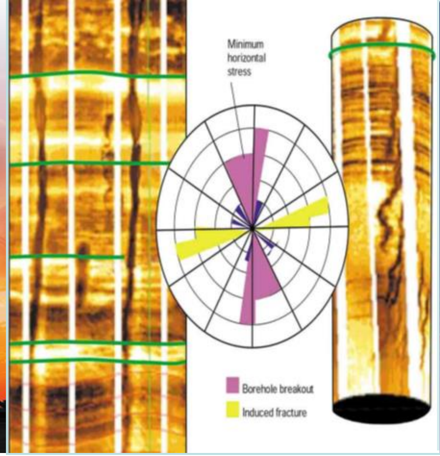

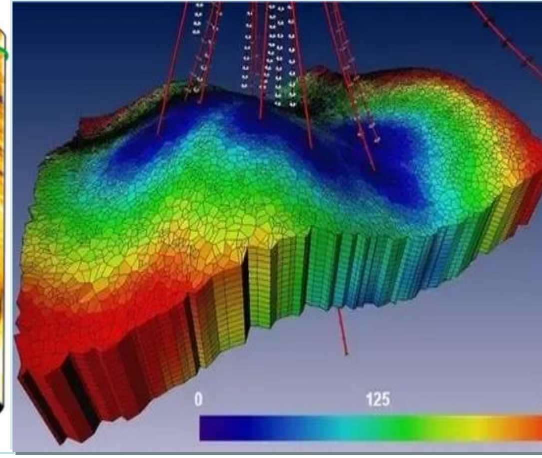

Methods of Determining Permeability

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Permeability (K)

Permeability: Is the property a rock has to transmit fluids. It is related to porosity but is not always dependent upon it. Permeability is controlled by the size of the connecting passages (pore throats or capillaries) between pores. It is measured in darcies or millidarcies

absolute permeability : the ability of a rock to transmit a single fluid when it is 100% saturated with that fluid

Effective permeability : refers to the presence of two fluids in a rock, and is the ability of the rock to transmit a fluid in the presence of another fluid when the two fluids are immiscible

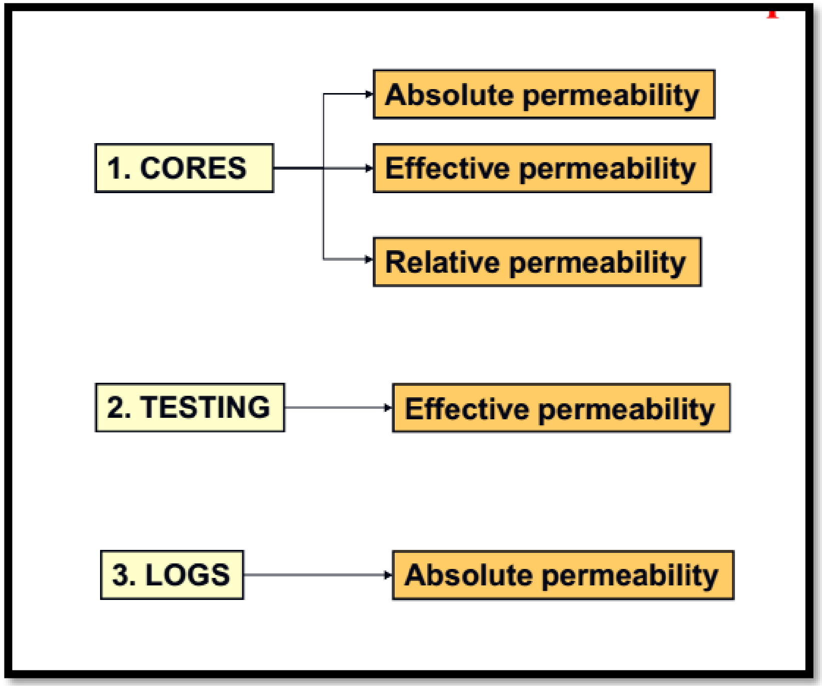
Relative permeability : is the ratio between effective permeability of fluid at partial saturation, and the permeability at 100% saturation (absolute permeability).

Methods of Determining Permeability

Many methods to estimate the permeability but the best one form core and well test as well as NMR log ,
Note :From convertional log the permeability not accurate

Methods of Determining Permeability

1. Core analysis
2. From log
3. Well test analysis (Build up test)
4. DST , MDT , RFT
5. NMR



1-Permeability From Core

1. From Core (Laboratory Determination of Permeability)

Laboratory Determination of Permeability Single-phase absolute permeability is measured on core in a steel cylinder where pressures P1 and P2 are measured for a given gas flow rate Q.

For a gas: from Darcy's law for horizontal flow,

$$Q = \frac{kA\left(P_1^2 - P_2^2\right)}{2\mu x}$$

For an incompressible liquid: for horizontal flow

$$Q = \frac{kA(P_1 - P_2)}{\mu x}$$

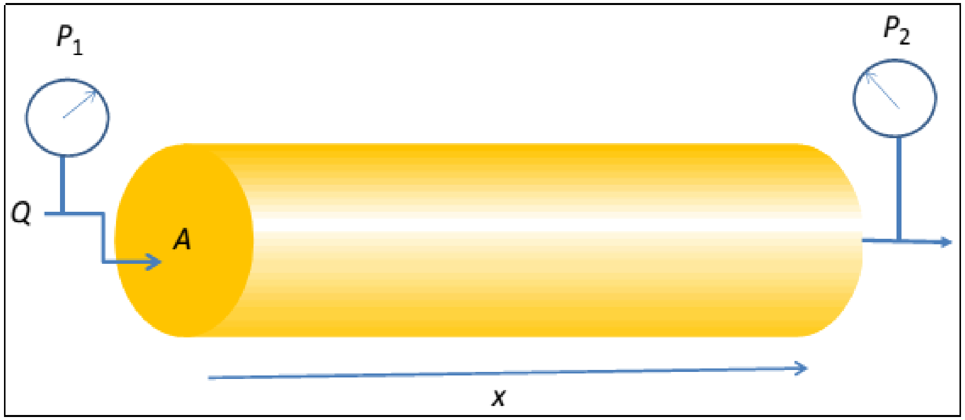


Figure 2.6 Measurement of permeability—schematic.

Where : Q : volumetric flow rate (cm3/s); A : area (cm2); m : viscosity of the gas or liquid; P : pressure (atmospheres); x : length of core (cm). This gives the value for permeability k in Darcy's equation.

2- Permeability from log (from porosity)

In many cases, there may exist relationships between the porosity and permeability, but such correlations usually are empirically derived for a given formation in a given area. They do not exhibit general application or validity. A more general empirical relationship, proposed by Wyllie and Rose, incorporates irreducible water saturation and has the form :

$$K = a \cdot \phi^x / S_{\mathrm{wi}}^y$$

2- Permeability from log (from porosity)

The basis of the relationship between permeability and irreducible water saturation is usually this type. The dependency of permeability on porosity is not evident from this data, however. Based on the general expression of Wyllie and Rose, several investigators have proposed various empirical relationships with which permeability can be estimated from porosity and irreducible water saturation. Known as Timur formula, derived from well logs:

$$K = 0.136 \frac{\phi^{4.4}}{S_{wi}^{2}}$$

Effective porosity

irreducible water saturation (15 -25%)

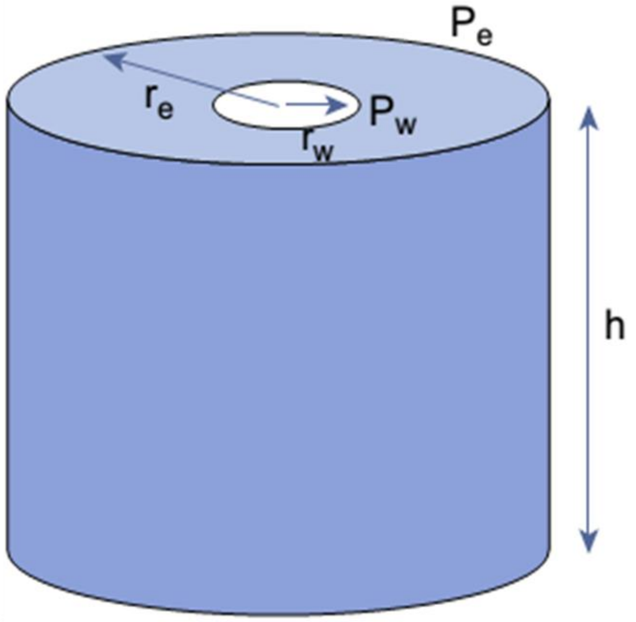
3-Permeability From Well-Test Analysis

Measurement of Permeability :

2-Permeability From Well-Test Analysis

$$Q = \frac{2\Pi kh(P_e - P_w)}{\mu \ln\left(\frac{r_e}{r_w}\right)}$$

For a constant production flow rate Q, permeability can be estimated from average formation thickness h, fluid viscosity m, bottom hole pressure Pw, initial reservoir pressure Pe at an assumed undisturbed (still at initial conditions) distance re from the well and wellbore radius rw using the equations.



4-Permeability From RFT

The pressure profiles recorded using the Repeat Formation Tester (RFT*) With this technique, permeability can be estimated from the pressure drawdown data during fluid flow and from the pressure buildup data following the flow test. Assuming a spherical flow from the formation towards the packer and the sampling probe, implying a small volume of formation, equilibrium conditions are usually reached very early in the drawdown period, thus the fall in pressure may be expressed by the equation:

$$\Delta P_{ss} = C \frac{qu}{2\pi r_p k_d}\left(1 - \frac{r_p}{r_e}\right)$$

ΔPss: pressure drop in psi during drawdown
C : factor depends on the type of flow
q : flow volume in cm3,
μ: : the fluid viscosity in centipoises
rp : the probe radius in cm
re : the external radius of the pressure perturbation.

4-Permeability From RFT

The ratio, r_p/r_e, is very small, r_p being very small compared to r_e. Also, the factor $C/2\pi r_p$ represents the type of flow, which is not entirely spherical depending on the packer characteristics. It is equal to 5660 for the standard probe/packer assembly and varies down to 1107 (for the large area packer) as a function of the packer and probe geometry. Thus we have:

$$k_d = 5660 \frac{qu}{\Delta P_{ss}}$$

The measurement of permeability carried out by this method has two limitations: At very high permeability the pressure drawdown is too small to be accurately measured by the strain gauge manometer whose resolution is 1 psi (0.1 psi with the

RFT-B tool). This resolution may, to an extent, be improved using a quartz manometer such as the Hewlett-Packard gauge whose resolution is 0.01 psi (0.002 psi for the RFT-B). At very low permeability, the pressure may fall below the bubble point. When this happens the gas (or the vapor) comes out of solution and the quantity of liquid coming from the formation is less than volumetric displacement of the pretest pistons. There are several factors which must be taken into account.

5-Permeability From NMR

Several decades of methods using the nuclear magnetic logging data for permeability are given by the works of many petrophysicists, the famous ones are from Schlumberger and Coates. All of the methods are concluded into two types.

(1) K from /NMR and distribution of T2

$$K = C_{ks} \cdot (\phi_{NMR})^{a_1} (T_{2\log})^{a_2}$$

T_{2log}	mean of logarithm of T_2
ϕ_{NMR}	total porosity from NMR
C_{ks}, a_1, a_2	empirical coefficient

(2) K from /NMR; /FFI; /BVI

$$K = C_{kc} \cdot \phi_{NMR}^{b_1} \left(\frac{\phi_{FFI}}{\phi_{BVI}} \right)^{b_2}$$

ϕ_{FFI}	free fluid porosity
ϕ_{BVI}	binding fluid porosity
C_{kc}, b_1, b_2	empirical coefficient

For sand b1 = 4 b2 = 2 lightly affected by hydrocarbonate. Cks and Ckc in Eqs. (10.14) and (10.15) are affected by the surface relaxation ability of rock, and so, for same region, different zone, these coefficient are different, and determined by core analysis experiments.

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Thanks