
شبكة المعلومات الجامعية


# بسم الله الرحمن الرحيم


# شبكة المعلومات الجامعية

# التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

# جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

## قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأفلام قد أعدت دون أية تغيرات

## يجب أن

تحفظ هذه الأفلام بعيدا عن الغبار

في درجة حرارة من ١٥-٢٥ مئوية ورطوبة نسبية من ٢٠-٤٠%

**To be Kept away from Dust in Dry Cool place of 15-25- c and relative humidity 20-40%**

# بعض الوثائـــــــق الاصليـــــة تالفـــة

# بالرسالة صفحات لم ترد بالاصل

# A BETTER UNDERSTANDING TO PETROPHYSICAL PARAMETERS EVALUATION WITH A SUGGESTED APPROACH

A THESIS SUBMITTED TO
THE FACULTY OF SCIENCE
CAIRO UNIVERSITY

IN PARTIAL FULFILLMENT OF
THE MASTER DEGREE
(M.Sc.)
IN GEOPHYSICS

BY
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(B.Sc.)

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**APPROVAL SHEET**
**Title of the M.Sc. Thesis**

# "A BETTER UNDERSTANDING TO PETROPHYSICAL PARAMETERS EVALUATION WITH A SUGGESTED APPROACH"

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# GENERAL STATEMENT

The present thesis is submitted to the Faculty of Science, Cairo University in Partial fulfillment for the requirements of Master of Science in Geophysics.

In addition to the research work materialized in this thesis, the author attended thirteen Postgraduate courses for one academic year in the following topics:

1. GEOTECTONIC
2. WELL LOGGING
3. PALEOMAGNETISM
4. ELECTROMAGNETIC
5. GRAVITY
6. RADIATION
7. ELECTRIC
8. MAGNETIC
9. SELECTED TOPICS
10. COMPUTER
11. INSTRUMENTATION
12. EXPLORATION METHODS
13. GERMAN LANGUAGE

He successfully passed the final examination of these courses.

**Prof. Dr. El-Sayed M.Abdel-Rahman**

**Chairman of the Geophysics Dept.,**
**Faculty of Science, Cairo University.**

# A STATEMENT

I certify here that all the results and conclusion presented here in this present thesis are fully arrived at by the author and no conclusive statements were taken from any of the files or internal reports that are usually supplied with the exploratory data which include log information in the July Oil Field.

Signature

Walid Mohamed Mabrouk

# PREFACE

In the process of reservoir evaluation, the most important petrophysical parameters in which geologists and geophysicists are too much interested to know are porosity, water saturation and permeability.

Precise evaluation of porosity requires the determination of formation factor ***a*** and cementation exponent ***m*** for different lithology. The determination of water saturation ($S_w$) depends mainly on the accuracy of evaluating the porosity as well as, permeability (k).

Conventionally, log analysts evaluate these parameters either from core measurements or through well log analysis and this sometimes requires the use of empirical approaches, thus, it was important to find a solution of this problem from well log analysis other than core measurements which are so expensive.

However, the aim of this study is mainly concerned with the evaluation of such parameters from well logging data through the introduction of three approaches in a very simple and realistic manner, which seem to be direct or indirect, and compared the results with those obtained from cores when they are available. On this basis, this study comes in three main chapters.

The first chapter starts with introducing brief review on some approaches addressed to evaluate porosity utilizing acoustic logs with reference to the basic relationships used in our proposed method. Following

with an interesting equation suggested for estimating porosity, indirectly, from sonic logs provided matrix transit time ($\Delta_{tma}$) and fluid ($\Delta_{tf}$) is known. Such an equation has to be define in the following form:

$$\phi_S = \sqrt{\frac{(\Delta_t - \Delta_{tma})(\Delta_t^{1/x} - \Delta_{tma}^{1/x})}{\Delta_t^{1/x}(\Delta_{tf} - \Delta_{tma})}}$$

Where: $\phi_S$ is the Sonic-Derived porosity (P.U. or %), $\Delta_t$ is the Sonic Transit Time (μsec/ft), $\Delta_{tma}$ is the Sonic Transit Time of matrix (μsec/ft), $\Delta_{tf}$ is the Sonic Transit Time of a fluid (189 μsec/ft for fresh water and 185 μsec/ft for saline water), and $x$ is the exponent related to the matrix nature

This proposed equation, which includes the different parameters ($\Delta_{tma}$, $\Delta_{tf}$ and $x$) has been checked among a wide variety of samples representing clean lithology, as well as, pours formation. The results demonstrate its validity and applicability, particularly in the absence of neutron and density logs, which are considered the proper tools for evaluating porosity. This equation was applied in two wells located in the Williston Basin, USA and Gulf of Suez Basin, Egypt. The results came in a good agreement, in both wells; with those obtained by the oil companies drilled these wells with a neglected amount of error. Care has to be taken when applying such approach in shaly formation, since the presence of shale in a formation increases the travel time causing the indicated porosity values to be higher in proportion to the amount of shale. In this case correction of the sonic log readings before estimating porosity using the new equation.

In chapter two, the author introduces the second major petrophysical parameters ($S_w$) through a general review of different water saturation techniques in both clean and shaly formations and ends up with introducing a new relationship binding the water saturation to different petrophysical parameters including the compressional wave velocity ($V_p$), which is expressed as:

$$S_W = \sqrt{\frac{aR_W\left[10^{6/x}V_p(\Delta_{tf}-\Delta_{tma})\right]^{m/2}}{R_t\left[(10^6-\Delta_{tma}V_p)(10^{6/x}-\Delta_{tma}^{1/x}V_P^{1/x})\right]^{m/2}}}$$

This equation, which is found to be in a good agreement with Fertl & Hammak (1971), Schlumberger (1975), Kamel et al. (1996), and Abdelrahman et. (2000), This agreement is attributed to the fact that all these equations compute the values of water saturation regardless of the distribution of shale.

A general review on different techniques employed to evaluate the third major parameter (Permeability), is introduced. Then, the author ends up chapter three with introducing a new theoretical equation for computing such important parameter in the following form:

$$k=\left[100P(1-V_{sh})^2(\sqrt{C\phi_T^2}-1)\left(\frac{1}{\phi_T}-1\right)^2\right]^2$$

where $k$ is the absolute permeability for each zone in millidarcy, $P$ is the porosity factor $\{P=[\phi_T{}^{m+2}/(1-\phi_T)^2]\}$, $V_{sh}$ is the volume of shale (fraction), $C$ is

the permeability factor ($C=1/\phi_T^2 S_{wi}^2$) depends on formation factor ($F=1/\phi_T^2$), and $\phi_T$ is the total porosity (fraction).

This equation, which gives approximate and theoretical values of k, was tested among a wide variety of data included in-situ measurement of porosity, formation factor, permeability, and irreducible water saturation for various cementing materials. The calculated permeability values computed by this equation are compared well with those obtained from cores.

It has to be indicated here that On applying such relationships on JULY OIL FILED representing in J-22-1 well, Gulf of Suez –Egypt, the results are found to be so close to those known about this field through core laboratory measurements. The complete set of open hole logging data and the geologic column of the interval under study are displayed in several figures and the output tables are represented in each chapters to show the results obtained by the new approaches compared to the conventional approaches.

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## CHAPTER ONE

**POROSITY ESTIMATION USING A COMBINATION OF WYLLIE-CLEMENCEAU EQUATIONS IN CLEAN SAND FORMATION FROM ACOUSTIC LOGS**