— University of Mosul —
College of Petroleum & Mining Engineering

Title of the lecture

Lecture fifth

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LECTURE CONTENTS

- Rock Compressibility

A reservoir thousands of feet underground is subjected to an overburden pressure caused by the weight of the overlying formations. Overburden pressures vary from area to area depending on factors such as **depth**, **nature of the structure**, **consolidation of the formation**, **and possibly the geologic age and history of the rocks**. Depth of the formation is the most important consideration, and a typical value of overburden pressure is approximately one psi per foot of depth.

The weight of the overburden simply applies a compressive force to the reservoir. The pressure in the rock pore spaces does not normally approach the overburden pressure. A typical pore pressure, commonly referred to as the reservoir pressure, is approximately 0.5 psi per foot of depth, assuming that the reservoir is sufficiently consolidated so the overburden pressure is not transmitted to the fluids in the pore spaces.

The pressure difference between overburden and internal pore pressure is referred to as the effective overburden pressure. During pressure depletion operations, the internal pore pressure **decreases** and, therefore, the effective overburden pressure **increases**. This increase causes the following effects:

- ❖ The bulk volume of the reservoir rock is reduced.
- ❖ Sand grains within the pore spaces expand.

These two volume changes tend to reduce the pore space and, therefore, the porosity of the rock. Often these data exhibit relationships with both porosity and the effective overburden pressure. Compressibility typically **decreases** with **increasing** porosity and effective overburden pressure.

The compressibility of a substance is defined as the shrinkage of a unit volume of the substance per unit increase in pressure.

There are three different types of compressibility that must be distinguished in rocks:

A) Rock matrix compressibility, C_r

Is defined as the fractional change in volume of the solid rock material (grains) with a unit change in pressure. Mathematically is given by:

$$C_r = -\frac{1}{V_r}\left(\frac{\partial V_r}{\partial P}\right)_T$$

A) **Rock bulk compressibility, C_b**

Is defined as the fractional change in volume of the bulk volume of the rock with a unit change in pressure. which defined mathematically by:

$$C_b = -\frac{1}{V_b}\left(\frac{\partial V_b}{\partial P}\right)_T$$

c) Pore compressibility, C_p

The pore compressibility coefficient is defined as the fractional change in pore volume of the rock with a unit change in pressure and given by the following relationship

$$C_p = -\frac{1}{V_p}\left(\frac{\partial V_p}{\partial P}\right)_T$$

The above equation can be expressed in terms of the porosity Φ by noting that Φ increases with the increase in the pore pressure; or:

$$C_p = \frac{1}{\emptyset}\left(\frac{\partial \emptyset}{\partial P}\right)_T$$

For most petroleum reservoirs, the rock and bulk compressibility are considered small in comparison with the pore compressibility C_p. The formation compressibility C_f is the term commonly used to describe the total compressibility of the formation and is set equal to C_p, i.e.:

$$\mathbf{C_f = C_p = \frac{1}{\emptyset}\left(\frac{\partial \emptyset}{\partial P}\right)_T}$$

It should be pointed out that the total reservoir compressibility C_t is extensively used in the transient flow equation and the material balance equation as defined by the following expression:

$$\mathbf{C_t = S_o C_o + S_w C_w + S_g C_g + C_f}$$