CTU
CZECH TECHNICAL UNIVERSITY IN PRAGUE

Vadose Zone Hydrology

Seminar 3

Soil Hydraulic Characteristics - Retention Curve

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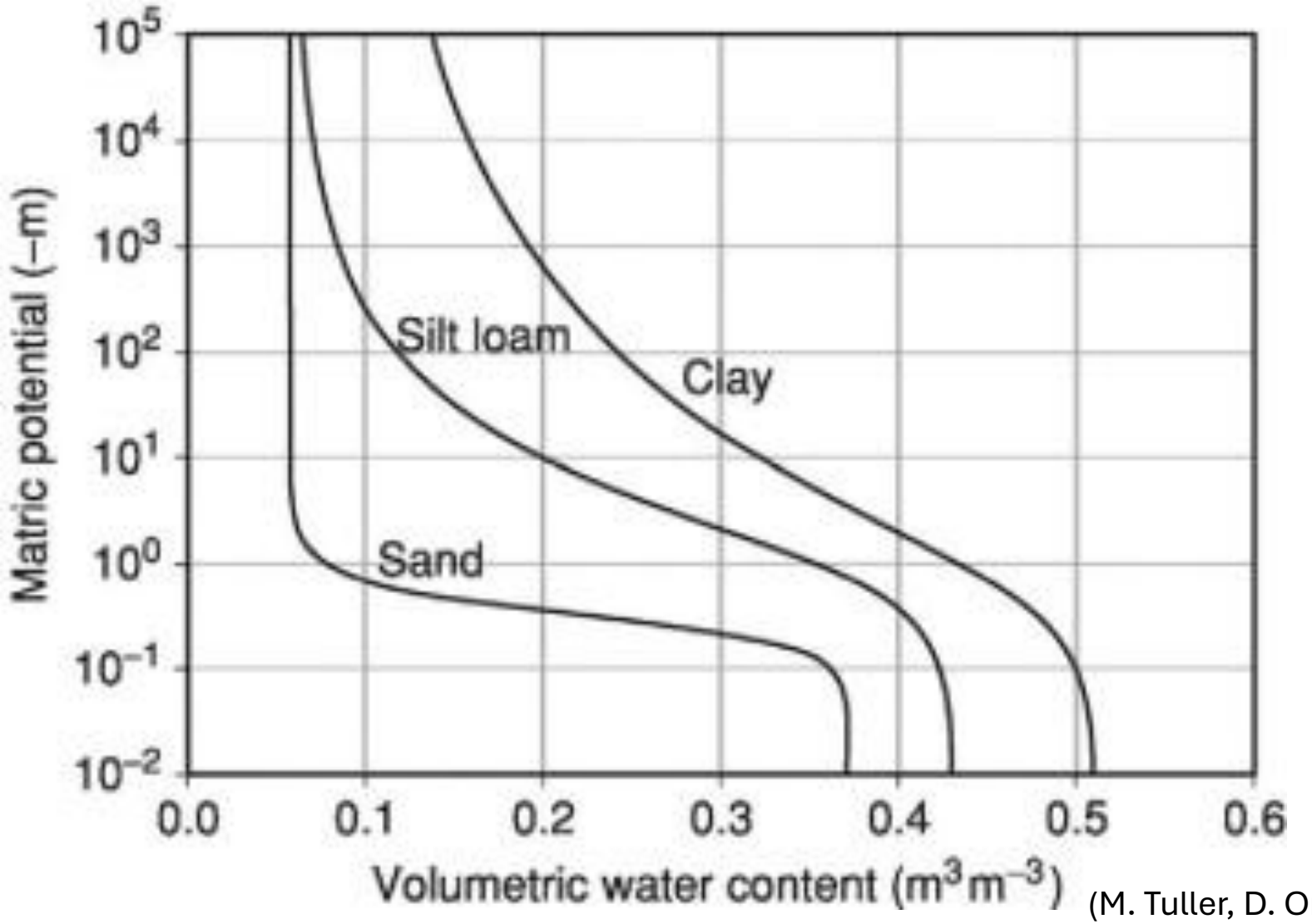
What is retention curve?

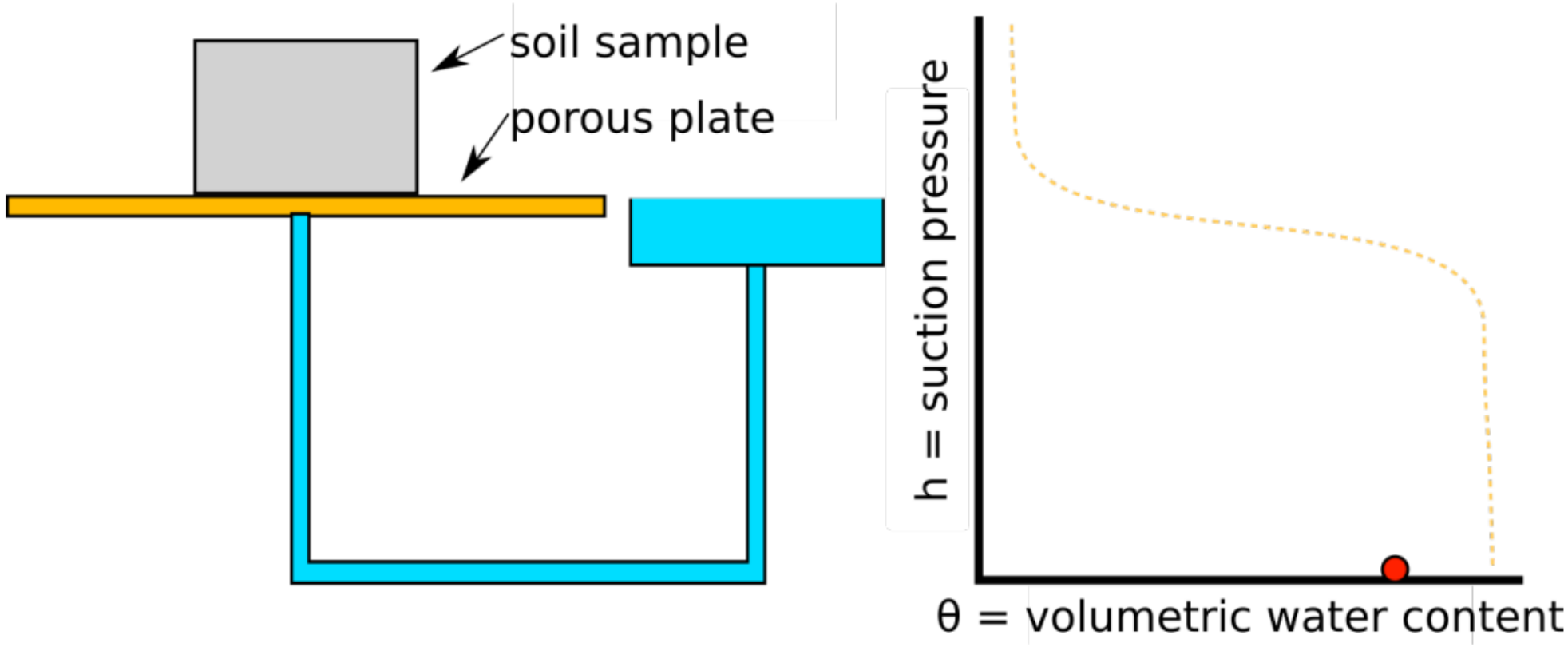
- A retention curve is the relationship between soil volumetric water content and soil water potential (or matric suction).
- Describes soil pore space in terms of filling and draining dynamics.
- It shows how much water is retained in the soil at different suction (negative pressure) levels.



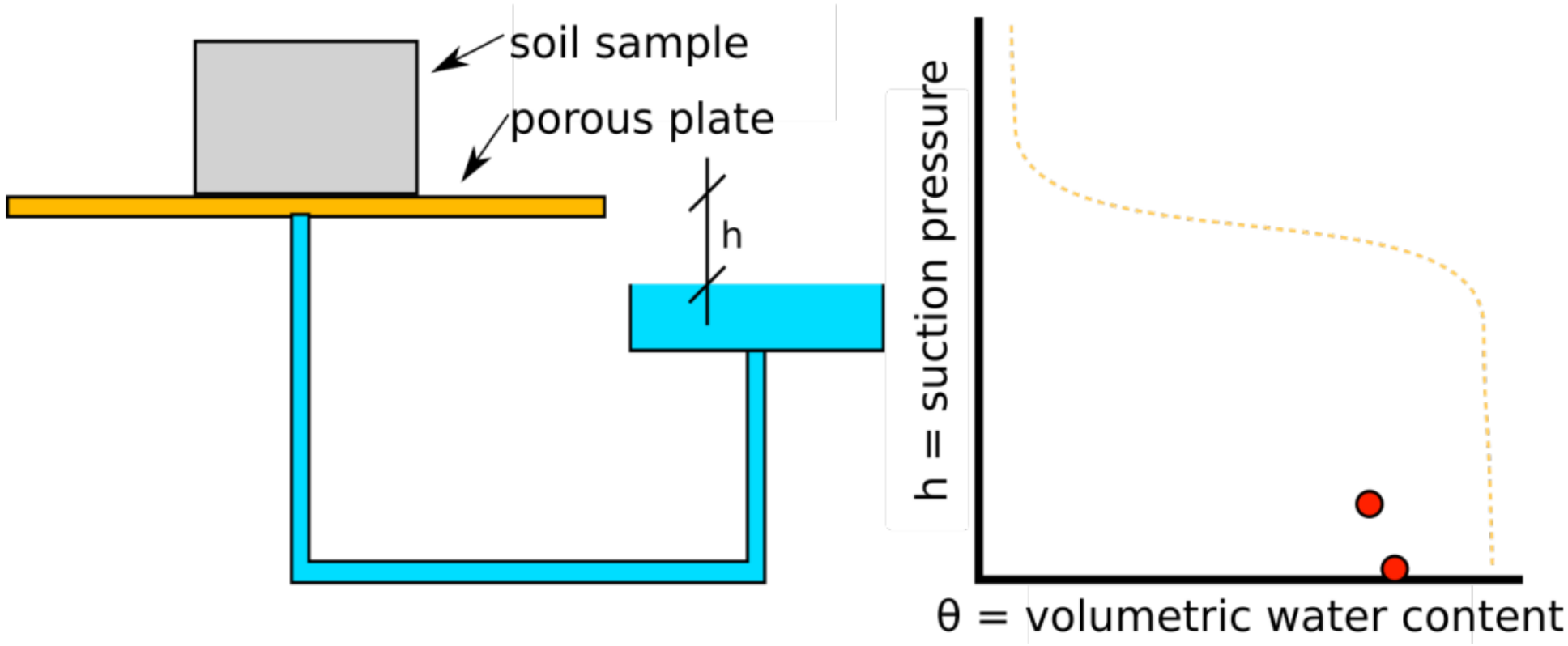
(M. Tuller, D. Or)

What is retention curve?

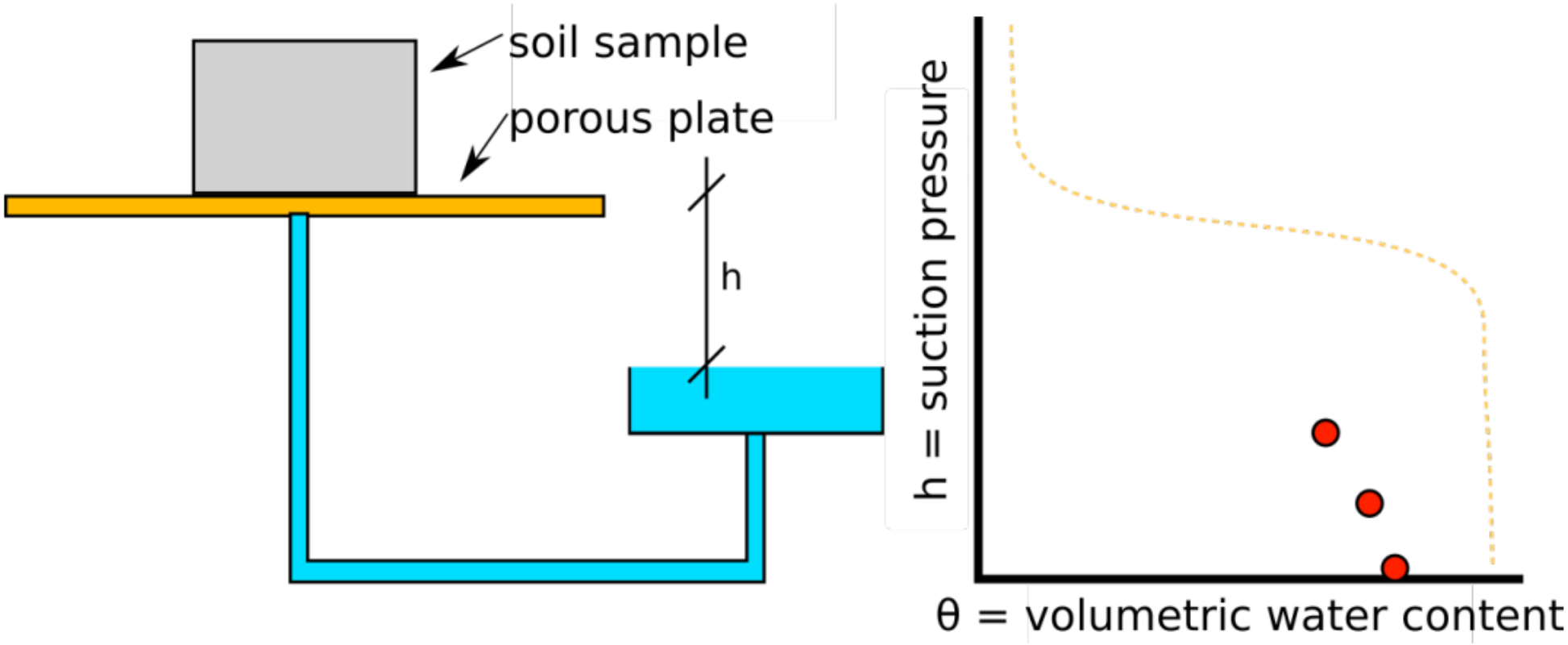
Measurement procedure



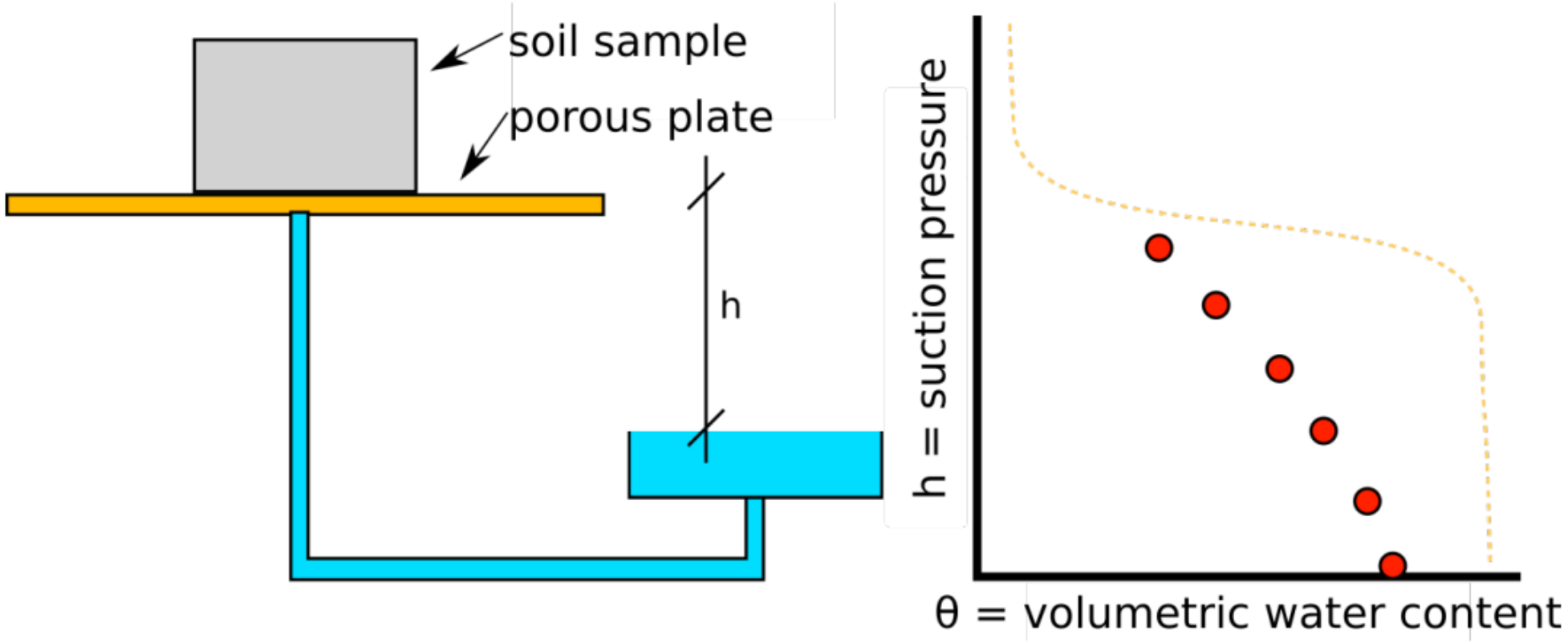
Measurement procedure



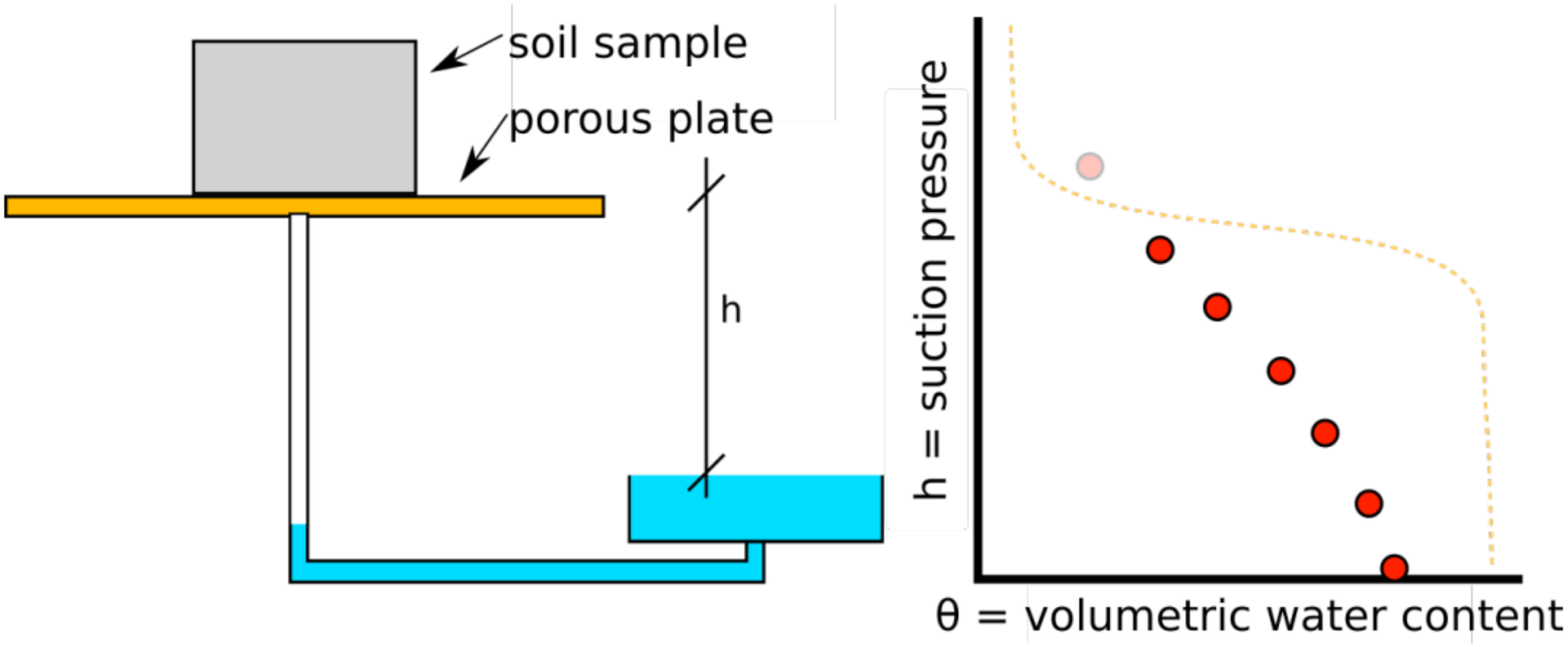
Measurement procedure



Measurement procedure



Measurement procedure



Measurement procedure

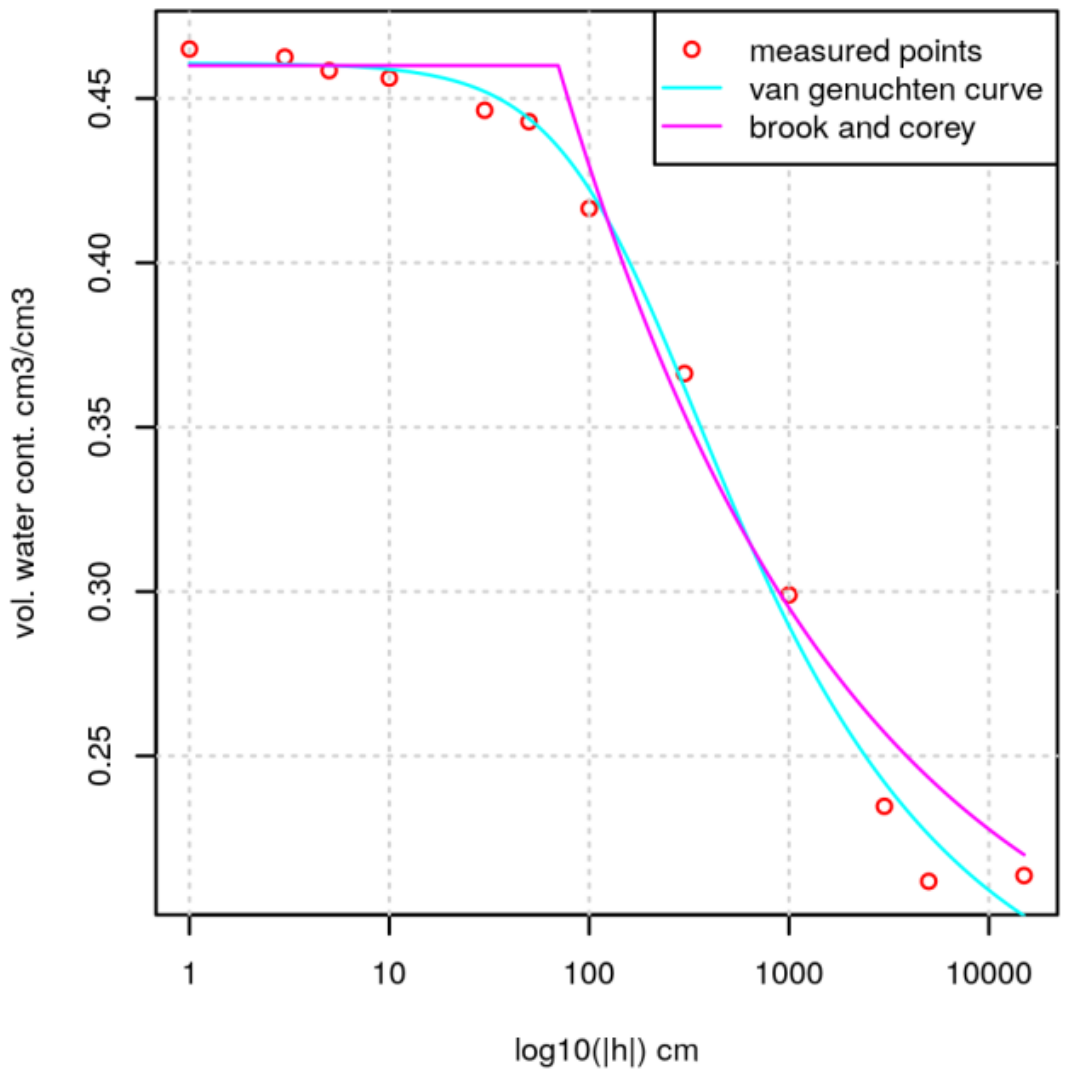
Parameterization of retention curve

- Models of porous media transport usually solve Richards Equation

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x}\left(K(h)\left(\frac{\partial h}{\partial x} + \cos(\alpha)\right)\right) - S$$

- Parameterization functions are used to obtain a continuous relationship for a smooth interpolation that can be integrated into numerical models.

- Improve the accuracy of Richard's Equation



Brooks & Corey (1964)

$$\theta_e(h) = \begin{cases} \left(\frac{h_b}{h}\right)^{\lambda}, & \text{if } h < h_b \\ 1, & \text{otherwise} \end{cases}$$

where h_b is bubbling pressure (vstupní hodnota vzduchu) and λ is pore size distribution index.

Effective vol. water content θ_e is defined as

$$\theta_e = \frac{\theta - \theta_r}{\theta_s - \theta_r},$$

where θ_s is saturated water content and θ_r is residual water content.

Van Genuchten

$$\theta_e(h) = \begin{cases} \frac{1}{(1+(\alpha|h|)^n)^m} & \text{pro } h < 0 \\ 1 & \text{pro } h \geq 0 \end{cases}$$

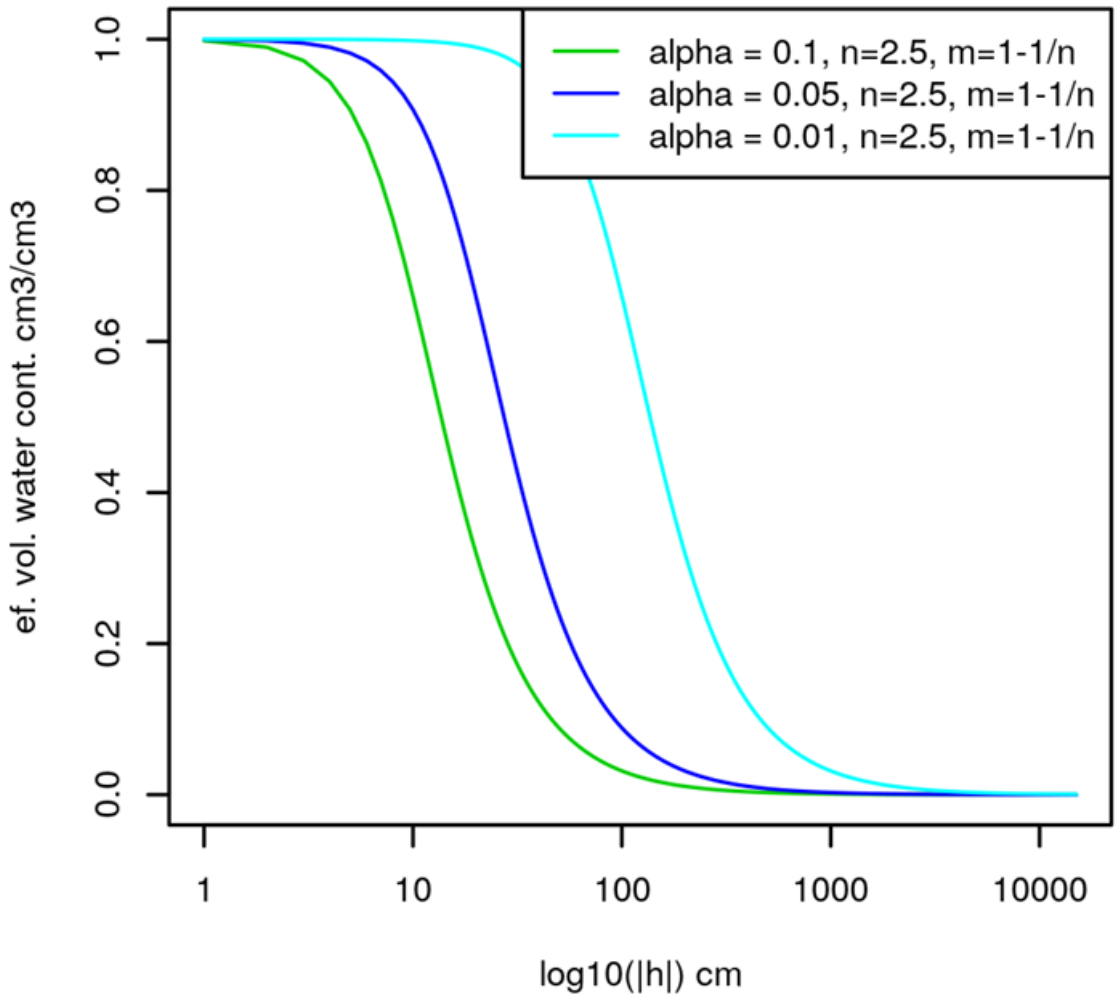
where α, n, and m are fitting parameters.

$\alpha = 1/h_b$
$\theta_e = (\theta - \theta_r)/(\theta_s - \theta_r)$, and

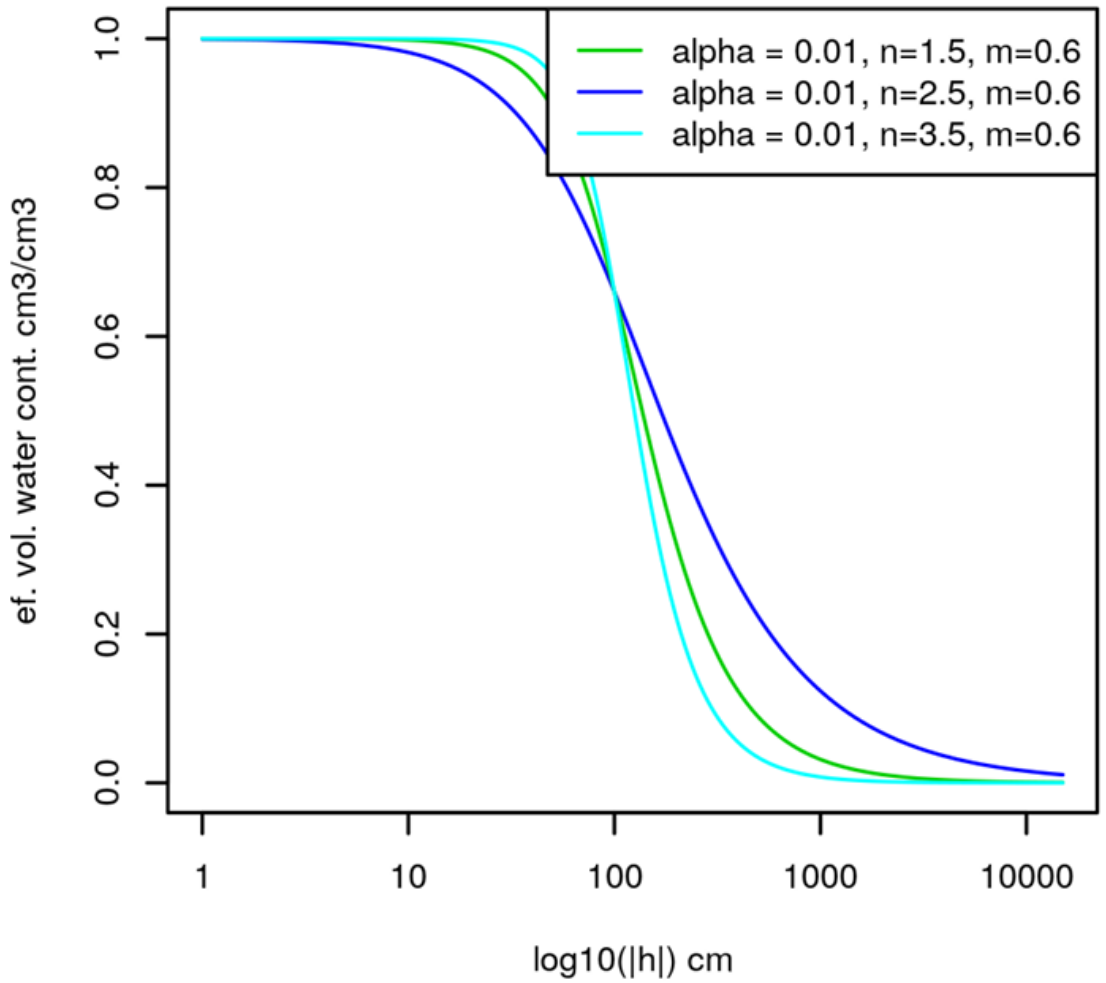
m is often
$m = 1 - 1/n$

van Genuchten RC is often used in models because it is continuously differentiable (in contrast to Brooks & Corey).

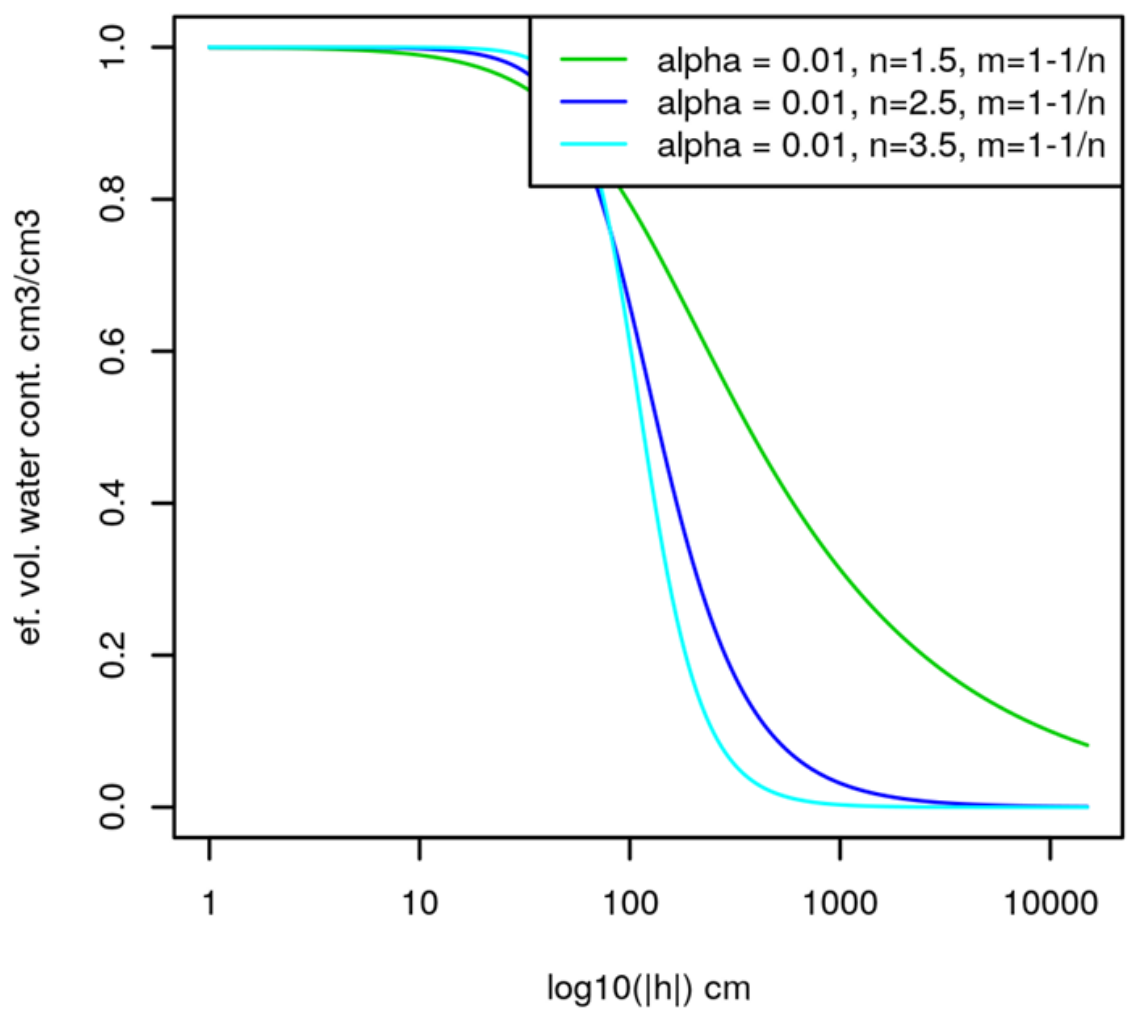
Van Genuchten Retention Curve



Van Genuchten Retention Curve



Van Genuchten Retention Curve



Pedotransfer Functions

Measuring the retention curve and unsaturated hydraulic conductivity is challenging and time-consuming.

Pedotransfer functions (PTFs) estimate these properties using easily available soil data.

Inputs typically include soil type, texture, and bulk density.

Large soil databases are required to develop accurate PTFs.

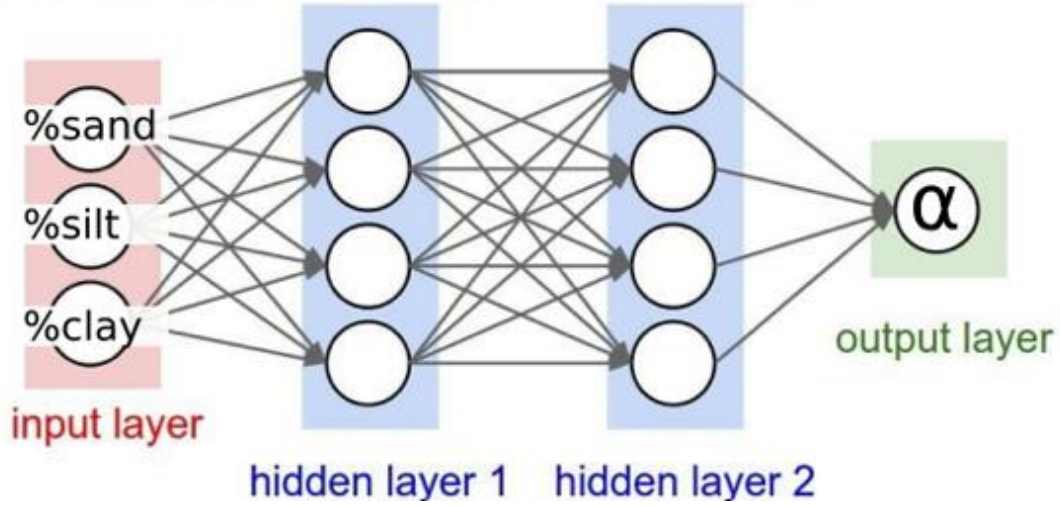
Pedotransfer Functions

- PTFs are derived using regression analysis or machine learning methods, such as artificial neural networks (e.g., ROSETTA in RETC).

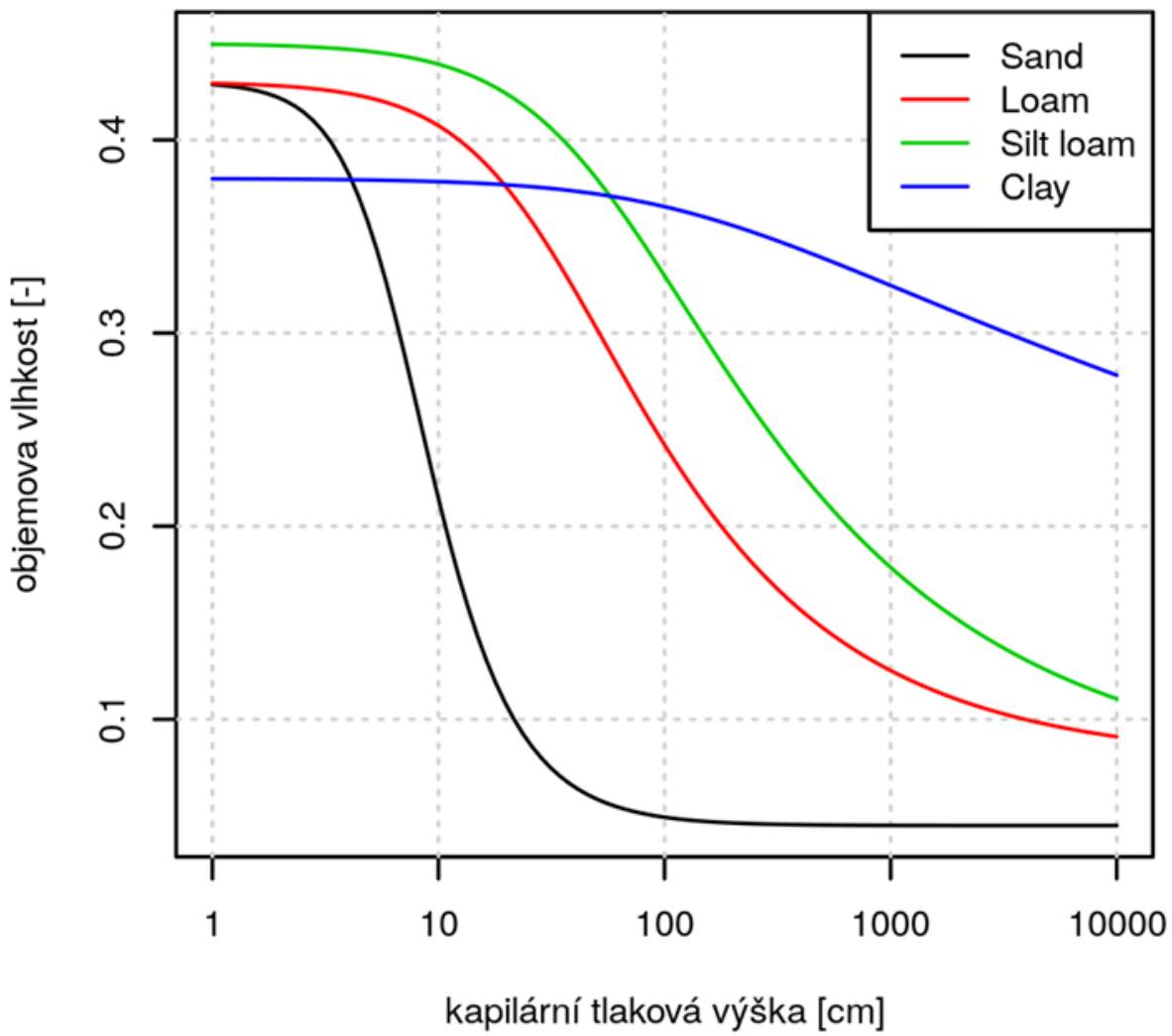
Regression analyses

$$\alpha = a\ \%sand + b\ \%silt + c\ \%clay$$

Artificial neural network

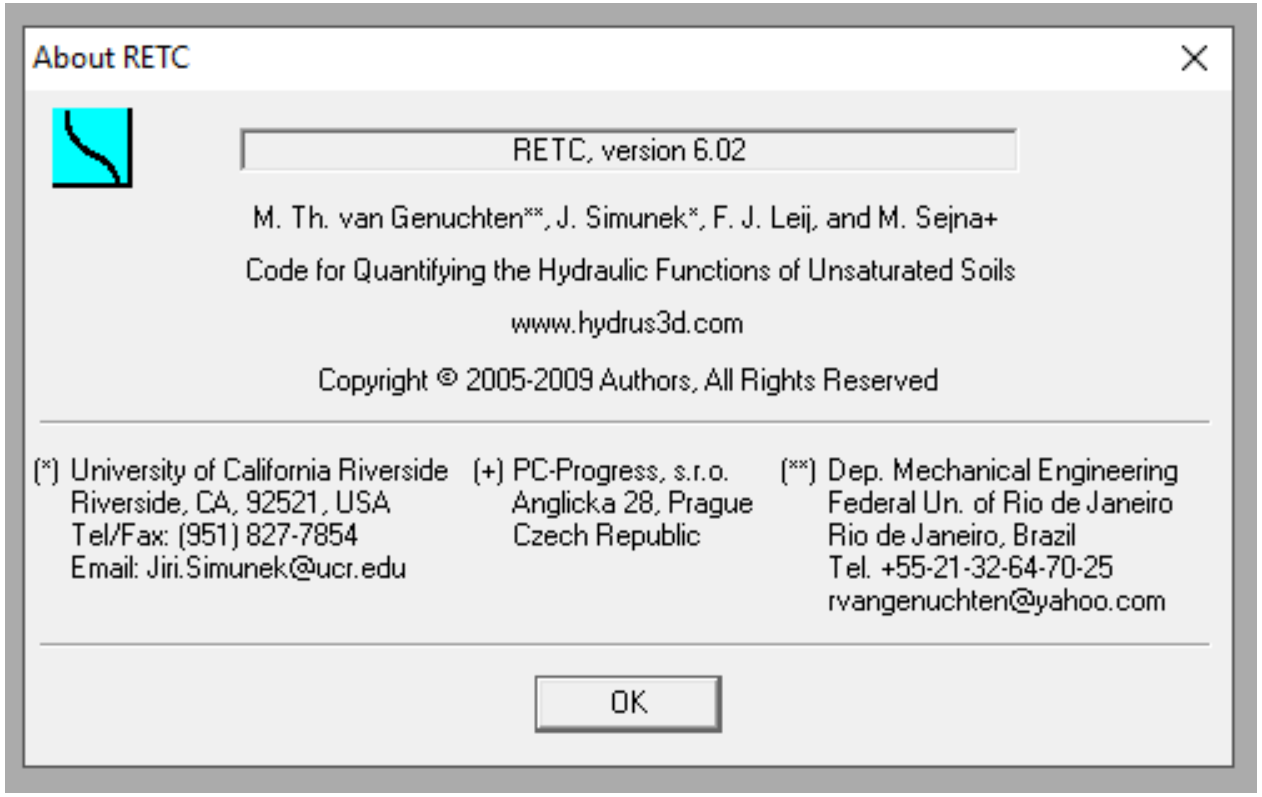


Pedotransfer Functions



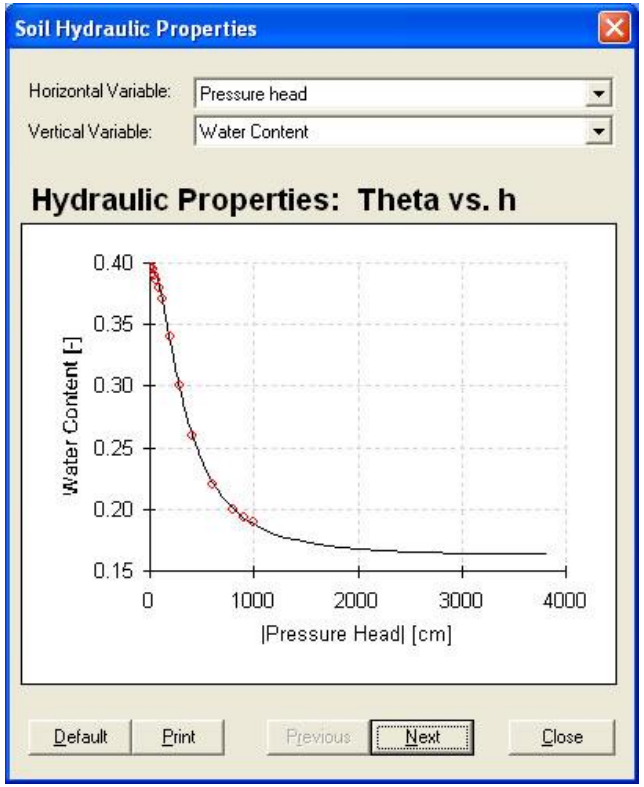
RETC

- **RETC** is a computer program which may be used to analyze the soil water retention and hydraulic conductivity functions of unsaturated soils.



RETC

- The program uses the parametric models of Brooks-Corey (1964), van Genuchten (1990), the lognormal distribution model of Kosugi (1996), and the dual-permeability model of Durner (1994) to represent soil water retention curve



Assignment

- Data of retention curve were measured at 2 soil samples at sand tank and in pressure chamber.
- Use program RECT to estimate van Genuchtens and Brooks & Corey RC parameters.

1. Get parameters for van Genuchten and Brooks & Corey retention curves.

2. Show measured points and parametrized RC in a graph. Measured data are below.

Soil 1

– h (cm)	Water cont.
1	0.365
10	0.232
30	0.177
58	0.149
89	0.137
500	0.119
6000	0.107

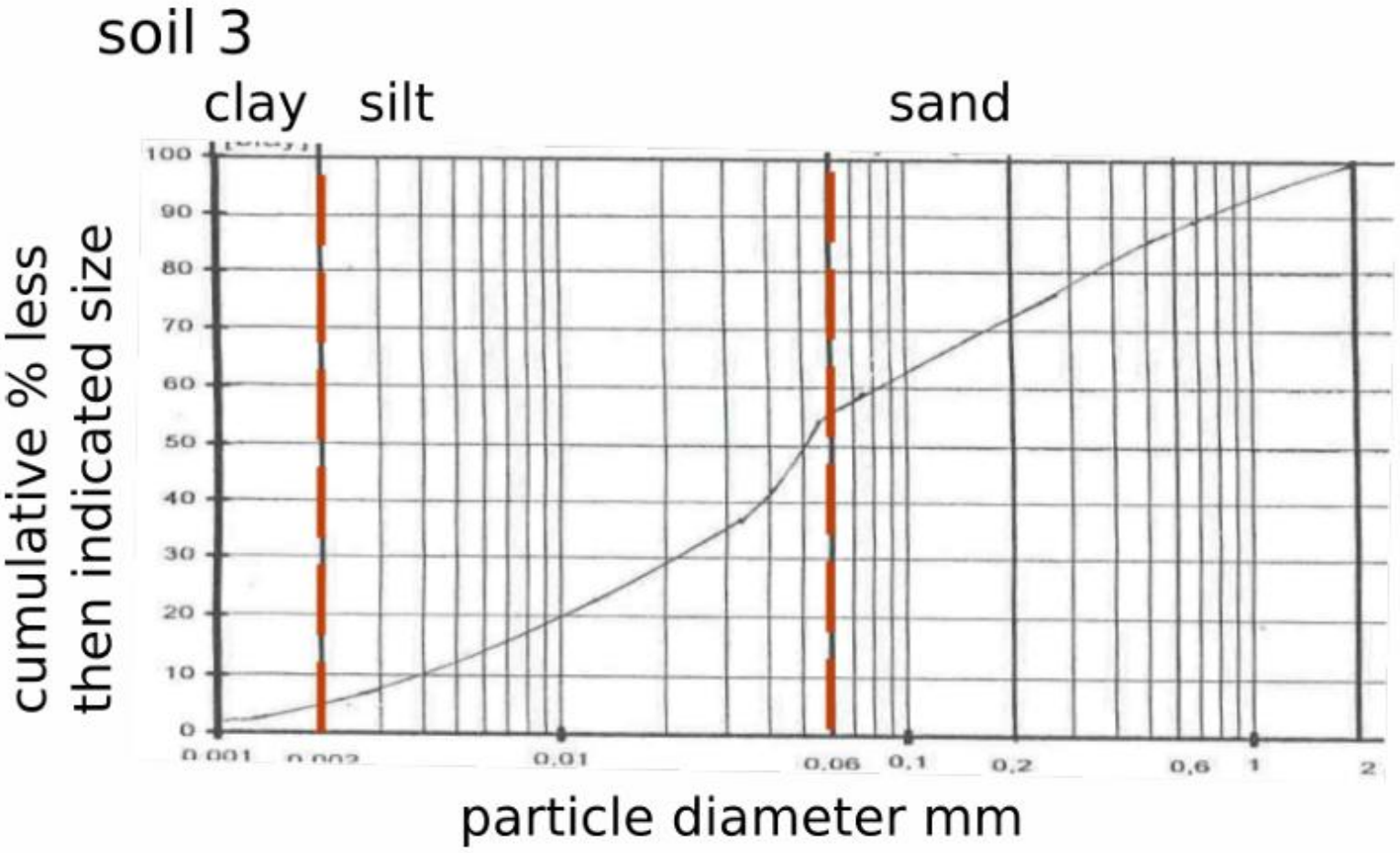
Ks = 280 cm/day

Soil 2

– h (cm)	Water cont.
1	0.310
10	0.268
30	0.241
58	0.199
89	0.177
500	0.152
6000	0.137

Ks = 65 cm/day

bulk density: $\rho_b = 1.95\ g/cm3$



Bonus Assignment: soil 3

References

- https://storm.fsv.cvut.cz/data/files/soil_retc.pdf
- https://www.pc-progress.com/en/default.aspx?retc

RETC Download: https://www.pc-progress.com/en/Default.aspx?retc-downloads