

CNR-IRSA, Montelibretti

Litho-stratigraphy vs. hydro-stratigraphy to inform flow models; insights from North America and Great Britain

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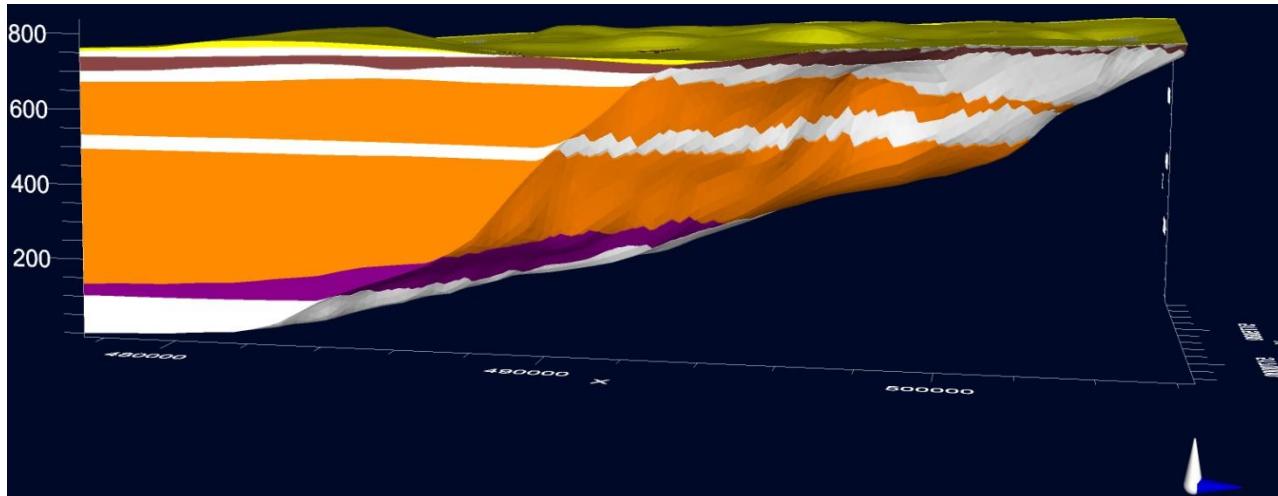


Topic

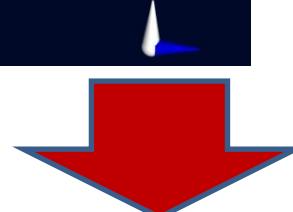
Observe mismatch (or match) between the lithostratigraphic (members, formations, groups and super-groups) units and the effective hydraulic units

→ Inform regional groundwater flow models (e.g., MODFLOW)

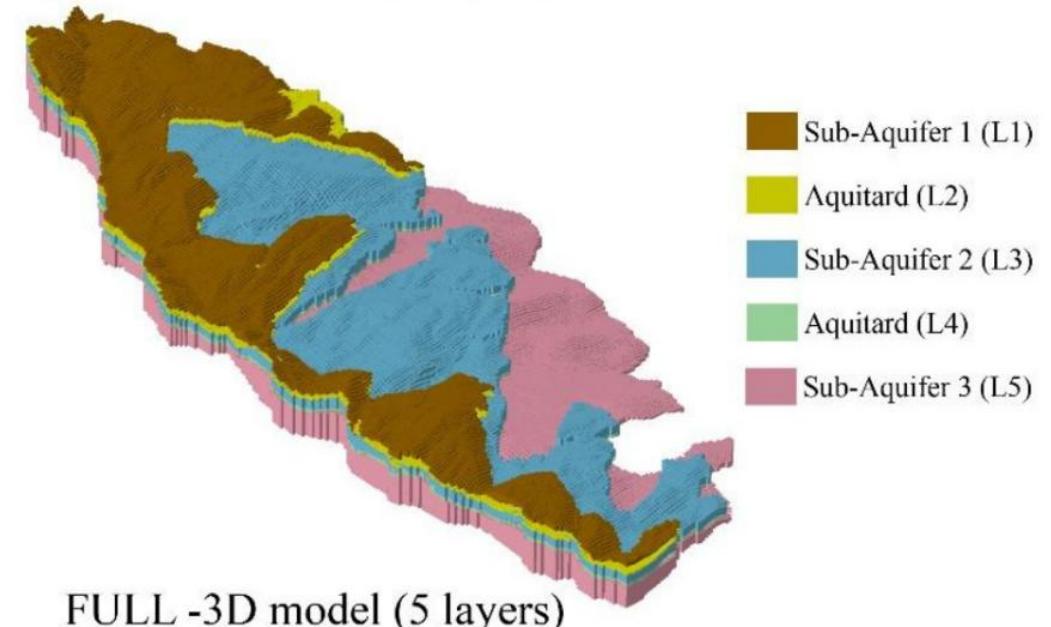
3D Conceptual Model



What I need to translate?



Numerical Model



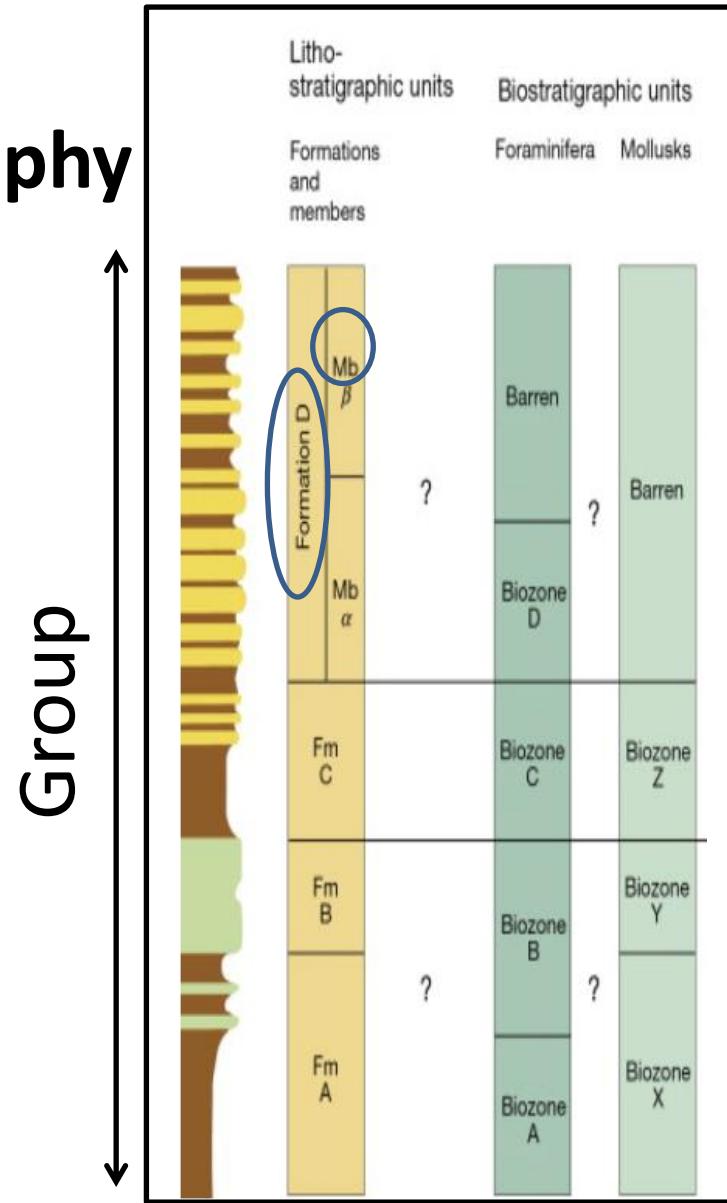
Medici et al. 2021 Int. J. Env. Res.
Preziosi et al. 2021 Water

3 Study Sites → Sub-horizontal (0°-15°) beds

Litho-stratigraphy

Systems

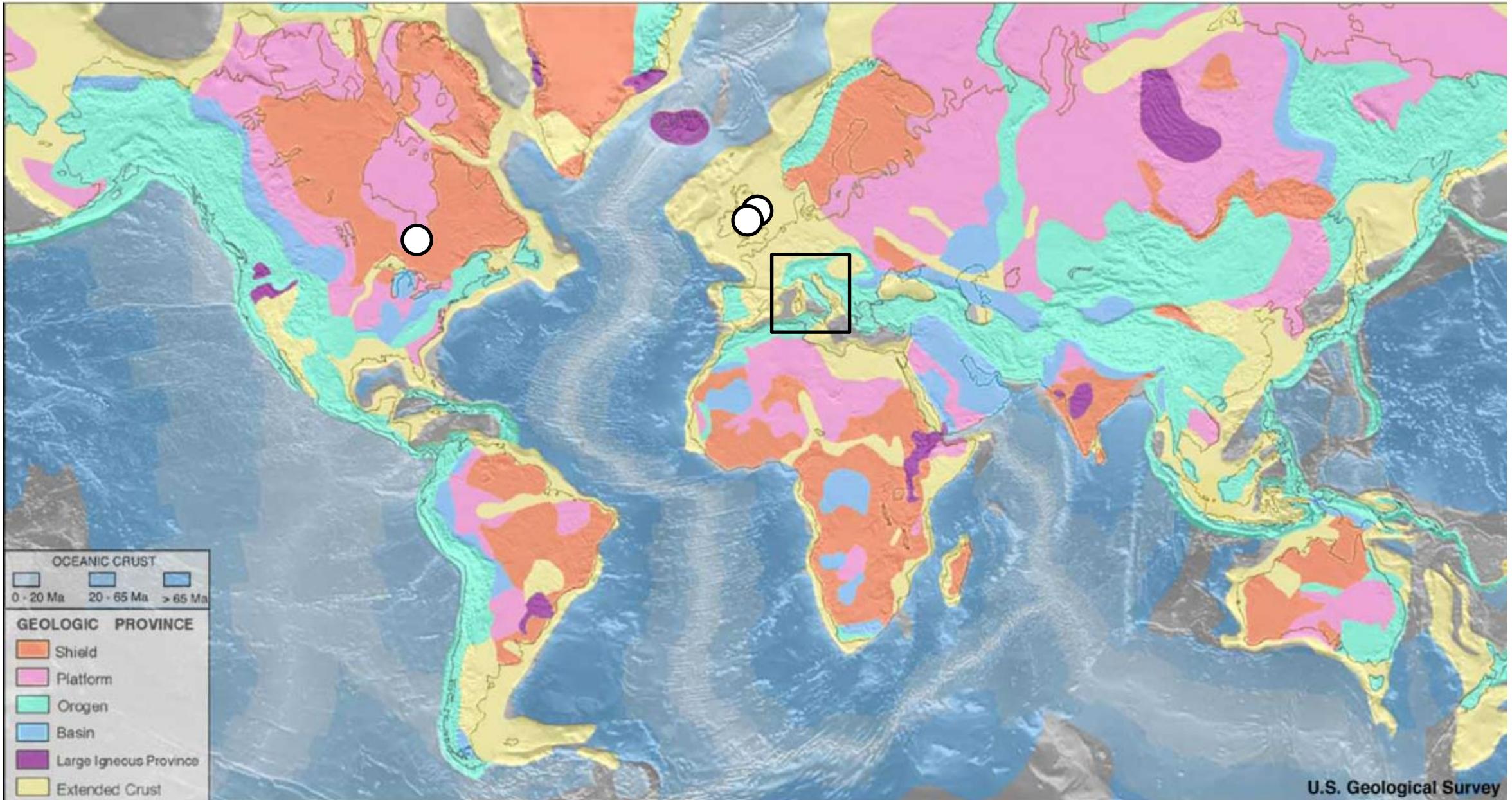
Scale



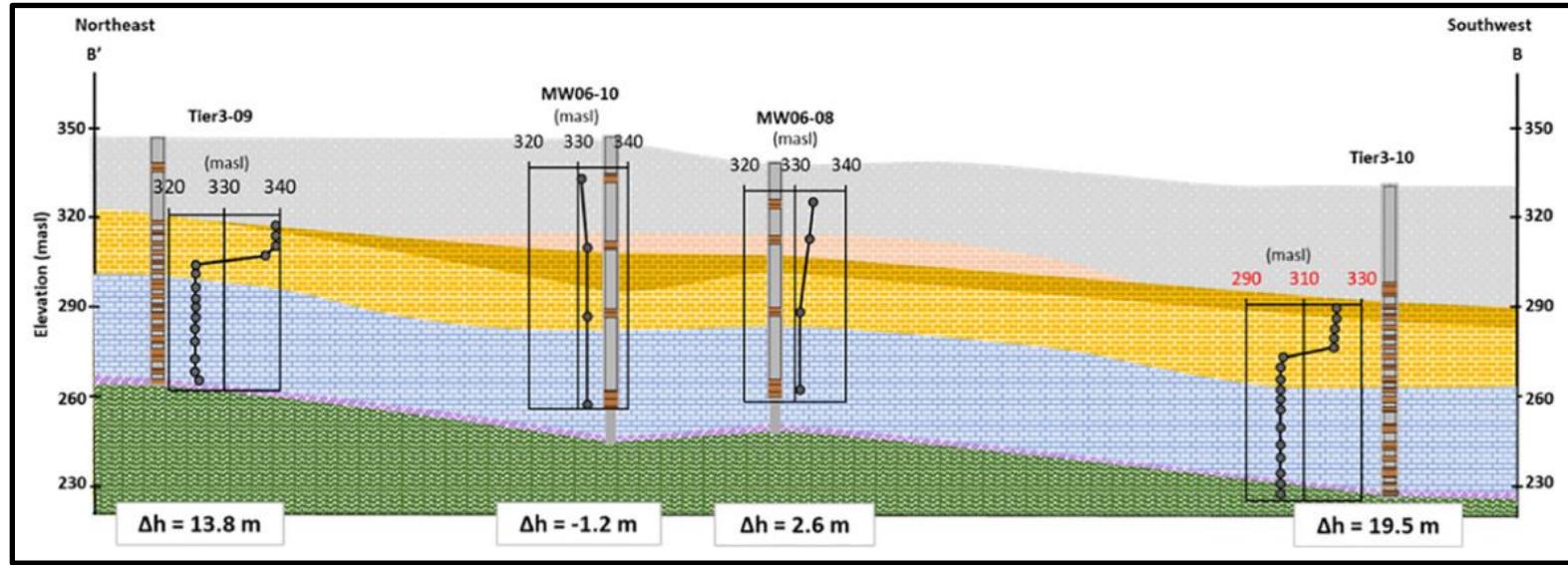
Spatial scale ↑ (+) ↓ (-)

1. Sellefield area, NW England
→ Geophysical logs, Pumping tests
→ 0 - 1100 m depths, 8 * 25 km
2. Yorkshire, NE England
→ Geophysical logs, Slug tests
→ 0 - 50 m, 8 * 10 km
3. Ontario, City of Guelph
→ Geophysical logs, Packer tests
(Wesbay, FLUTE technology)

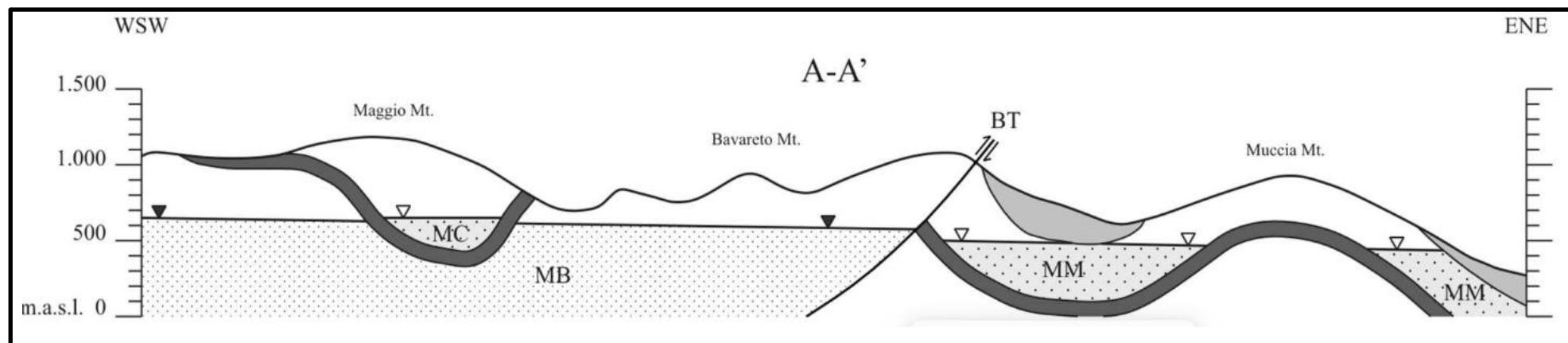
Worldwide Geological Map → Three sites



Continental platforms / Stable Europe



Appennines



Silurian Dolostone
→ Ontario (Canada)
Nunes et al. 2021

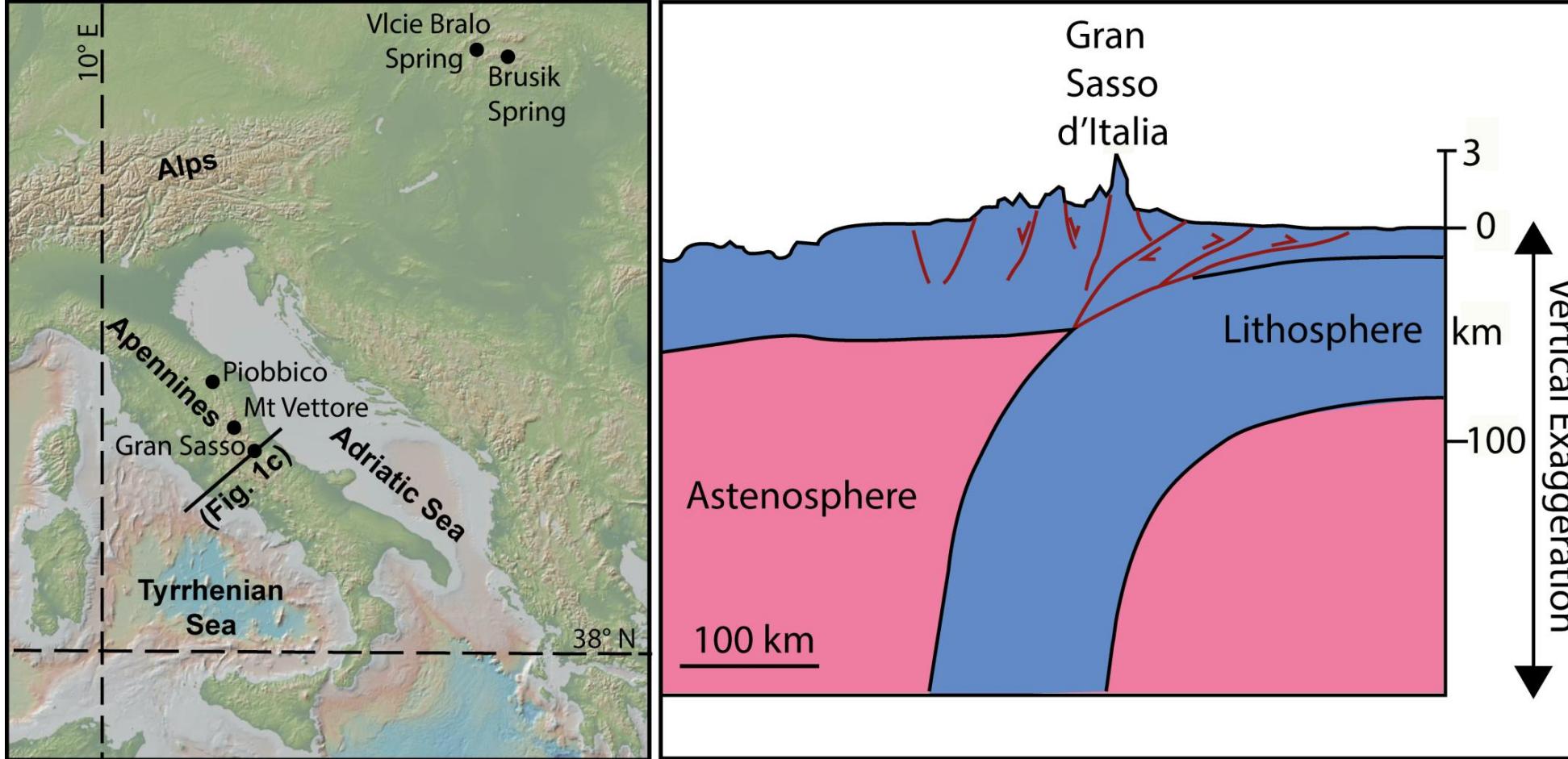
Science of the Total
Environment

Mesozoic carbonates
→ Central Italy
Mastrorillo
and Petitta 2014

Italian Journal of
Geoscience

Discussion → Alps, Apennines → Orogens

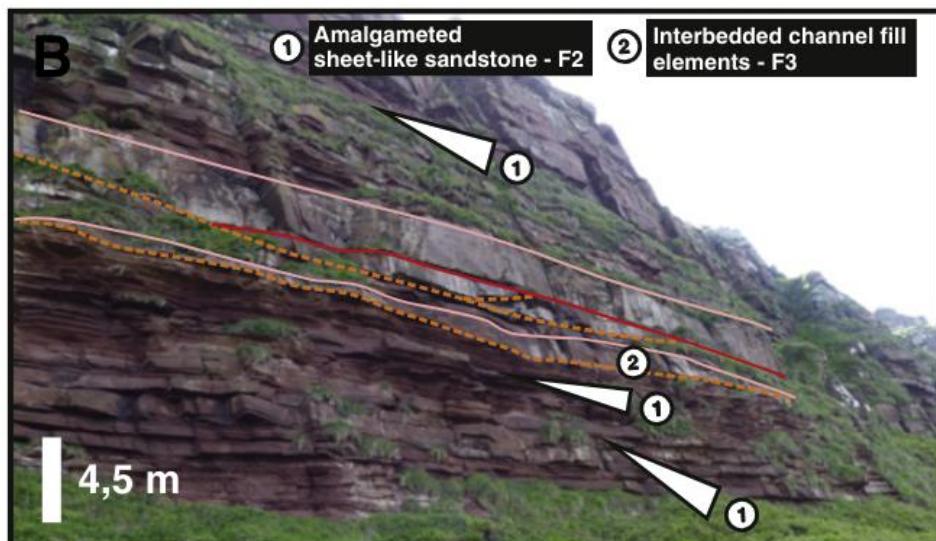
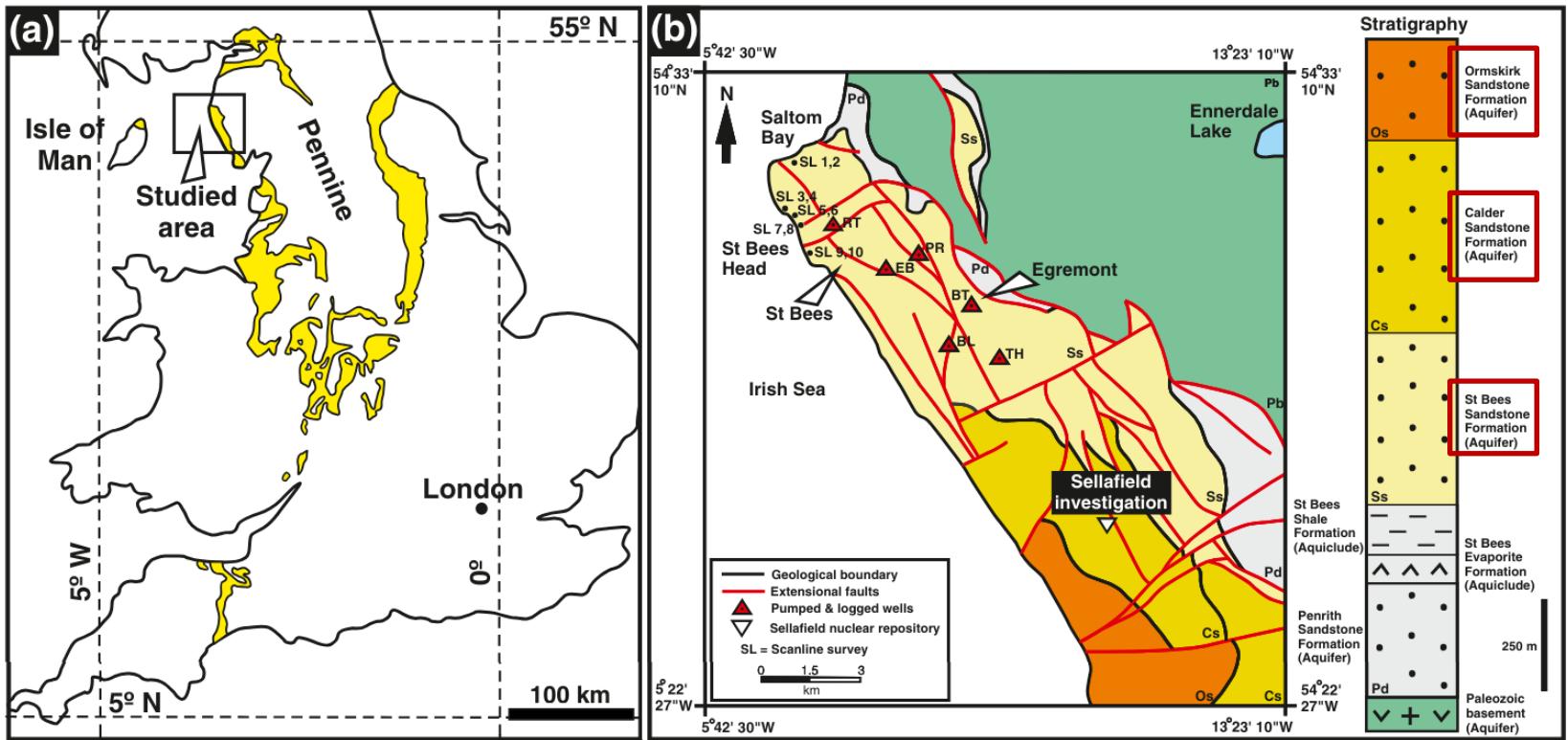
(+) ← Karst → (-)



Cardello and Doglioni 2015 Gondwana Research

Triassic Sherwood Sandstone → NW England

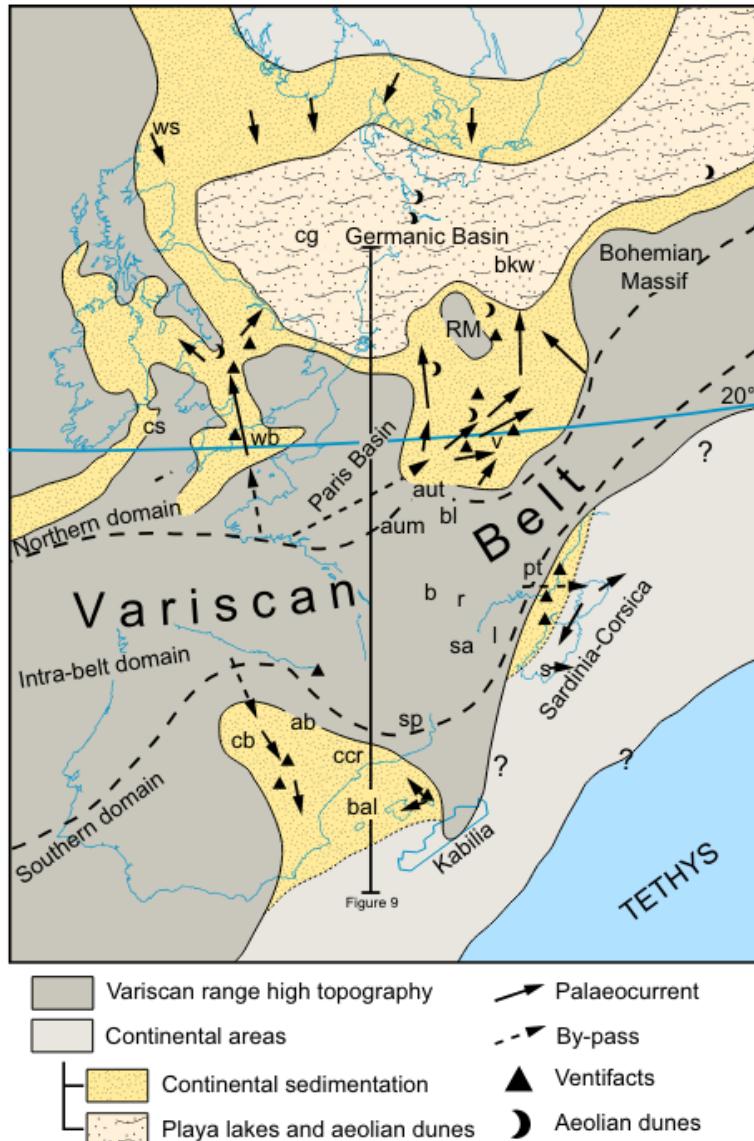
Group



Medici et al 2015
Sedimentary Geology

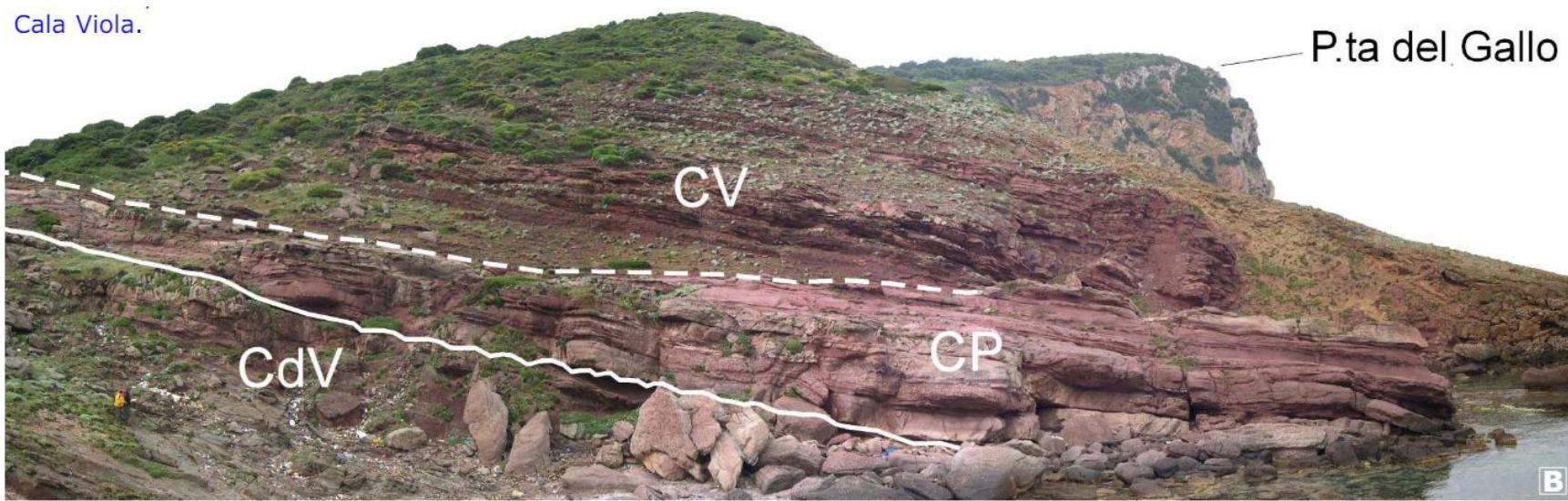
Medici et al. 2016
J. Contam. Hydrol.

Olenekian



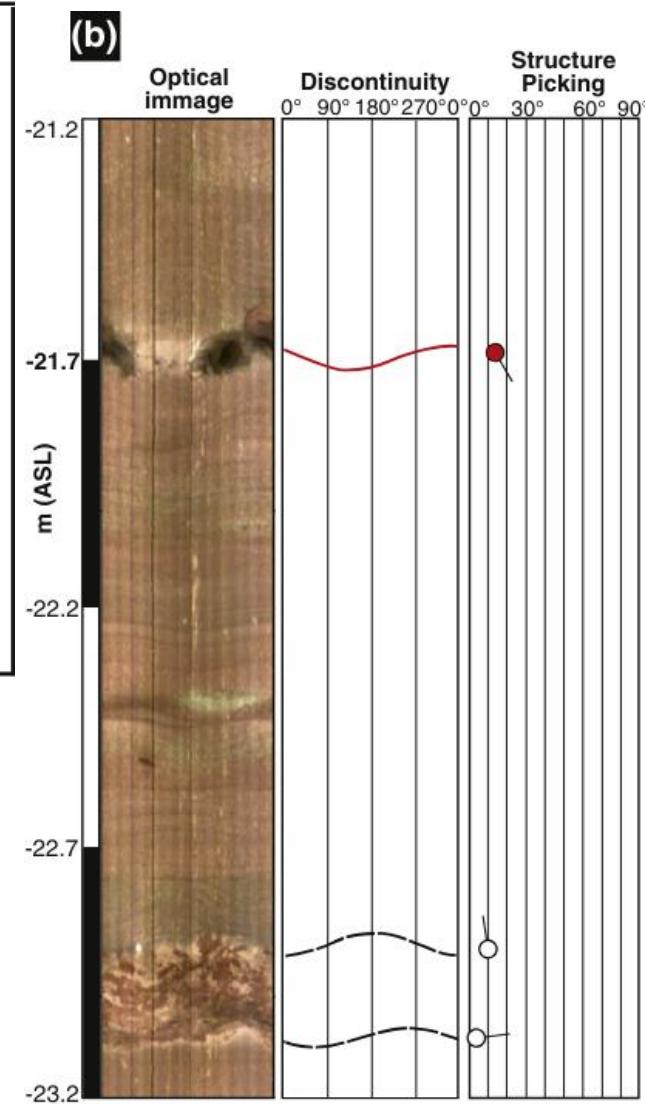
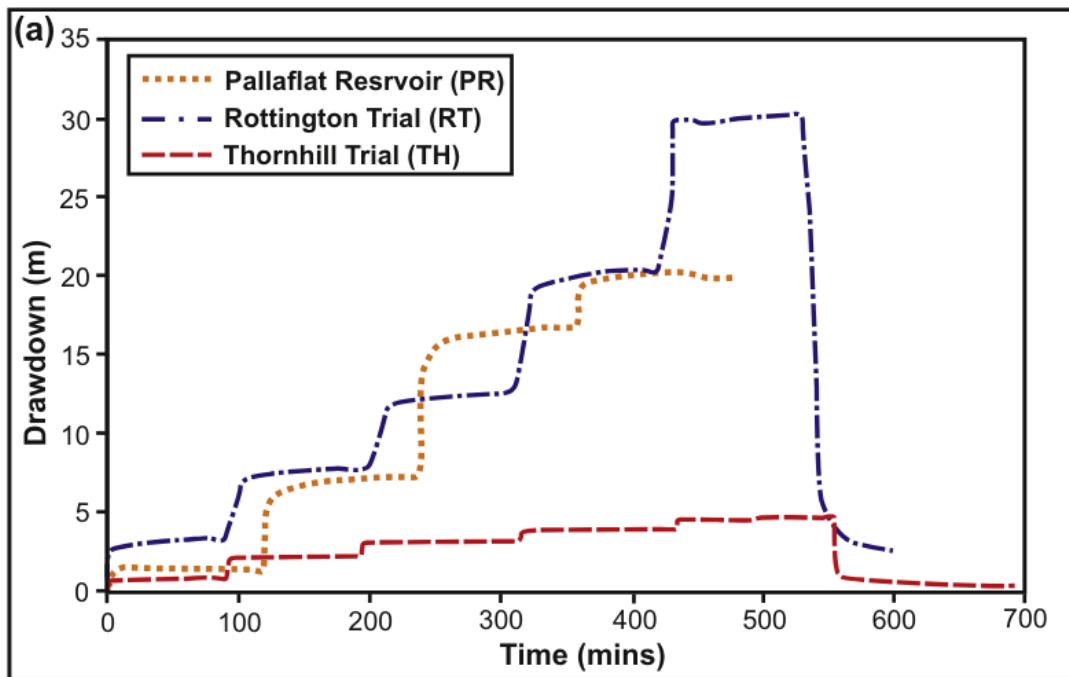
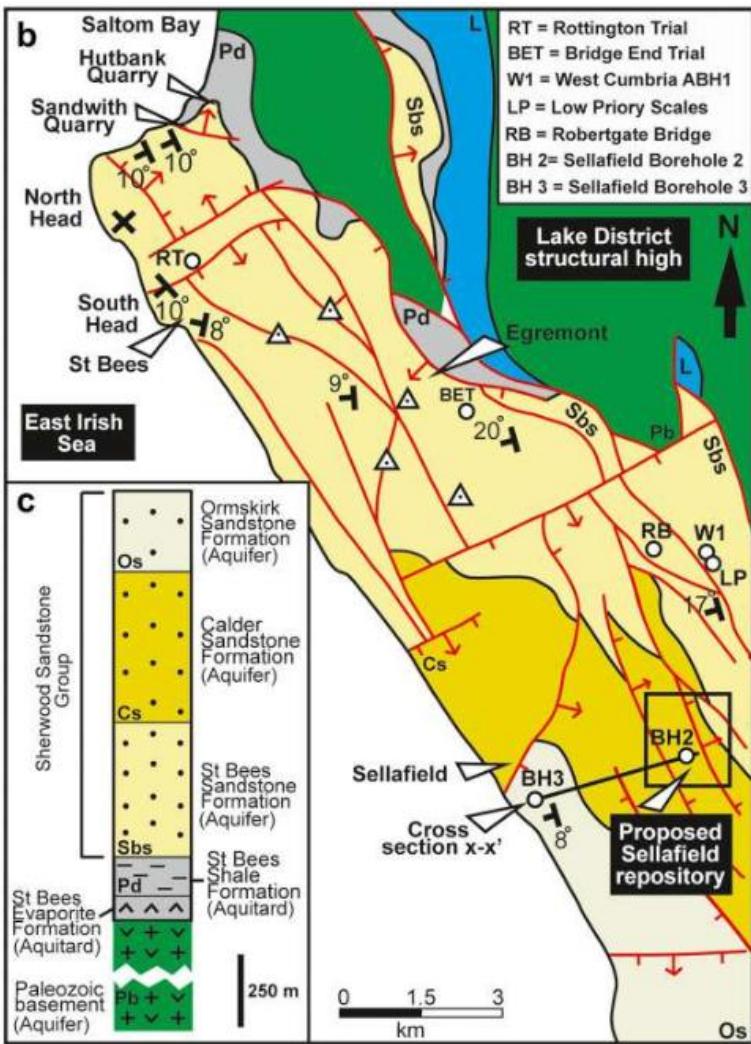
Bourquin et al. 2011
Pal. Pal. Pal.

Permo-Triassic Fluvio-Aolian Sandstones in Europe



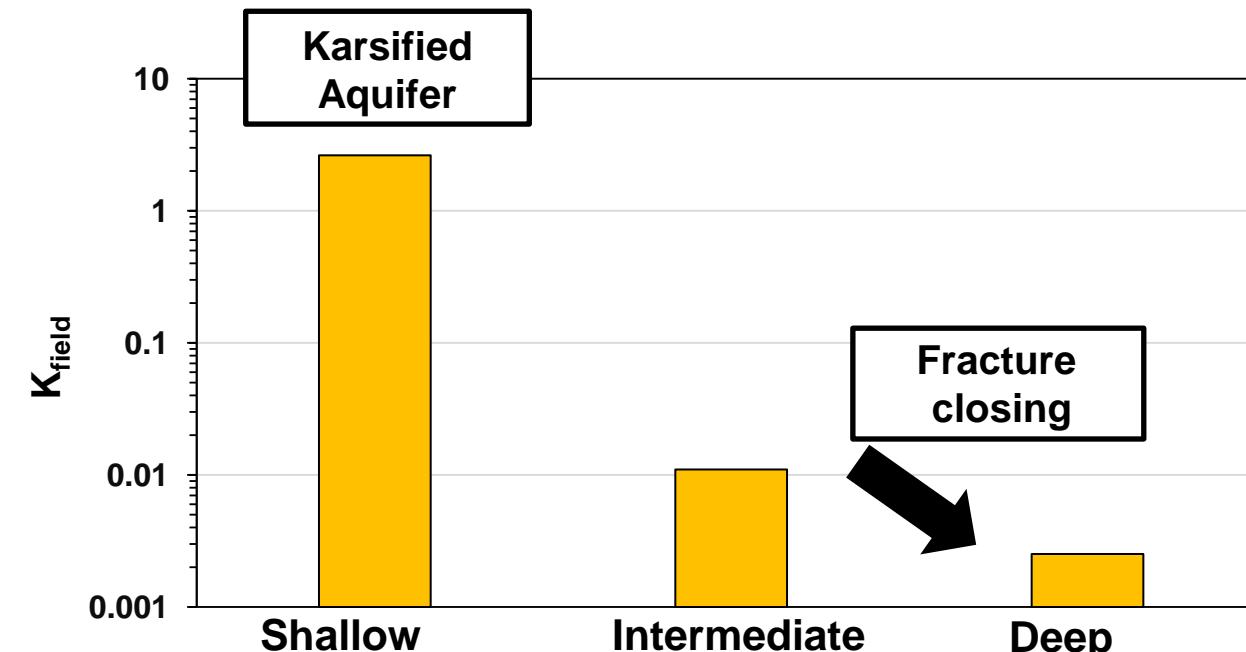
Fluvial Triassic Sandstone,
Nurra (Sardinia)
Ronchi et al. 2011
Geol. F. Trips

OTV/ATV logs and pumping test analyses (0-1.0 km) in a fluvial-eolian sequence



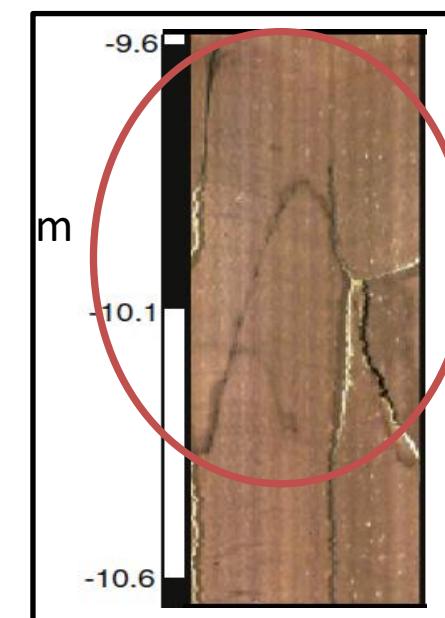
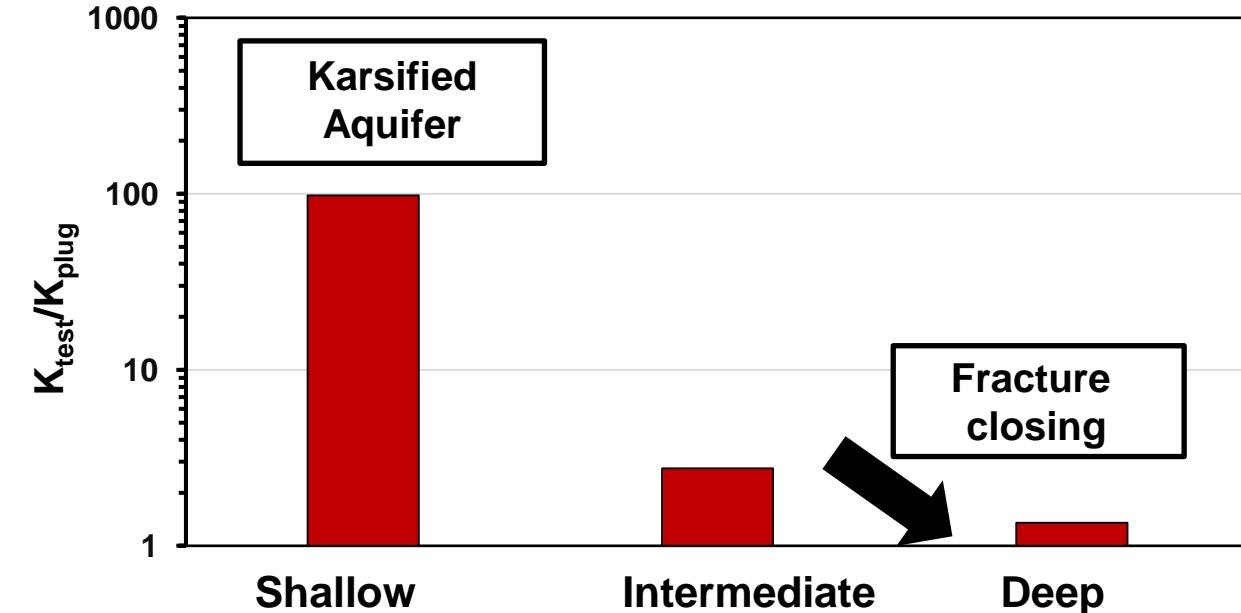
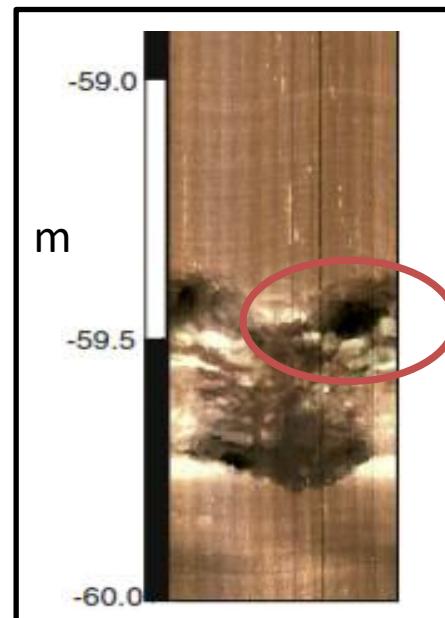
- (i) Medici et al. 2016
Journal of Contaminant Hydrology
- (ii) Medici et al. 2018
Hydrogeology Journal

Shallow vs. intermediate vs. deep aquifer → Permeability



Optical Logs
Shallow Aquifer
(0-150 mBGL)

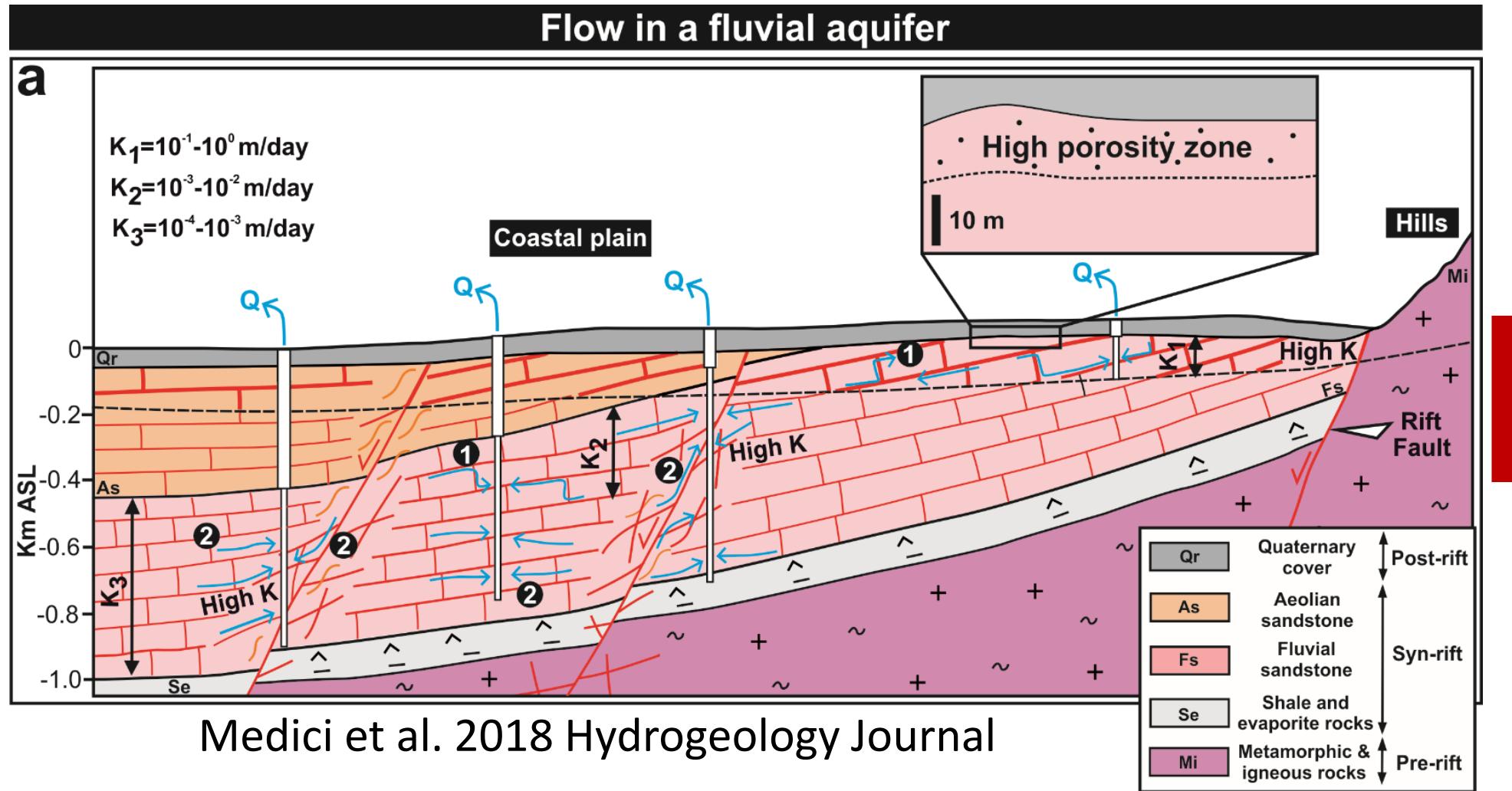
High permeability;
Alteration of
bedding fractures



Calcite
Dissolution

Medici et al 2016
*Journal of Contaminant
Hydrology*

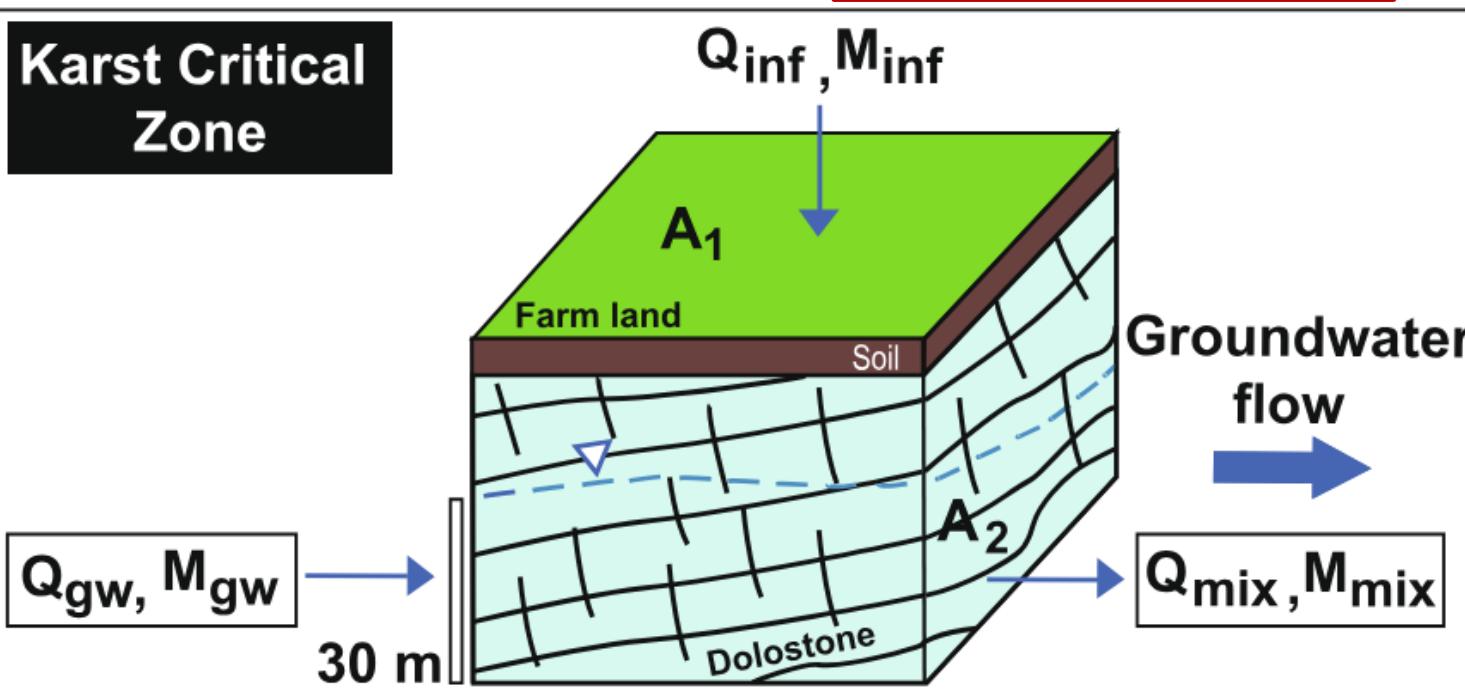
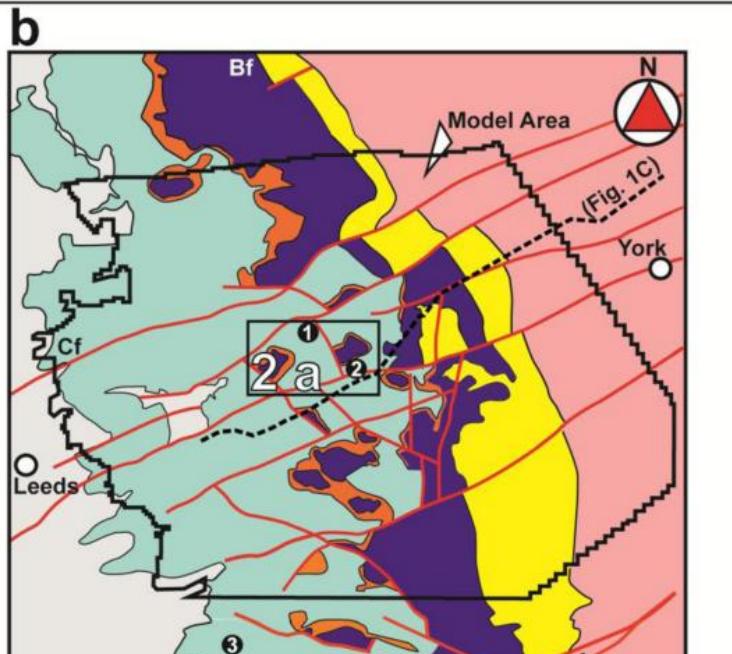
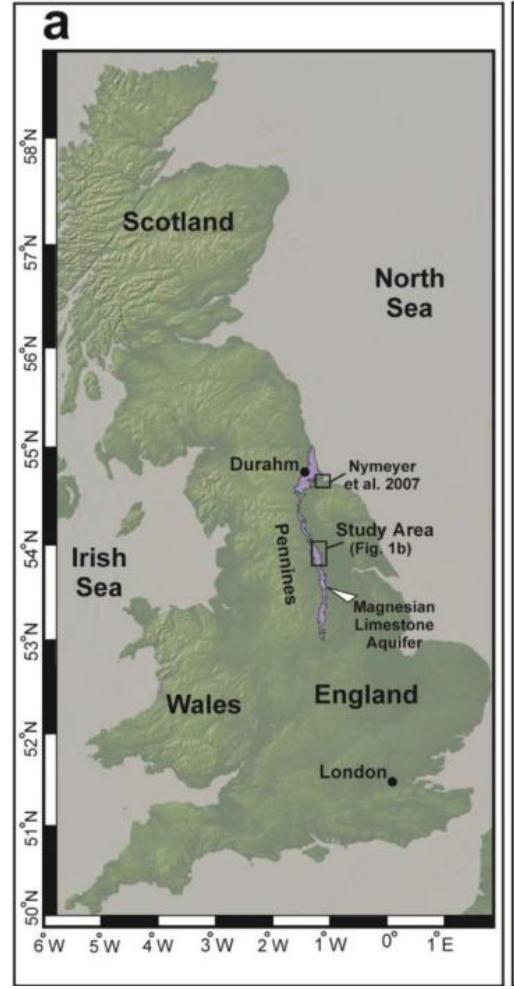
OTV/ATV logs and pumping test analyses (0-1.0 km) → Output



High K Zone
→ No fit
with the two
geological
formations

Permian Dolostone → Great Britain

- Sub-horizontal beds
- 3 Geological formations in the Magnesian Limestone Group
 - Brotherton Formation
 - Edlington Formation
 - Cadeby Formation

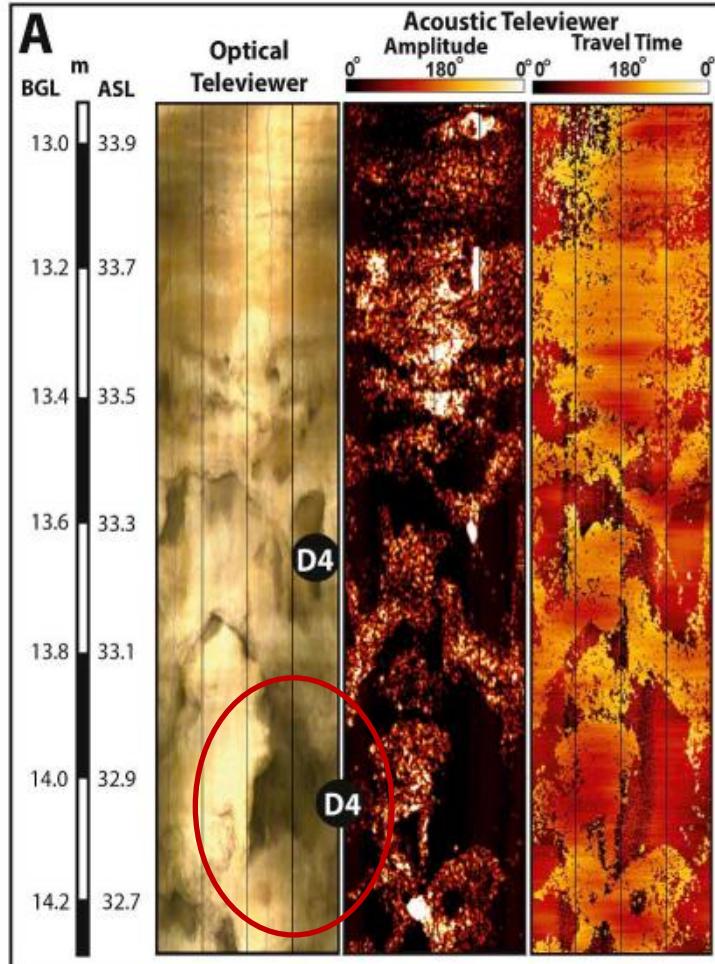


→ Medici et al. 2019
Env. Sci. Pollut. Res.

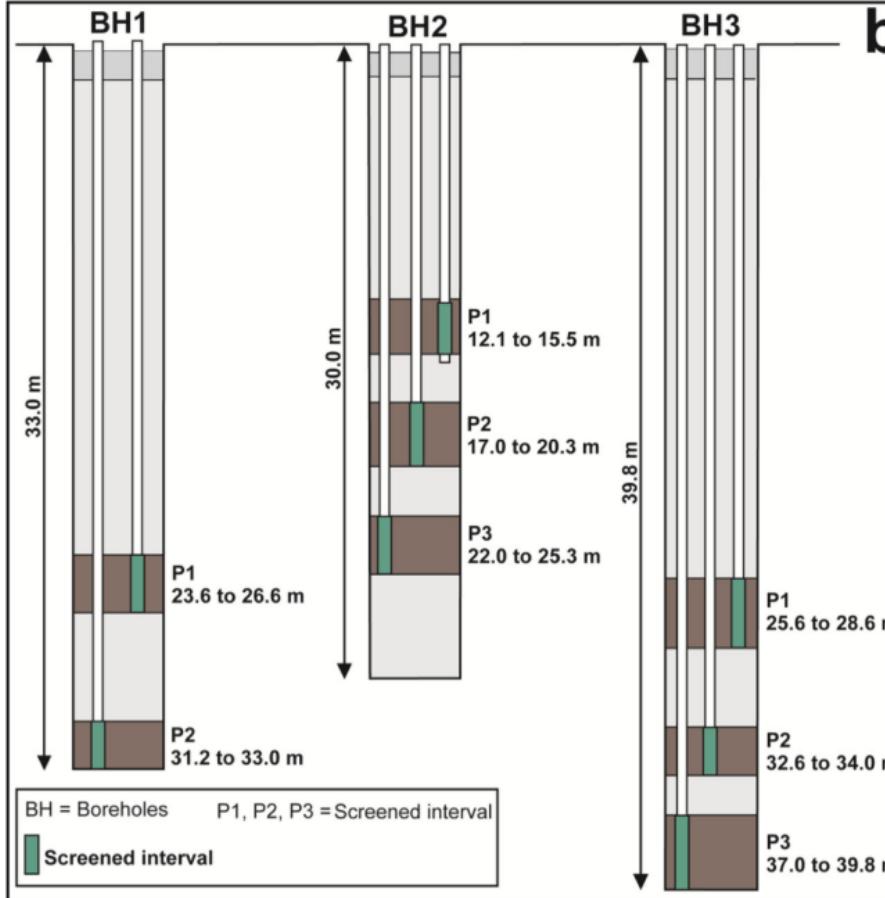
→ Medici et al. 2021
J. Hydrol.

Hydro-geophysical Characterization

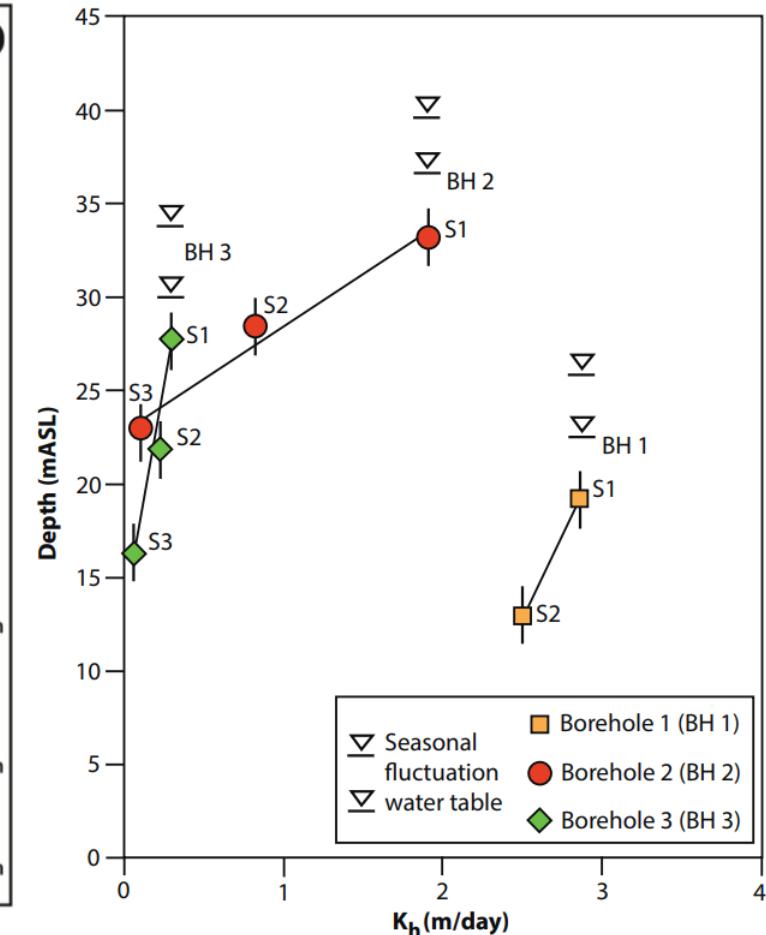
Acoustic Televiewer



MLS

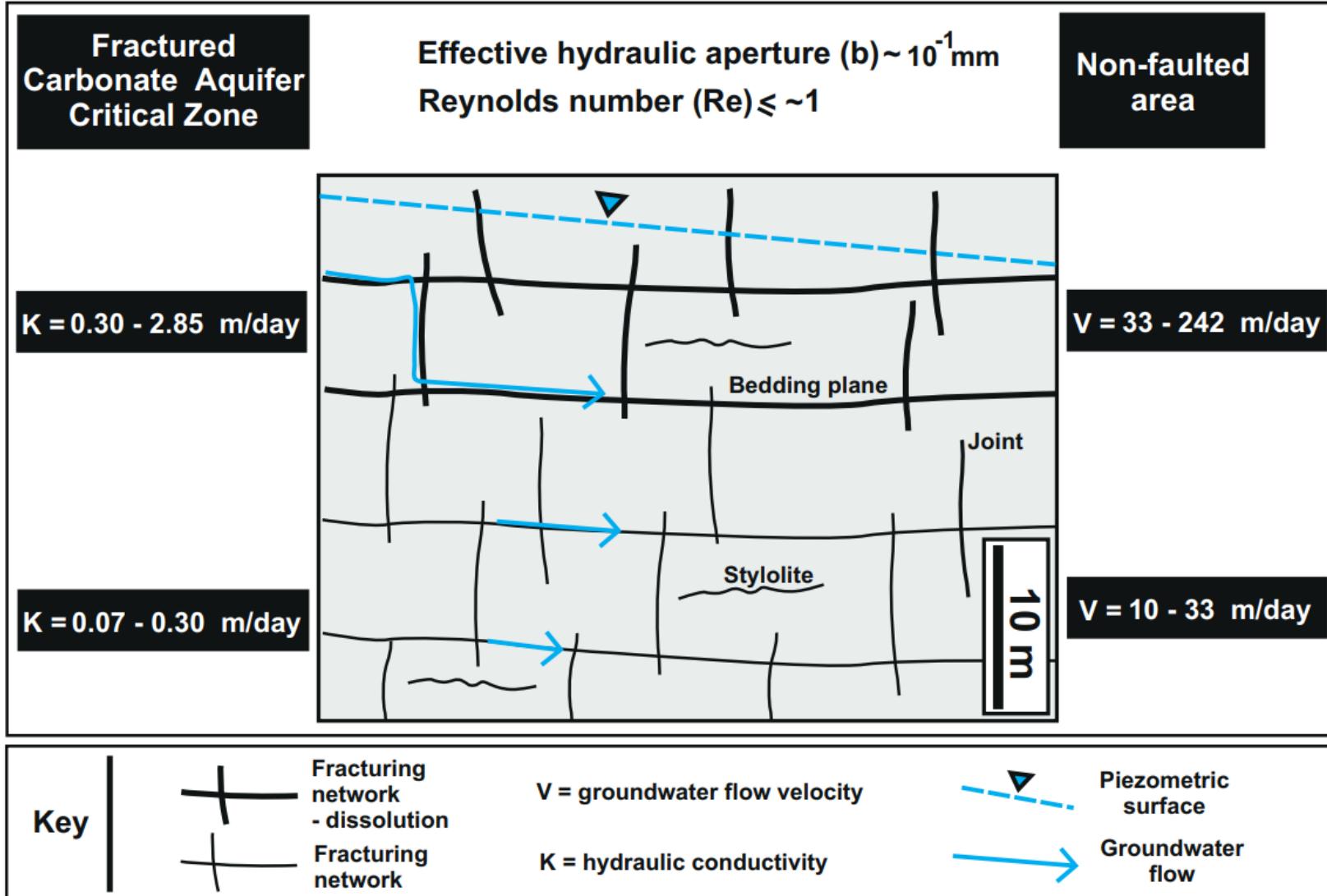


Slug tests



Medici et al. 2019a J. Contam. Hydrol.
Medici et al. 2019b Env. Sci. Polut. Res.

Hydro-geophysical characterization → Output

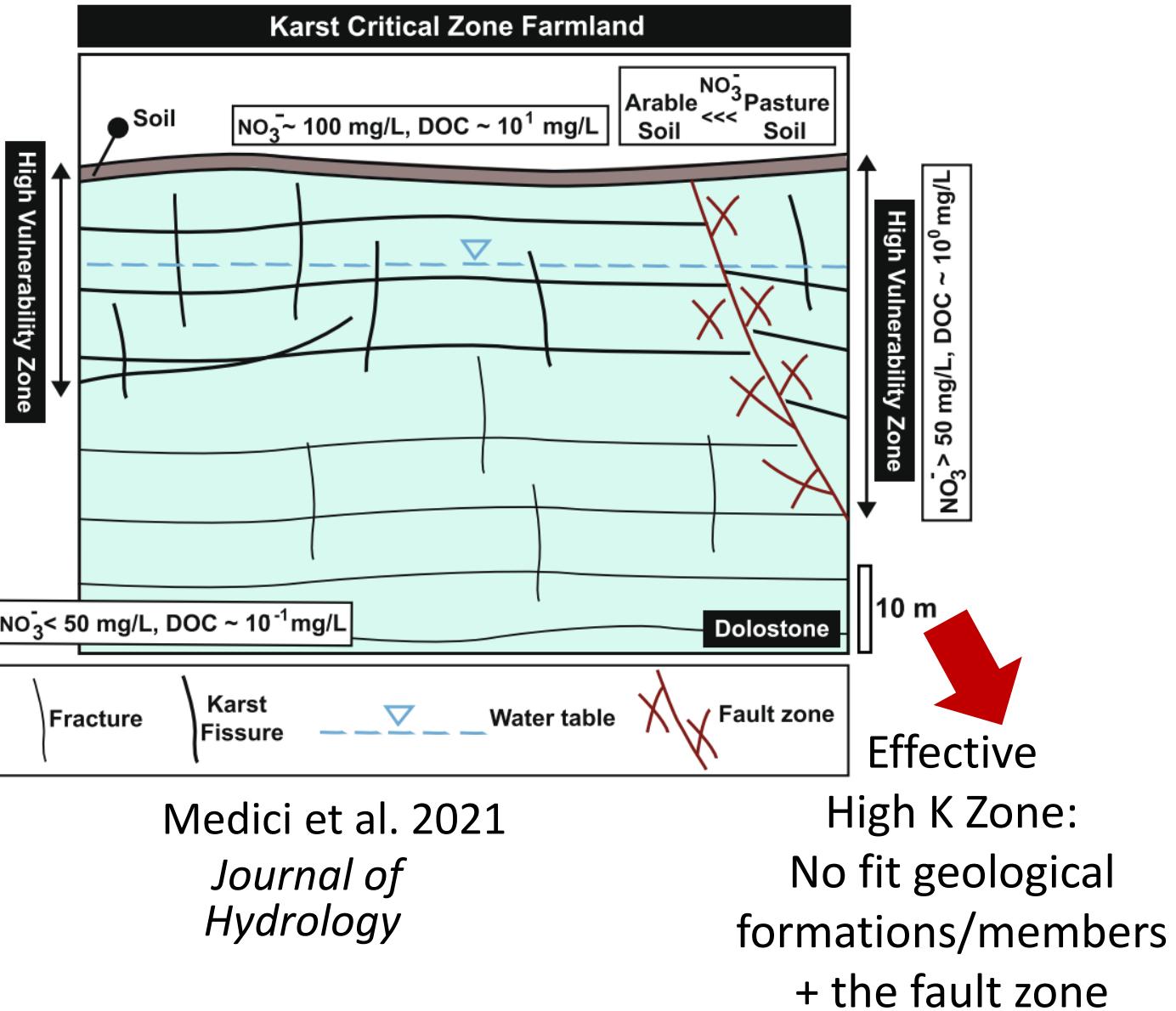
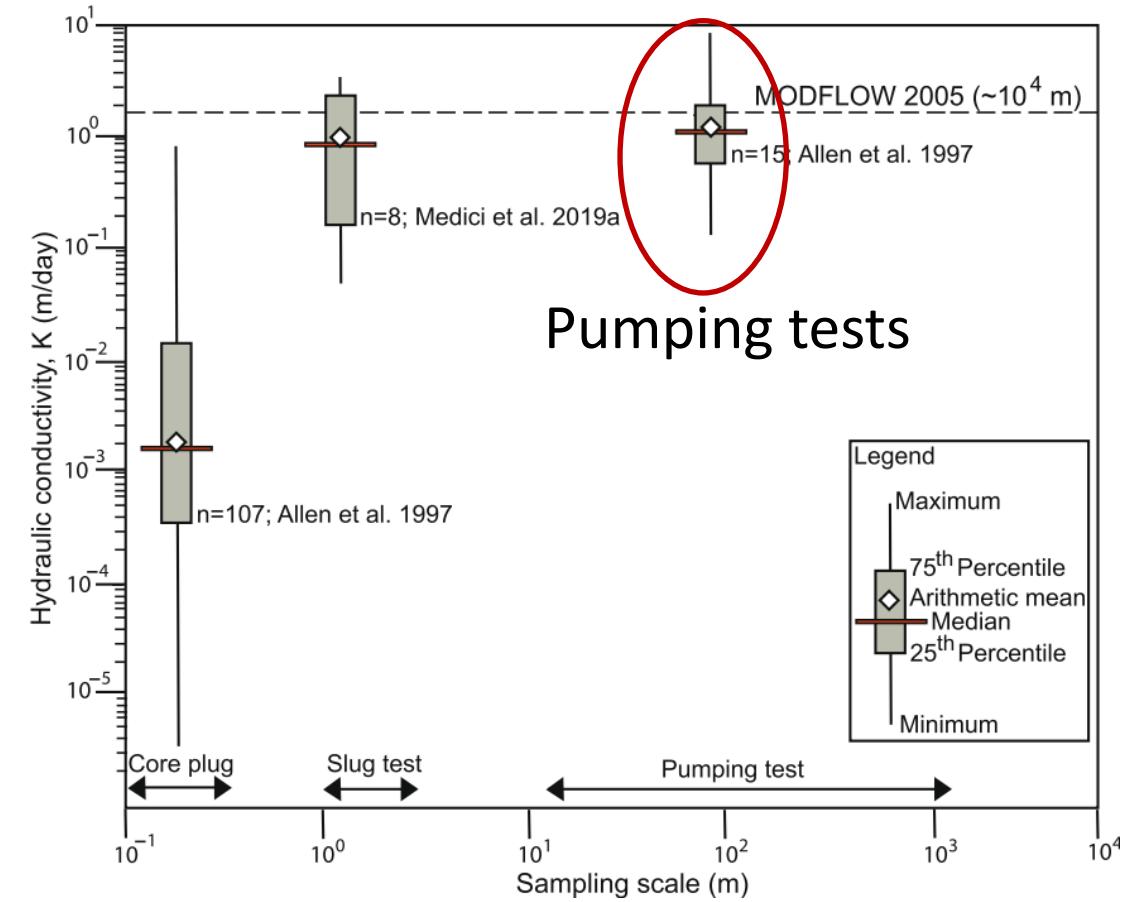


→ Slug tests,
hydraulic monitoring, ATV

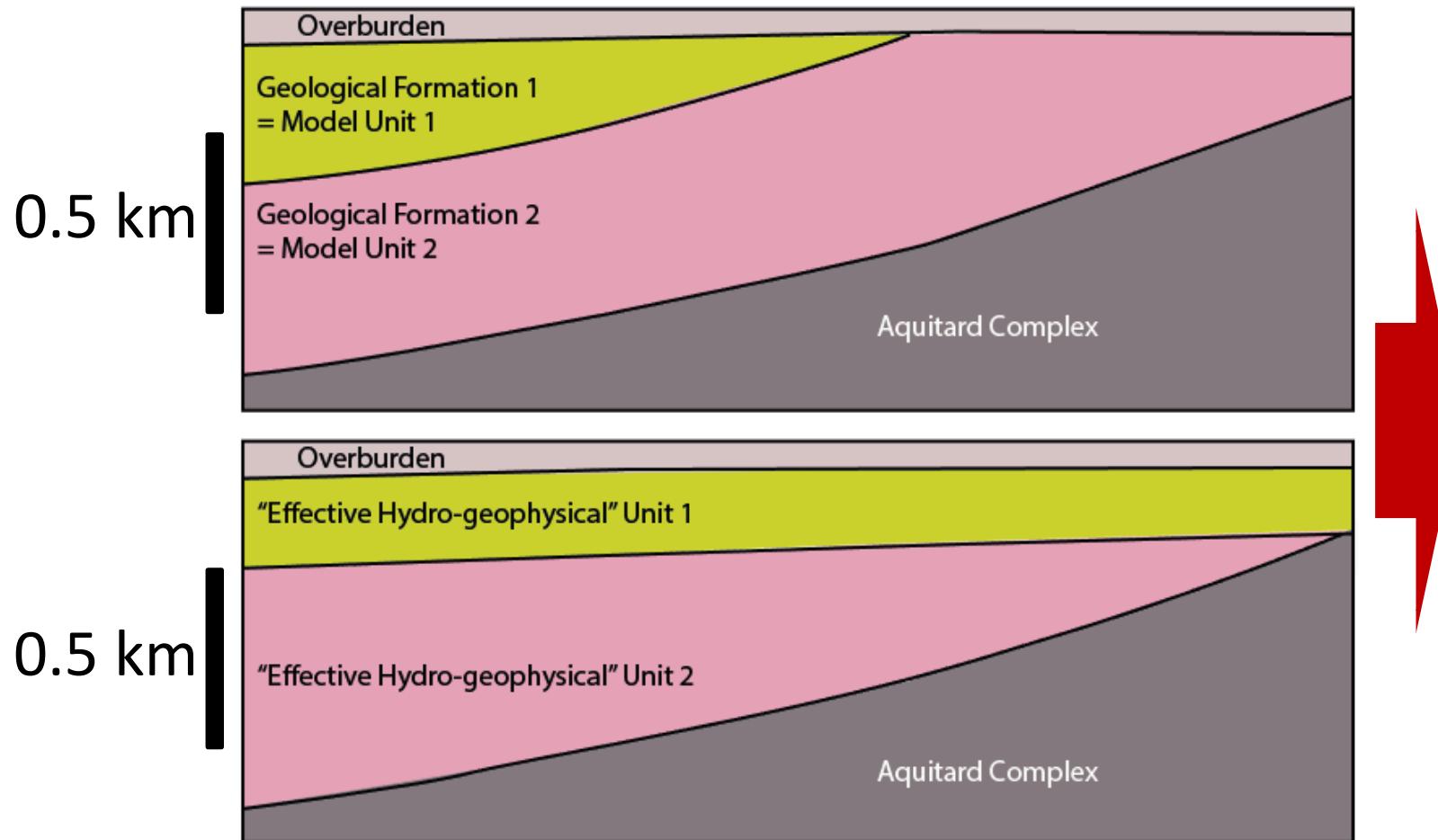
→ First 15 meters below
the water table → High K
and flow velocity

Medici et al. 2019
J. Contam. Hydrol.

Pumping tests and fault zones



Preliminary Summary

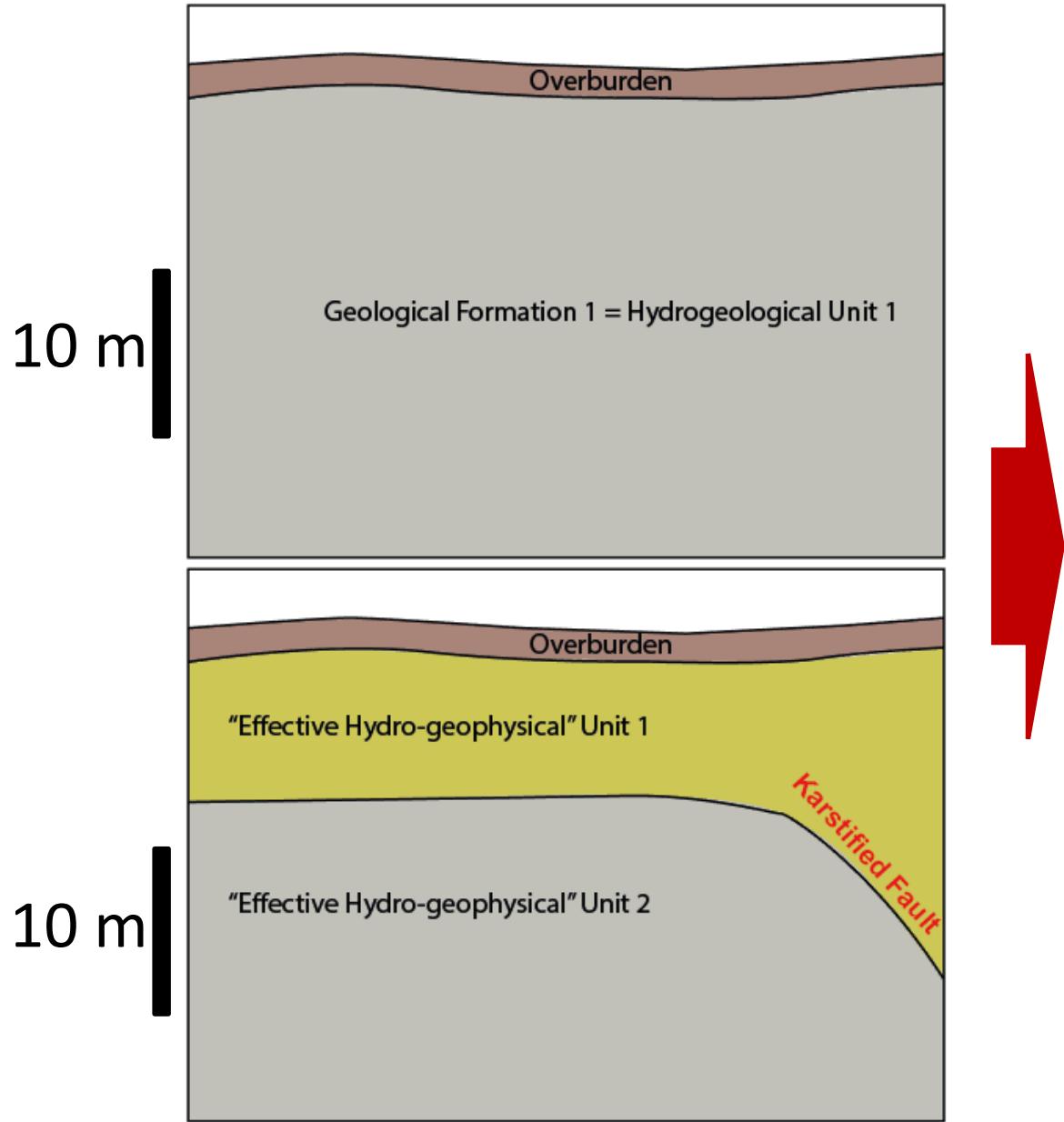


Triassic Sandstone, UK

Need to determine
the “effective
hydro-stratigraphy”

→ The litho-stratigraphy
seems not useful at the
hierarchy scale of
the geological formation

Preliminary Summary

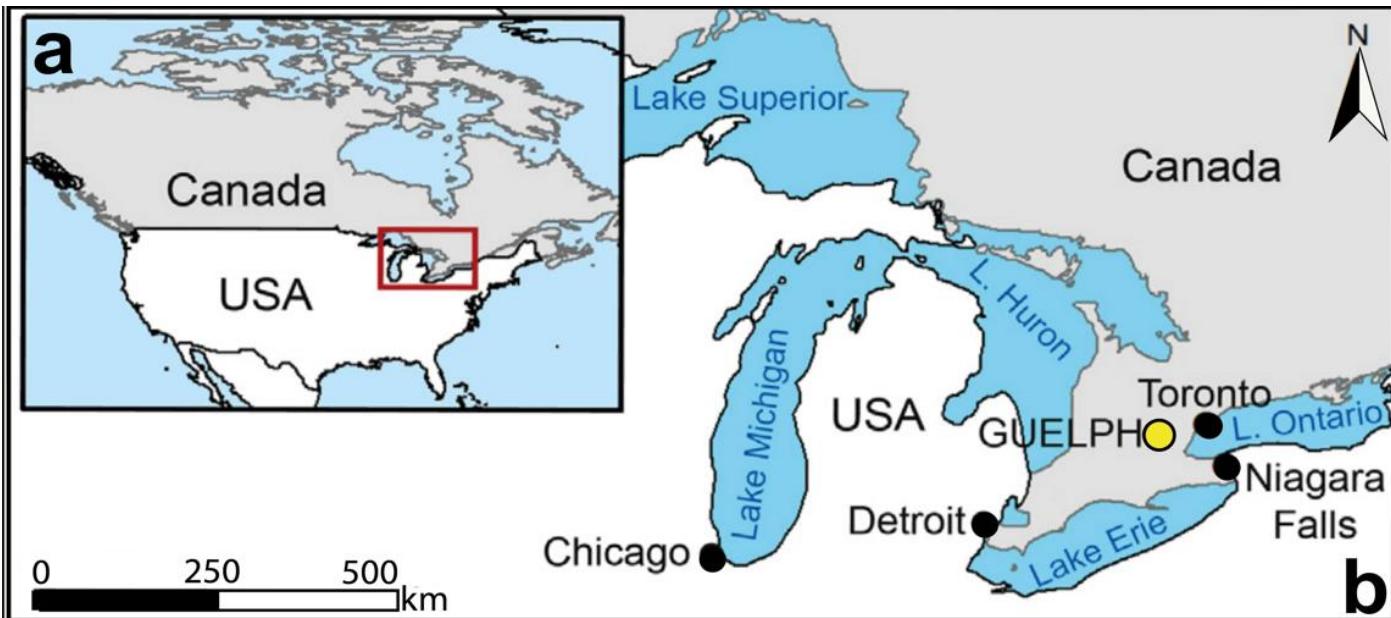


Need to determine
the “effective
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→ The litho-stratigraphy
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hierarchy scale of
the geological formation

Permian Dolostone, UK

Ontarian Silurian Dolostone Lockport Group

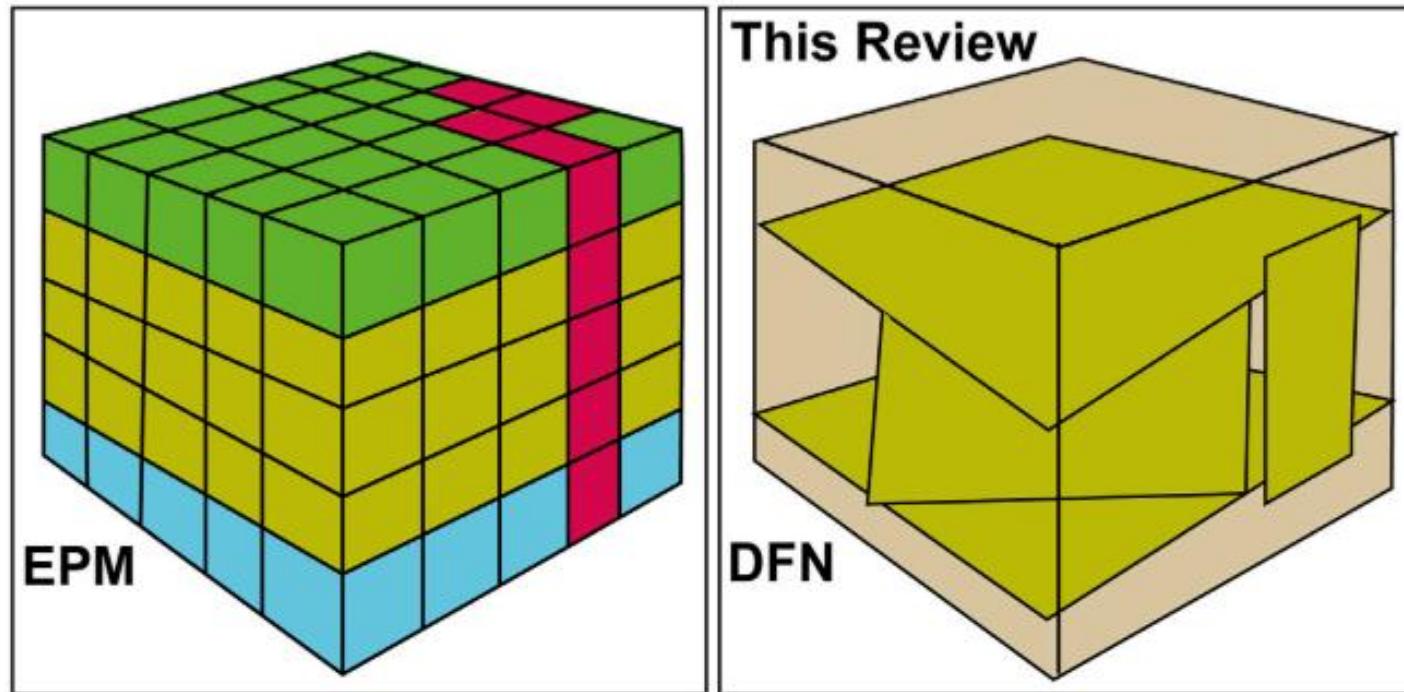


- 4 geological formations
- 7 members
- Vinemount Member “assumed” aquitard made of marls

Revised Early Silurian Stratigraphy – Niagara Escarpment			
	Lithology	Formation	Member
Lockport Group	[Orange wavy pattern]	Guelph	Hanlon
	[Orange wavy pattern]		Wellington
	[Dark grey horizontal lines]	Eramosa	Stone Road
	[Yellow wavy pattern]		Reformatory Quarry
	[Blue wavy pattern]	Goat Island	Vinemount
	[Blue wavy pattern]	Gasport	Ancaster
	(= upper unit of unsubdivided Amabel Fm)		
Clinton Group	[Blue wavy pattern]	Pekin	Niagara Falls
	[Blue wavy pattern]	Gothic Hill	(= middle unit of unsubdivided Amabel Fm)
	(Lions Head Mbr of former Amabel Fm – extends from Beaver Valley to Bruce Peninsula – controls base of caves & karst = Rochester Fm)		
	[Light blue wavy pattern]	Irondequoit	(= basal unit of unsubdivided Amabel Fm)
	[Green wavy pattern]	Rockway	
	[Red wavy pattern]	Merriton	(= upper Fossil Hill Fm)
	[Green wavy pattern]	Cabot Head	

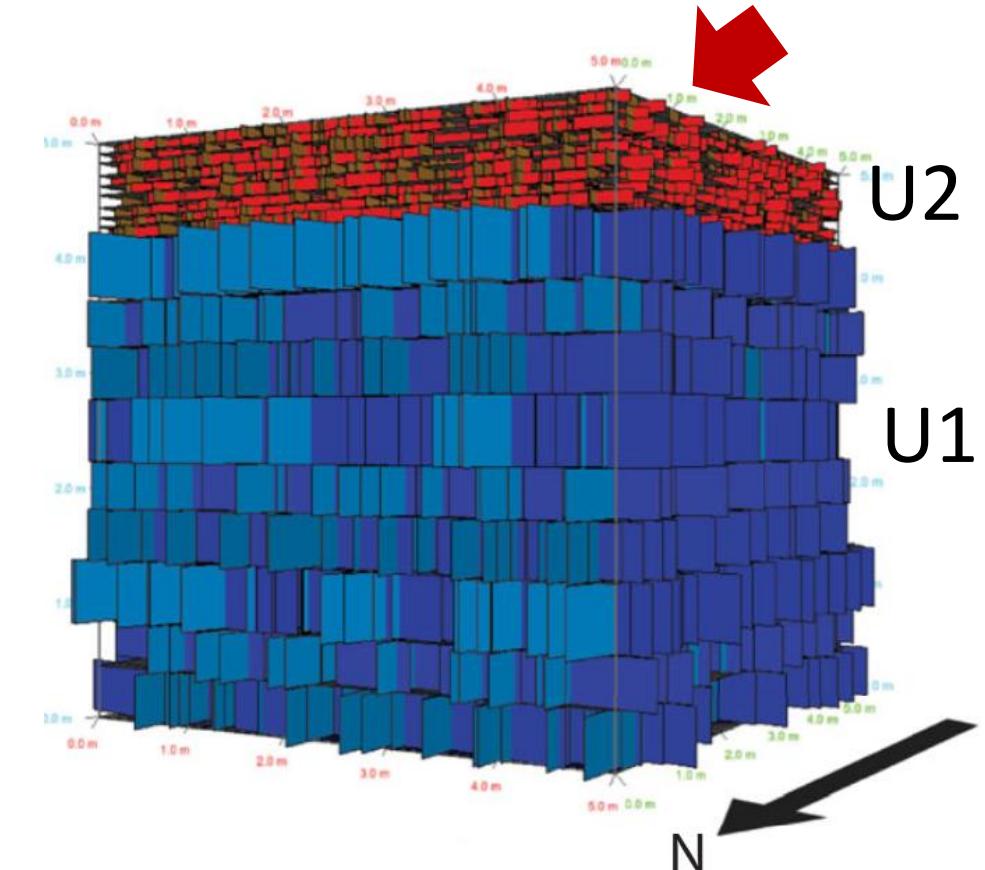
(modified from Brunton 2009; Brunton et al. 2012)

Lithostartography vs. mechanical units vs. hydraulic units



Medici et al. 2023
Front. Earth. Sci.

Ancaster Member
Goat Island Fm.

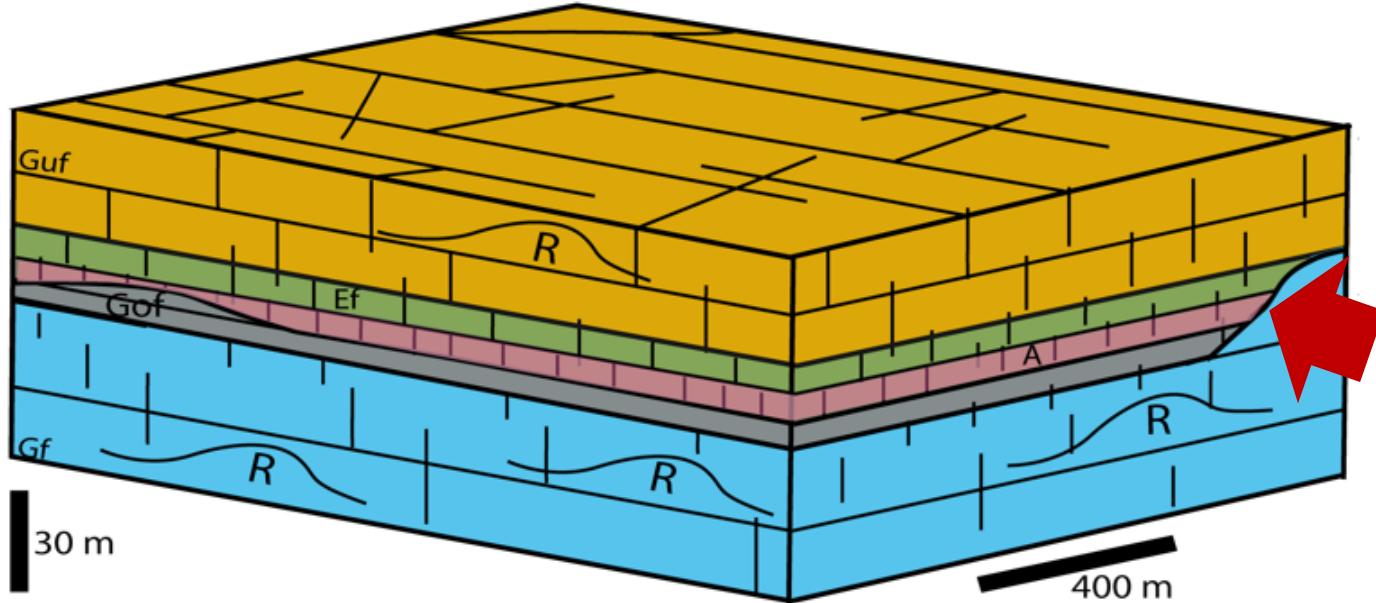


Formenti et al. 2022
Geol. Magaz.

Previous conceptual model → Assumed Aquitrad (A) → Vinemount Member

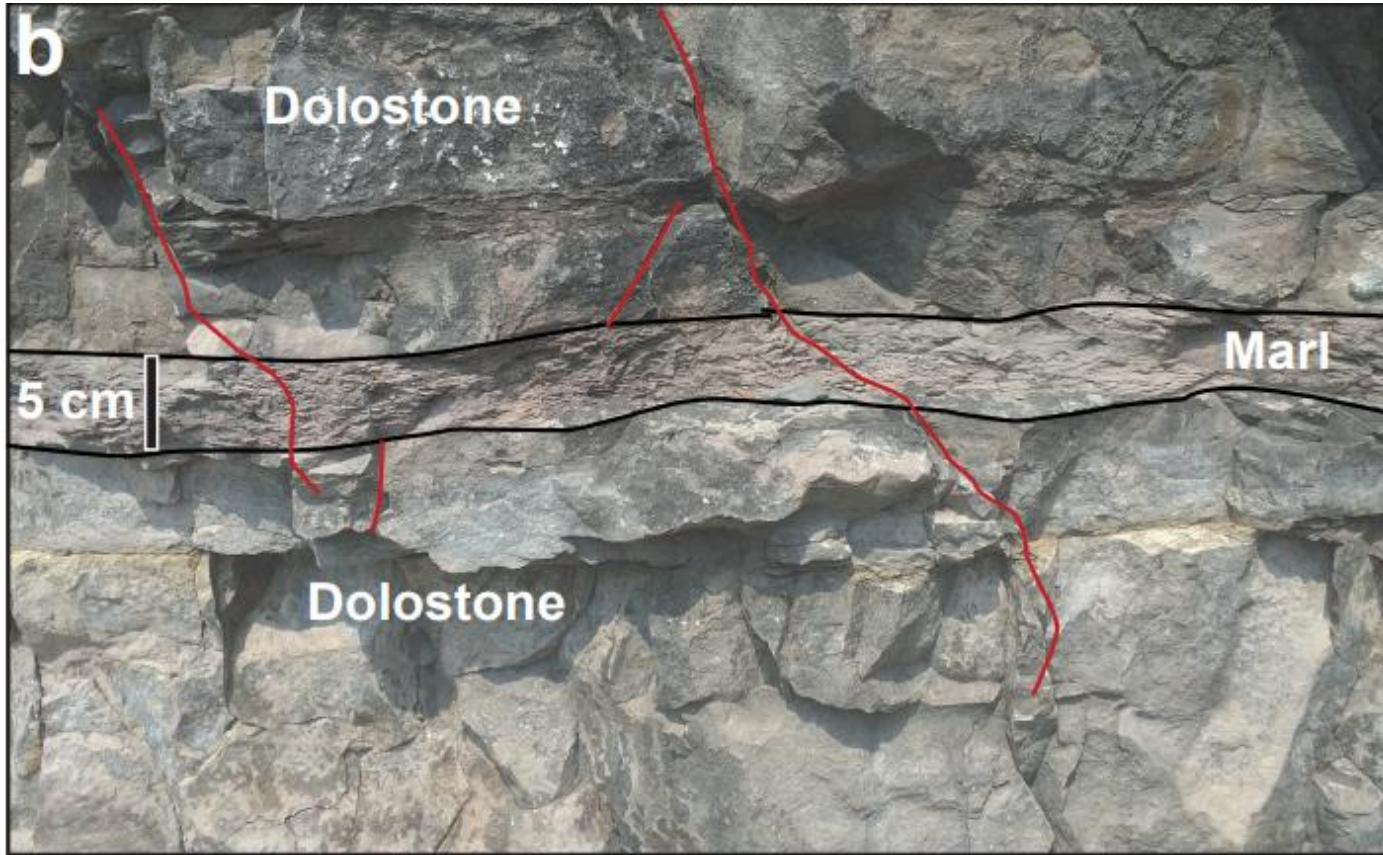
a

Lithostratigraphical approach
cores, pumping tests

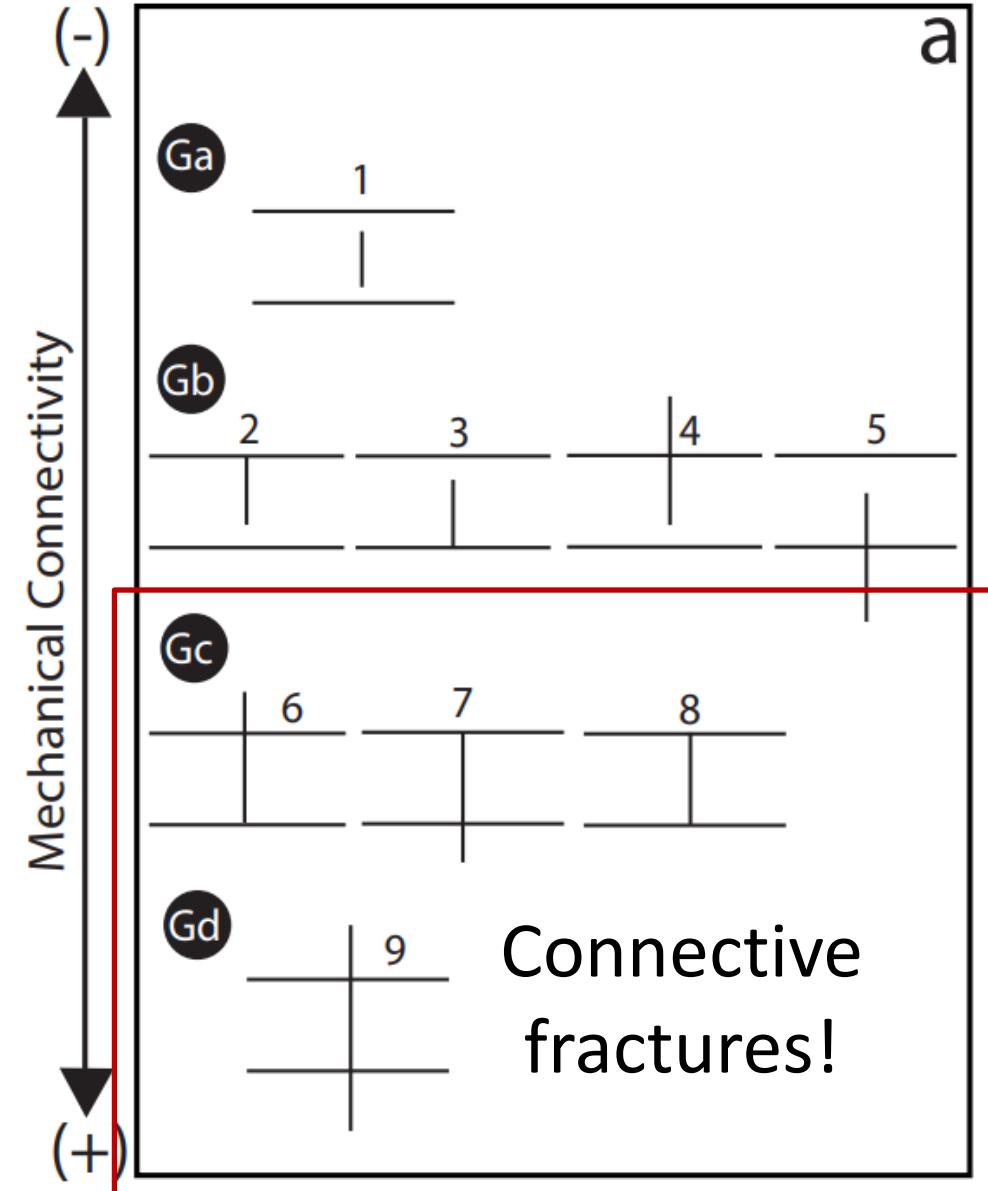


- Vinemount Member
- Marls
- Variation of hydraulic head < 45%

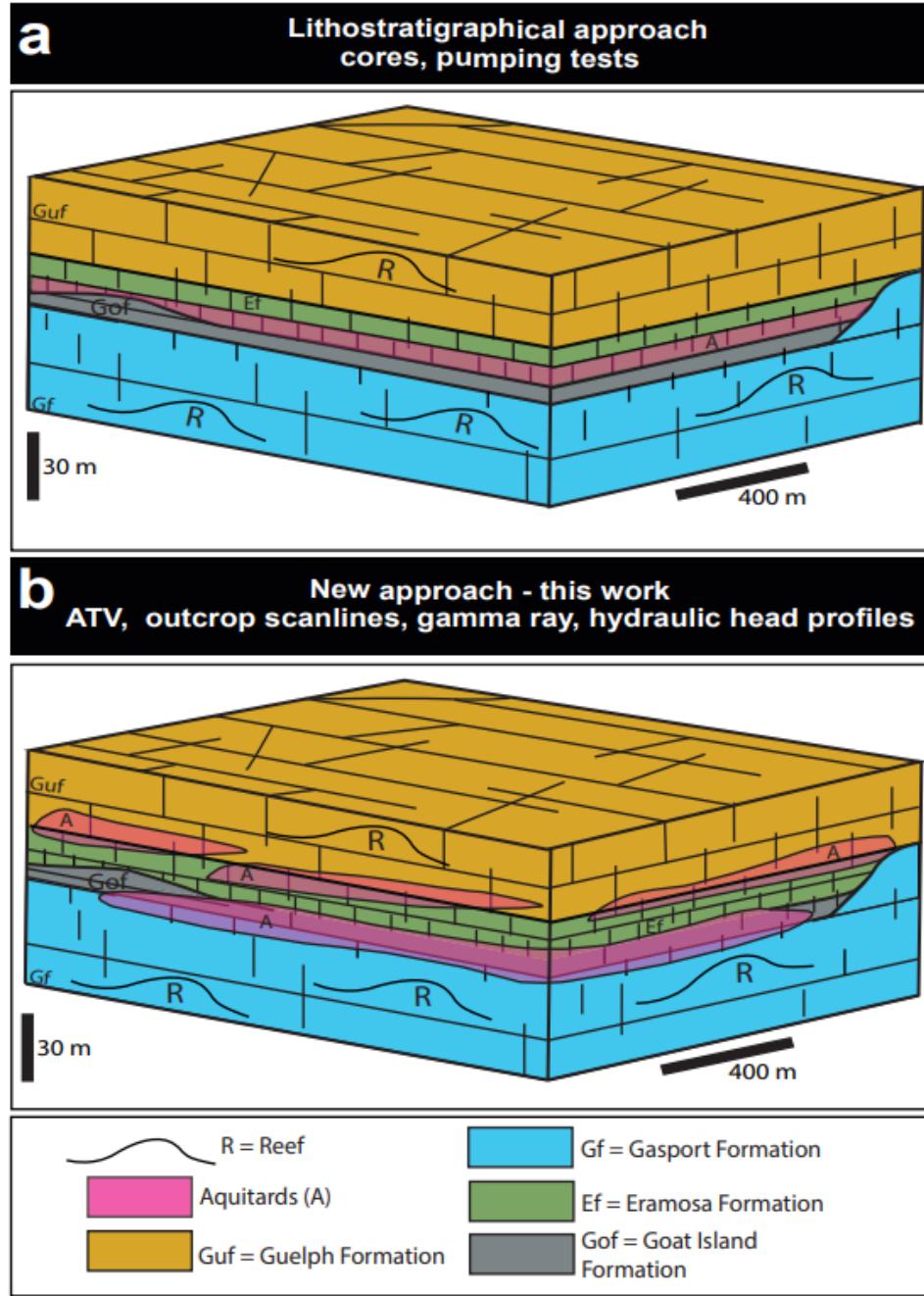
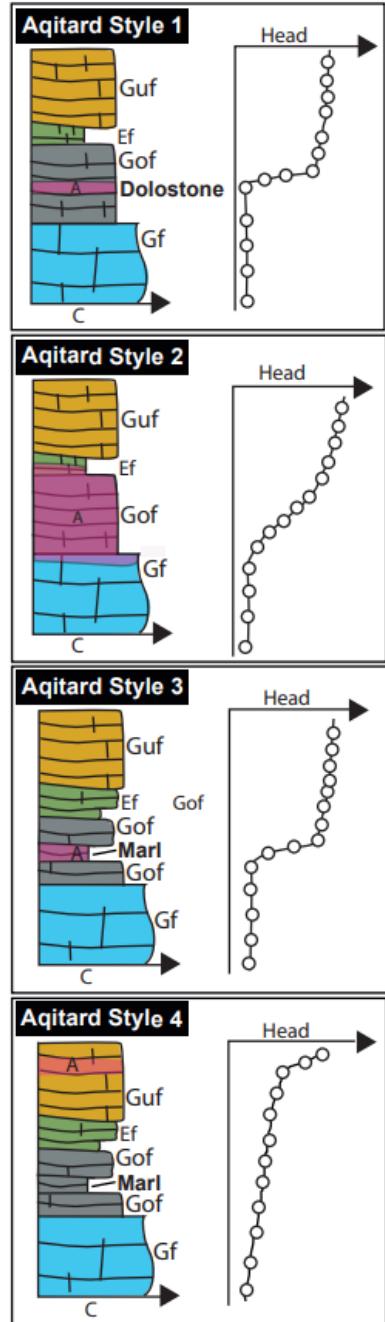
Outcrops in Quarries



Measuring: Dip (i) direction and (ii) angle,
(iii) position, (iv) length, (v) aperture
+ → novel scheme!



Conceptual models

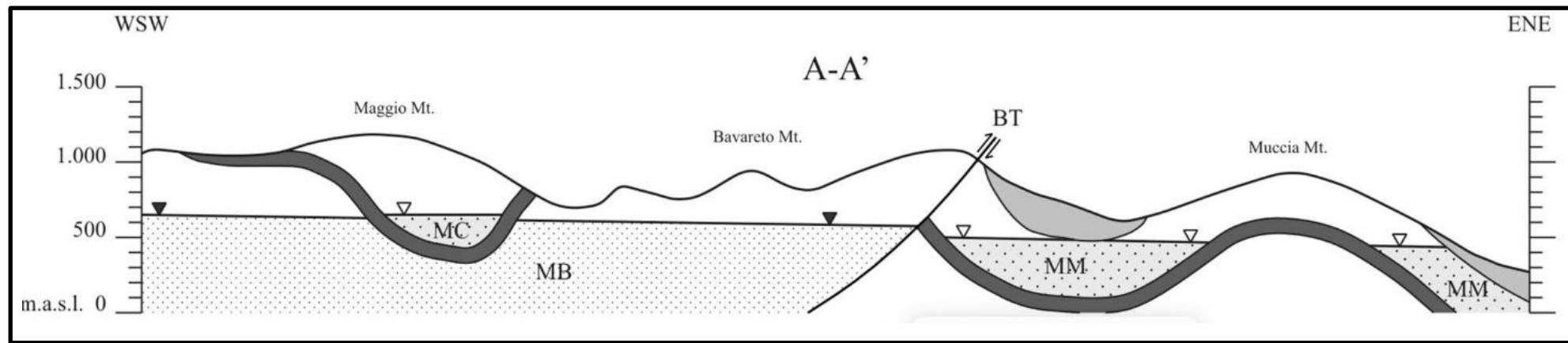


“litho-stratigraphical”
aquitard

Effective
“hydro-geophysical”
aquitard

Conclusions

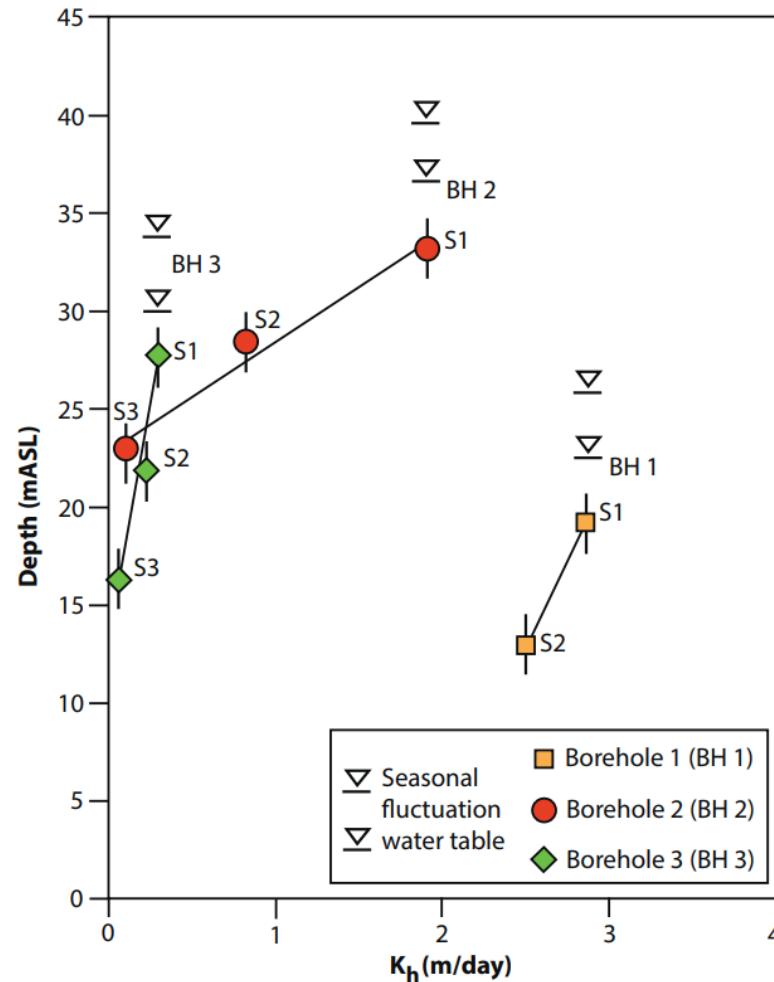
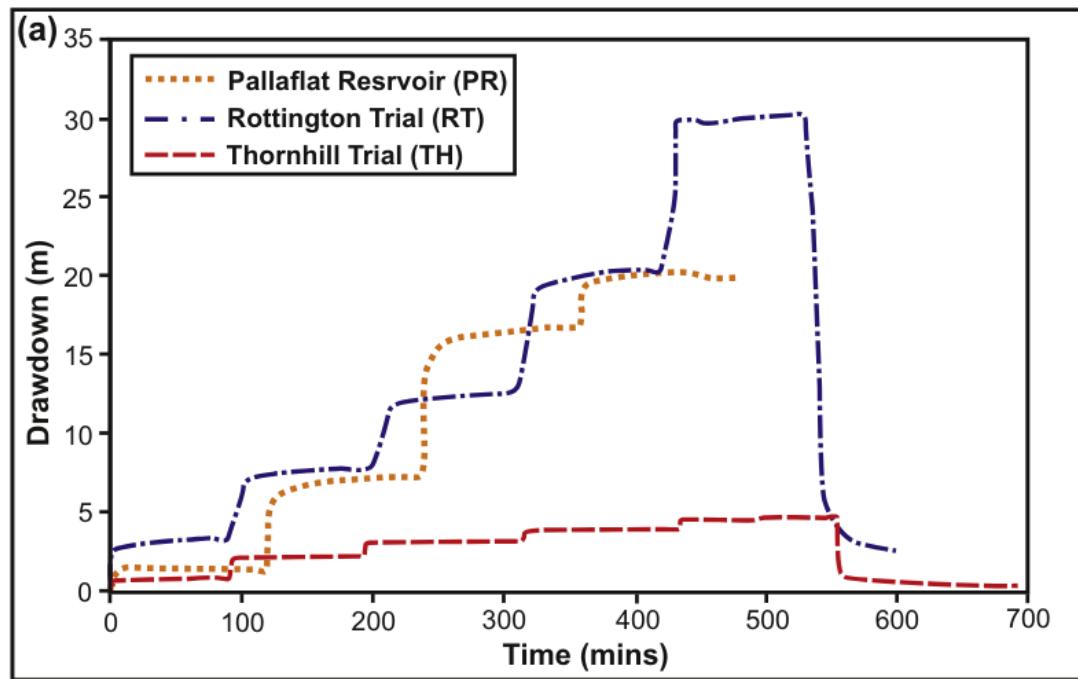
- The use of the lithostratigraphy → Best to do not translate into numerical models (e.g., MODFLOW) → Even in areas not heavily tectonized
- Appennines and Alps are heavily tectonized



Mastrorillo and Petitta 2014, It. J. Geosci.

Conclusions

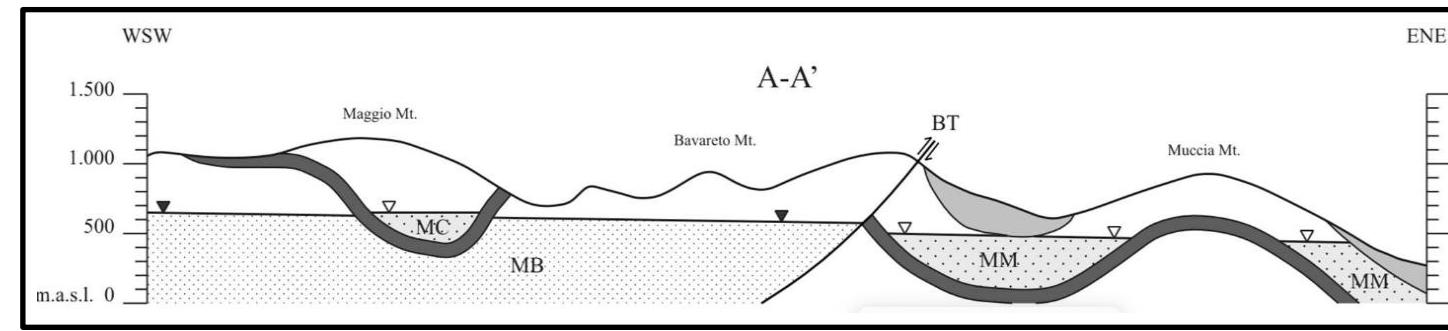
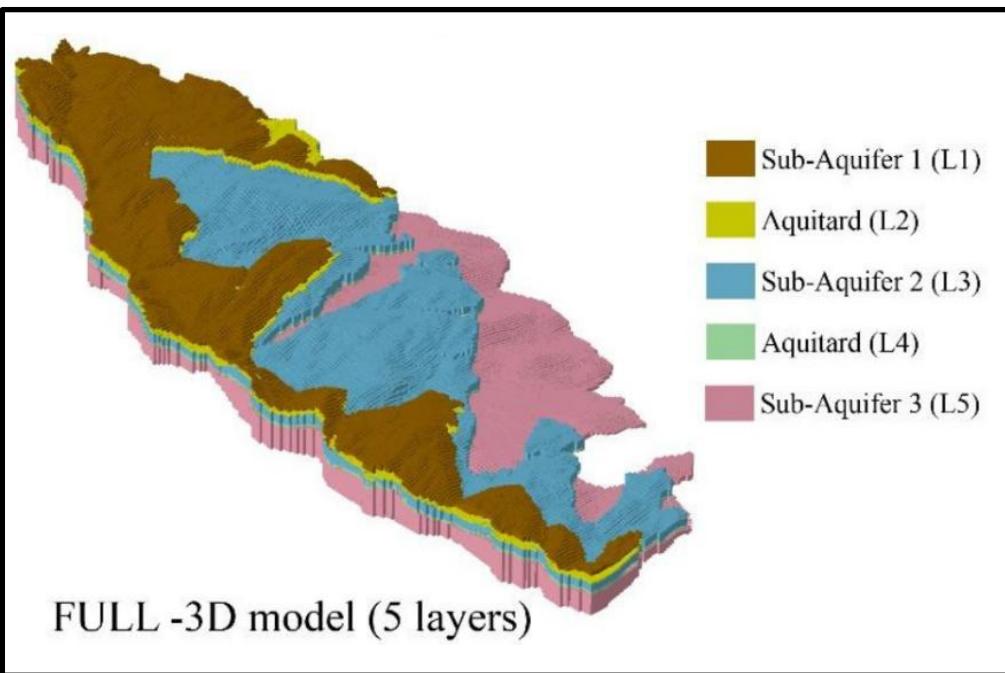
- Support the conceptual models behind numerical models →
Hydraulic testing



Medici et
al. 2016, 2019
J. Contam.
Hydrol.

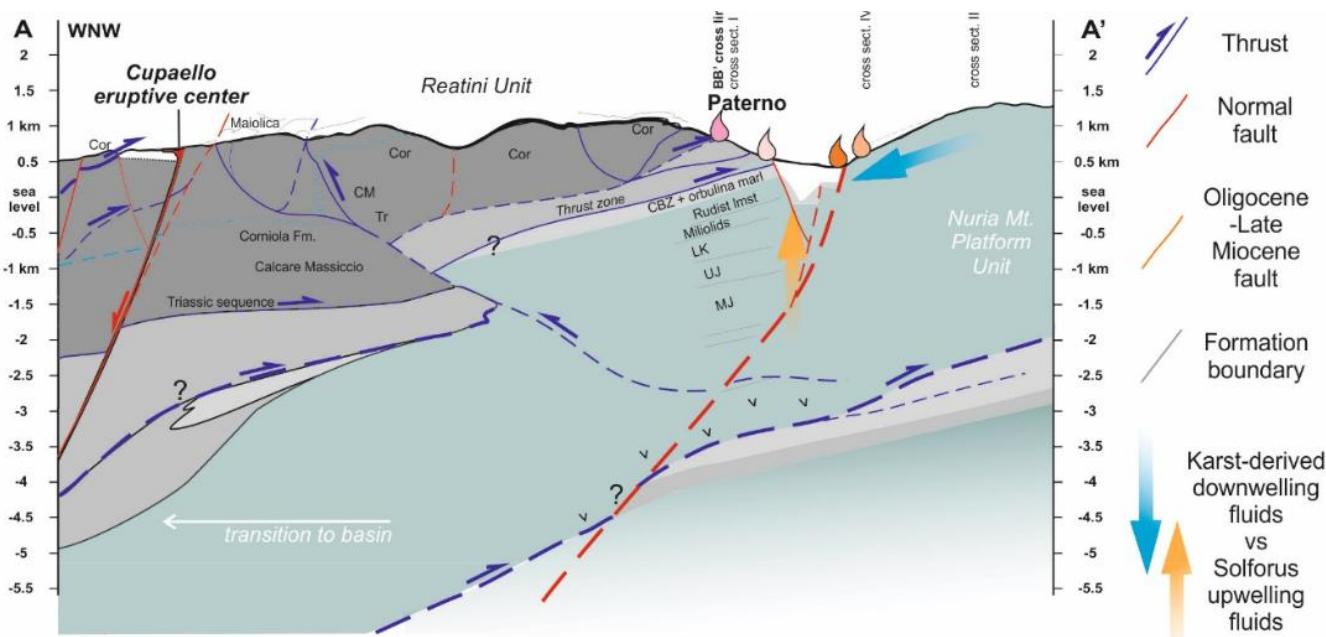
Discussion / shallow aquifers:

- Permeability threshold, 0-150 mBGL?
- Any relationship with the lithostratigraphy?
- How to treat karst in EPM? Neglect because of the REV?



Preziosi et al. al 2021 *Water*
Mastrorillo and Petitta 2014 *It. J. Geosci.*

Carbonates in the appennines organized in lithostratigraphic units



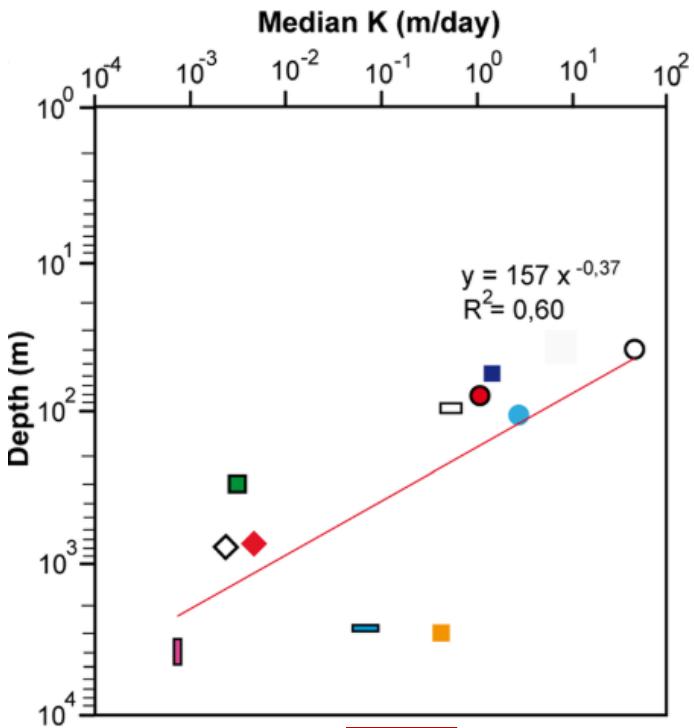
Different hydrochemistry
in the deep aquifers
→ K, threshold???

MODFLOW, EPM

Barberio et al. 2021 Appl. Sci.

**Discussion:
shallow/deep aquifers**

Triassic Sandstone, Great Britain



K, thresholds known
→ no monitoring
EPM models
→ Published in 2006

Medici et al. 2019 Hydrogeol. J.

Thank you for the attention!

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