Hydrogeo-psychology: The sunk cost fallacy of deep drilling in hard-rocks in India

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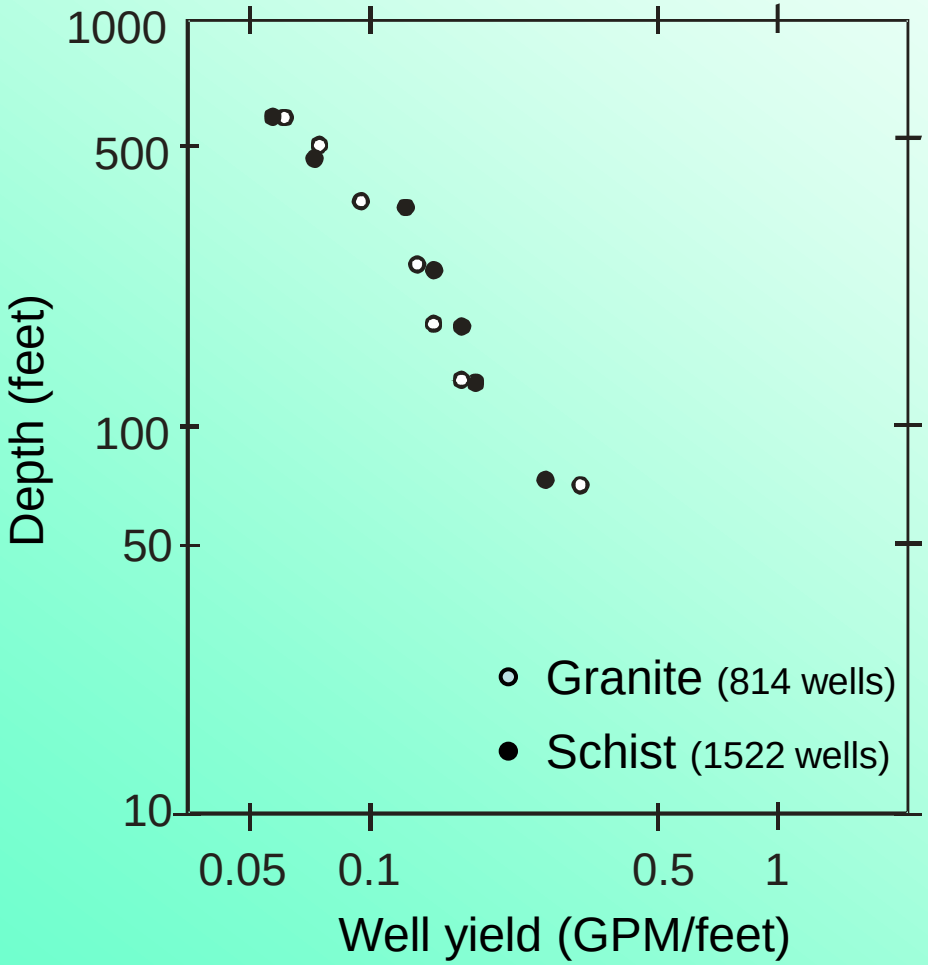
Dry shallow wells and deepening

Maheshwaram, Andhra-Pradesh, India

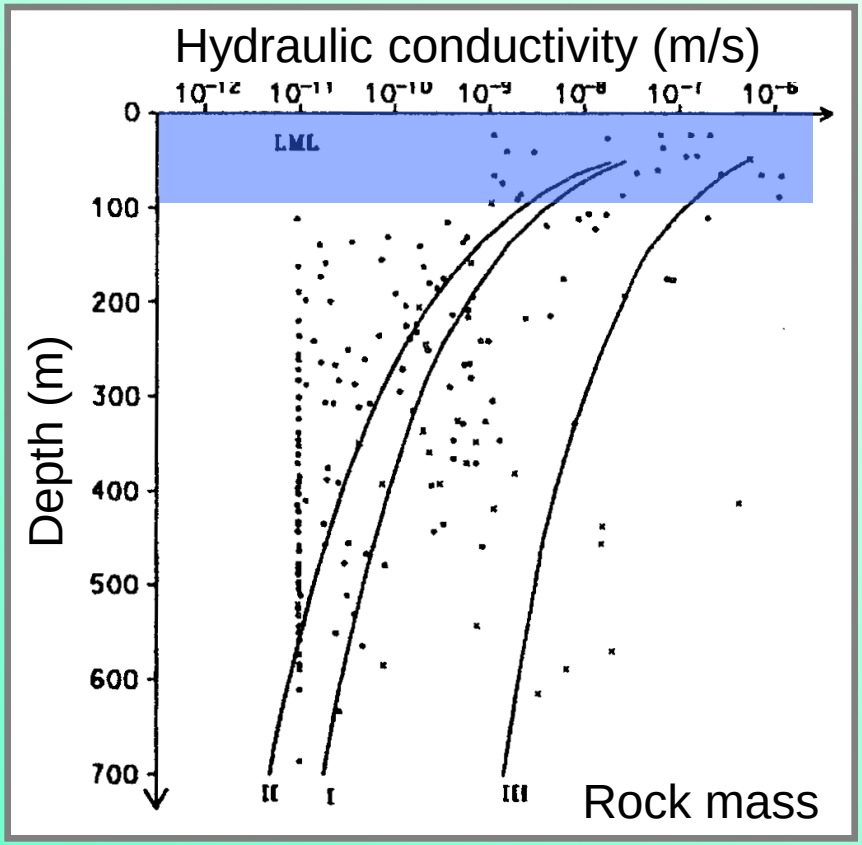
Kolar, Karnataka, India

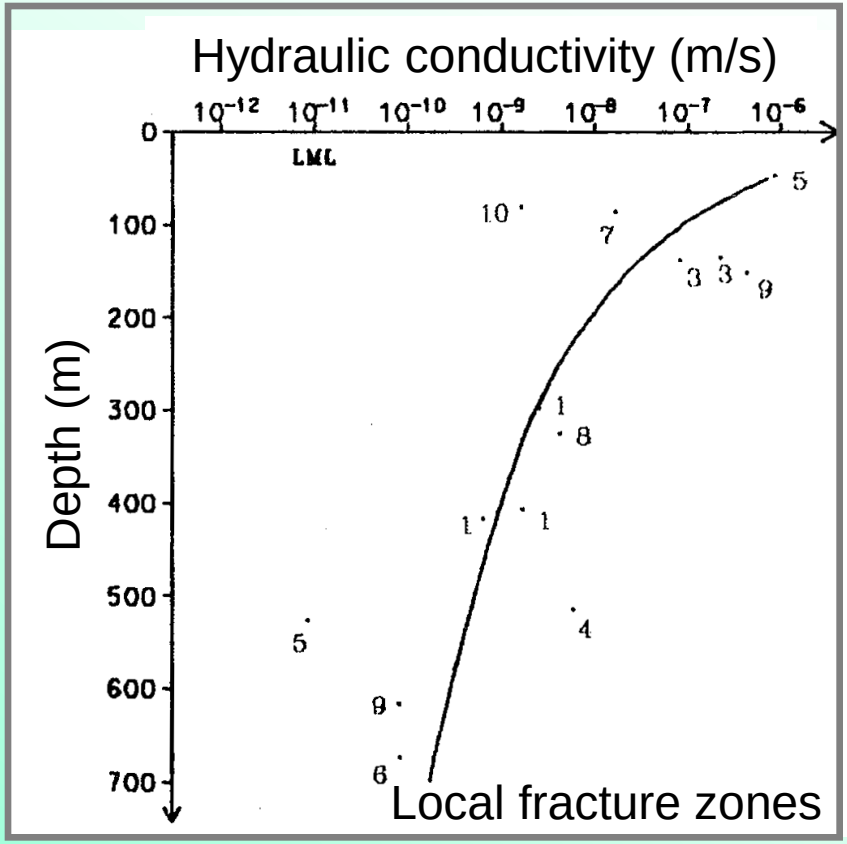
Granite and schist from Eastern United States



modified from Davis and Turk (1964) Ground Water

Gneiss from Fjällveden, Sweden

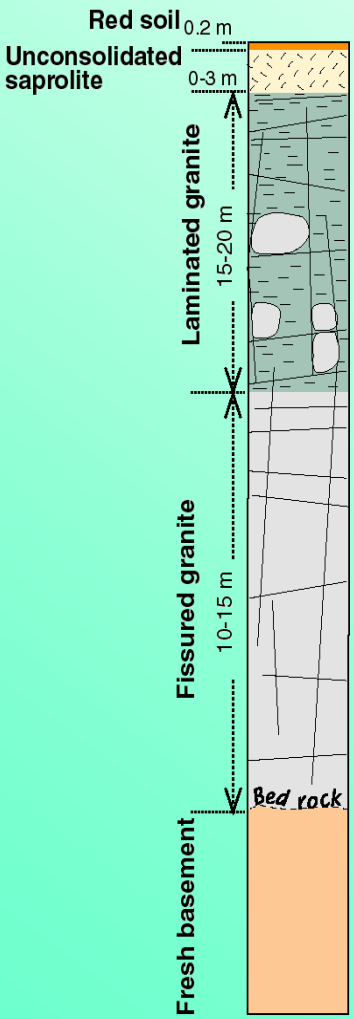




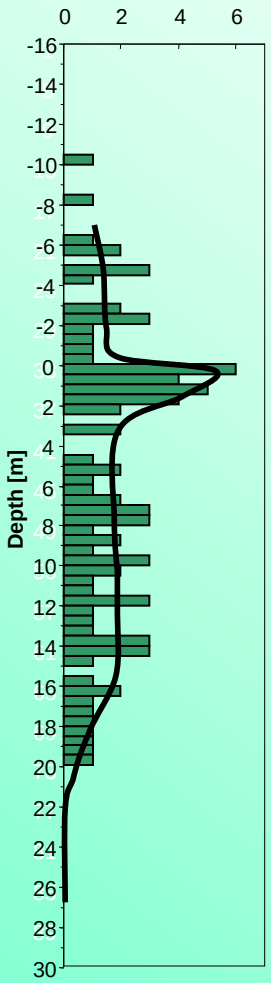
- Depth dependence of hydraulic conductivity

modified from Gustafson & Krasny (1994) - Applied Hydrogeology

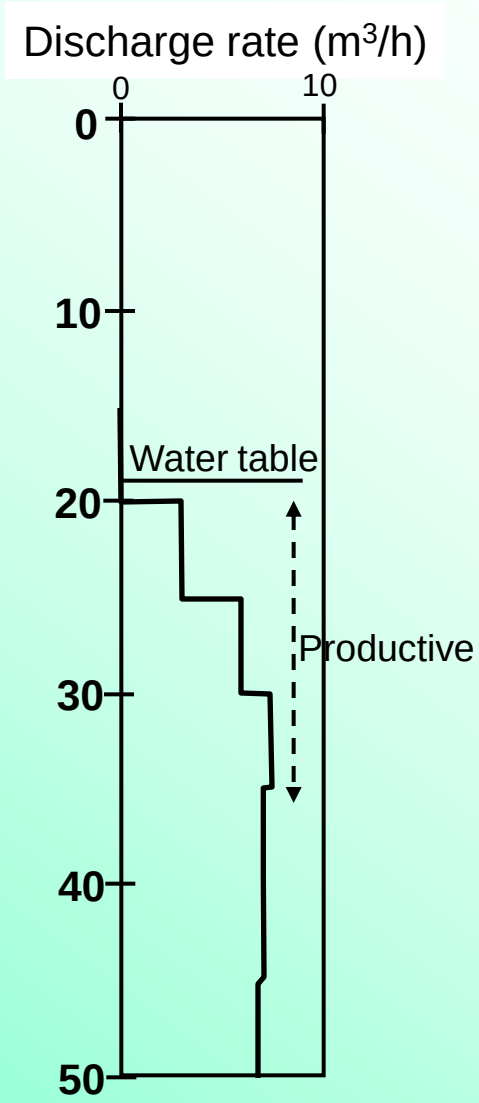
Granite from South India



Geological section



Vertical profile of fractures

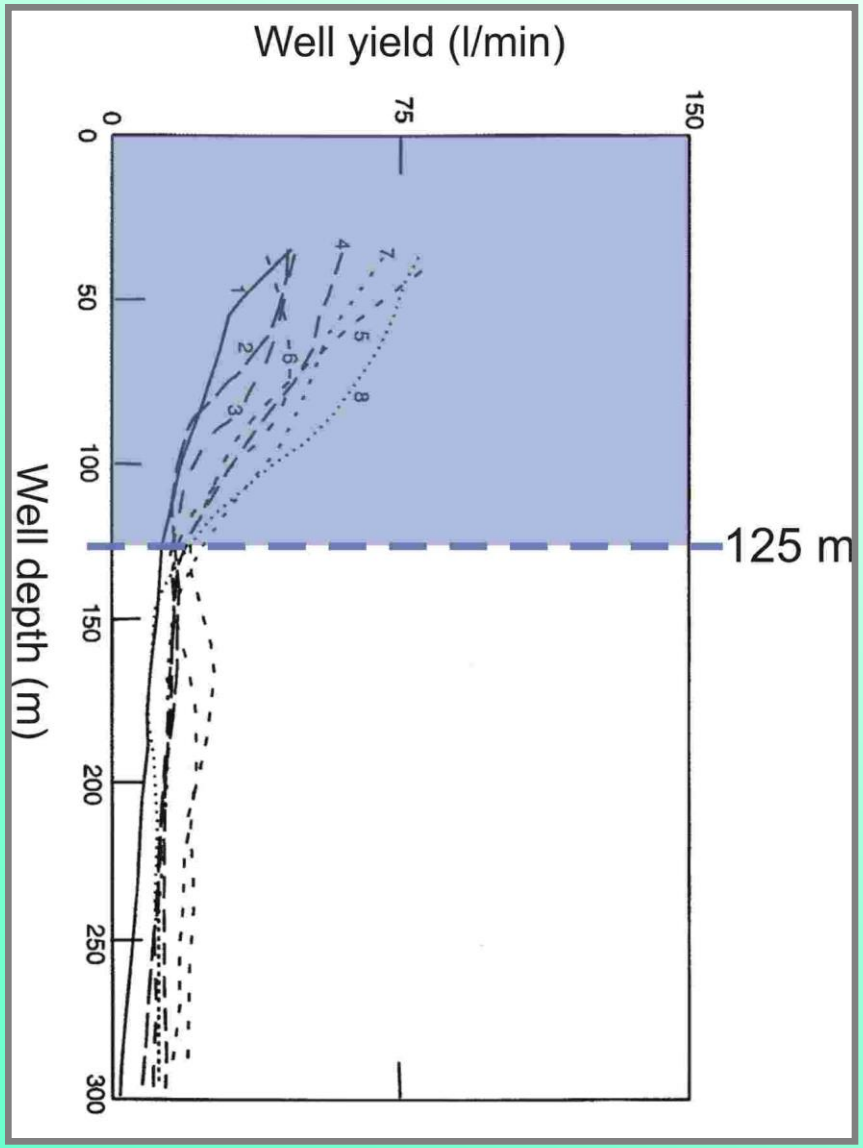


Vertical profile of air lift discharge

The air lift profile shows that the yield of the borewells is not improved beyond 30 to 40 meters. This is due to the limited thickness of the fissured granite.

The vertical extension of active fractures is limited to about 40 meters.

Pinardville quardrangle, New Hampshire

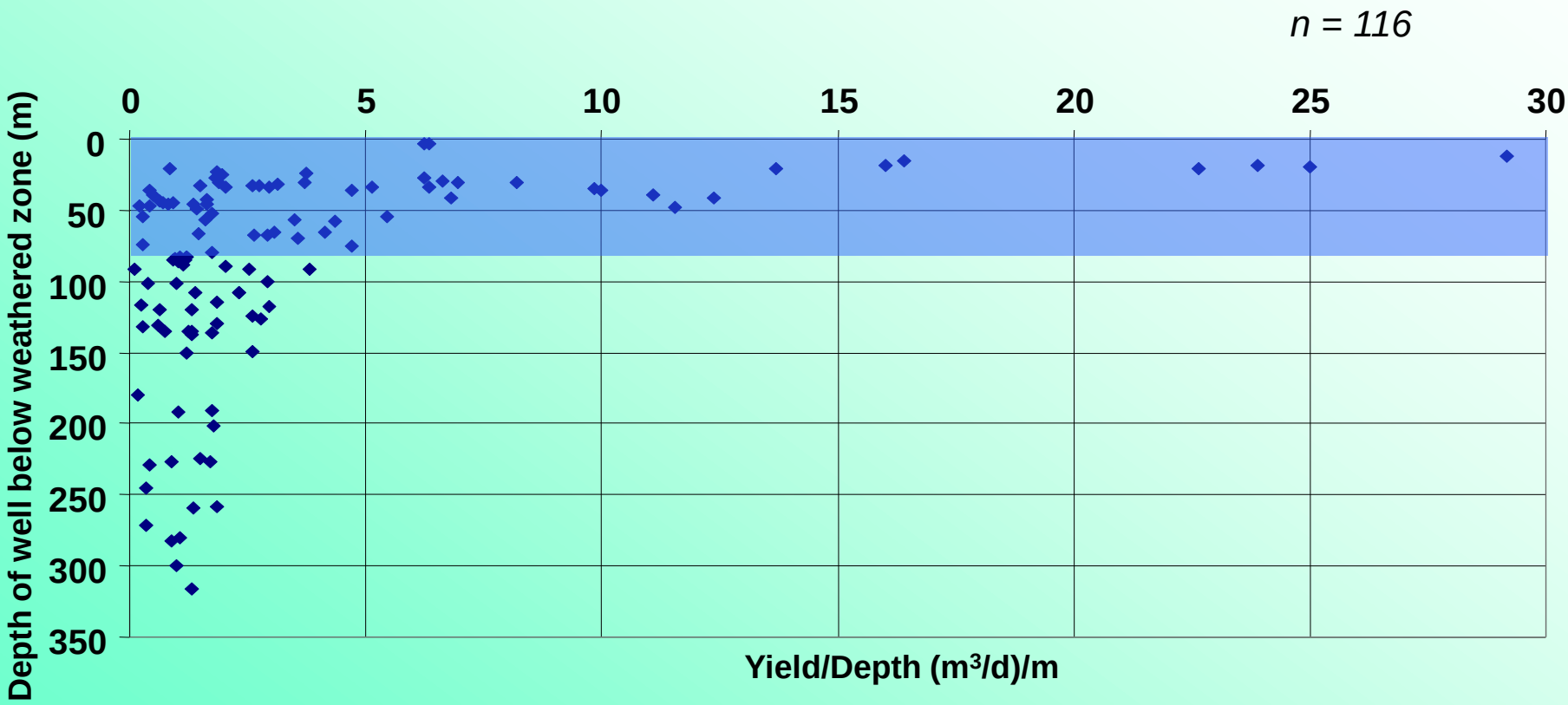


Beyond 125 m, the yield of the drilled wells is very low.

It means that, if the expected yield has not been obtained before that depth, drilling deeper does not increase the well yield !

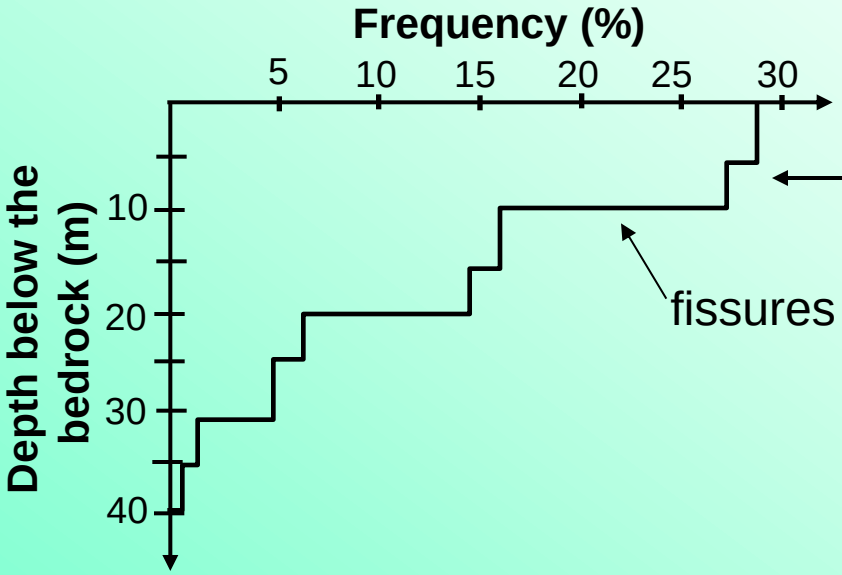
modified from Drew et al. (2001) – Ground Water

Yield – depth relationship, South Korea

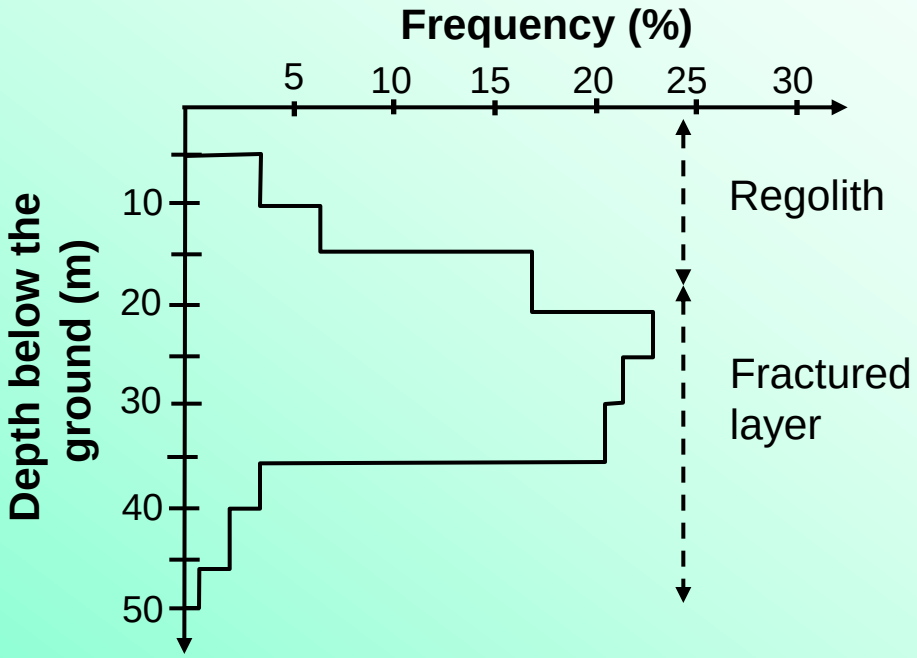


From Cho et al. (2003) – Ground Water in Fractured Rocks, Prague

Victoria Province, Zimbabwe

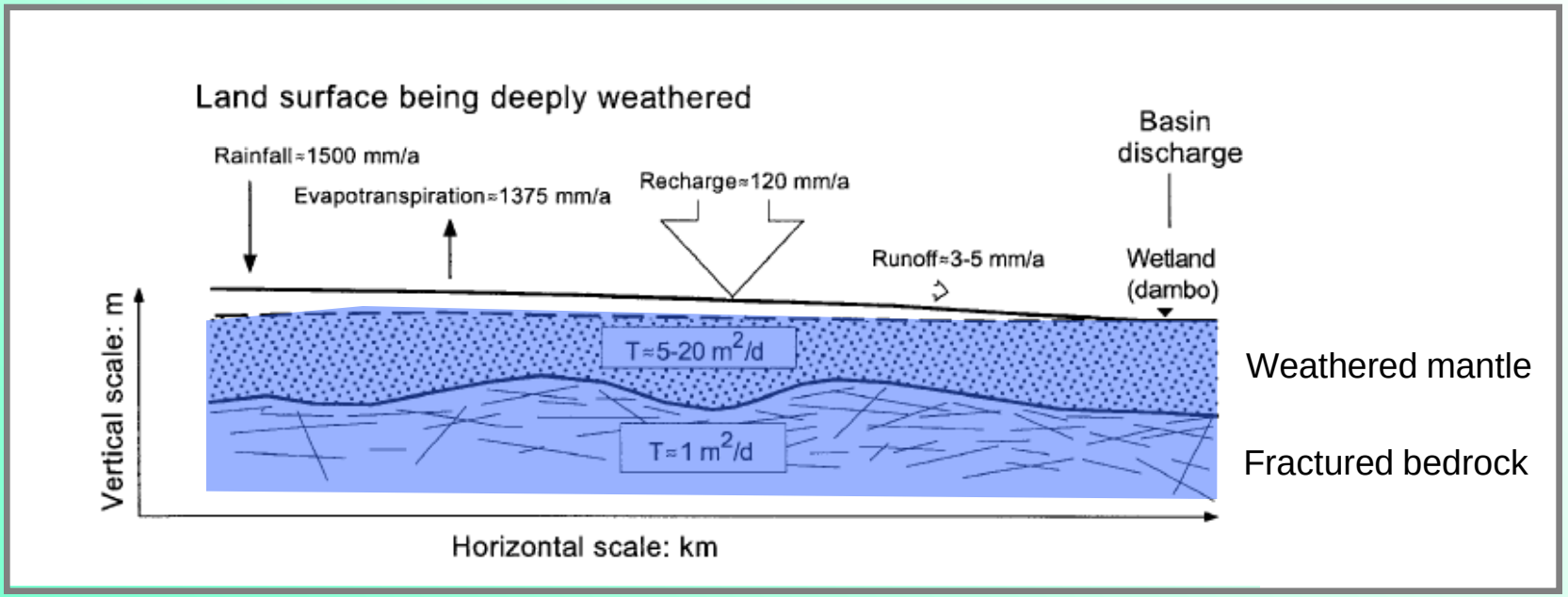


Most of the fractures are located at the top of the fractured layer



modified after Houston & Lewis (1988) – Ground Water

Hydrogeological model of Uganda



modified after Taylor & Howard (2000) – Hydrogeology

The Scientific Knowledge

- Groundwater flows in crystalline rocks dominantly occur in a shallow higher-permeability zone (“active” zone) that overlies a deeper lower-permeability zone hosting little flow (“inactive” zone)
- Higher permeability at shallower depths is generally attributed to a greater degree of weathering and/or smaller overburden loads allowing more fractures to remain open
- The thickness of the active layer is dependant on local geological settings
- Statistically, beyond the active zone, the probability to increase the yield of a given well in hard-rocks is very low

Staw Experiment 1

- Where: American Business School - When: 1976
- Who: students in management

1) A special fund should be allocated to one venture. Students have to decide which venture according to financial data provided to them.
2) Students choose a venture for the allocation of the fund.
3) Students are informed that the venture to which they gave the special fund had no improved results, on the contrary…
4) A new special fund is now available. The students are informed about the bad results of their first venture, and have to choose again between the two ventures.

Result: most of the students decide to allocate the available resource to the same venture, despite evidence that its results are not good !

Why a gap between Practice & Science ?

In Psychological Sciences, we speak about:

Escalation of commitment	*where people justify increased investment in a decision, based on the cumulative prior investment, despite new evidence suggesting that the decision was probably wrong*

Staw (1976) – Organizational Behavior and Human Performance

We must say « stop »

Madam A and Madam B:

- Go to watch a very bad movie (free for A)
- A leaves the theater and goes to the other event
- B stays at the theater
- A enjoys
- B waits the end of the movie
- B waits for the bus, delayed
- B comes back home very late

Sunk cost fallacy

Piège abscons

An other experiment (*Arkes and Blumer 1985):*

- Two stays are booked by students: one weekend stay at 100 € and another at 50 € (looking much better)
- Students are informed both stays fall the same weekend!
- They have to choose: most of them have chosen the stay at 100 €

Why a gap between Practice & Science ?

In Psychological Sciences, we speak about:

Sunk cost fallacy

increasing the resources available to an unsuccessful venture (or choice) in the hope of recovering past losses

Arkes and Blumer (1985) - Organizational Behavior and Human Decision Processes

What is the link with hydrogeology ?

- In water exploration, the escalation of commitment consists in drilling a borehole deeper in the hope of recovering the money wasted to drill the first dry meters. Once started, it is difficult to decide to stop drilling if the well is dry as the driller thinks that expected water-bearing structure could be a few meters away. This is similar to the compulsive gambler who needs, after losing, to gamble again to cover his loses.
- Of course, it can sometimes happen that a dry well becomes productive after deepening but, as suggested by the limited thickness of the active zone, it becomes a matter of luck.

Is there any solution ?

General sunk cost fallacy

1) One person has decided to spend effort (time, money, energy) in order to reach an objective
2) Objective is not sure
3) Settings are such that the person has the feeling that any additional expense will contribute to meet the objective
4) The process will continue if the person does not actively stop it
5) The person has not fixed any limit to its potential investment

Deep drilling sunk cost fallacy

1) One person has decided to spend money in a borewell to tap ground water
2) The borewell could run dry
3) The person things that water bearing fracture could be a few meters deeper
   => trend to increase the drilling depth to tap water
4) Usually, the drilling company will continue in case there is no explicit stop from the geologist
5) The person has not fixed any limit to the drilling depth

Conclusion

- The present trend of wells deepening in hard-rock is statistically not justified and financially unreasonable
- In order to stop it, before drilling a well, one maximum drilling depth should be defined according to the local hydrogeological knowledge