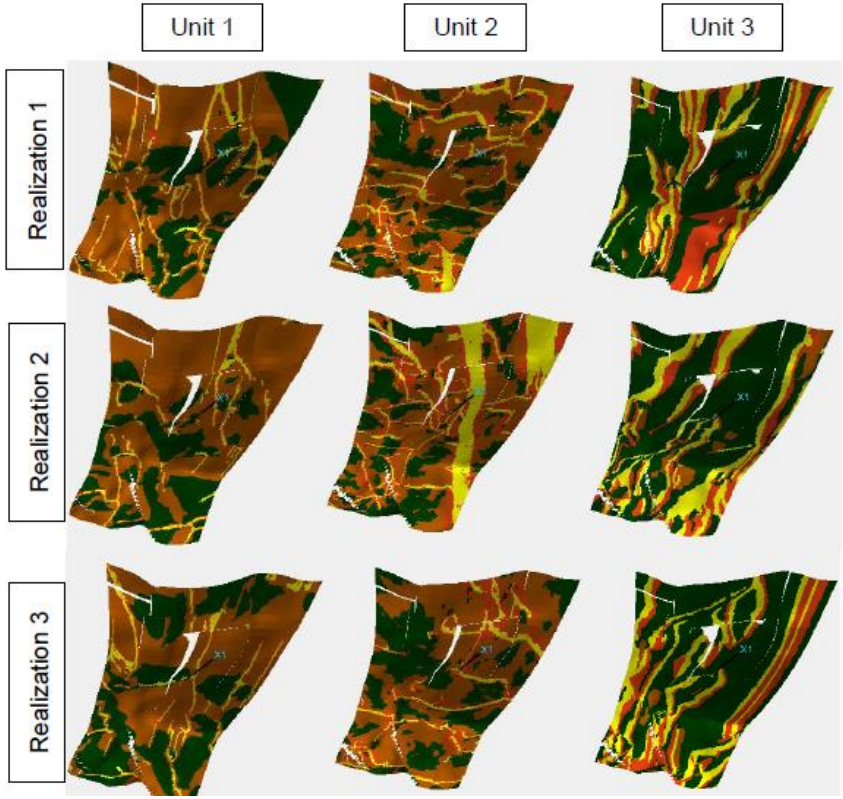
Hamdi et al., 2014

Example of a modern Fluvial System (Magdalena River, S America)

Multiple Multipoint Training Images and Realisations



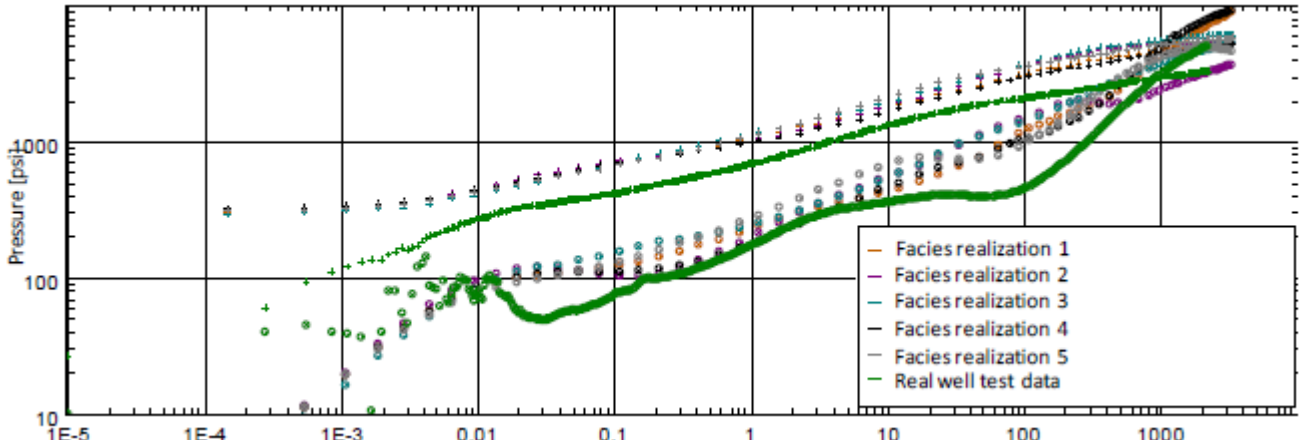
Parana Analogue ⟶ Magdalena Analogue



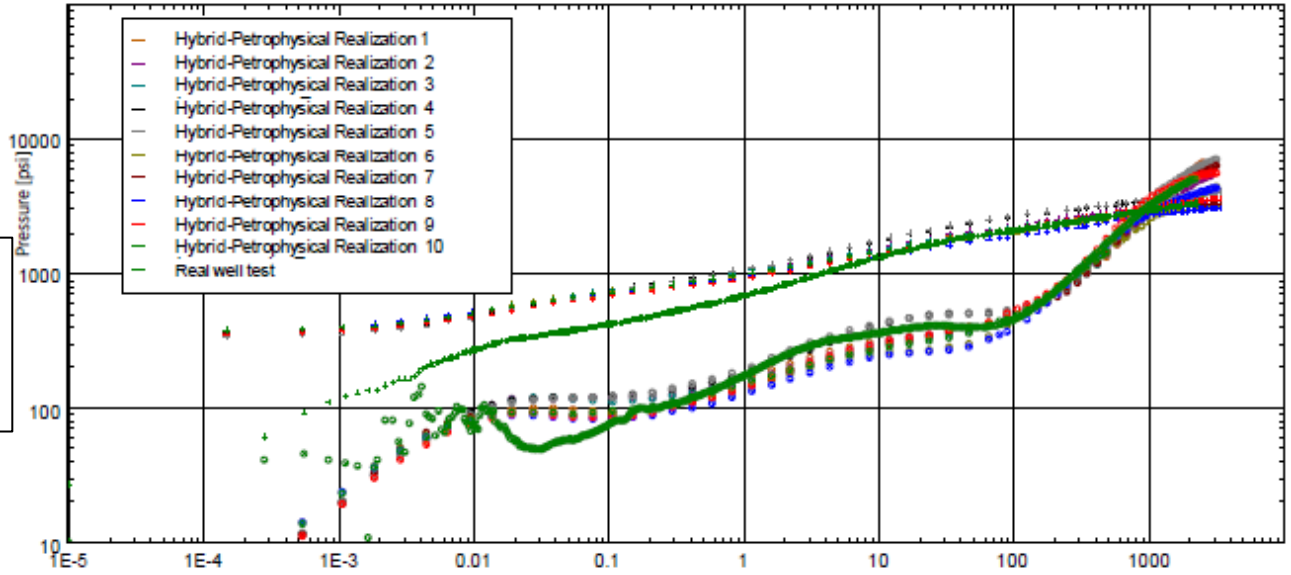
Hamdi et al., 2014

Dynamic Calibration

Initial match



Match after box cropping and hybridisation

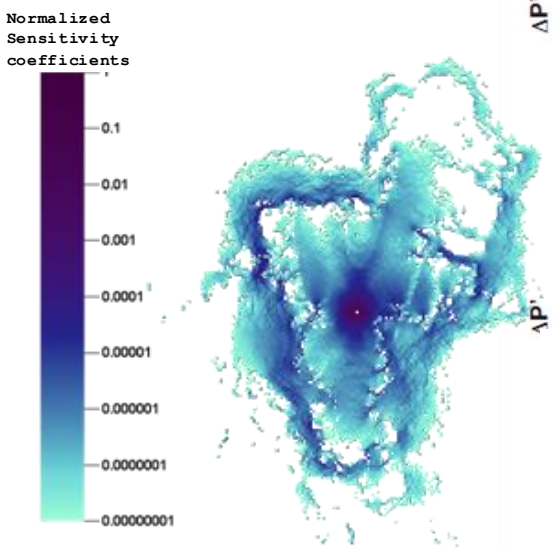


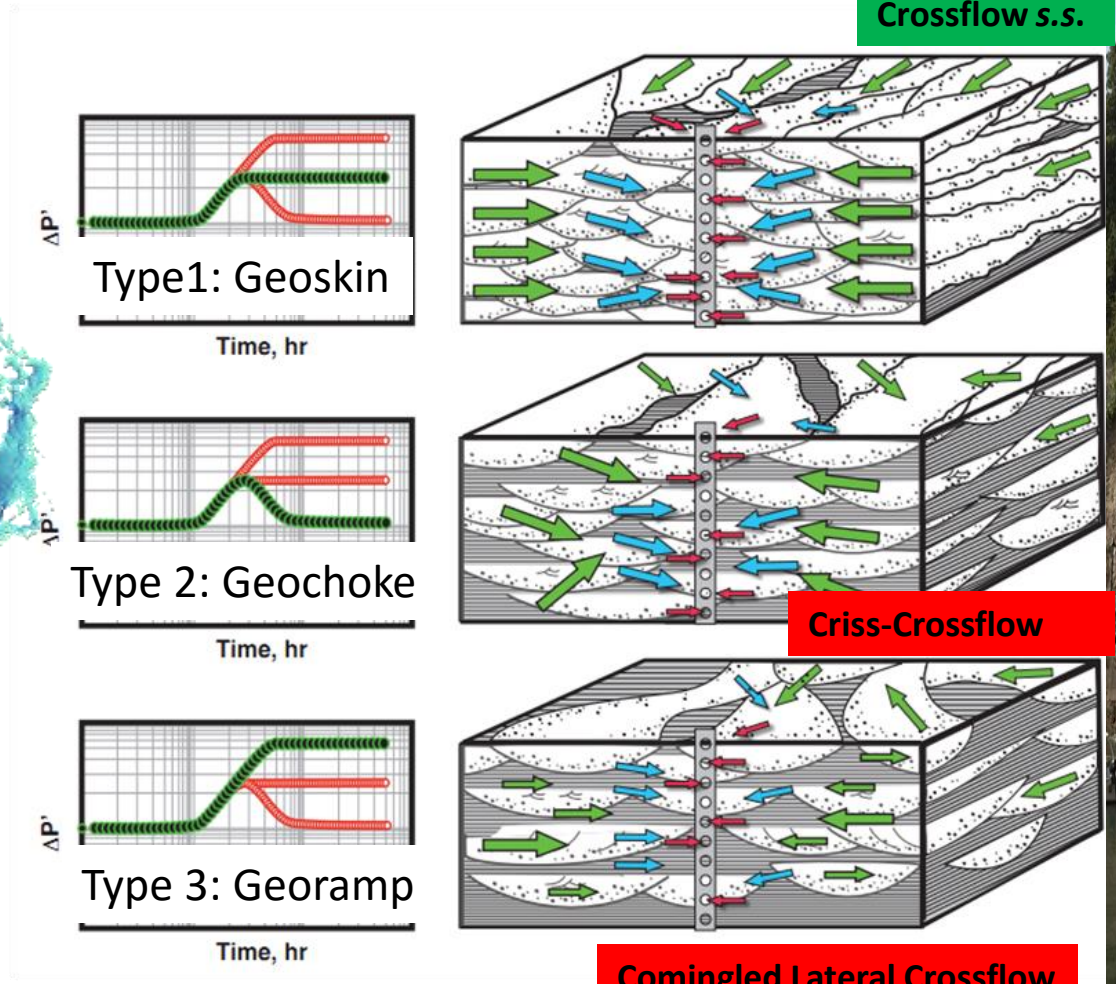
Hamdi et al., 2014

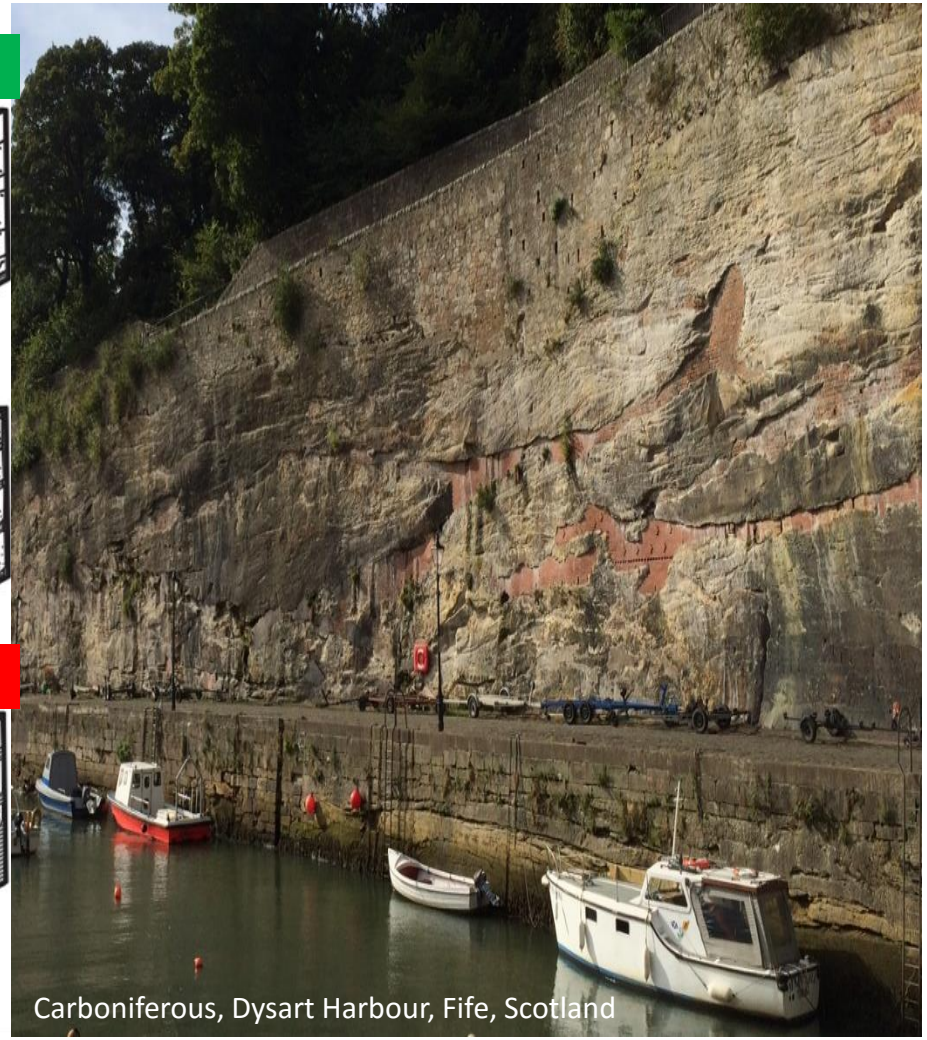
Challenges/Opportunities

- Appreciation of Canal vs Channel models
- Modern Rivers
  - Choosing the right analogy
  - Google Earth vs Real Earth
- Preservation of fluvial systems
- Importance of anisotropy (k_v/k_h, k_x, k_y, k_z)
- Need for appropriate “fluvial” geological language
  - Braided/Meandering/Anastomosing/Linear
  - Laterally connected stacking pattern
- New fluvial well test language
  - Geoskin
  - Geochoke
  - (Geo)Ramp (extended comingled lateral cross-flow)
  - Isolated meander-loop depletion/recharge (“De Rooij” Model)
- Better communication (“geoengineering”)

New Braided Fluvial Models







Back to the past – Spireslack Quarry, Ayrshire

Edwards, 2016

References

- Dunlop, and Corbett, 1996, “Well test modelling in a multi-storey fluvial channel” Best Poster Winner, EAPG Amsterdam
- Corbett, 2009, *Petroleum Geoengineering: Integration of Static and Dynamic Models*, SEG/EAGE Distinguished Instructor Series, **12**, SEG, 100p. ISBN 978-1-56080-153-5
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