Contribution of hydraulic tests at different scale to the characterization of fracture network properties in crystalline rock aquifers

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NGRI

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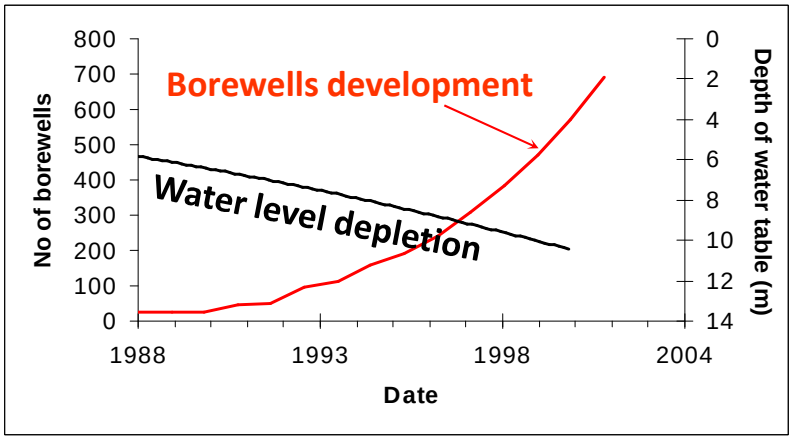
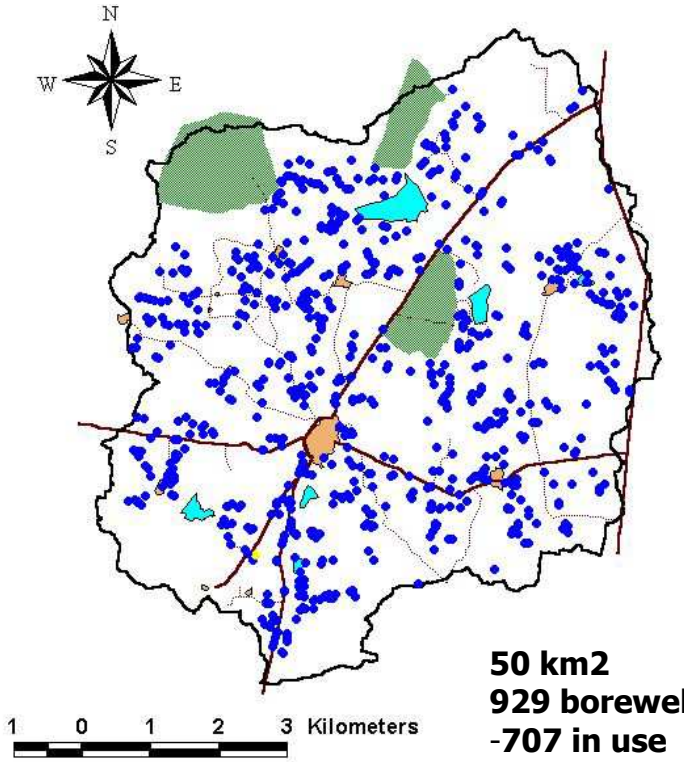
From 1980 up to now: groundwater boom in India

- From 1 million borewells up to 27 millions
- Sustains 60 % of irrigated land
- Constitutes one main factor of the Green Revolution
- 10 % of GDP of India



20 BW/km²



50 km2
929 borewells:
-707 in use
-228 not used

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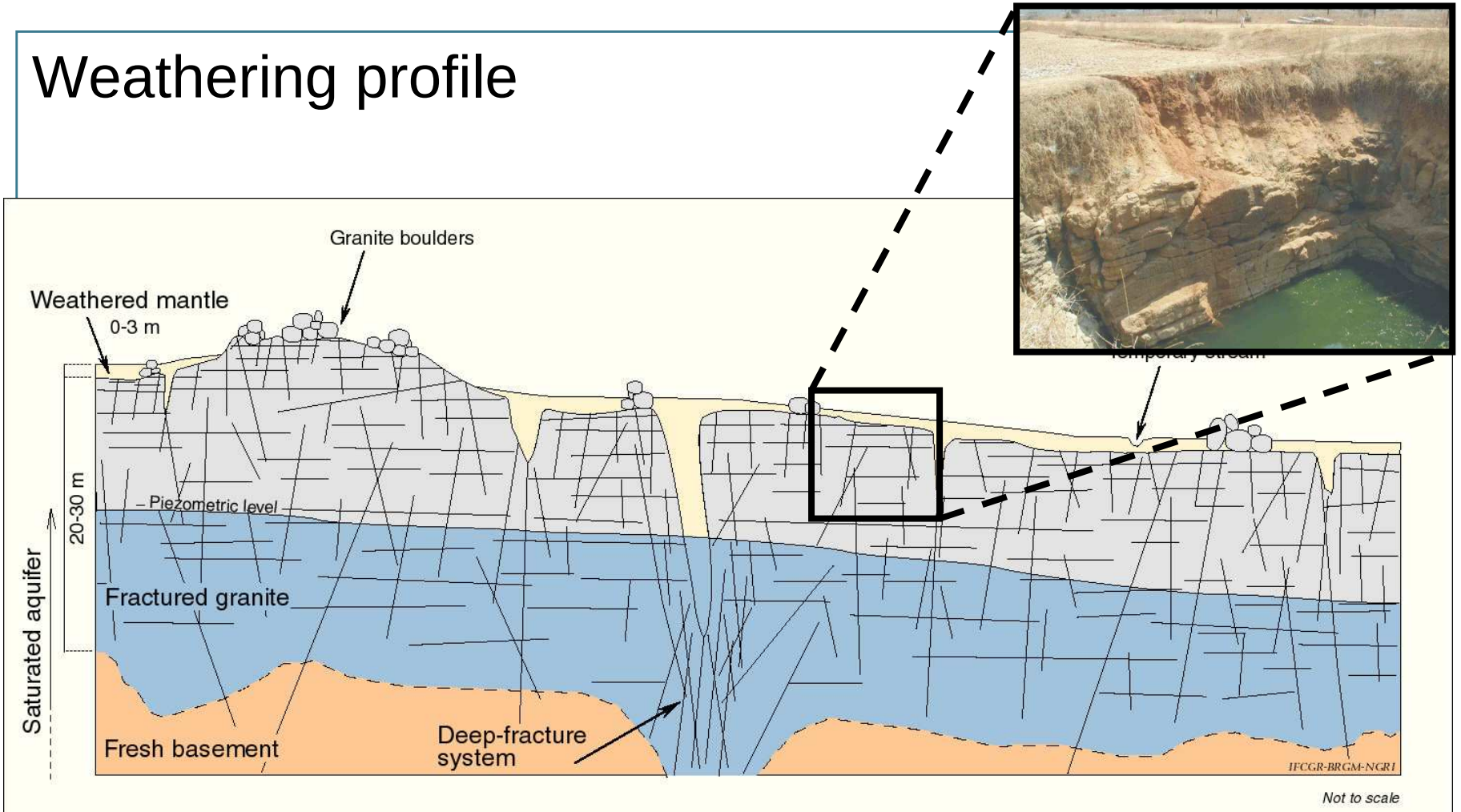
1970

From Toth (2013)

Now

Weathering profile



- **30 slugtests**
- **17 flowmeter**
- **22 injection tests**
- **6 pumping test sites**

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Fractures networks

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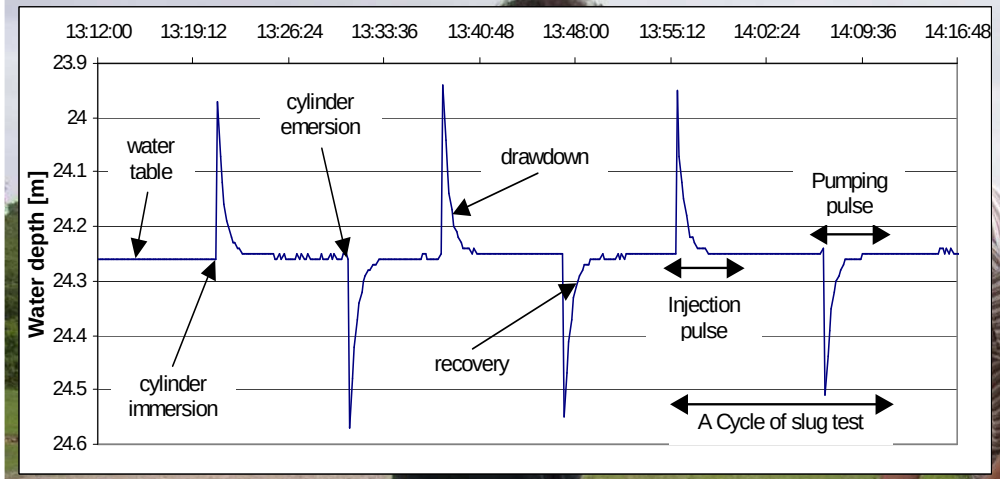
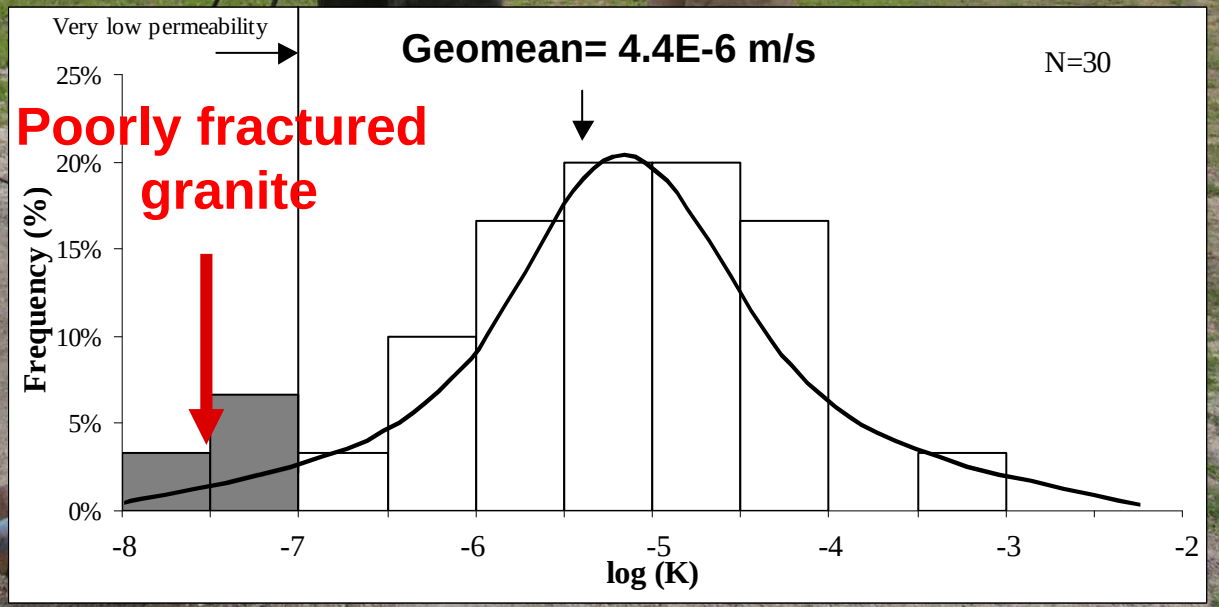
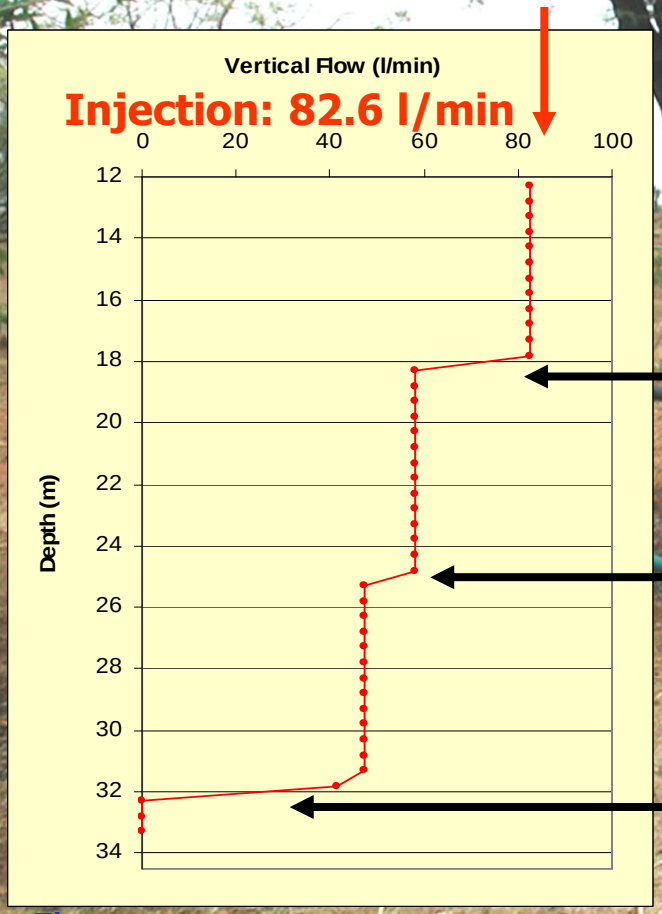
Local hydraulic conductivity from slugtests (30)



Distribution of hydraulic conductivity

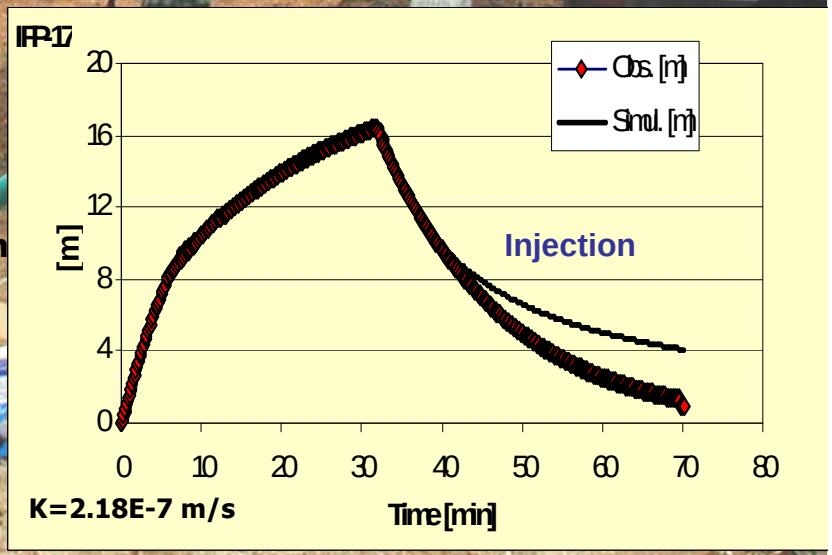


Fractures distribution from Injection (28) and flowmeter tests (17)

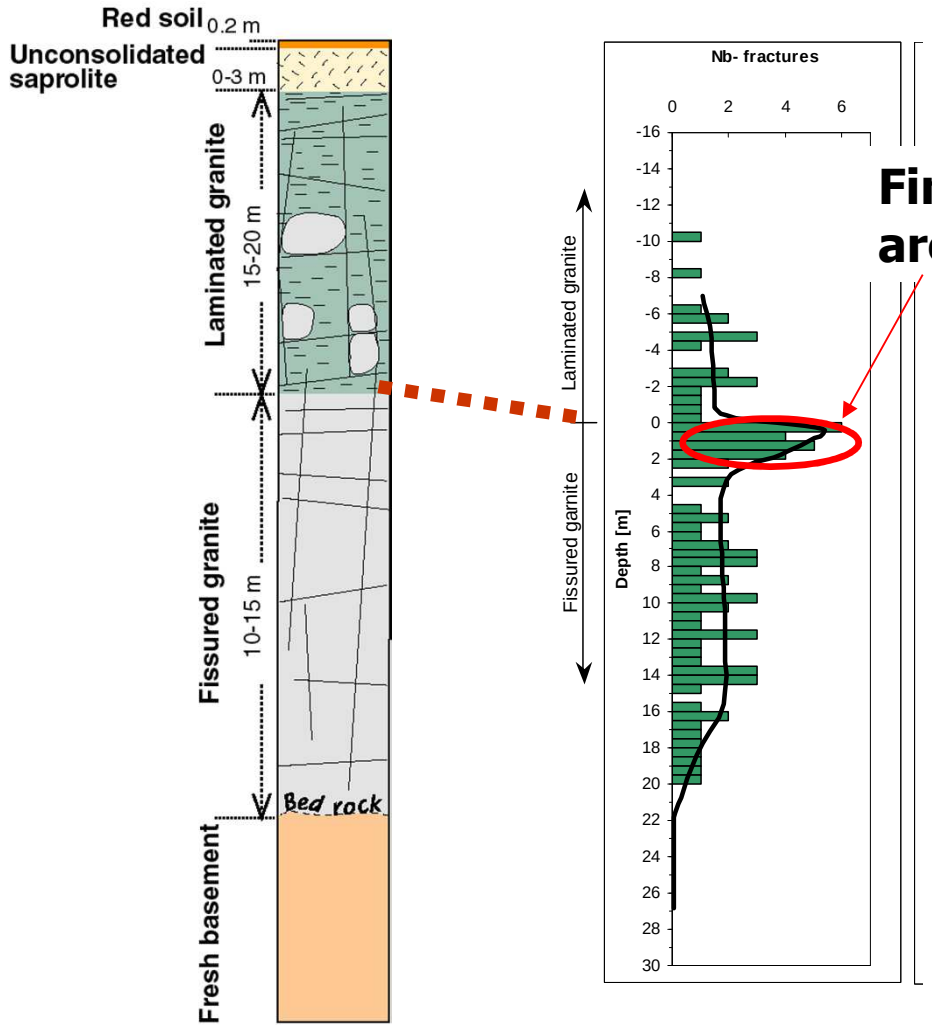


Flowmeter

Conductive Fractures zon



Fractures distribution from flowmeter tests (17)



First 2 meters of the fissured layer are significantly <u>more fissured</u>

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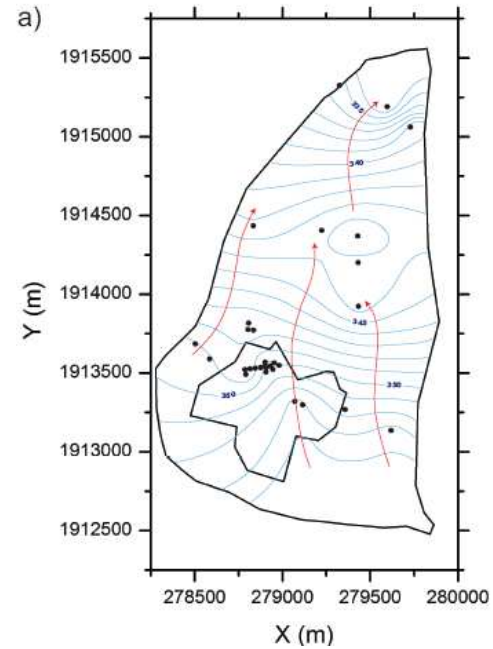
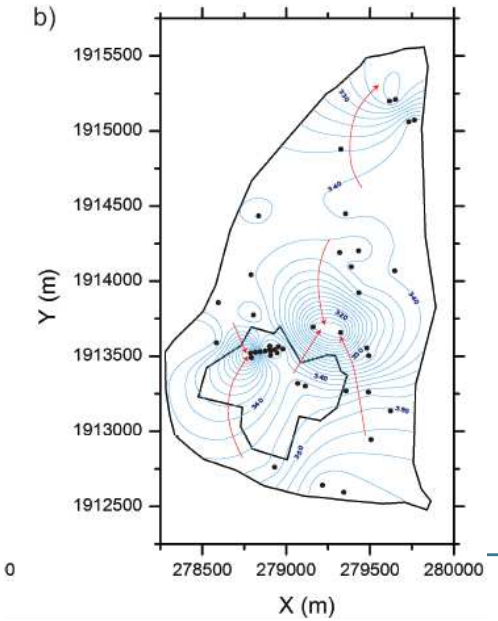
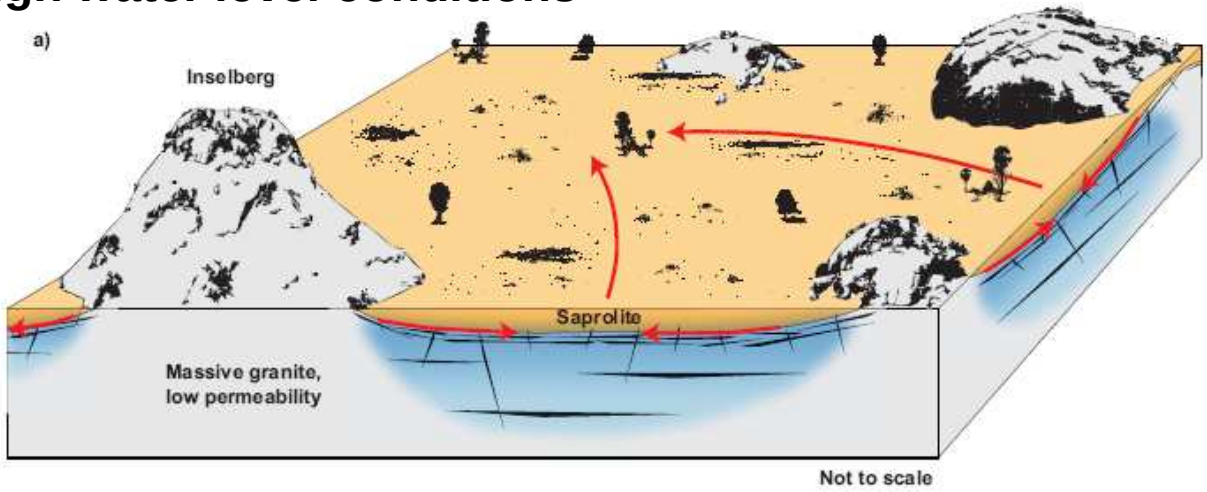
Impact of WL fluctuations on fracture network connectivity

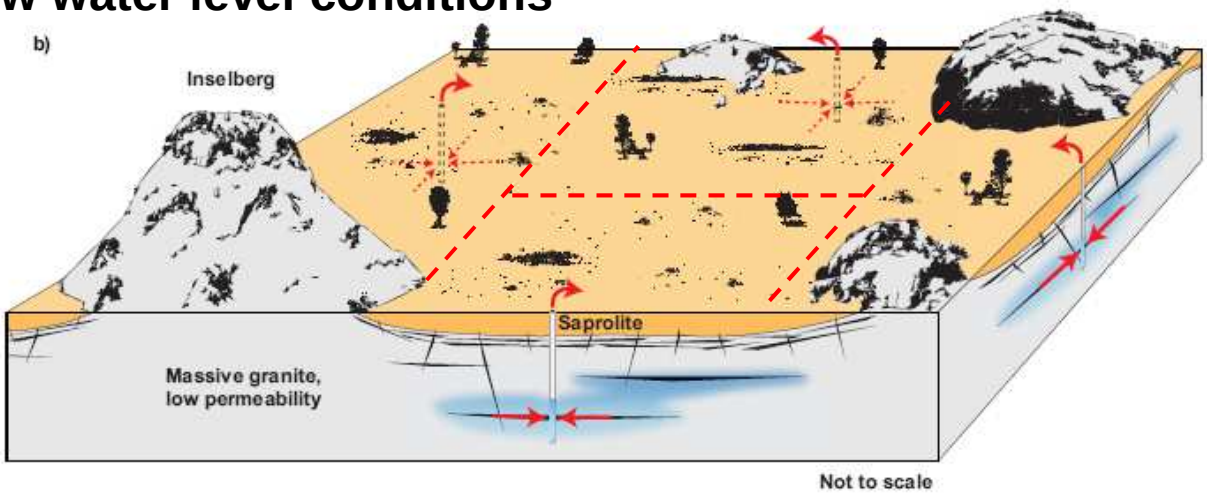




High water level conditions



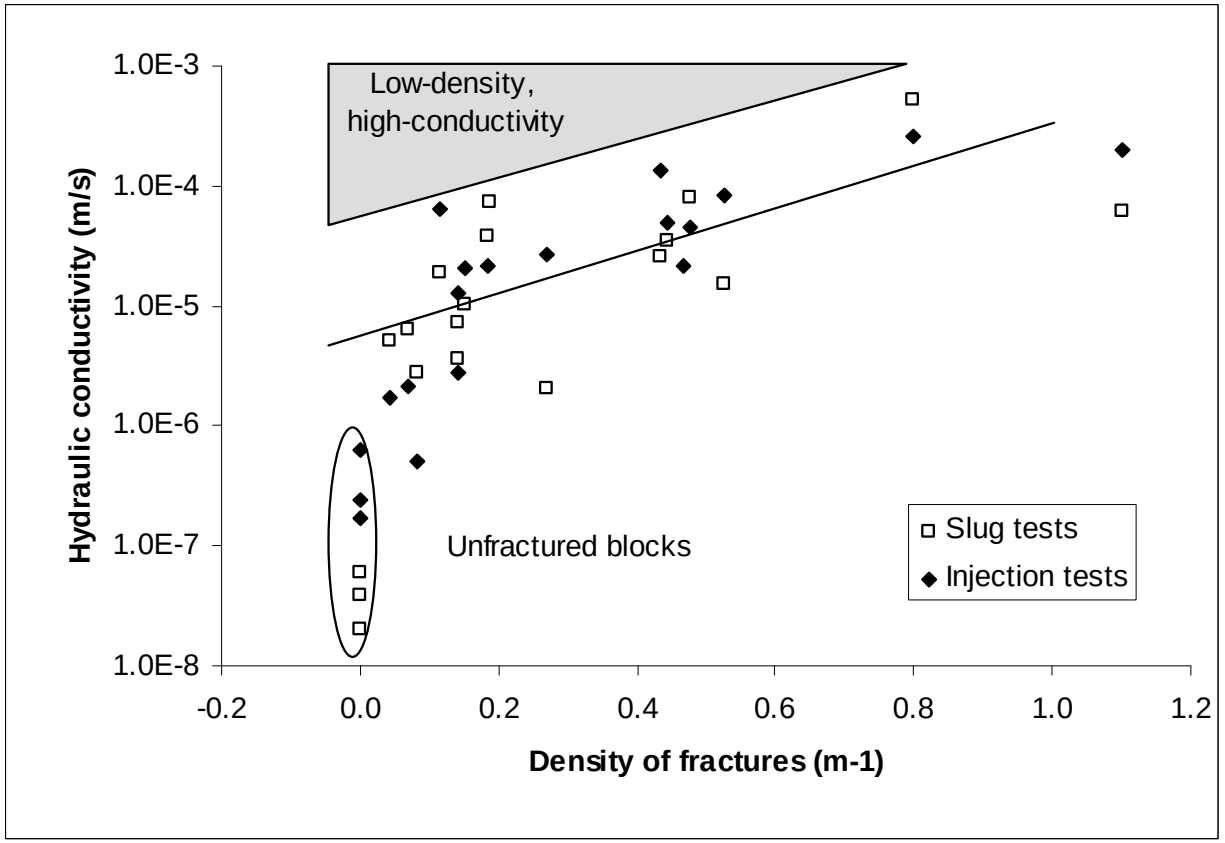
Low water level conditions



Groundwater flow Flowing fracture Hypothetical permeable and saturated reservoir

Guihéneuf et al., 2014

Influence of the density of fractures on hydraulic conductivity



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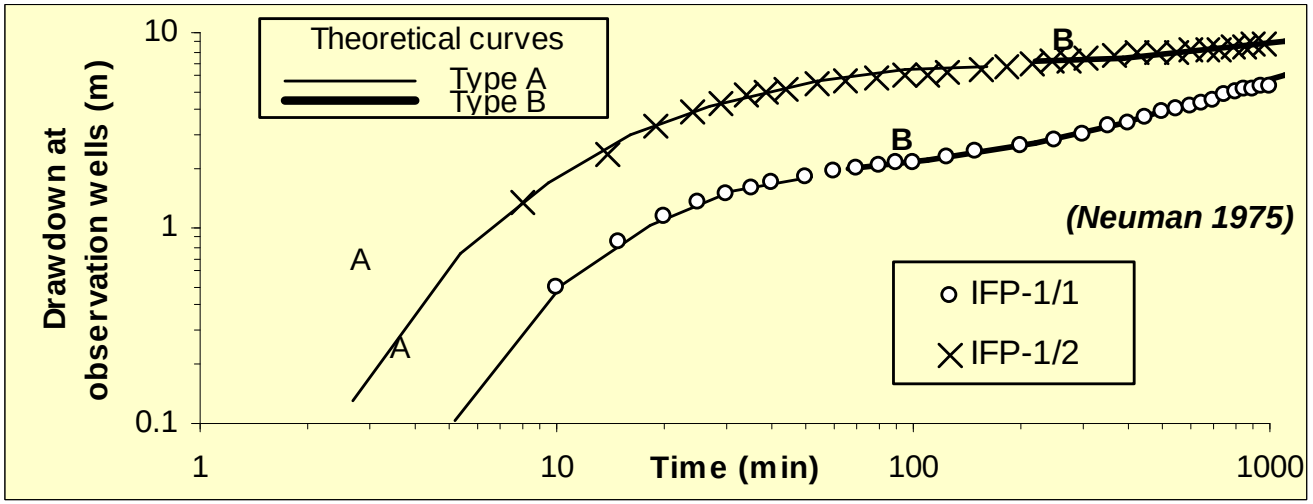
Anisotropy of permeability

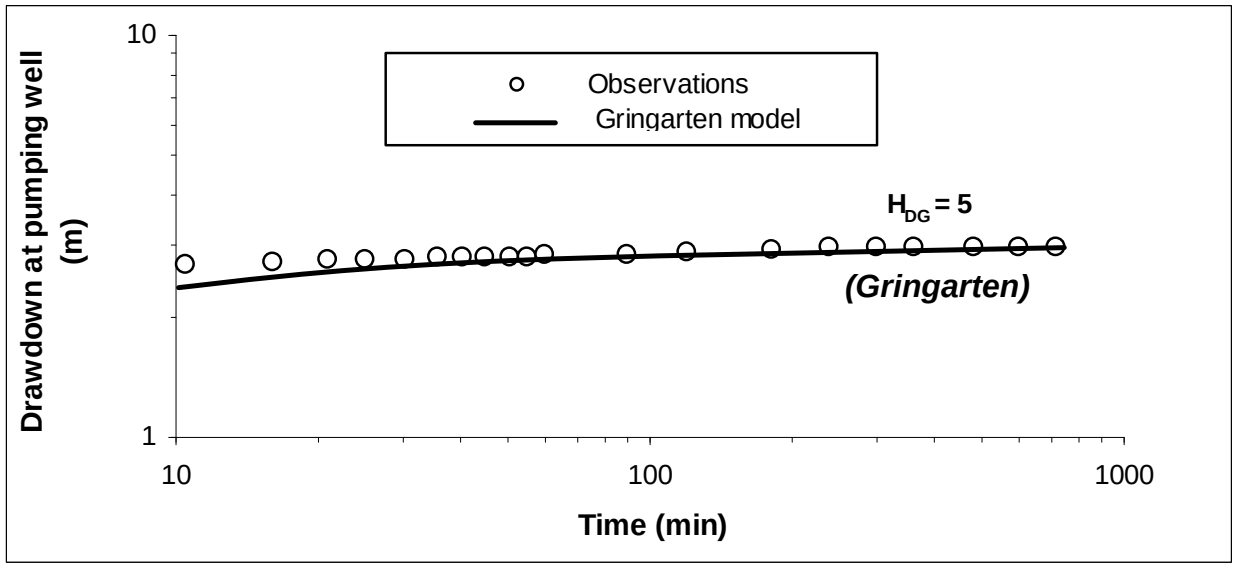


$K_h = 10\ K_z$

$K_h = 10^{-5}$ m/s

$K_z = 10^{-6}$ m/s

Sy=0,004



r_f= 3 - 16 m

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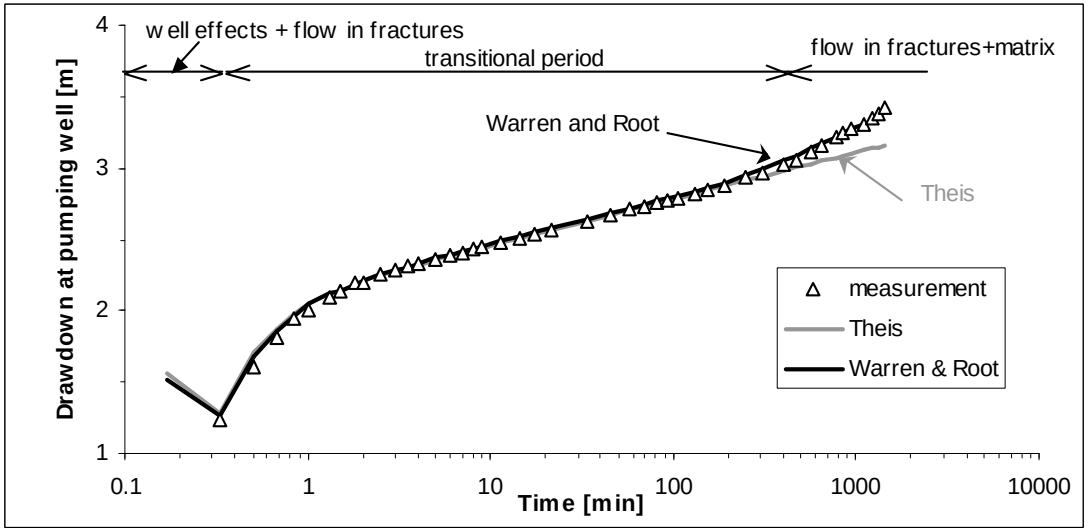
Double porosity



Warren and Root 1963

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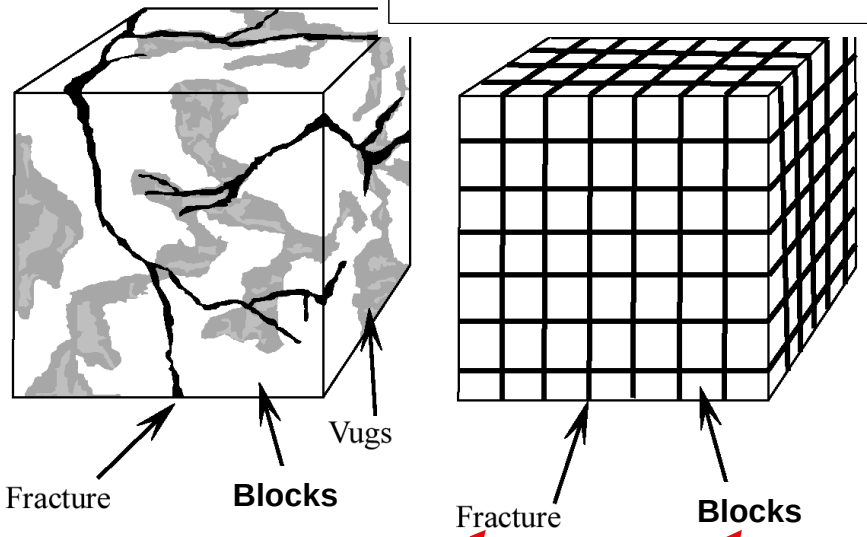

naturally fissured rock formation

Kf= 2.1 E-5 m/s
Sf= 5.8E-4

Kb= 5.1 E-8 m/s
Sb= 5.7E-3

orthogonal fissures network

Sy=Sf+Sb=0,006

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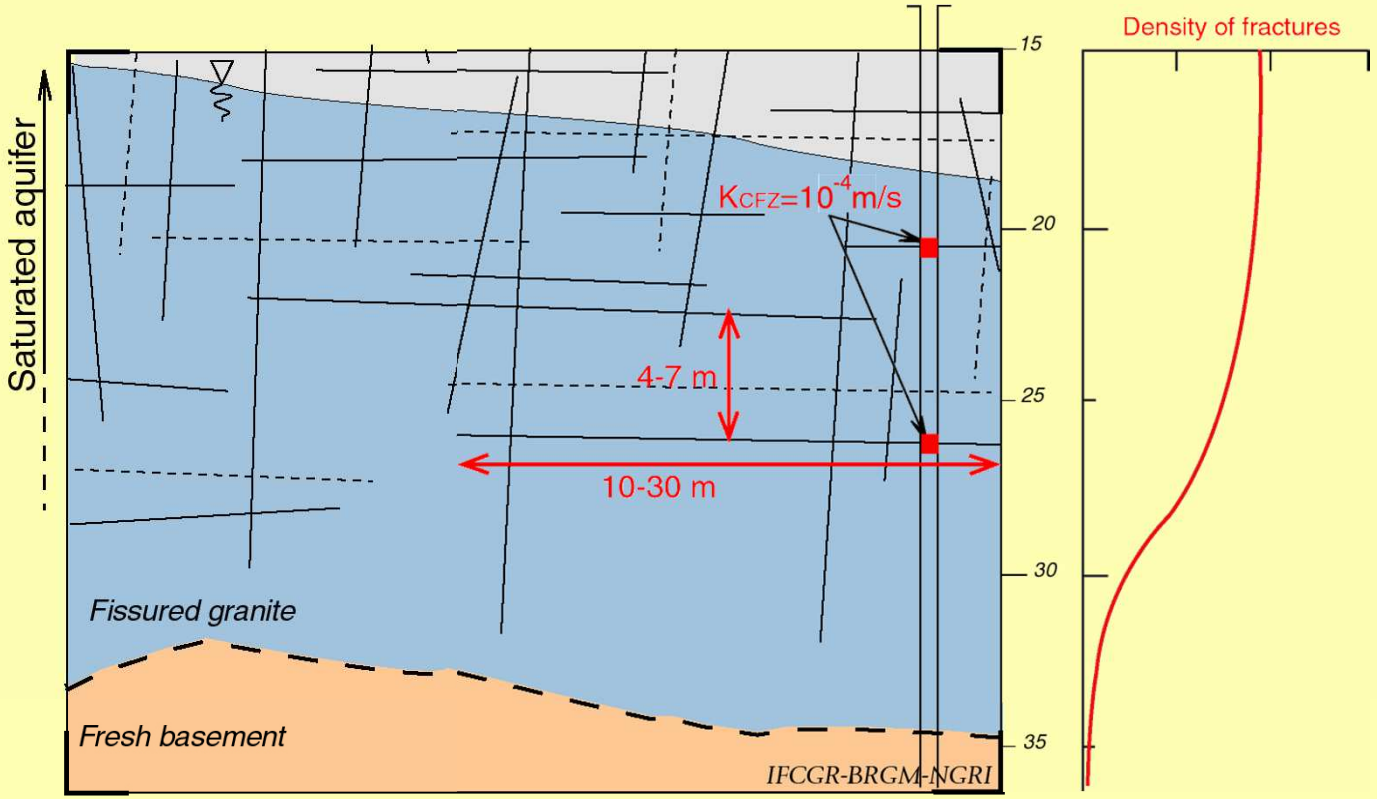

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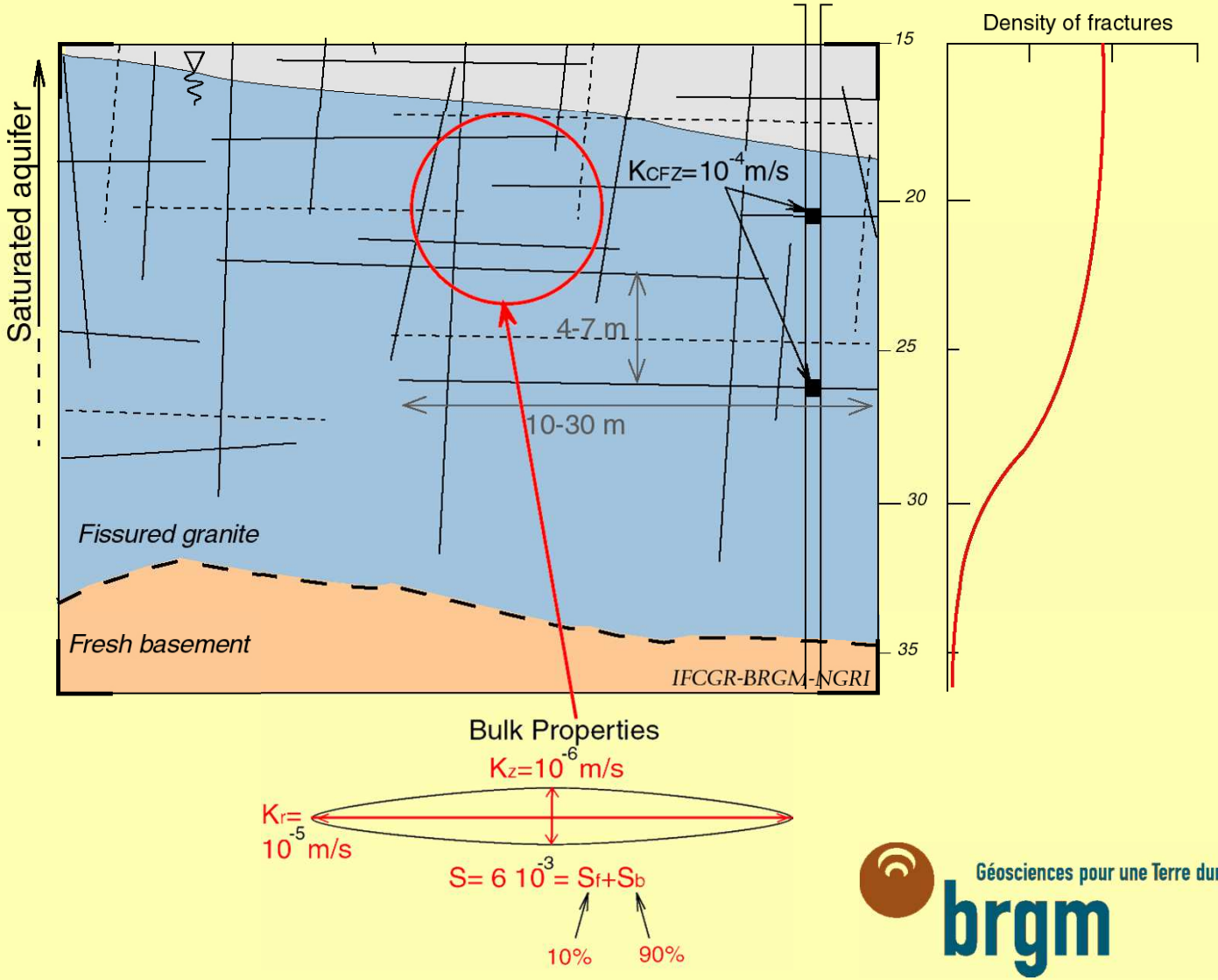
The permeability anisotropy…



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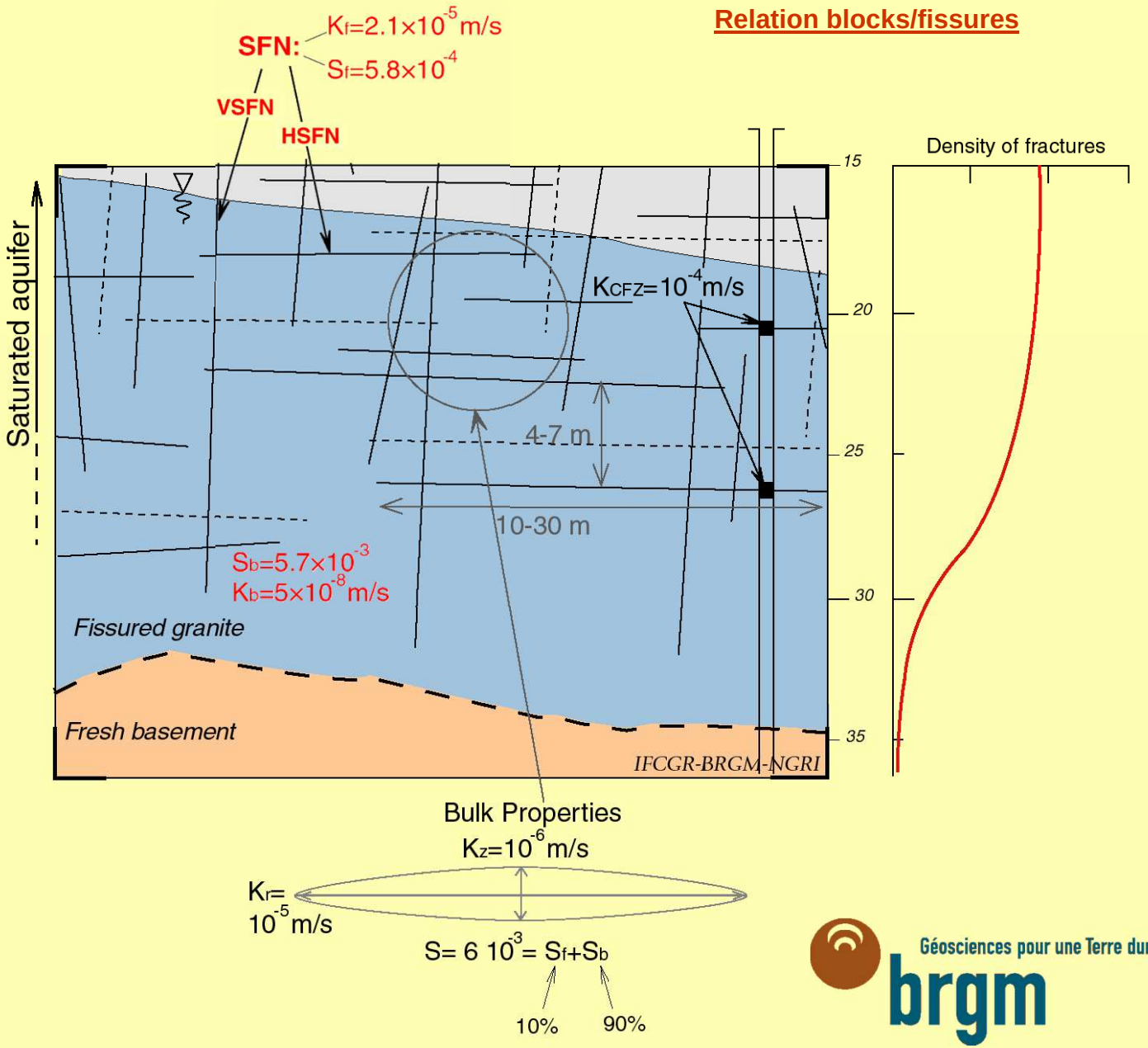
Relation blocks/fissures



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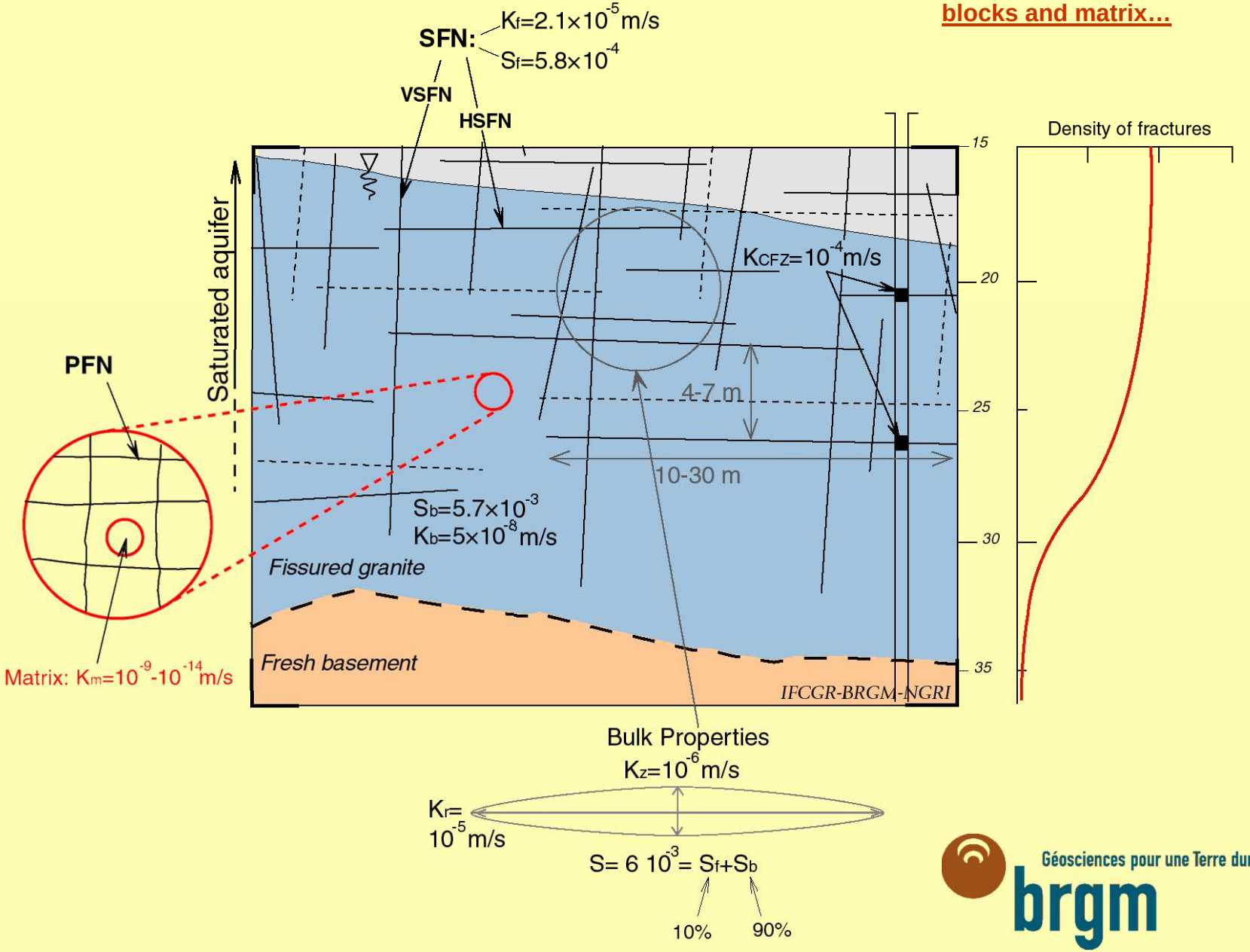
blocks and matrix…



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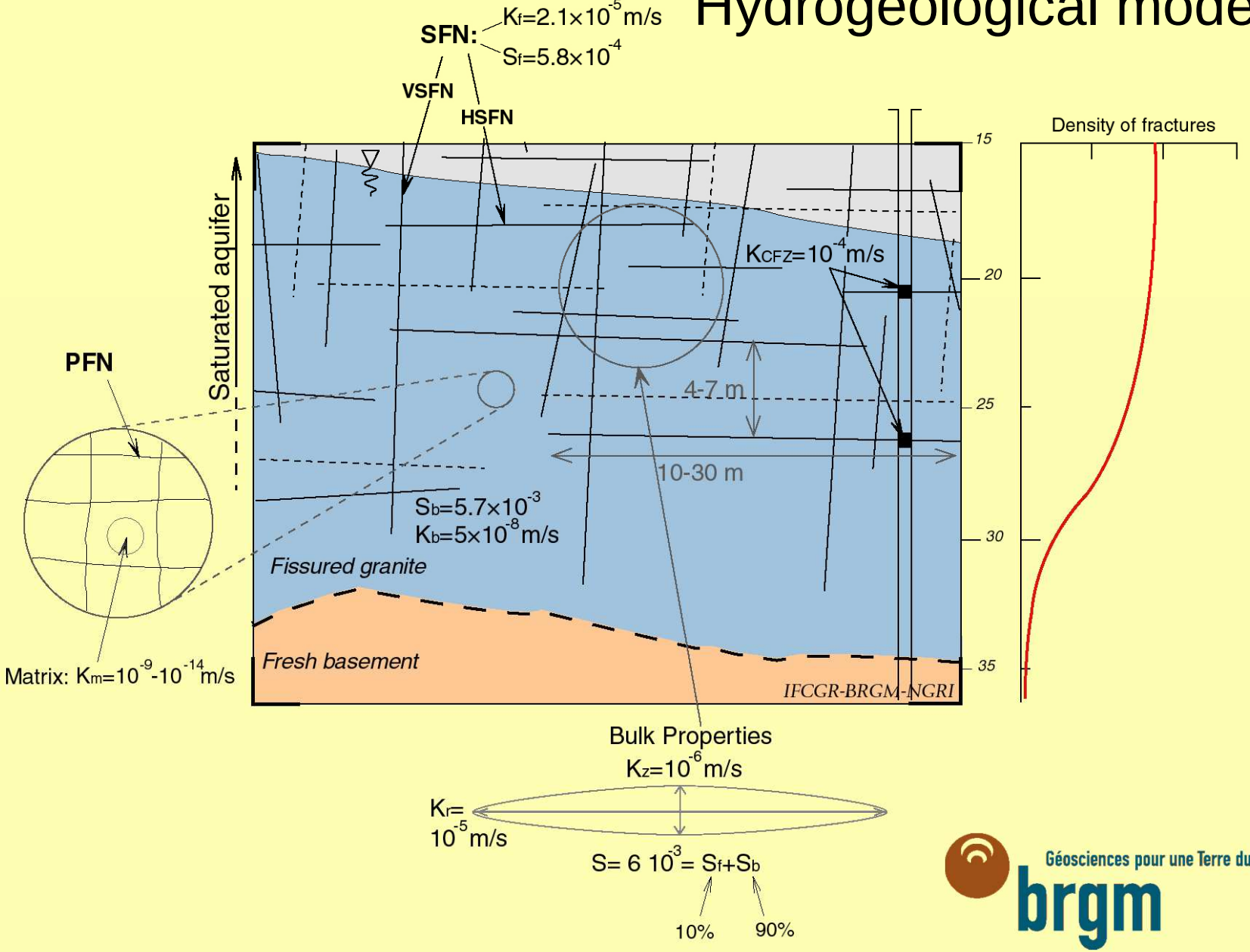
Hydrogeological model



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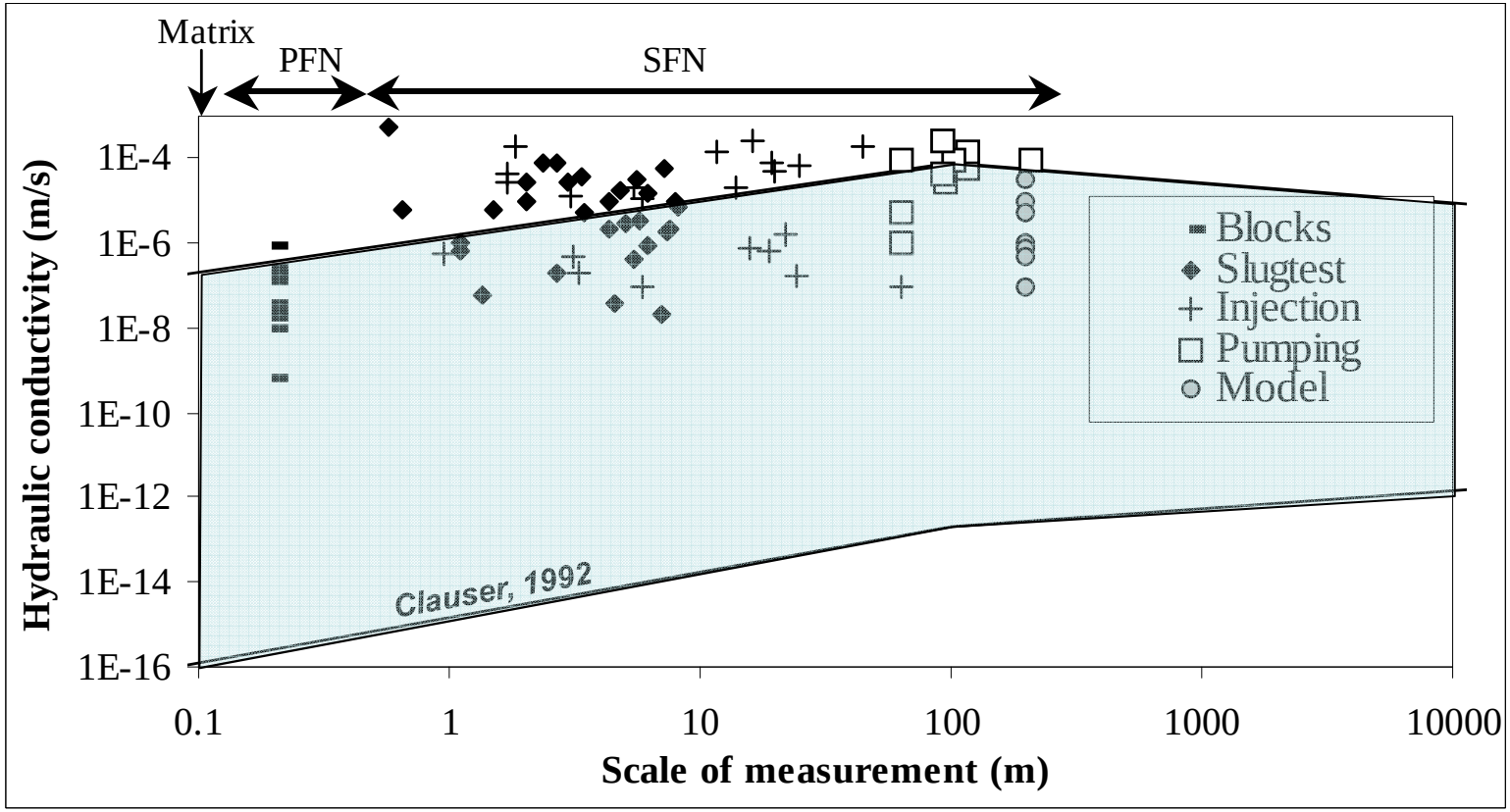
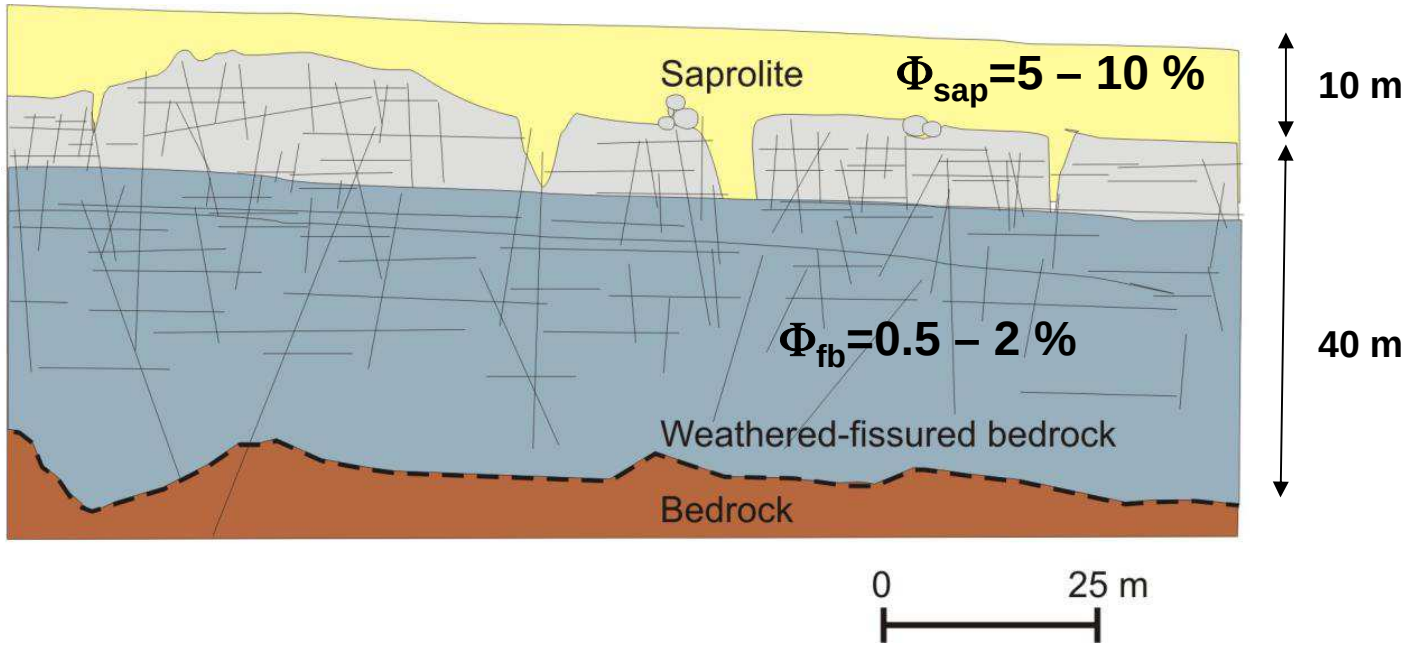
Scale effect ?



- Increase of permeability from matrix to block due to PFN
- Increase of permeability from block to slugtest scale due to SFN

- No change scale effect from slugest test to pumping and model scale

Storage volume is strongly limited



Depleted conditions: V = 40 x 0.01 = 0.4 m

Pumping rate : 0.2 m/yr -> recycling time: 2 years

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