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**TITLE: SUMMARY OF ELECTRICAL CONDUCTIVITY OF FLUID SATURATED ROCKS.**

**OYENIYI VICTOR OREOLUWA**

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**DEPARTMENT OF CHEMICAL AND PETROLEUM ENGINEERING**

**COLLEGE OF ENIGINEERING**

**AFE BABALOLA UNIVERSITY ADO-EKITI (ABUAD)**

**ELECTRICAL CONDUCTIVITY OF FLUID SATURATED ROCKS.**

**RESISTIVITY RELATIONS.**

Porous rocks are comprised of minerals, rock fragments and void spaces. Solids are non-conductors with exception of certain clay minerals. The electrical properties of a rock depends on the geometry of the voids and the fluids with which those voids are filled. The fluids of interest in petroleum reservoirs are oil, gas and water. Oil and gas are non-conductors. Water is a conductor hen it contains dissolved salt. Current is conducted in water by movement of ions and can therefore be termed electrolytic conduction.

 The resistivity of a material is the reciprocal of conductivity and is commonly used to define the ability of a material to conduct current.

 P = rA ÷ L

P= resistivity

r = resistance

A = cross-sectional area of the conductor

L = length of the conductor

 For electrolytes, p is commonly reported in ohms-centimeters, r is expressed in ohms, A in square centimeters and L in centimeters. Resistivity can be expressed more conveniently in ohms-meters.

Formation Factor.

The most fundamental concept in considering electrical properties of rocks is that of formation factor.

formation factor is

f= Ro ÷ Rw

where, is the resistivity of the rock when saturated with water having a resistivity of Rw

The relationships between the electrical properties and other physical properties of the rock are complex but can be illustrated by the following developments.

Consider a cube of salt water having a cross-sectional area A, a length L, and a resistivity ... If an electrical current is caused to flow across the cube through an area A and a length L, the resistance of the cube can be determined. Let this resistance be r. Then

n=;R \*L

In second instance, cube 2 represents a cube of porous rock of the same dimensions of cube l and 100 per cent saturated with water of resistivity the solids to be non-conducting, the electrical flow must then Considering the solids to be non-conducting, the electrical flow must then be through the water-filled pores. The cross-sectional area available for conduction is now A,, actual or effective cross section of the water-filled pores. The path length of current flow is increased to a value La, the average length that an ion must traverse in passing through the pore channels.

MEASUREMENT OF ELECTRICAL RESISTIVITY OF ROCKS

Measurement of electrical resistivity of rocks requires a knowledge of the dimension of the rocks, the fluid saturation of the rock, the resistivity of the water contained in the rock and a suitable resistivity cell in which to test the sample.

Cells used to test the samples includes;

* Core sample resistivity cell
* Combined interstitial water and resistivity cell

EMPIRICAL CORRELATION OF ELECTRICAL PROPERTIES.

Archie, as previously mentioned, reported the results of correlating laboratory measurements of formation factor with porosity. He expressed his results in the form

F = 4-"

Archie derived from experimental data that F = -\3, Slawinski and Maxwell derived theoretical expressions for the formation factor based on models of unconsolidated spheres. Slawinski stated that for spheres in contact,

F = (13219-0.3219)° ÷ D

For dispersed spheres, not necessarily in contact, Maxwell states that

F = 3 ÷ -¢ \* 2-d

Wyllie investigated the influence of particle size and cementation on the formation factor of a variety of materials. Unconsolidated materials were packed in tubes, and some were artificially consolidated.

Wyllie's experimental data are compared with the results calculated using Archie's and Slawinski's and Maxwell's expressions . Archie's and Slawinski's equations fit the data reasonably well except for the aggregate of cubes. The data for the cubes fall above the other data as well as above all three lines calculated from the equations. This could possibly be indicative of a greater tortuous path length in such a system. It may be noted that cementation results in increased values of formation factor over that observed for uncemented aggregates. Furthermore, the cemented aggregates exhibit a greater change in formation factor with a change in porosity than the unconsolidated aggregates. The

curves no longer pass through the point F = 1, ¢ = 100 per cent.

From these data, wyllie concluded that the general form of relation between formation factor porosity should be

F= Cϕ^-m

Where m is a constant depending on cementation and C a constant controlled by the porosity of the unconsolidated matrix prior to cementation. This is identical with the general form equation deduced theoretically using simple models.

 Winsauer et al also reported a similar relationship based on correlation of data from a large number of sand stone cores. This equation is referred to as the humble relation

F= 0.62ϕ^2.18

 EFFECTS OF CONDUCTIVE SOLIDS

 The clay minerals present in natural rock act as a conductor and are sometimes referred to as conductive solids, but it is actually the water that are the conducting minerals, the effect of the clay on the resistivity of the rock is dependent upon the amount, type and manner of distribution of clay in the rock.

 The formation factor for a clayey sand increases with decreasing water resistivity and approaches a constant value at a water resistivity of about 0.1Ω.m.

RESISTIVITY OF PARTIALLY WATER SATURATED ROCKS.

 A rock containing both water and hydrocarbon has a higher resistivity than the rock when fully saturated with water. The resistivity of partially water saturated rocks has been shown to be a function of the water saturation Sw.

METHODS OF CHANGING THE SATURATION IN THE TEST SPECIMEN

* Dynamic air brine in which the desired water saturation was obtained by flowing air and water simultaneously through the sample.
* Dynamic air in which only air was introduced at the inlet, displacing both air and water from the outlet.
* Static air in which air displaced water from the sample through a capillary barrier which prevented the flow of air from the sample.