Evidence of hydraulically active fractures in Champlain Sea clay deposits and their impact on transient groundwater flow dynamics and slope stability.

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Department of Geology and Geological Engineering

Context

Ministère de la Sécurité publique

Groundwater is a key factor in slope stability.

Simplifications :

1) Steady-state conditions.

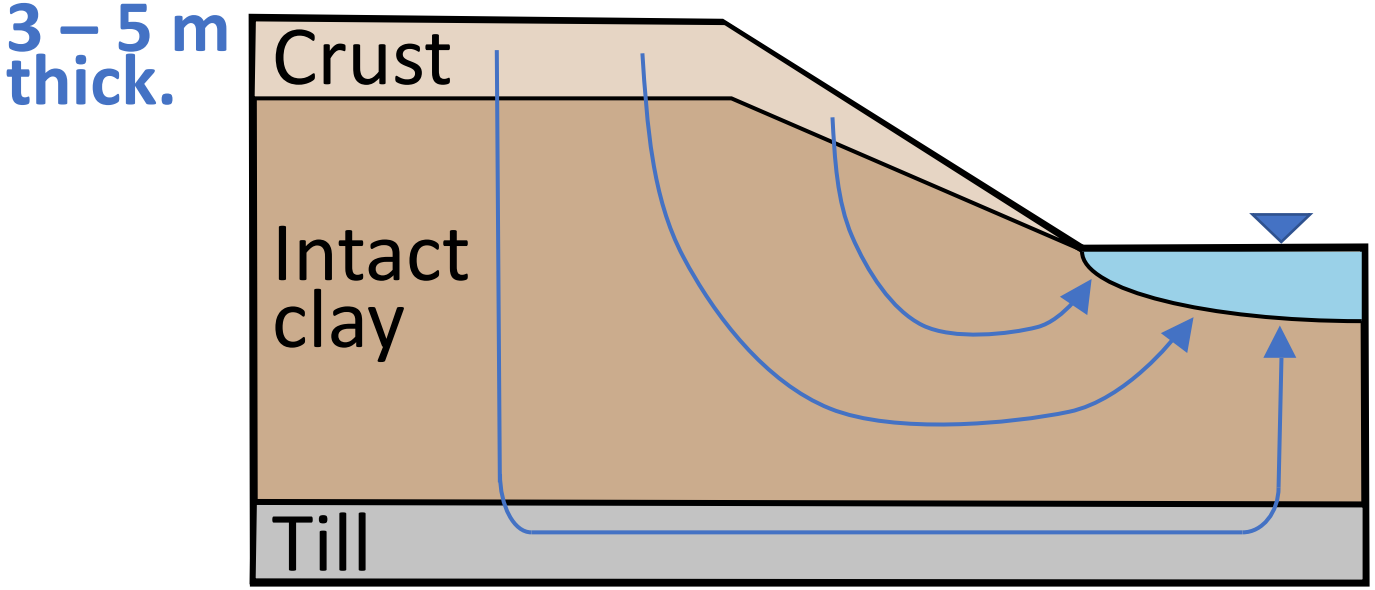
Context

Ministère de la Sécurité publique

Groundwater is a key factor in slope stability.

Simplifications :

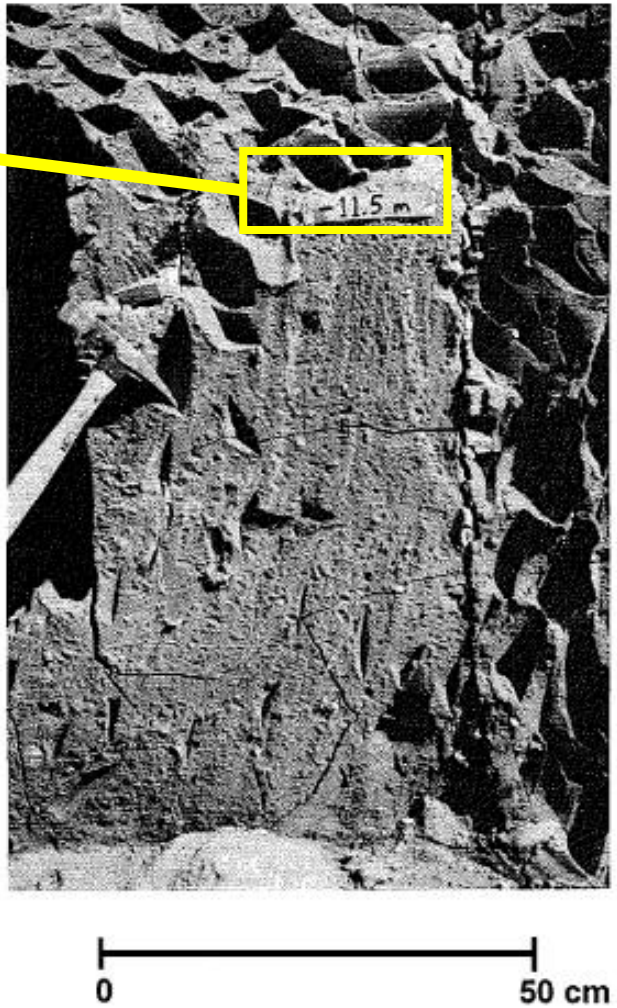
1) Steady-state conditions.
2) Stratigraphy



Context

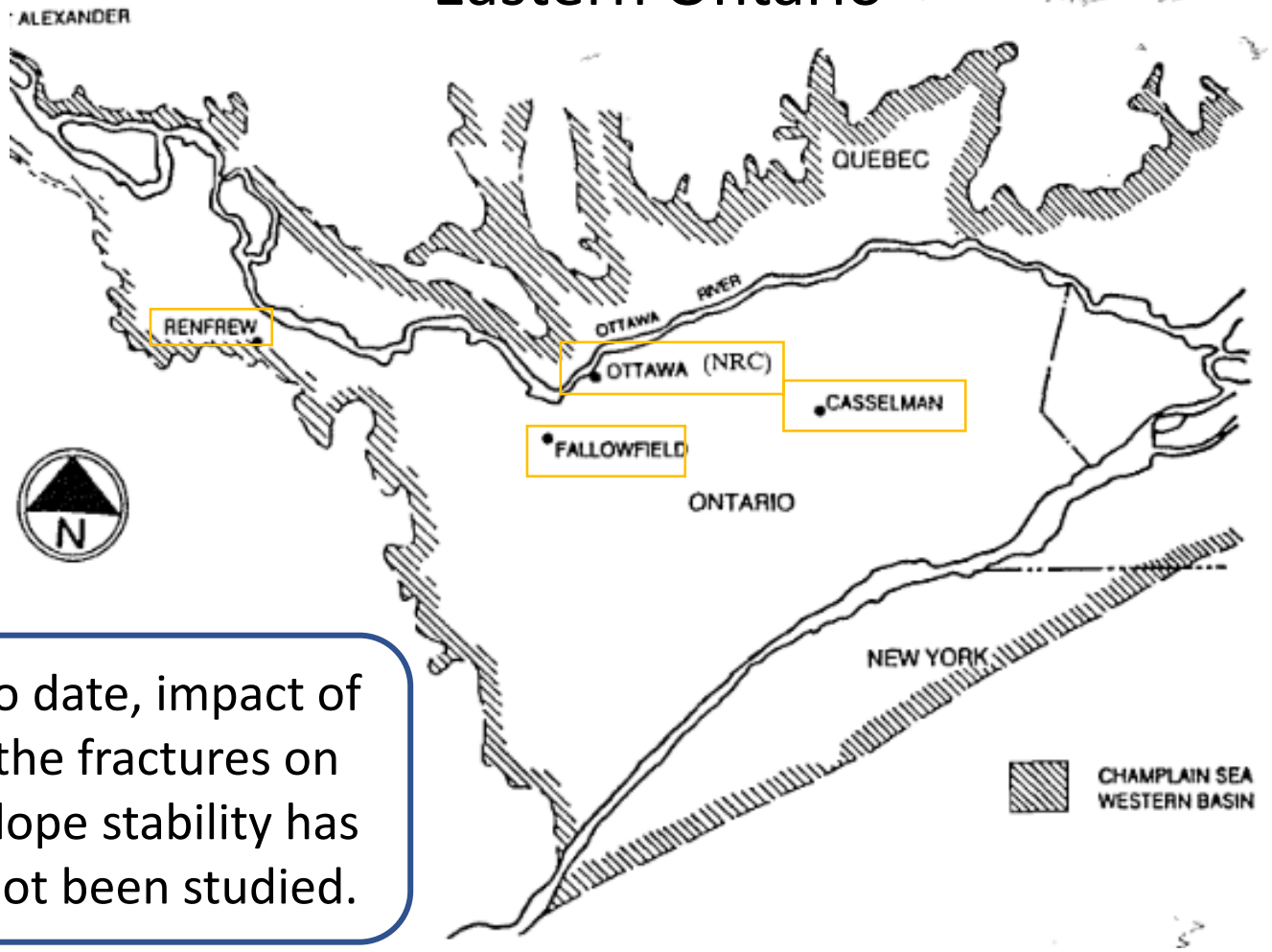
Clay till
Southwestern Ontario

-11.5 m



(Mckay & Fredericia, 1995)

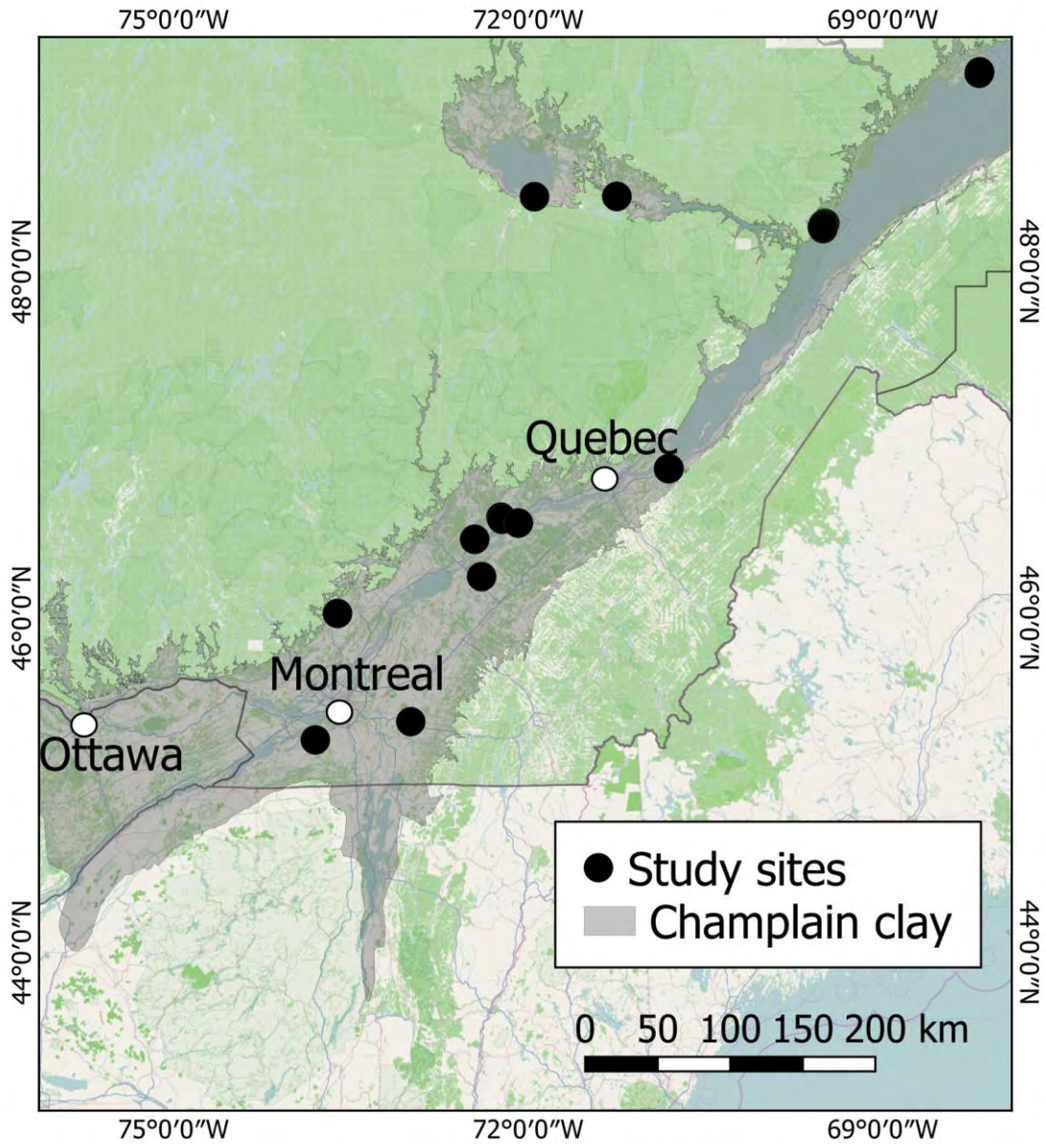
Champlain clay
Eastern Ontario



To date, impact of the fractures on slope stability has not been studied.

(O'Shaughnessy & Garga, 1994)

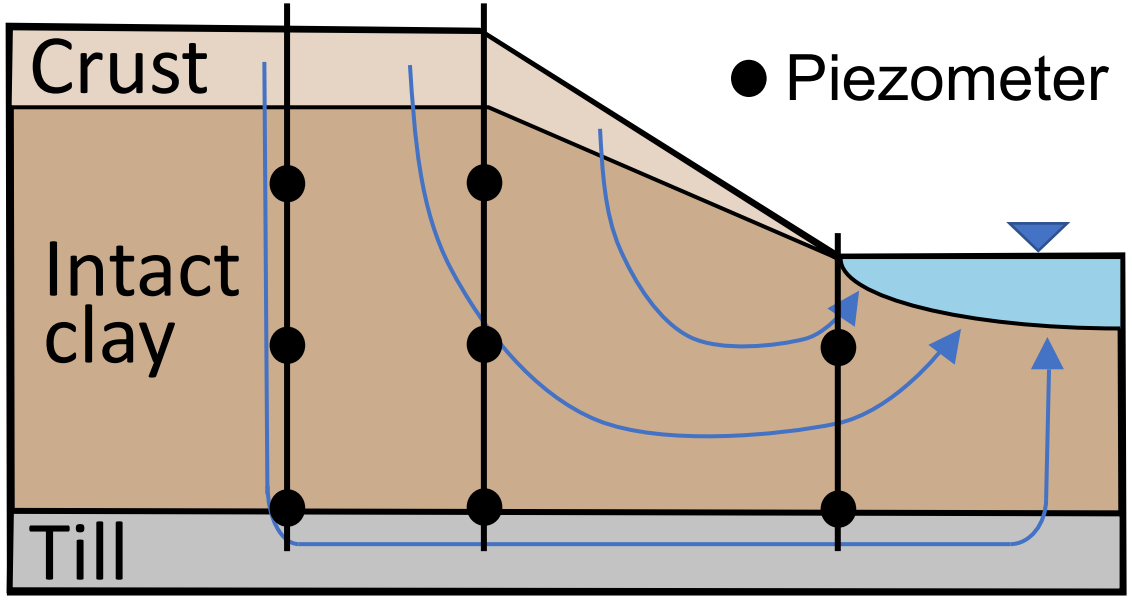
Ground water monitoring network



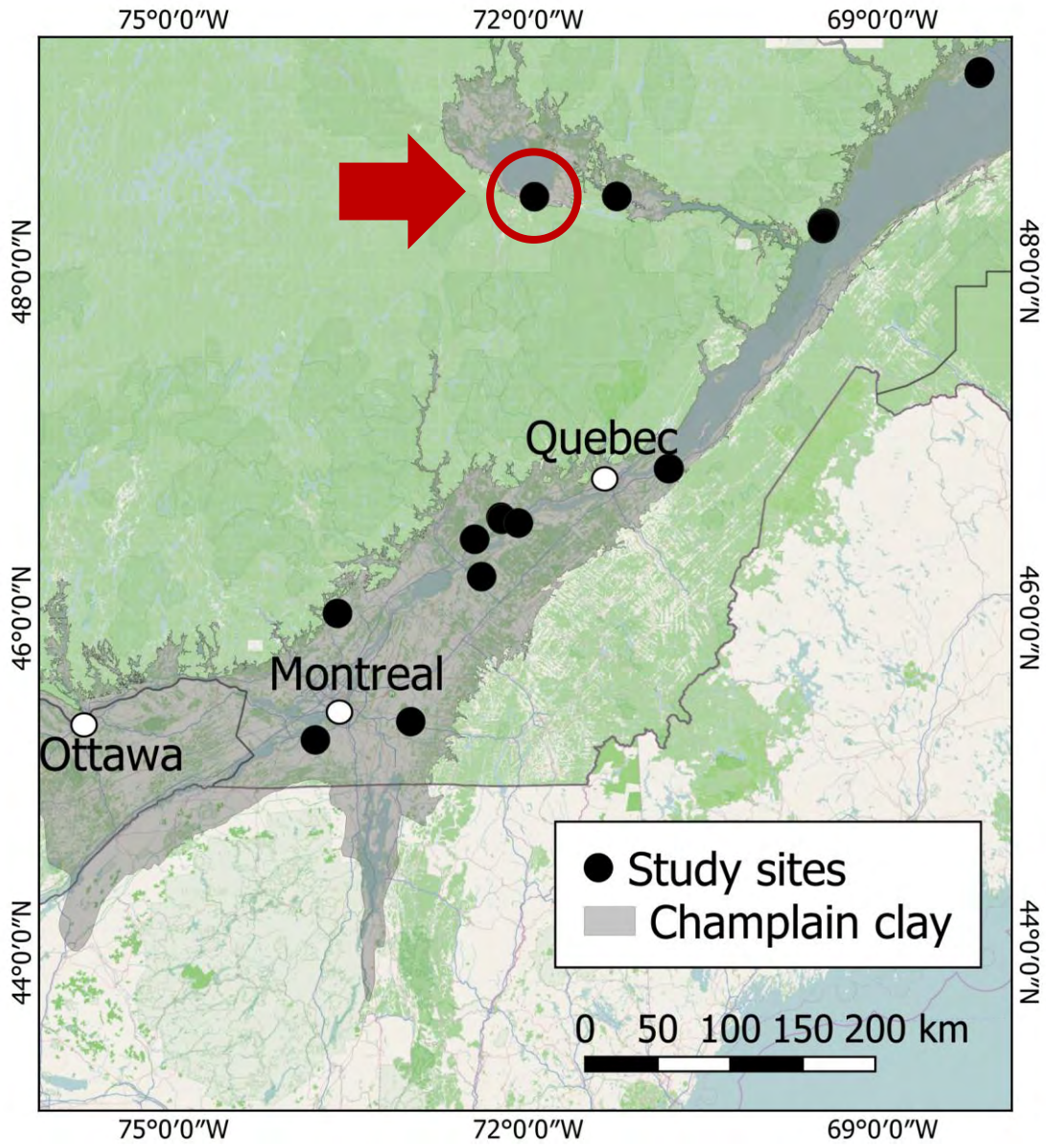
12 monitoring sites

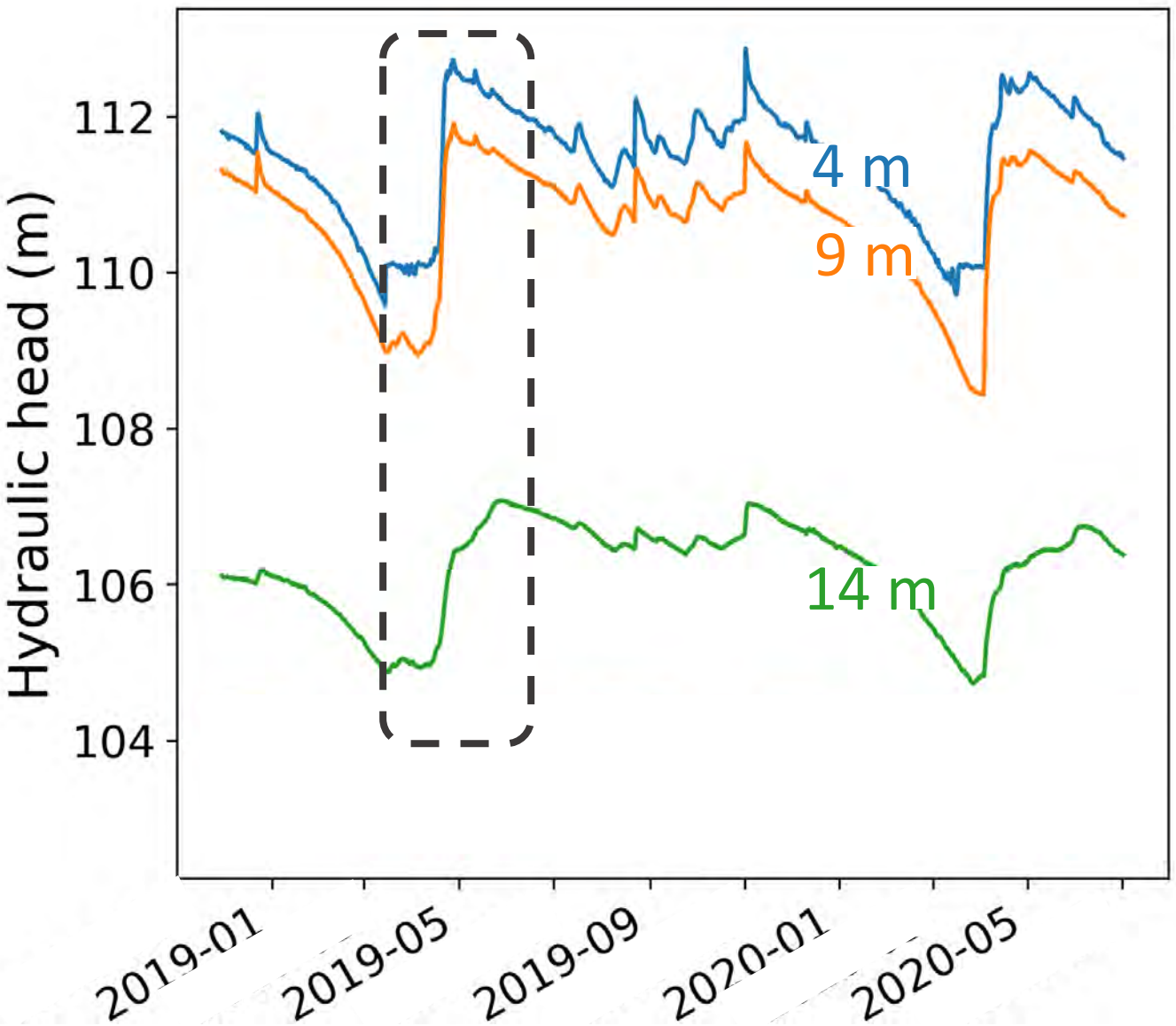
More than 200 piezometers arranged in 45 nests

Study site configuration



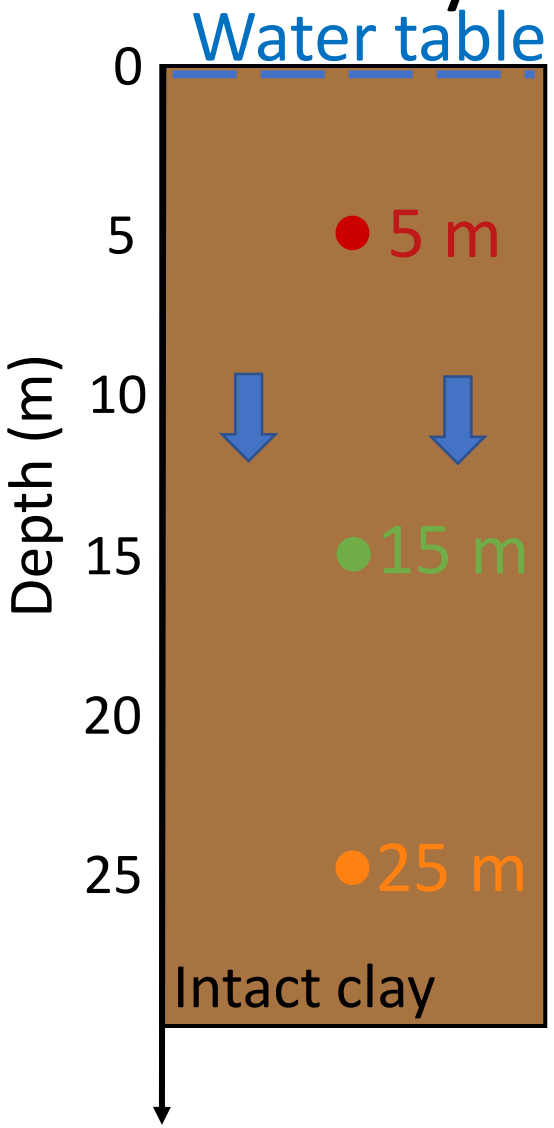
Sign of hydraulically active fractures in a piezometer nest

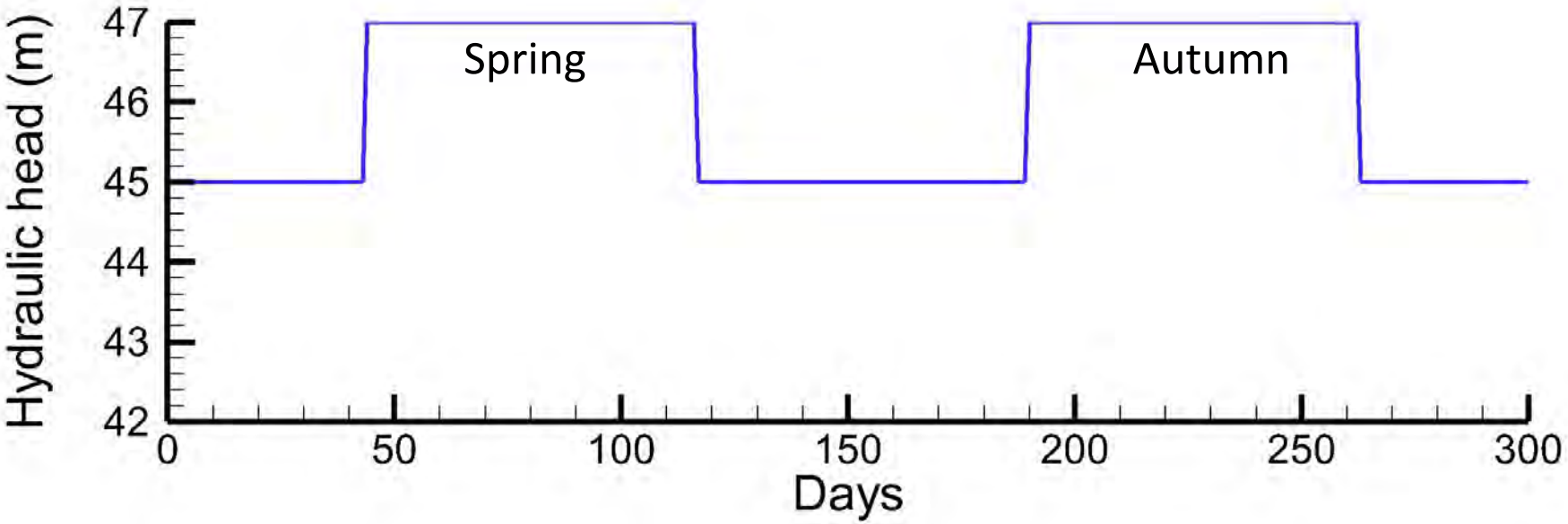


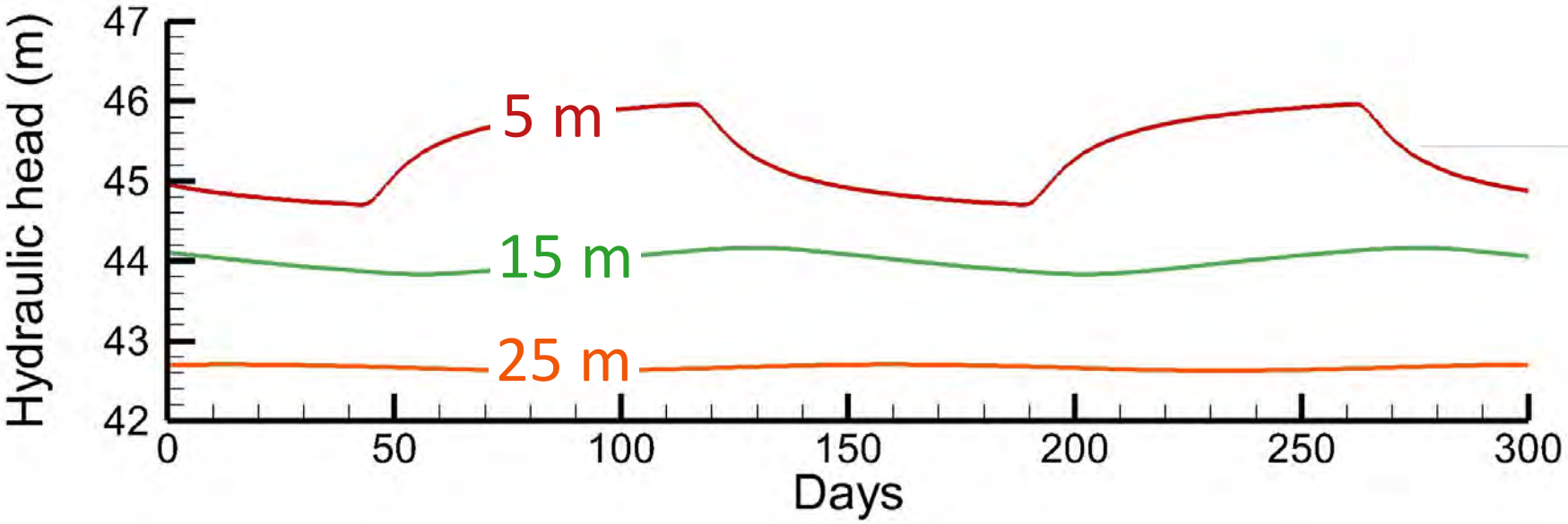


Theoretical behavior

- Intact clay

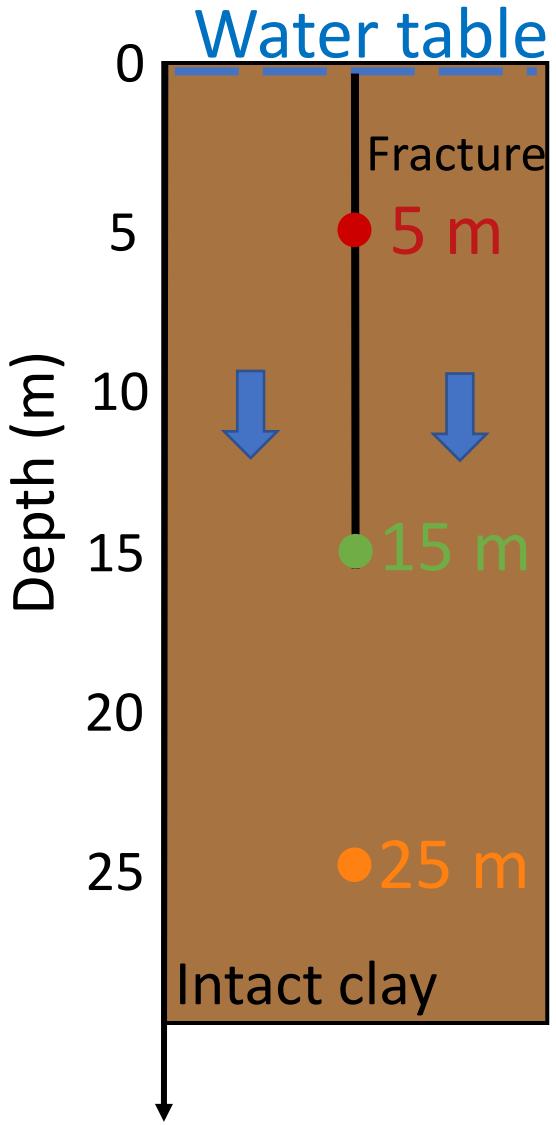


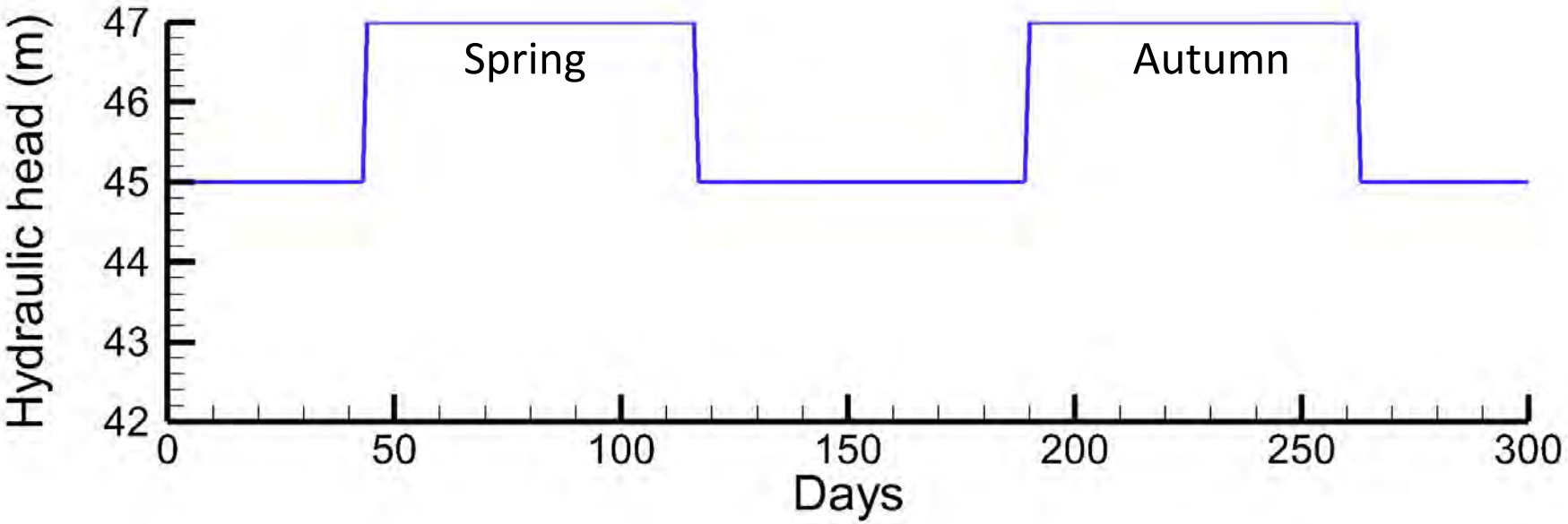


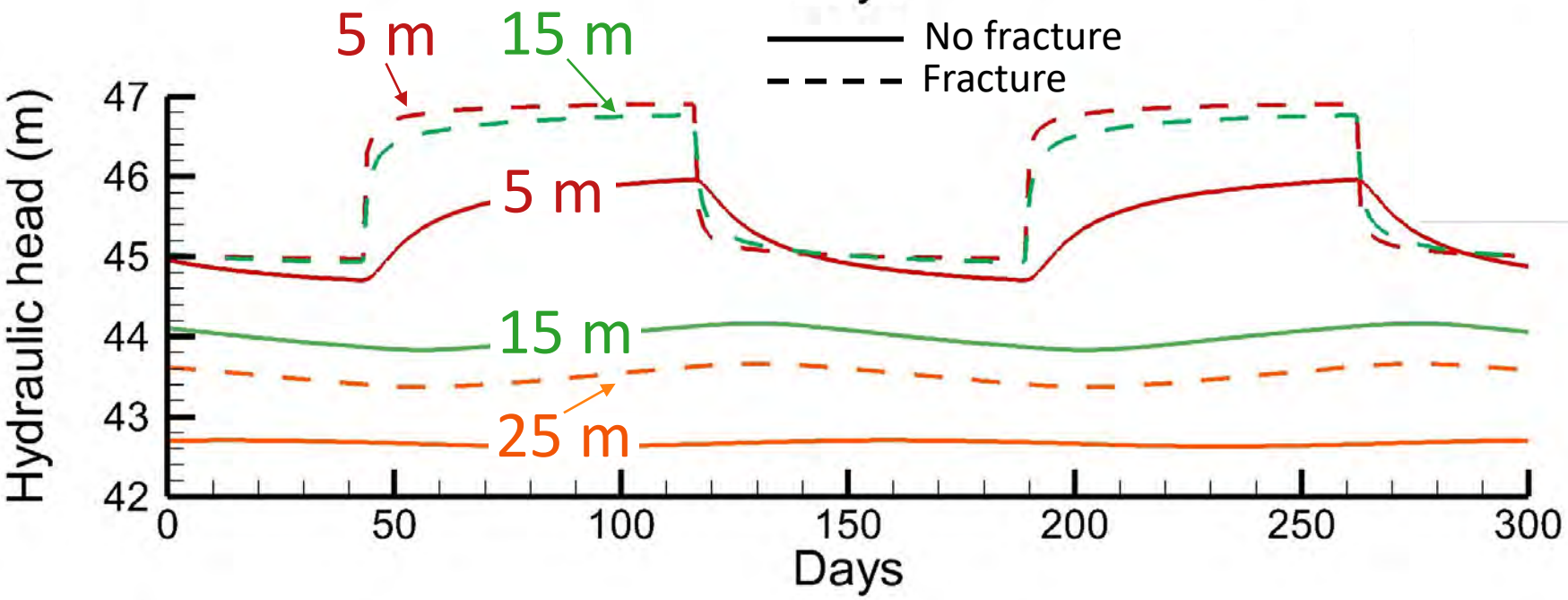


Theoretical behavior

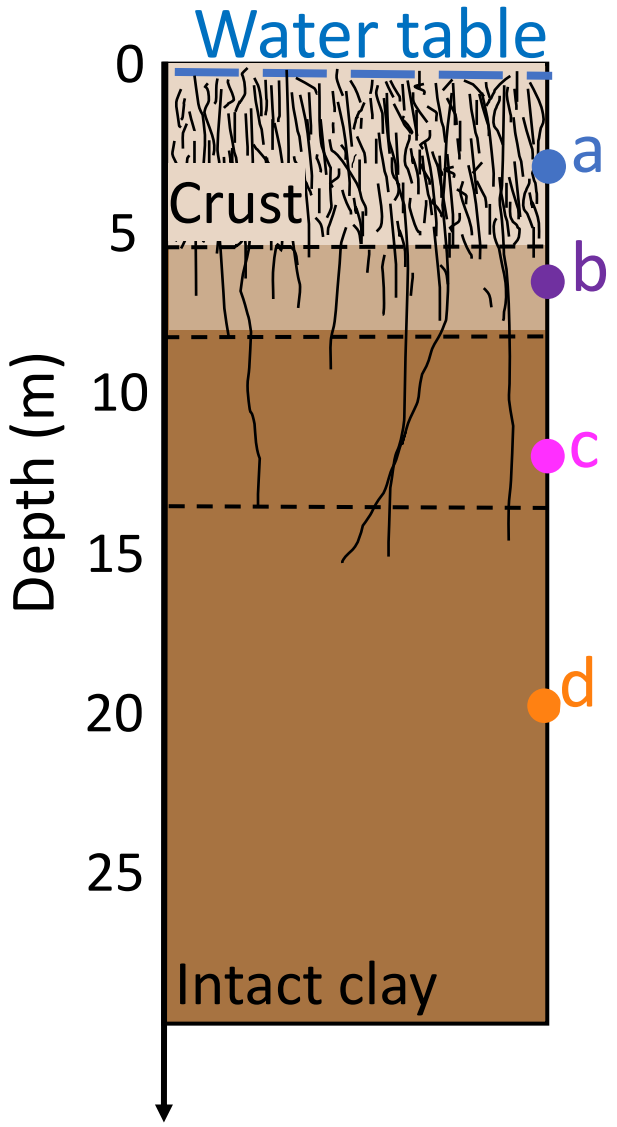
- Fracture

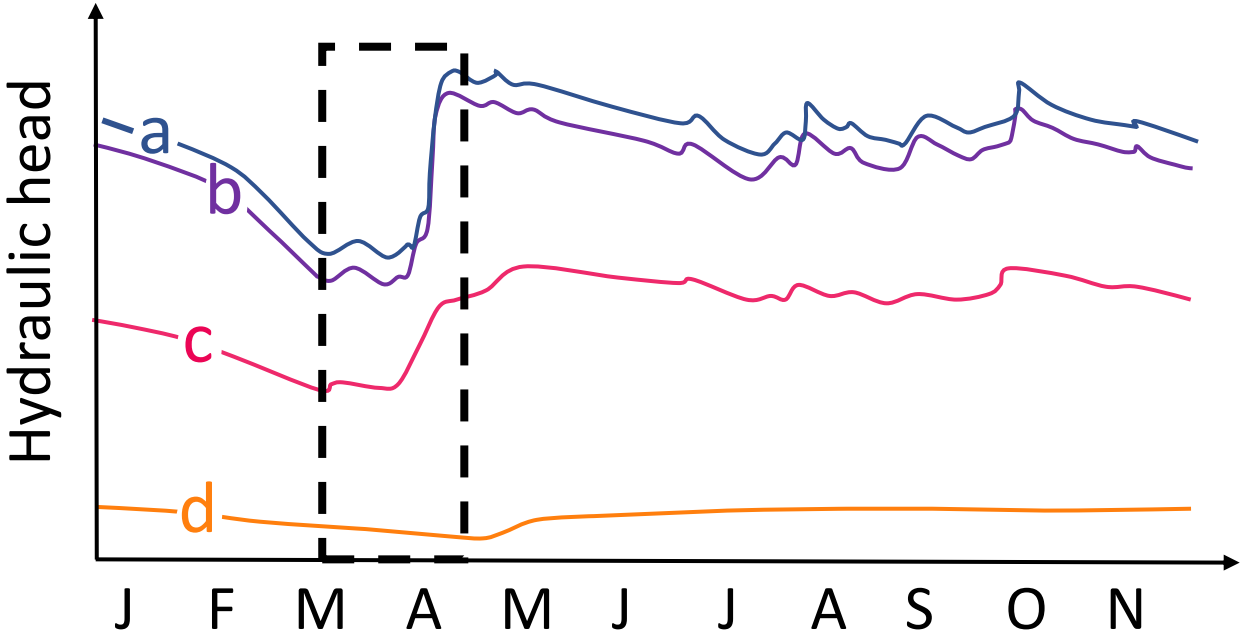






Conceptual model





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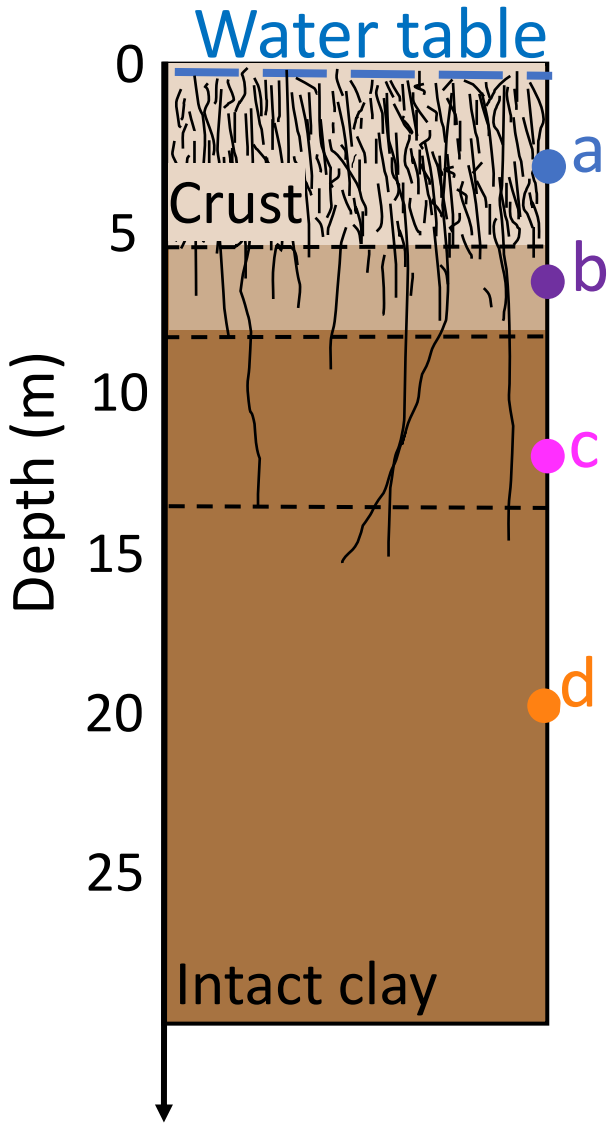
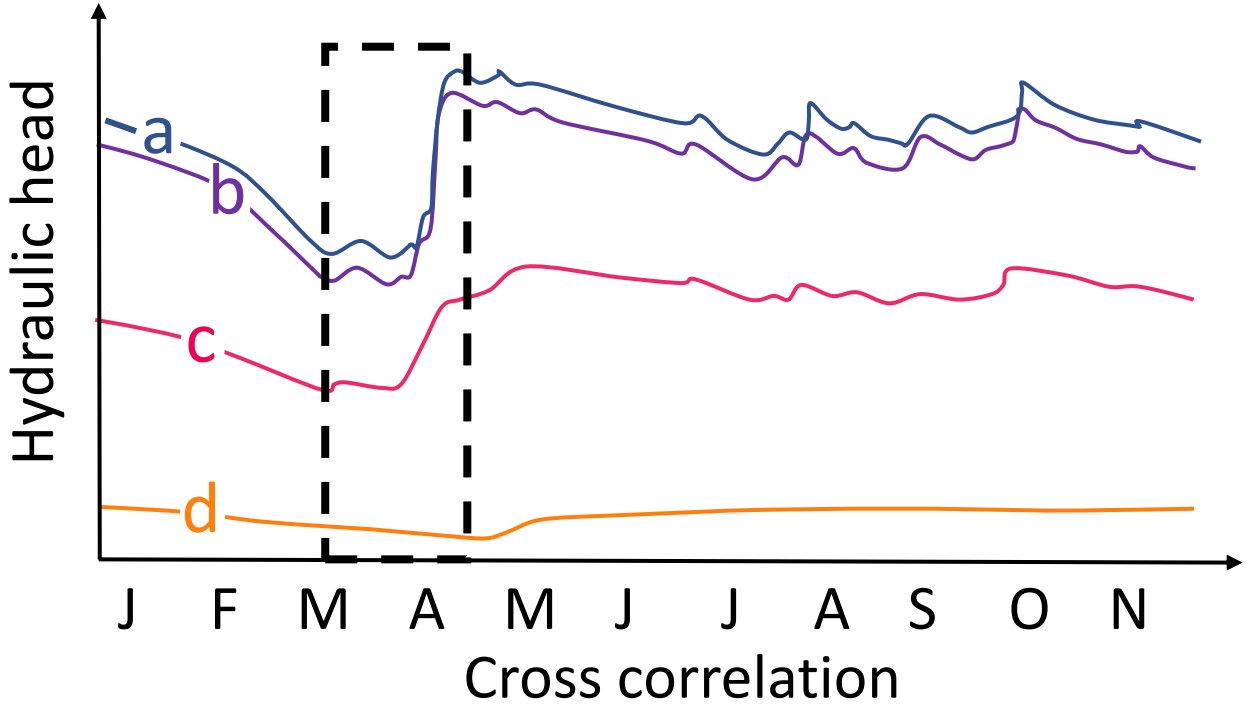
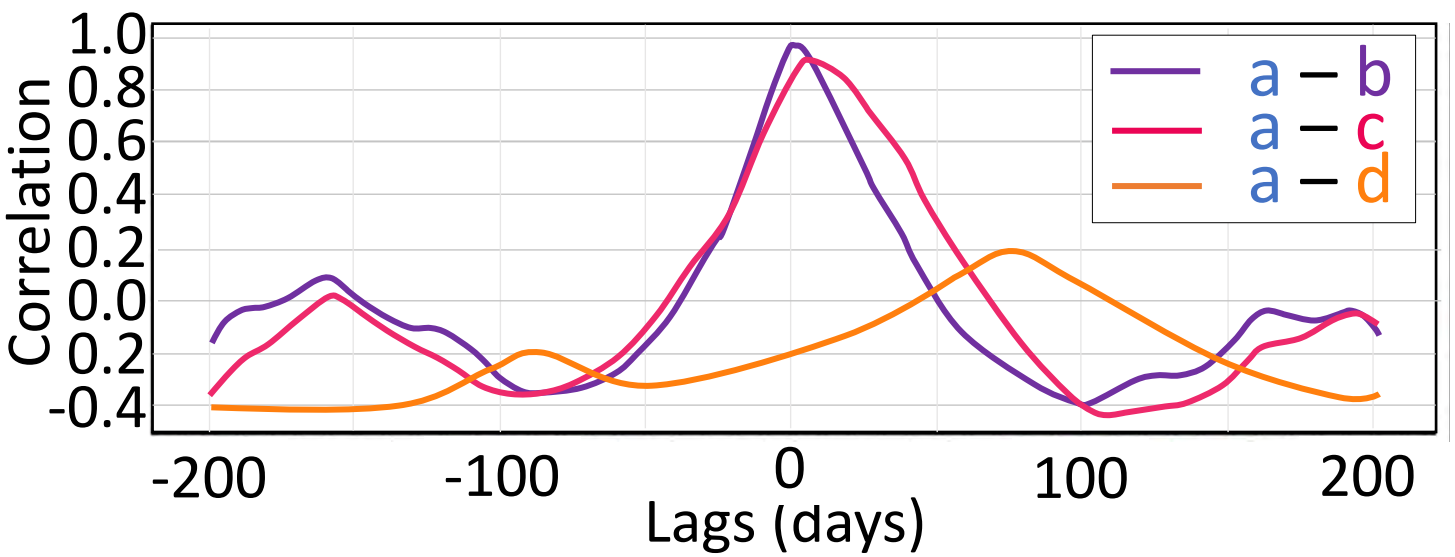
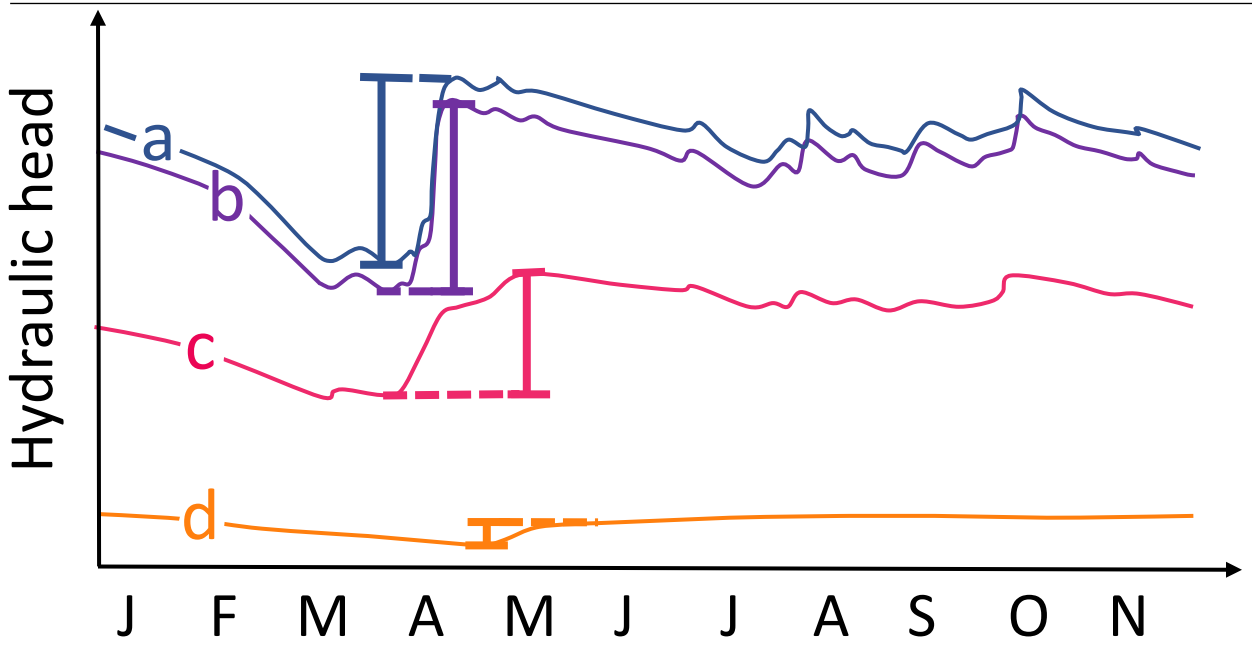


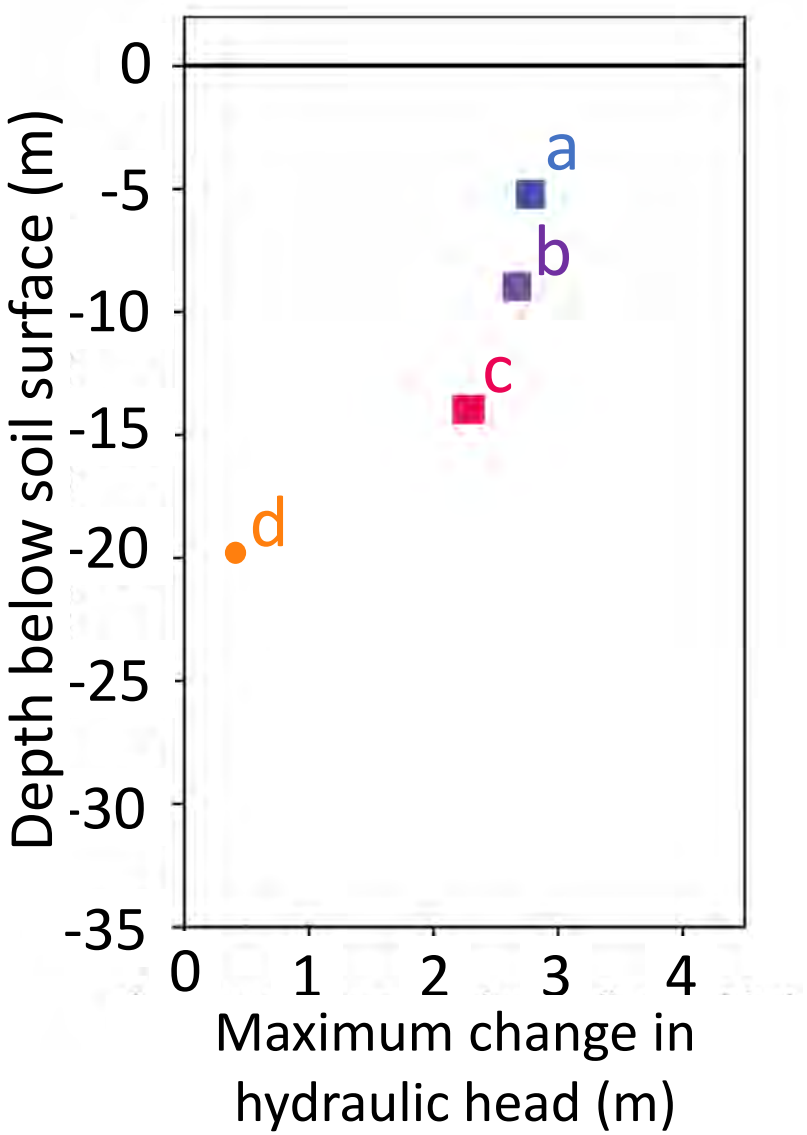




Methodology



Maximum change in hydraulic head



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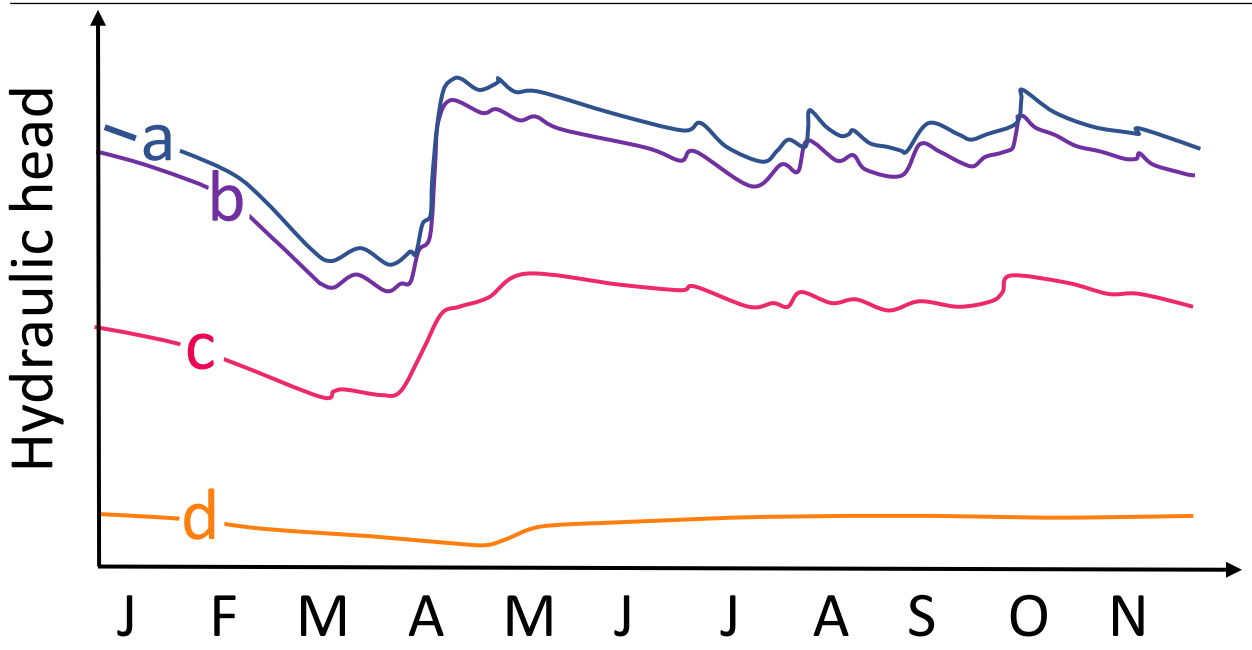

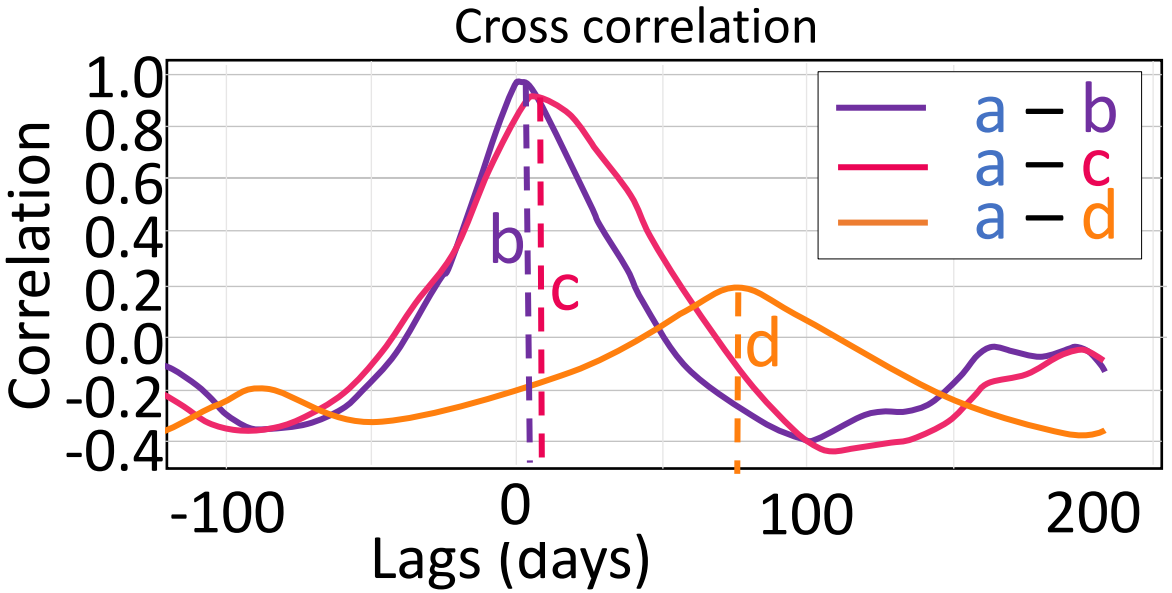

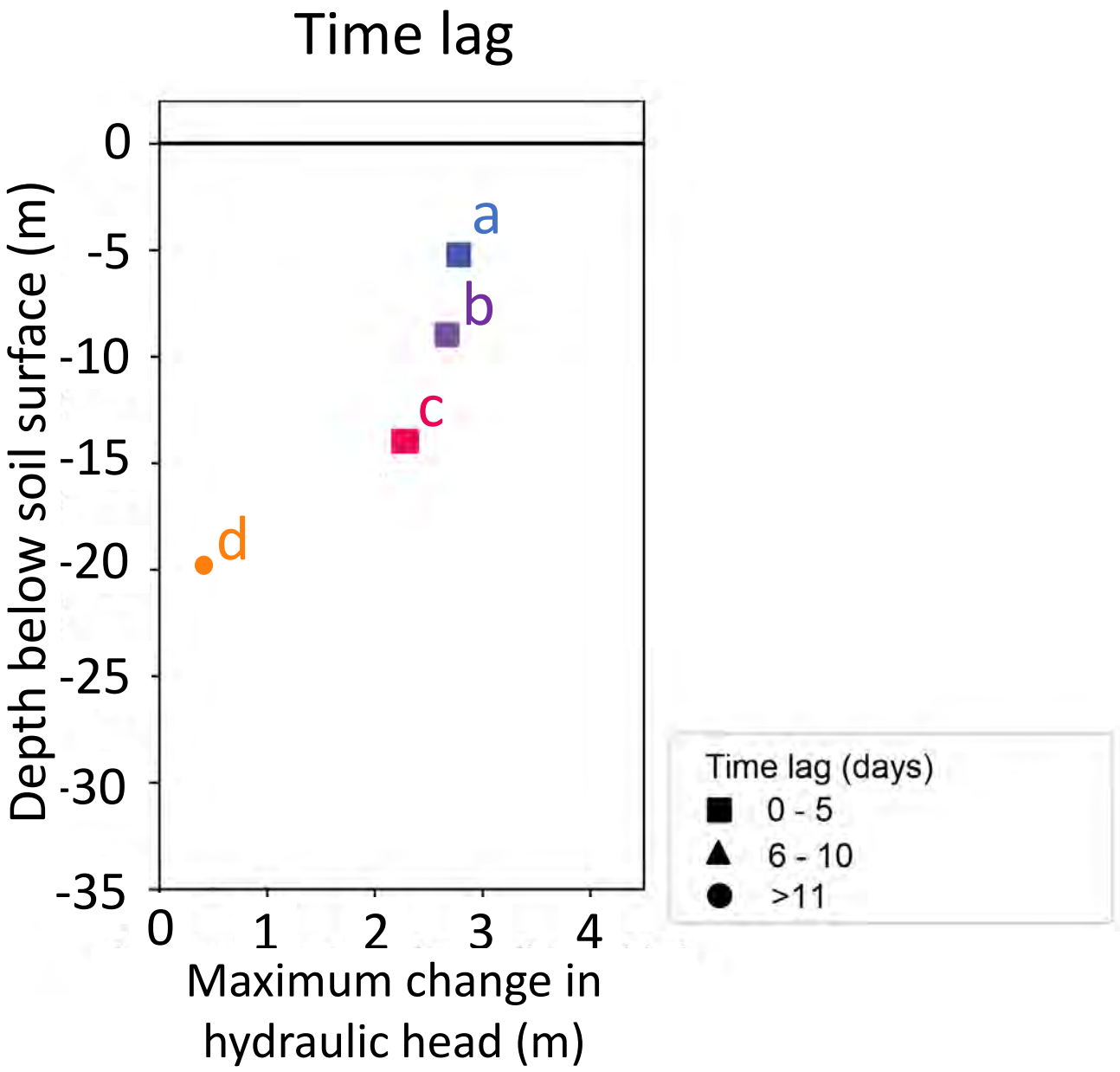

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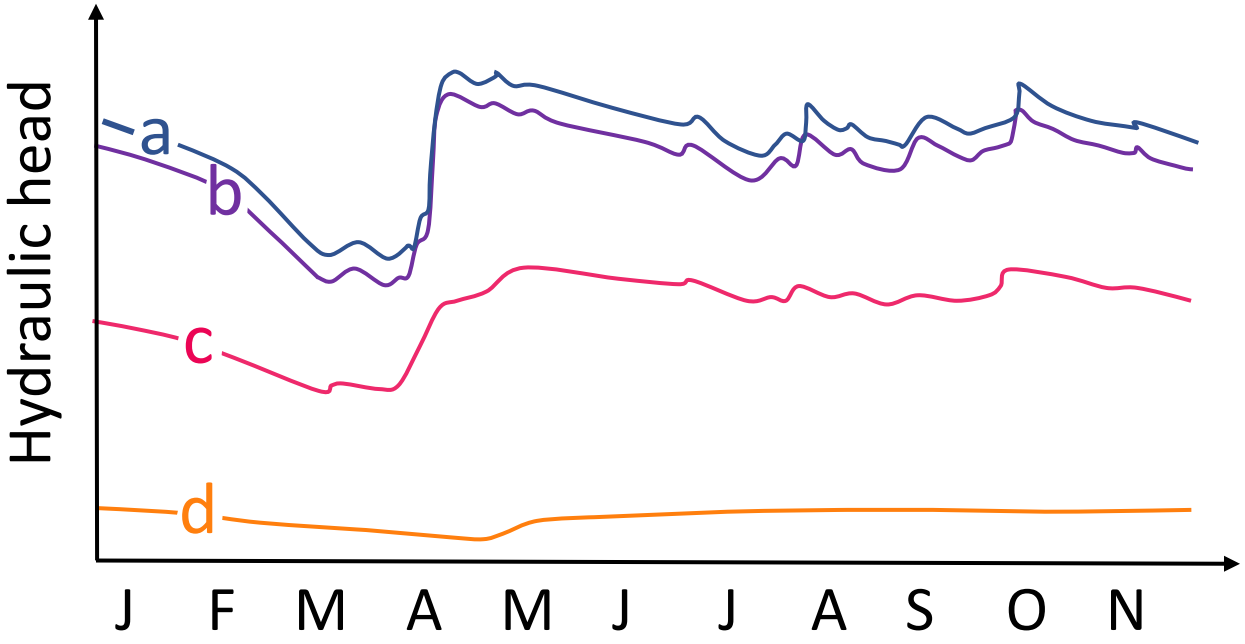
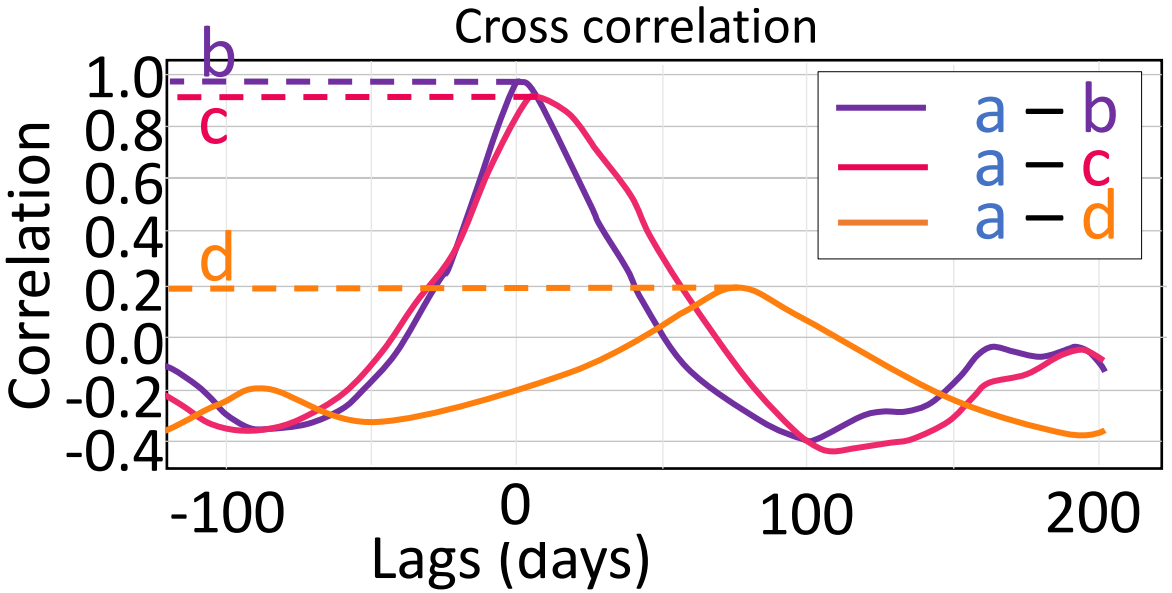
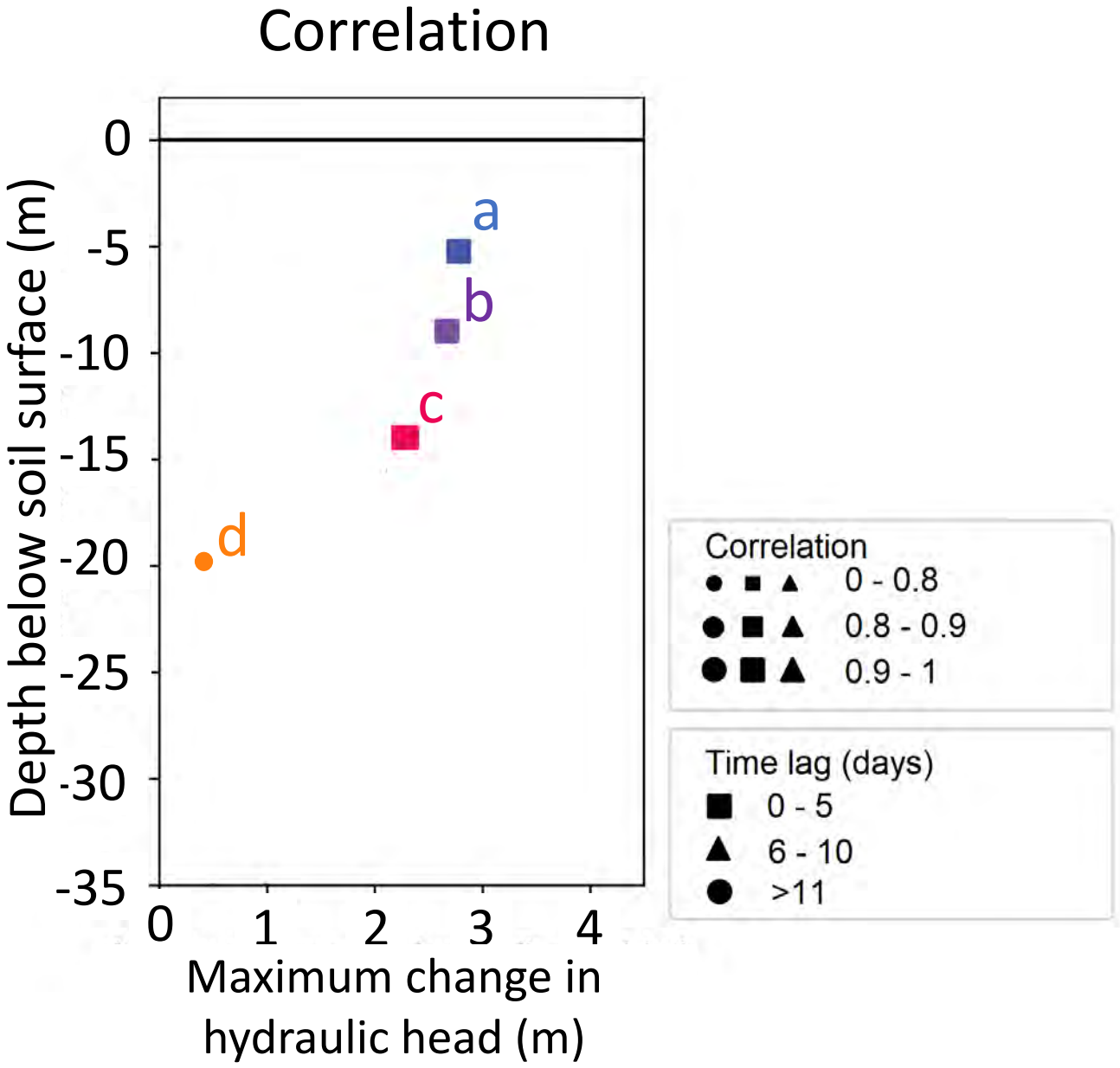


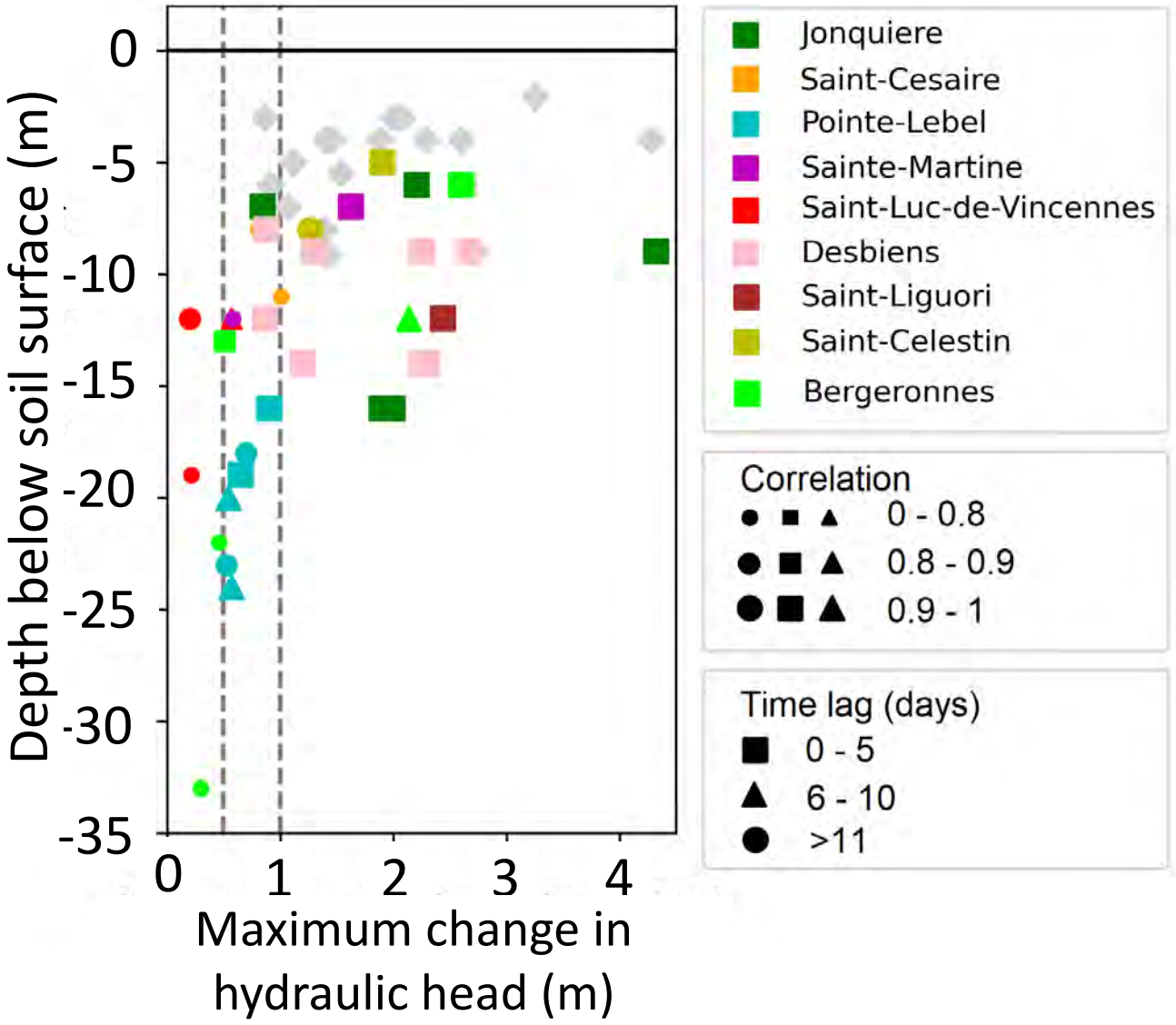




Evidence of hydraulically active fractures

Signs of hydraulically active fractures.

- Large hydraulic head variations
- Small time lags
- High correlation
- Other researchers: Hydraulic head variations larger than 0.5 or 1 m



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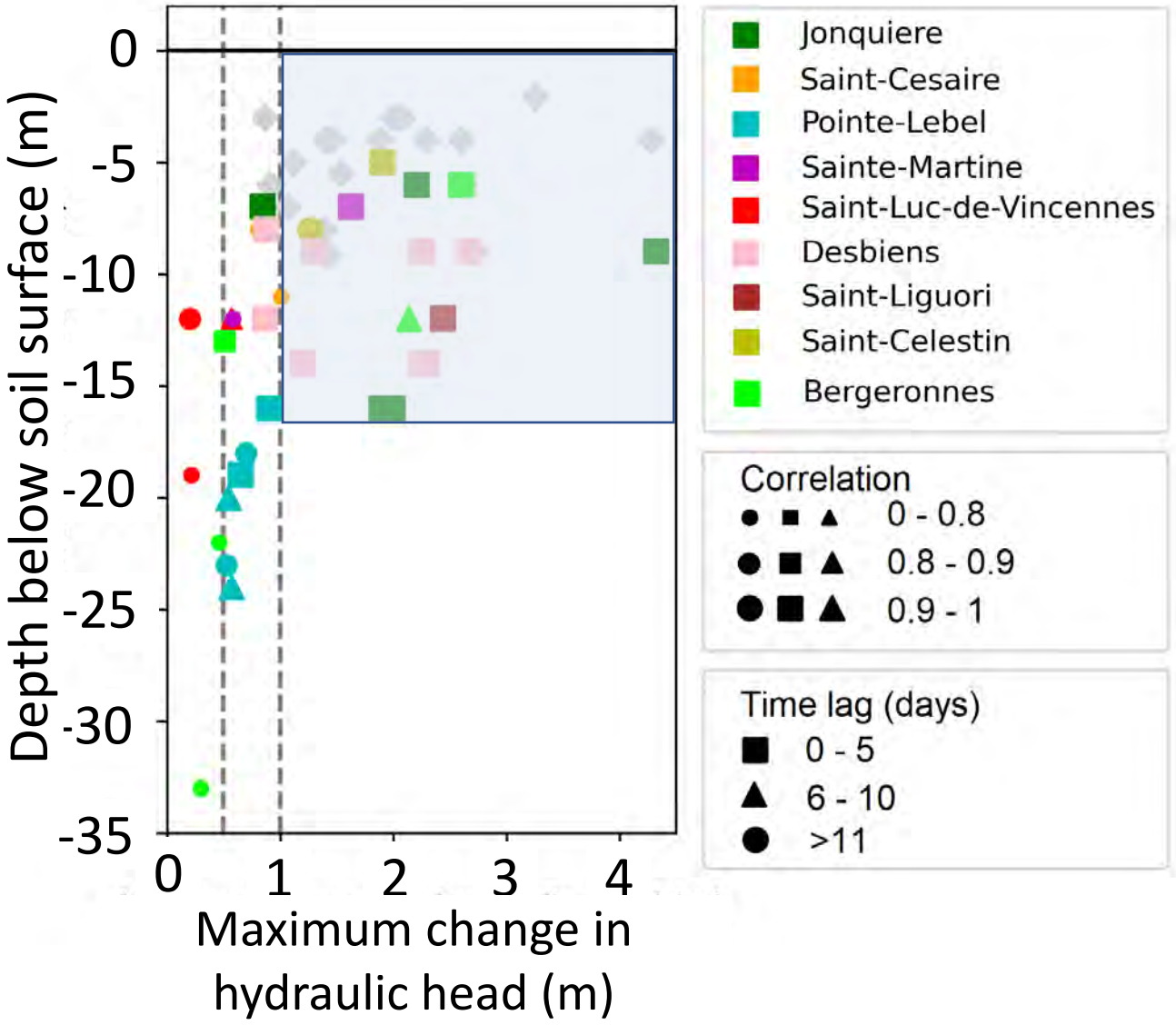
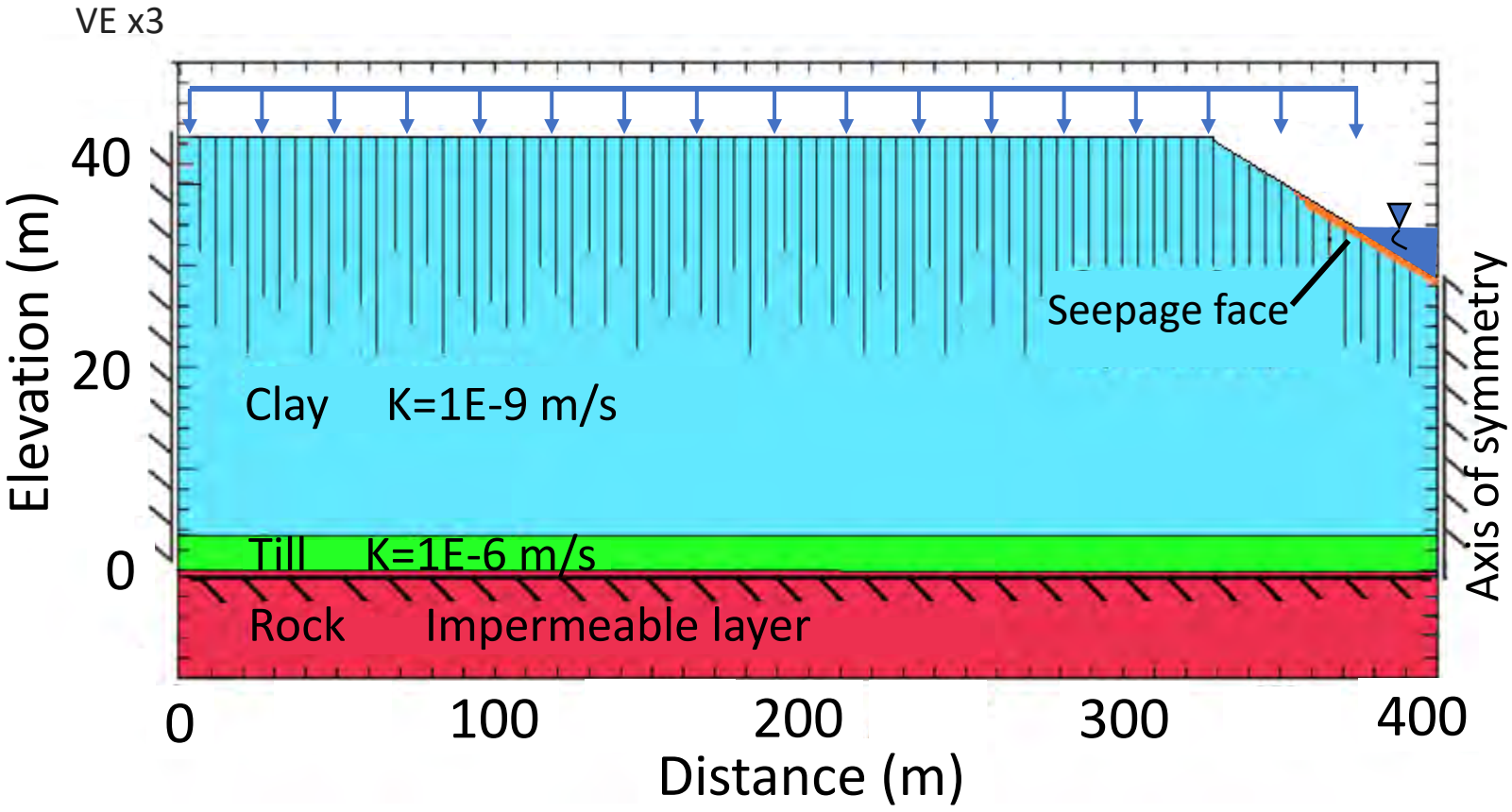


Hydrogeological simulation



Assumptions:

2D cross section
Vertical fractures
Fractures are equally spaced
Steady state

Numerical model:

Saltflow (Molson & Frind, 2020).

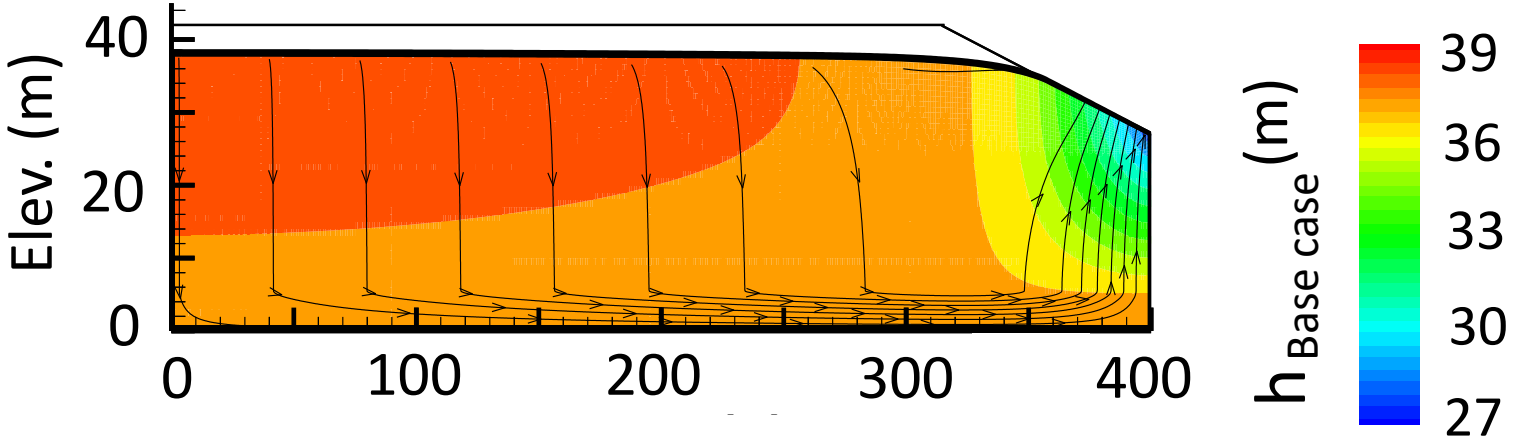
Scenarios:

Base case
- No fractures

Spacing between fractures
- 8 m
- 1 m

Hydrogeological simulation

Base case:
Without fractures

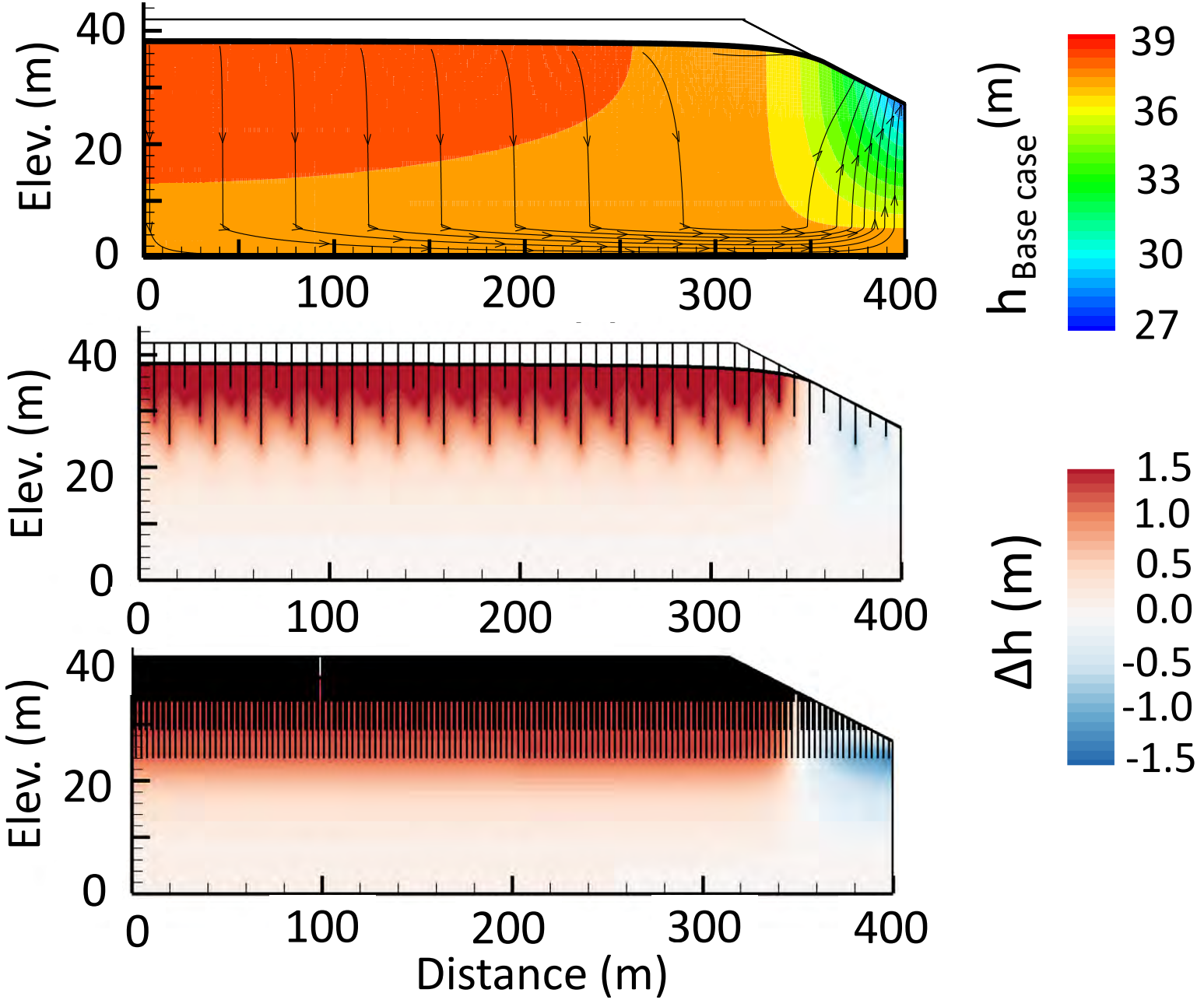


Hydrogeological simulation

Base case:
Without fractures

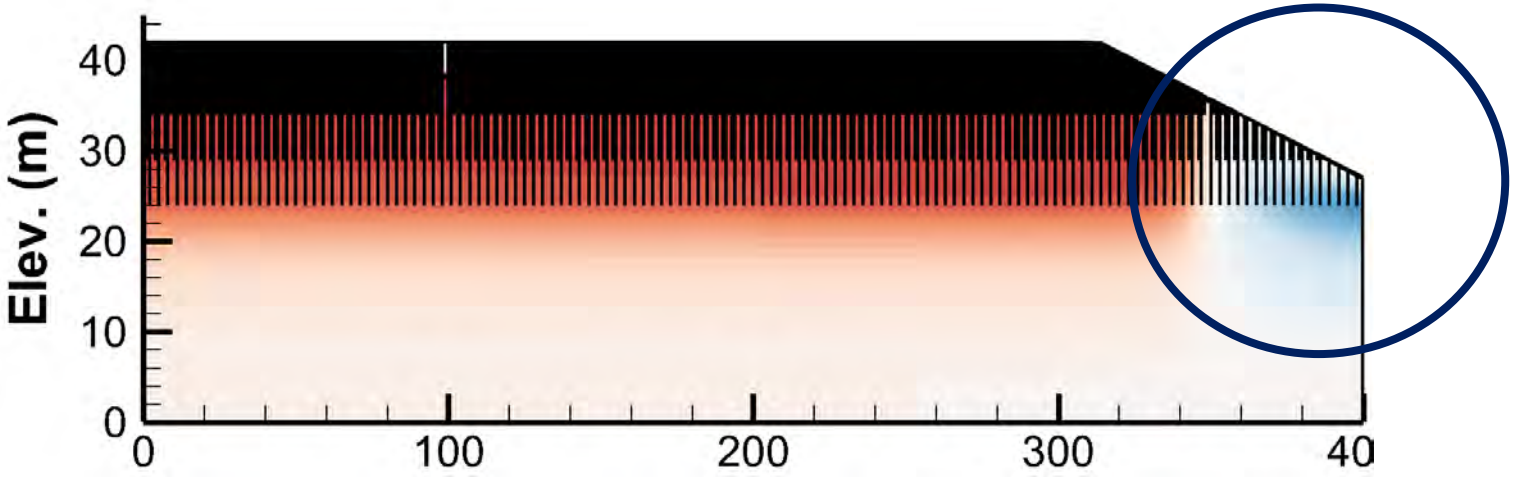
8 m spacing

1 m spacing



Conclusions

- There is evidence of hydraulically active fractures beyond the crust.
- The presence of fractures allows for a wider range of hydraulic head in the slopes
- Preliminary results shows that the fractures **reduce** pore pressure at the bottom of the slope which **increases** slope stability.



Acknowledgment

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- Julie Therrien. Ministère des Transports du Québec
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Transports Québec

Sécurité publique Québec

Fondsvert

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Water Research Centre

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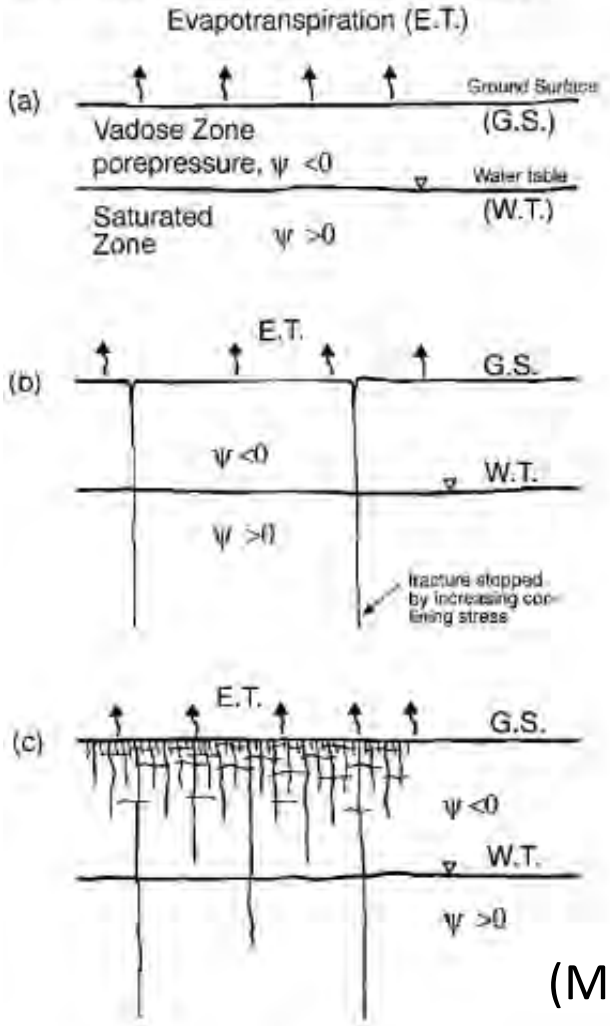
Origin of the fractures

Fig. 12. Conceptual model of fracture formation in a clay-rich deposit due to desiccation: (*a*) prior to formation of fractures; (*b*) formation of initial vertical fractures; (*c*) subsequent formation of vertical and nonvertical fractures above the water table.



Reduction of compressive stresses in the vadose zone.

(Mckay & Fredericia, 1995)

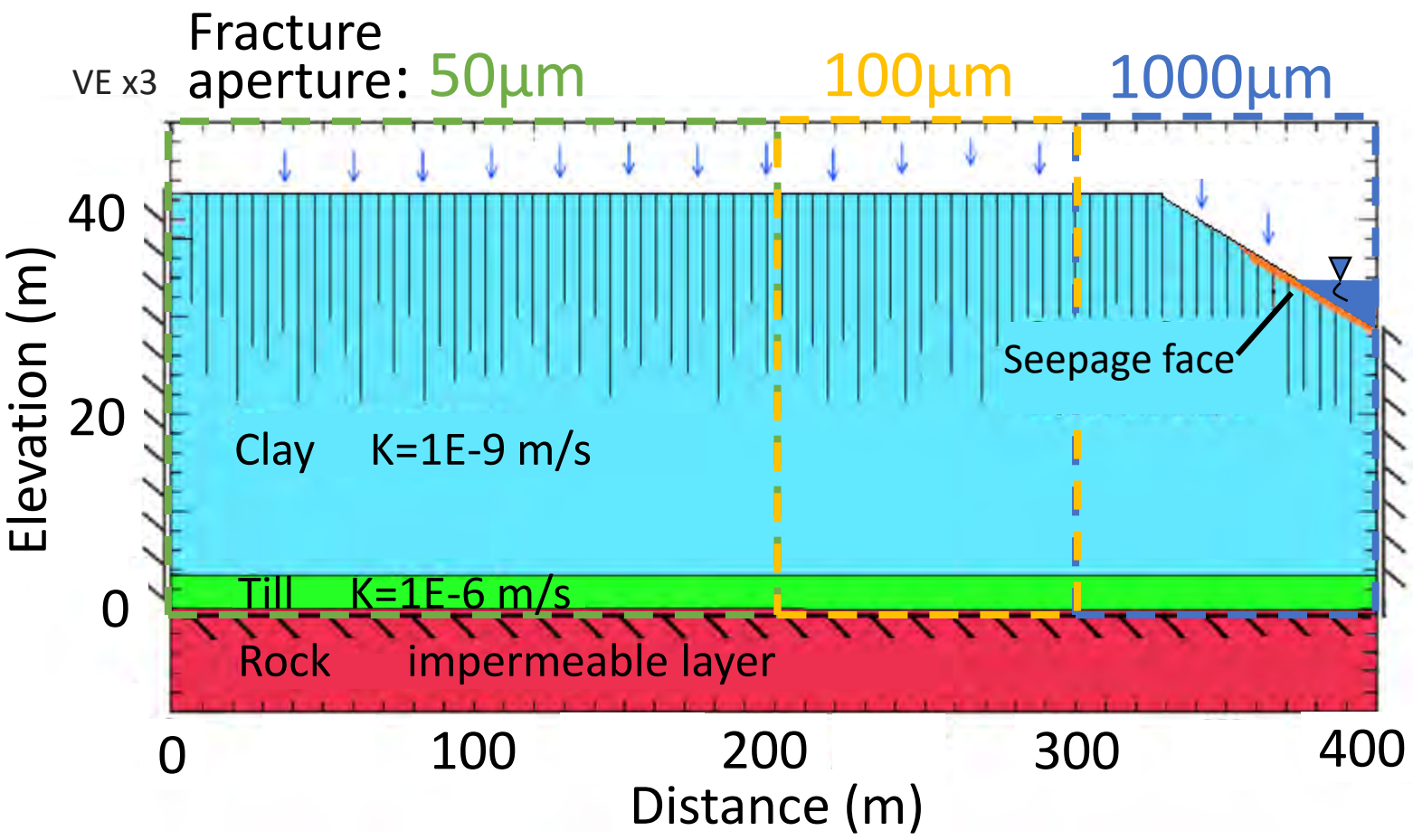
Mase et al. (1990)

-Developed a linear elastic fracture formation model

-If the water table decline from surface to 3 m depth

-For the clay till, vertical fractures could propagate to depths of up to 15 m.

Hydrogeological simulation



Assumptions:

Fractures are equally spaced

Numerical model:

Saltflow

Scenarios:

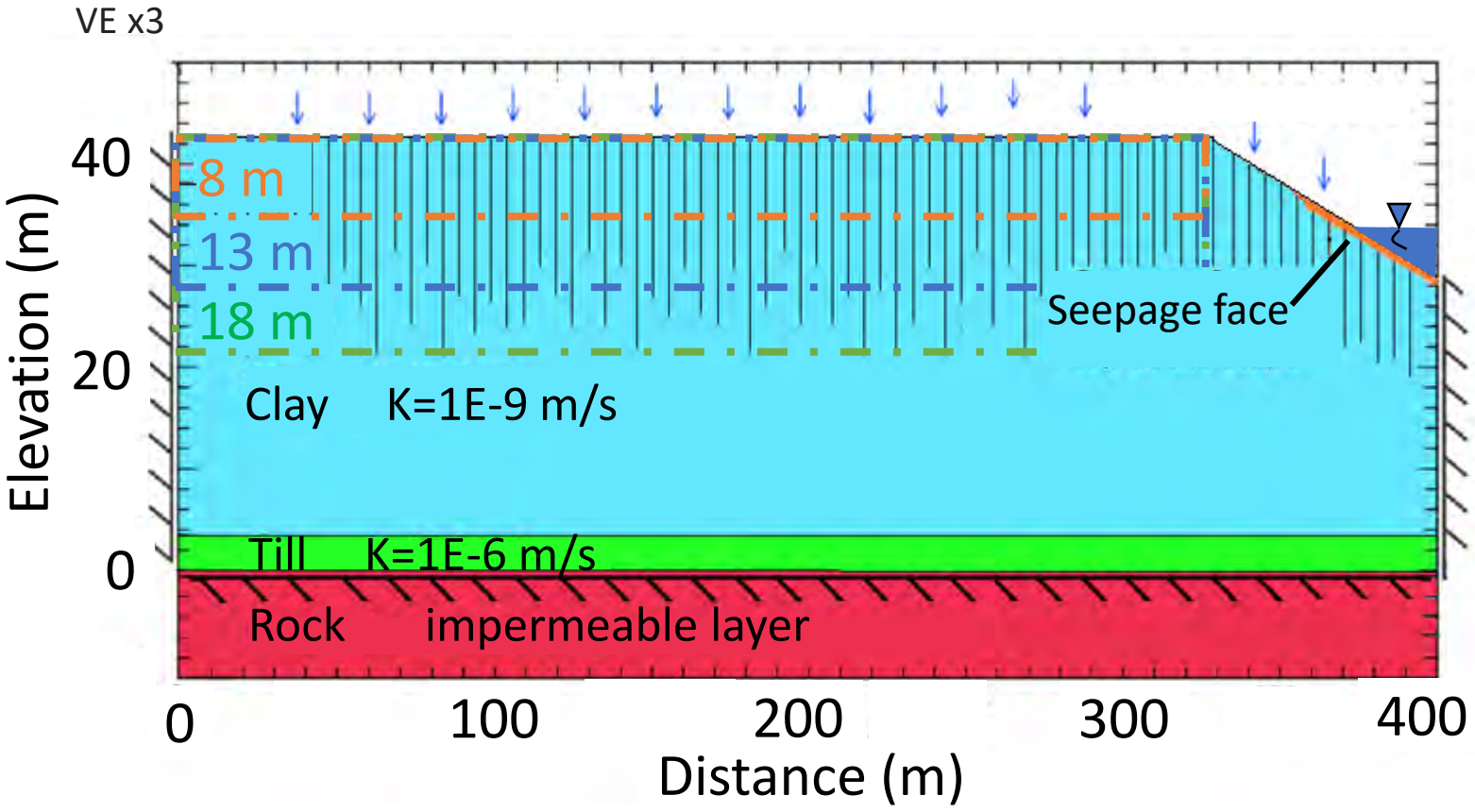
Base case

- No fractures

Spacing between fractures

- 8 m
- 1 m

Hydrogeological simulation



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