Permeability

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Definition

Permeability is a measure of the ability of a fluid to pass through its porous medium

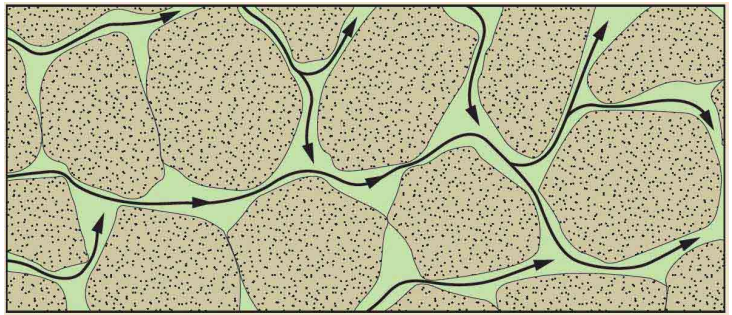
The **standard unit** for permeability is the **Darcy (d)** or, more commonly, the **millidarcy (md)**

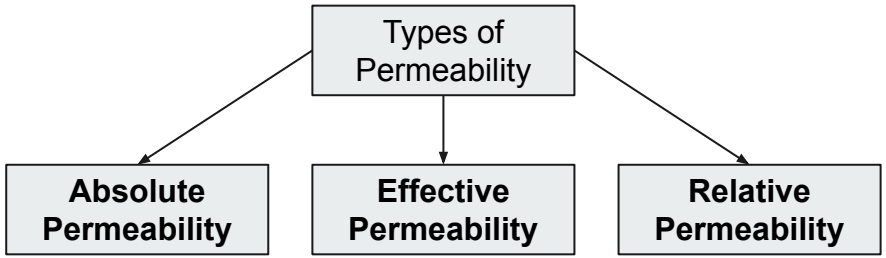
Formula

Darcy's Law:

$$Q = \frac{-kA\,\Delta P}{\mu L}$$

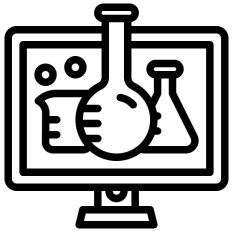
- Q → Total discharge
- k → coefficient of permeability
- A → cross sectional area of flow
- ΔP → Pressure drop ($P_f - P_i$)



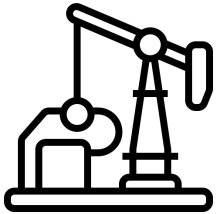


Measuring Techniques

Lab

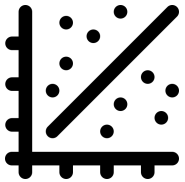


Hydrodynamics



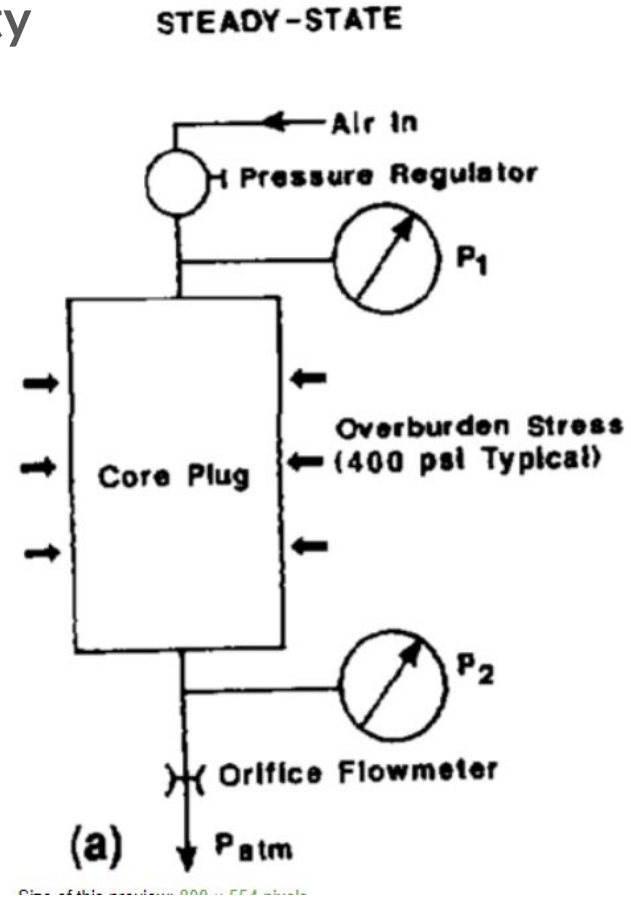
Hydrodynamics log

Correlation



Profile method by full-size core

1. Gas permeability



$$k_a = \frac{2000 p_a \mu q_a L}{(p_1^2 - p_2^2)^2 A}$$

- k_a = air permeability, md
- p_a = atmospheric pressure, atm
- p_1 = upstream pressure, atm
- p_2 = outlet pressure, atm
- L = length, cm
- μ = air viscosity, cP
- q_a = gas flow rate at atmospheric pressure, cm^3/sec
- A = cross-sectional area, cm^2

2. Liquid permeability

$$k_1 = \frac{1000\mu_1 q_1 L}{\Delta p A}$$

- k_1 = liquid permeability, md
- L = length, cm
- μ_1 = liquid viscosity, cP
- q_1 = gas flow rate at atmospheric pressure, cm^3/sec
- A = cross-sectional area, cm^2
- Δp = pressure drop, atm

Examples

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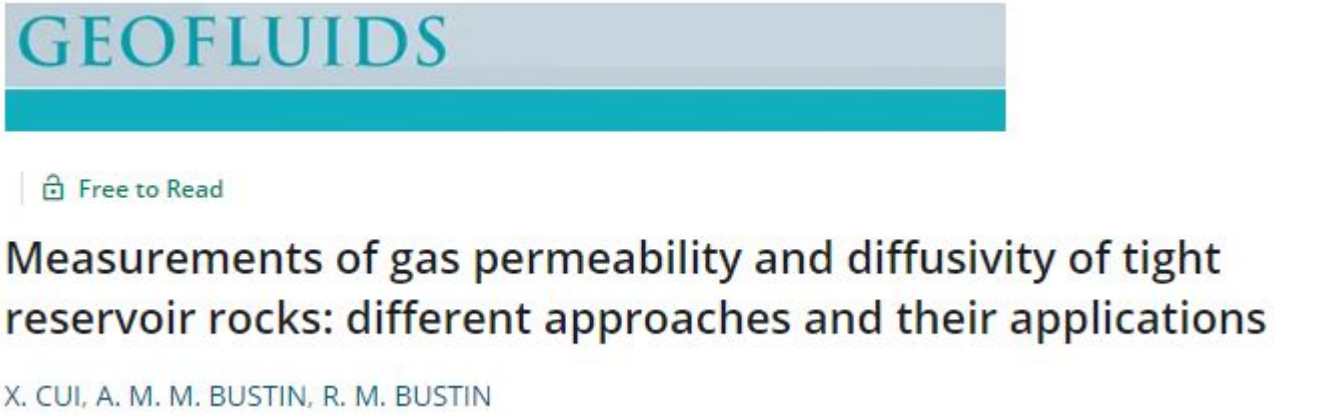
Volume 65, May 2019, Pages 224-236

Gas permeability tests on core plugs from unconventional reservoir rocks under controlled stress: A comparison of different transient methods

https://doi.org/10.1016/j.jngse.2019.03.003

Examples

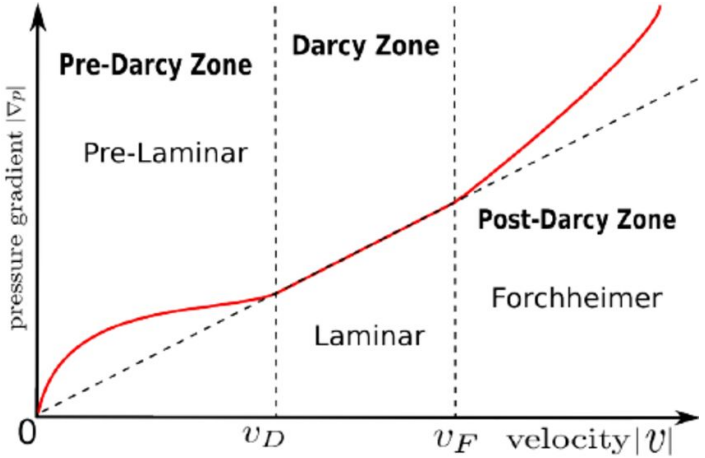


https://doi.org/10.1111/j.1468-8123.2009.00244.x

Darcy's law limitations

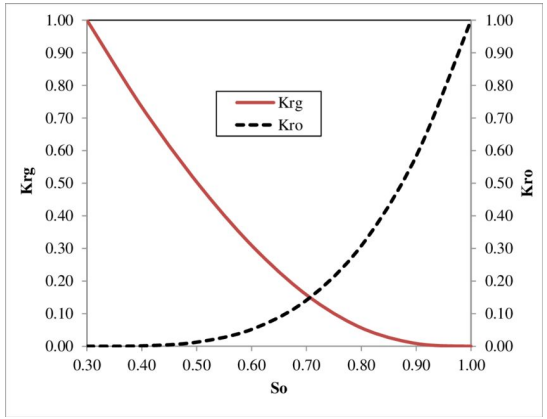
$$q = \frac{A \cdot k}{\mu} \frac{\Delta P}{L}$$

- 100% saturation
- laminar flow
- steady state flow



$$q_w = \frac{A \cdot k}{\mu_w} \frac{\Delta P}{L} \times k_{rw}(S_w)$$

$$q_o = \frac{A \cdot k}{\mu_o} \frac{\Delta P}{L} \times k_{ro}(S_o)$$



- Newton's law of viscous friction
- low filtration velocities
- for filtration of non-Newtonian fluids (e.g., some oils), the relationship between the pressure gradient and the filtration rate may be nonlinear or non-algebraic

Conclusion

Permeability is

- one of the **main parameters** of rocks
- ability **to pass fluids** through the rock
- evaluation of the **reservoir properties** of rocks

Thank you for your attention