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# GEOLOGICAL SIGNIFICANCE OF SHALE AND MATRIX CONTENTS AS DEDUCED FROM WELL LOGGING DATA OF BAHARIYA FORMATION, KANAYIS AREA, WESTERN DESERT - EGYPT.

BY

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## ABSTRACT

In an attempt to identify the environment of deposition of Bahariya Formation, the amount of shale and matrix have been evaluated from well logging analyses. The lateral distribution of the shale and the matrix rock constituents have been represented in a ternary diagram which reflects a fluviatile and fluvio-marine conditions in the Late Cretaceous time.

## INTRODUCTION

The area under investigation lies between latitudes 30° 25' and 31° 15' N and longtitudes 27° 30' and 28° 10'E, (Fig 1). Geophysical borehole data including electric, sonic and density logs were available from the six drilled wells: Kanayis-1x, Minqar-1x, Fadda-1x, Nasr-1x, Kheima-1x and Marzuk-1x.

SARABAND and CORIBAND techniqes have been utilized for establishing a comprehensive analytical formation evaluation system. The first technique is intended for sand-shale reservoirs while the second deals with the complex lithologies.

The results of applying such system of open hole logging analysis is the determination of the shale and matrix volumes and types. Such analysis deals with the presentation of maps showing the distribution of shales and matrices for Bahariya Formation. This analysis also includes the study of the various geologic conditions prevailing in the basin of sedimentation and their influence on the distribution of the lithologic components of the deposited rock units.

## DETERMINATION OF SHALE CONTENT

The responses of different well logs are affected by proportions of shale and their physical properties. As a result, the reliable estimation of shale content is necessary for the quantitative evaluation of shaly formations.

The determination of shale content of the analyzed rock forming zones is achieved using the following mono-tools; Self Potential, Gamma ray, Resistivity and Neutron. In addition to these tools, a good approximation of shale content is given using these formulae -

$$Vsh \simeq 1 - \frac{PSP}{SSP} \quad \text{(Self Potential tool)} \ldots\ldots\ldots \qquad (1)$$

where :

Vsh : is the volume of shale.

PSP : is the pseudo - static Self Potential

SSP : is the static - Self Potential.

$$Vsh \simeq \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}} \quad \text{(Gamma - ray tool).} \qquad (2)$$

where :

$GR_{log}$ : is the gamma-ray reading for each zone .

$GR_{min}$ : is the minimum gamma-ray value (clean formations)

$GR_{max}$ : is the maximum gamma-ray value (shale)

$$Vsh \simeq \frac{Rsh}{Rt} \quad \text{(Resistivity tools)} \ldots\ldots\ldots\ldots \qquad (3)$$

where :

Rsh : is the shale resistivity

Rt : is the resistivity of the clean uncontaminated zone.

$$Vsh \simeq \frac{\phi N}{\phi N_{sh}} \quad \text{(Neutron tool )} \ldots\ldots\ldots \qquad (4)$$

where :

$\phi_N$ : is the Neutron log porosity

$\phi_{N_{sh}}$ : is the Neutron log porosity opposite shale beds.

Moreover a variety of combinations between the porosity tools, bulk desity ($\rho b$), interval Sonic transit time ( $\Delta T$) and Neutron porosity ($\phi_N$) may be helpful in evaluating the shale content graphically using dia-porosity crossplots, relating two different types of porosity tools [2].

Each combination between any two alternatives is based principally on three parameters called the matrix, the fluid ( $\Delta T_f$, $\rho_f$ and $\phi_{NF}$) and shale parameters ( $\rho sh$, $\Delta T_{sh}$ and $\phi_{Nsh}$) . Each parameter is repesented as an apex of a triangle plotted in the dia-porosity diagram.

It is observed that a considerable degree of resemblance was found between the graphical and analytical methods.

## MATRIX VOLUME ESTIMATION

The matrix content can be simply estimated using the following preliminary relation [6] :

$$\text{Matrix volume} = 1- (V_{sh} + \phi )$$

where $\phi$ : is the porosity estimated graphically from dia-porosity cross plots or analytically from single tools.

The matrix types of the individual rock components could be detected using M-N or MID crossplots [7] .

Unfortunately, it was impossible to carry out these later techniques due to the lack of neutron tool in some wells, which is needed to differentiate between the different rock components .

Satisfied results could be achieved using the relationship between bulk density ( $\rho b$) and Sonic transit time ( $\Delta$ T), [4]CP-7. These results can be checked with the rock components in the actual well logs.

## DATA REPRESENTATION

For the Bahariya Formation, two techniques have been applied, mono- and dia-porosity tools.

Only Sonic and density data are available together with induction data to produce the matrix parameters ($\rho ma$) and ( $\Delta$ Tma ). Figures 2,3,4,5,6 and 7 indicate such relations for Bahariya Formation at each well located in the study area.Table 1 gives the values of the different parameters concerning matrix, fluid and shale in Kanayis- 1x, Minqar-1x and Fadda-1x wells. These values represent the apeces of a triangle indicated in the dia-porosity crossplots (Figures 8,9,10,11 and 12).

From the study of such curves, the shale content and the effective porosity values could be graphically evaluated, the result of such evaluation are shown in table 2. Table 3 shows the analytical evaluation of well zones of Minqar-1x well.

With respect to the matrix content, $\rho_b - \Delta t$ crossplot is used to differentiate among the sandstones, limestones, dolomites and evaporites.

## LITHOFACIES ANALYSIS

Lithofacies analysis deals with the presentation of maps showing the distribution and variation of shale and matrix contents of Bahariya Formation.

The shale content of the Bahariya Formation tends to increase in percentage toward the southwest of the study area near Nasr-1x well (34%), as shown in figure 13. On the contrary the matrix content tends to decrease in the same direction (Fig 14).

The matrix content comprises an increasing sandstone percentage to the southwest, towards Nasr-1x, Marzuq-1x and Minqar-1x wells and a decrease of carbonate content as shown in figures 15 and 16, Figs 17 and 18 show the variation and distribution of limestone and dolomite in the study area.

A ternary diagram is constructed to represent the composition of Bahariya Formation in the different wells as shown in figure 19.

Analysis of such lithofacies maps (Figs 13 to 18) could throw light on the depositional environment of Bahariya Formation. In general, the Upper Cretaceous sediments were deposited under near shore fluviatile conditions in the south, then gradually changed to shallow marine carbonate conditions in the north, [1,8].

## CONCLUSIONS

The lithofacies analysis of the Bahariya Formation reflects an increase of the clastic rocks towards the sea shore and increase of the carbonate rocks towards the depocentre of the basin . This indicates that it was deposited under fluviatile and fluviomarine conditions from the start of Late Cretaceous time in this area.

## ACKNOWLEDGEMENTS

The authors wish to express their great gratitude to Professors M.M, El Awady, S.El-Ansary and A.Abu El-Ata for their assistance during the progress of this study. The authors would also like to thank the management of E.G.P.C. for providing these data.

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Table (1): Matrix, fluid and shale parameters.

| Wells | Matrix | | | fluid | | | shale | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\rho_{ma}$ | $\Delta T_{ma}$ | $\phi N_{ma}$ | $\rho_f$ | $\Delta T_f$ | $\phi N_f$ | $\rho_{sh}$ | $\Delta T_{sh}$ | $\phi N_{sh}$ |
| Kanayis-1x | 2.65 | 55.5 | 0 | 1 | 189 | 100 | 2.29 | 110.5 | — |
| Minqar-1x | 2.65 | 55.5 | 0 | 1 | 189 | 100 | 2.32 | 130 | — |
| Fadda-1x | 2.65 | 55.5 | 0 | 1 | 189 | 100 | 2.4 | — | 42 |

Table (2) : Petrophysical parameters of Minqar-1x (Graphical method).

| Zone No. | $V_{sh}$ | | | | | $\Phi_e$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\rho_b$ $\Delta T$ | $\Phi_N$ $\Delta T$ | $\Phi_s$ $\rho_b$ | $\Phi_D$ $\Phi_N$ | Weighted Value | $\rho_b$ $\Delta T$ | $\Phi_N$ $\Delta T$ | $\Phi_s$ $\rho_b$ | $\Phi_D$ $\Phi_N$ | Weighted Value |
| 1 | 73 | 80? | 20? | 57 | 34 | 1 | 0 | 18 | 0 | 0 |
| 2 | 16 | 0 | 0 | 0 | 4 | 3 | 48 | 16 | 49 | 10 |
| 3 | 100 | 100? | 68 | 43 | 51 | 1 | 0 | 16? | 4 | 2 |
| 4 | 44 | 0 | 0 | 0 | 11 | 1 | 28 | 23 | 29? | 1 |
| 5 | 28 | 45 | 0 | 60? | 14 | 18 | 8 | 32? | 8 | 11 |
| 6 | 11 | 0 | 50 | 0 | 15 | 1 | 43 | 3 | 44? | 2 |
| 7 | 13 | 48 | 58 | 52 | 43 | 21? | 1 | 16 | 1 | 1 |
| 8 | 28 | 3 | 100 | 0? | 63 | 8 | 21 | 0 | 23 | 4 |
| 9 | 13 | 25 | 23 | 27 | 22 | 19 | 12 | 20 | 12 | 12 |
| 10 | 17 | 15 | 68 | 0 | 33 | 14 | 14 | 9 | 15 | 9 |
| 11 | 100 | 100 | 0 | 100 | 71 | 0 | 0 | 43? | 0 | 0 |
| 12 | 57 | 34 | 0 | 27 | 39 | 2 | 14 | 23? | 13 | 10 |
| 13 | 11 | 34 | 0 | 61? | 6 | 24 | 10 | 34 | 9 | 10 |
| 14 | 28 | 0 | 0 | 0 | 7 | 7 | 28 | 23 | 29? | 15 |
| 15 | 8 | 42 | 0 | 73? | 4 | 26 | 7 | 34 | 6 | 8 |
| 16 | 22 | 10 | 20 | 0? | 21 | 10 | 17 | 14 | 17 | 12 |
| 17 | 0 | 42 | 52? | 45 | 16 | 28? | 1 | 20 | 6 | 8 |
| 18 | 18 | 0 | 0 | 0 | 4 | 0 | 42 | 4 | 44 | 2 |
| 19 | 3 | 23 | 28 | 45? | 18 | 23 | 11 | 20 | 10 | 11 |
| 20 | 05 | 0 | 0 | 0 | 21 | 0 | 35 | 39? | 35 | 0 |
| 21 | 22 | 20 | 15 | 12? | 28 | 13 | 14 | 18 | 14 | 14 |
| 22 | 22 | 0 | 50 | 0 | 24 | 6 | 38? | 1 | 4 | 4 |
| 23 | 0 | 3 | 40? | 13 | 5 | 17 | 18 | 17 | 17 | 17 |
| 24 | 0 | 33 | 35? | 0 | 0 | 22 | 25 | 14 | 25 | 14 |
| 25 | 0 | 18 | 28 | 36? | 0 | 28 | 13 | 23 | 12 | 13 |
| 26 | 24 | 0 | 0 | 0 | 6 | 7 | 28 | 19 | 29? | 13 |
| 27 | 3 | 12 | 90? | 27 | 3 | 22 | 17 | 26 | 16 | 17 |
| 28 | 30 | 20 | 90 | 0 | 60 | 1 | 11 | 1 | 13? | 1 |

Table (3); Log Data and Petrophysical Parameters of Mingar-1X

| Zone No. | Depth | Input Data | | | | | | | Volume of shale content | | | | | Porosity | | | | Rock Material | | | | | Interpreted Lithology |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SPL | GRL | $R_{ML}$ | RIL | FDC | BHC | CNL | | | | | | | | | | | | | | | |
| | | SP | GR | $R_{xo}$ | $R_t$ | $\rho_b$ | $\Delta_t$ | $\phi_N$ | $V_{sh(R)}$ | $V_{sh(N)}$ | $V_{sh(sp)}$ | $V_{sh(GR)}$ | $V_{sh}$ | $\phi_D$ | $\phi_S$ | $\phi_N$ | $\phi_{AV}$ | Sh | S.S | L.S | dol. | Anhy. | |
| | | MV | API | ohm.m | mmhos/m | g/cc | $\mu s/f$ | % | | | | | | | | | | | | | | | |
| 1 | 5584.0 | -4.16 | 45 | 17 | 800 | 2.35 | 111.0 | NOT RECORDED | 0.23 | NOT COMPUTED. | 0.59 | 0.67 | 0.41 | 0 | 0.19 | NOT COMPUTED | 0.10 | 41 | 0 | 43 | 0 | 0 | Dol. and sh. |
| 2 | 5695.0 | 0.00 | 25 | 28 | 300 | 2.54 | 72.0 | | 0.08 | | 1.00 | 0.04 | 0.06 | 0.46 | 0.14 | | 0.27 | 6 | 0 | 67 | 0 | 0 | Argill. L.S. |
| 3 | 5704.0 | -3.00 | 46.75 | 7 | 1500 | 2.24 | 132.0 | | 1.00 | | 0.88 | 0.04 | 0.88 | 0.06 | 0.20 | | 0.23 | 61 | 0 | 9 | 0 | 0 | Calc. sh. |
| 4 | 5720.0 | -12.57 | 52.5 | 20 | 850 | 2.47 | 89.0 | | 0.28 | | 0.21 | 0.24 | 0.24 | 0.28 | 0.20 | | 0.24 | 24 | 31 | 21 | 0 | 0 | Argill S.S. with L.S. |
| 5 | 5795.0 | -11.36 | 30 | 14 | 1200 | 2.25 | 100.0 | | 0.37 | | 0.25 | 0.05 | 0.15 | 0.10 | 0.30 | | 0.20 | 15 | 65 | 0 | 0 | 0 | Argill. S.S. |
| 6 | 5835.0 | 0.00 | 26.25 | 42 | 100 | 2.59 | 65.0 | | 0.02 | | 1.00 | 0.25 | 0.14 | 0.86 | 0.06 | | 0.23 | 14 | 47 | 0 | 0 | 0 | Argill. S.S. with carb. inter. |
| 7 | 5845.0 | -16.64 | 52.50 | 31 | 1450 | 2.28 | 82.5 | | 1.00 | | 0.10 | 0.70 | 0.40 | 0.03 | 0.20 | | 0.12 | 40 | 44 | 0 | 0 | 0 | S.S. and sh. |
| 8 | 5863.0 | -6.66 | 37.50 | 20 | 600 | 2.42 | 85.0 | | 0.22 | | 0.44 | 0.83 | 0.64 | 0.21 | 0.08 | | 0.14 | 64 | 32 | 0 | 0 | 0 | Aren. sh. |
| 9 | 5920.0 | -14.14 | 45.00 | 13 | 1200 | 2.39 | 90.0 | | 0.45 | | 0.16 | 0.17 | 0.17 | 0.13 | 0.22 | | 0.14 | 17 | 89 | 0 | 0 | 0 | Argill. S.S. |
| 10 | 5940.0 | -10.00 | 58.24 | 16 | 800 | 2.36 | 86.0 | | 0.34 | | 0.29 | 0.48 | 0.34 | 0.15 | 0.13 | | 0.14 | 34 | 52 | 0 | 0 | 0 | S.S. and sh. |
| 11 | 5950.5 | 0.00 | 57.5 | 14 | 875 | 2.25 | 130.0 | | 0.41 | | 1.00 | 0.75 | 0.58 | 0.04 | 0.37 | | 0.21 | 58 | 31 | 0 | 0 | 0 | Aren. sh. |
| 12 | 5962.5 | 0.00 | 57.50 | 21 | 400 | 2.40 | 100.0 | | 0.23 | | 1.16 | 0.81 | 0.42 | 0.16 | 0.35 | | 0.21 | 42 | 0 | 37 | 0 | 0 | Sh. and L.S. |
| 13 | 5973.0 | -15.83 | 22.50 | 18 | 1500 | 2.22 | 95.0 | | 0.78 | | 0.12 | 0.83 | 0.88 | 0.11 | 0.32 | | 0.22 | 8 | 70 | 0 | 0 | 0 | Argill. S.S. |
| 14 | 5986.0 | -11.30 | 47.81 | 14 | 600 | 2.43 | 85.0 | | 0.40 | | 0.21 | 0.03 | 0.12 | 0.28 | 0.21 | | 0.25 | 12 | 83 | 0 | 0 | 0 | Argill. S.S. |
| 15 | 6004.0 | -14.66 | 18.75 | 8 | 1000 | 2.18 | 98.0 | | 0.50 | | 0.10 | 0.04 | 0.07 | 0.09 | 0.33 | | 0.21 | 7 | 81 | 11 | 0 | 0 | Calc. S.S with sh. str. |
| 16 | 6073.5 | -5.00 | 47.81 | 19 | 500 | 2.40 | 85.0 | | 0.25 | | 0.49 | 0.50 | 0.37 | 0.17 | 0.18 | | 0.17 | 37 | 46 | 0 | 0 | 0 | S.S and sh. |
| 17 | 6092.5 | -17.50 | 20.00 | 10 | 1600 | 2.22 | 88.0 | | 0.49 | | 0.09 | 0.15 | 0.12 | 0.03 | 0.33 | | 0.16 | 22 | 72 | 0 | 0 | 0 | Argill. S.S. |
| 18 | 6127.0 | -12.50 | 22.50 | 22 | 400 | 1.88 | 80.0 | | 0.10 | | 0.11 | 0.10 | 0.18 | 0.40 | 0.03 | | 0.22 | 18 | 62 | 0 | 0 | 0 | Argill. S.S. |
| 19 | 6142.5 | -17.50 | 30.00 | 12 | 1300 | 2.27 | 47.0 | | 0.63 | | 0.09 | 0.16 | 0.14 | 0.12 | 0.27 | | 0.20 | 14 | 86 | 0 | 0 | 0 | Argill. S.S. |
| 20 | 6155.0 | +1.16 | 41.25 | 30 | 350 | 2.55 | 100.0 | | 0.15 | | - | 0.33 | 0.24 | 0.35 | 0.29 | | 0.32 | 24 | 44 | 0 | 0 | 0 | Argill. S.S. |
| 21 | 6179.0 | -18.00 | 48.75 | 20 | 675 | 2.36 | 88.0 | | 0.27 | | 0.29 | 0.34 | 0.31 | 0.15 | 0.19 | | 0.17 | 31 | 51 | 0 | 0 | 0 | S.S. and sh. |
| 22 | 6195.0 | -11.66 | 40.00 | 32 | 300 | 2.55 | 64.0 | | 0.21 | | 0.24 | 0.49 | 0.23 | 0.35 | 0.04 | | 0.28 | 23 | 57 | 0 | 0 | 0 | Argill. S.S. |
| 23 | 6217.5 | -20.83 | 15.00 | 10 | 1575 | 2.28 | 80 | | 0.62 | | 0.02 | 0.06 | 0.05 | 0.17 | 0.21 | | 0.19 | 5 | 76 | 0 | 0 | 0 | Argill. S.S. |
| 24 | 6237.0 | -20.83 | 10.00 | 11 | 1100 | 2.35 | 74.0 | | 0.33 | | 0.02 | 0.00 | 0.02 | 0.24 | 0.17 | | 0.22 | 7 | 77 | 0 | 0 | 0 | Argill. S.S. |

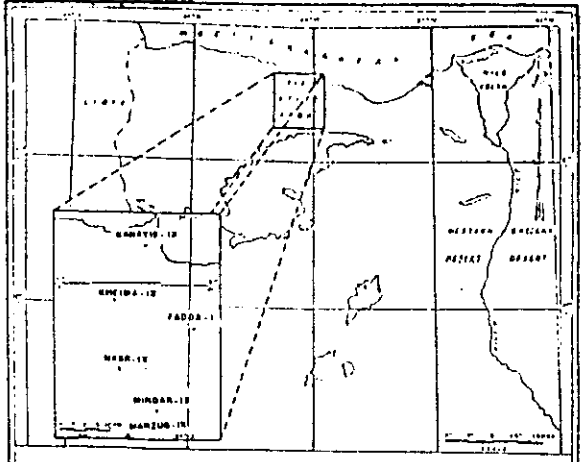

FIG (1) LOCATION MAP OF THE STUDY AREA

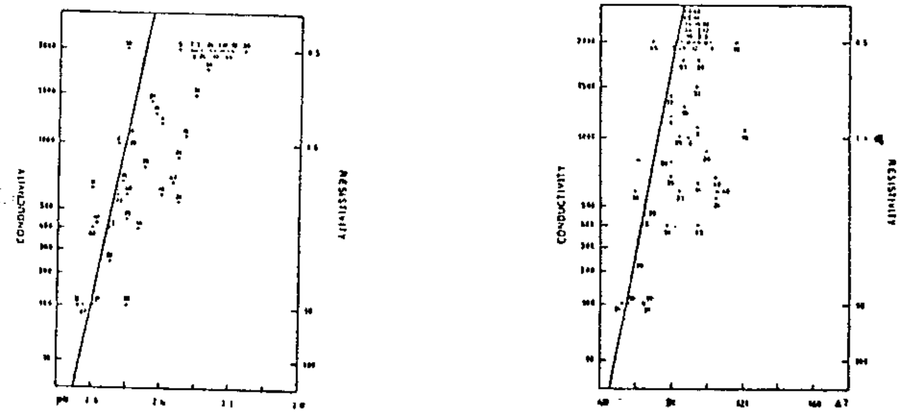


FIG ( 2 ) MONO-POROSITY CROSS-PLOTS ,KANAYIS WELL-IX

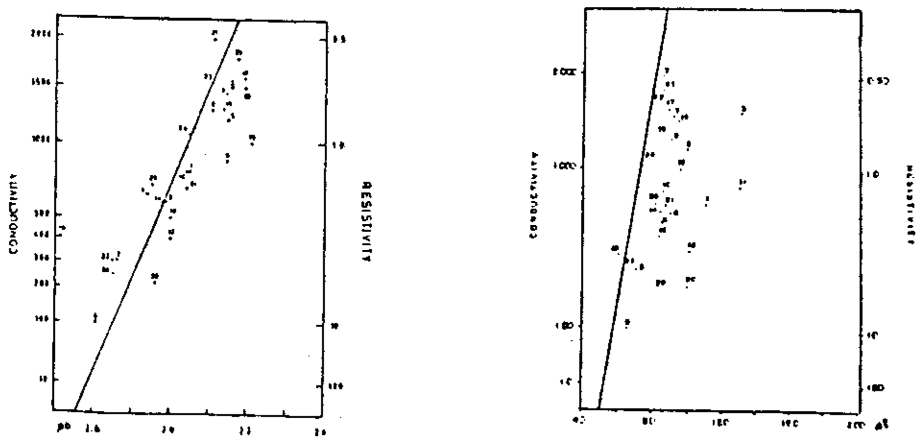


FIG ( 3 ) MONO-POROSITY CROSS-PLOTS, MINQAR WELL-IX

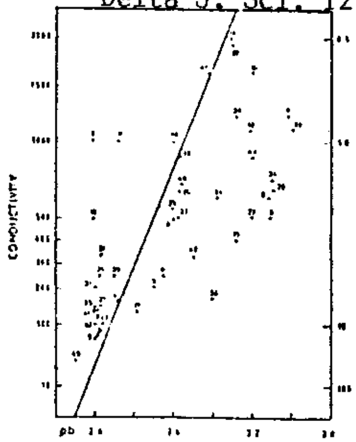


FIG. ( 4 ) MONO-POROSITY CROSS-PLOT, FADDA WELL-IX

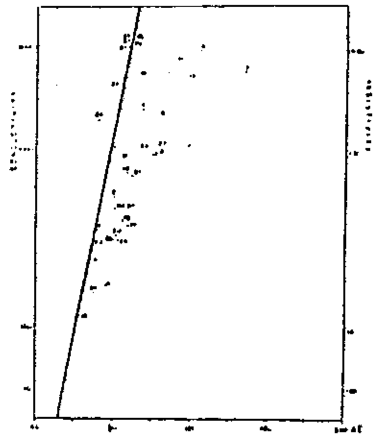

FIG. ( 5 ) MONO-POROSITY CROSS-PLOT, NASR WELL-IX

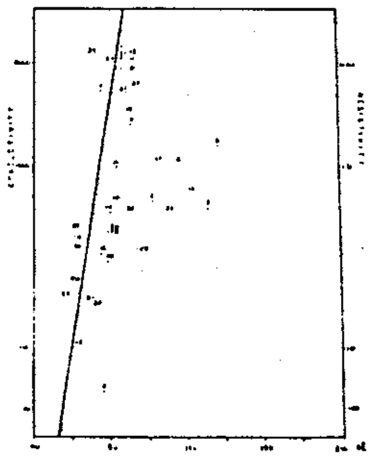

FIG. ( 6 ) MONO-POROSITY CROSS-PLOT, KHEIMA WELL-IX

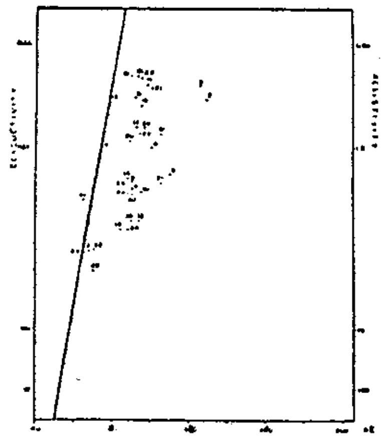

FIG. ( 7 ) MONO-POROSITY CROSS-PLOT, MARZUQ WELL-IX

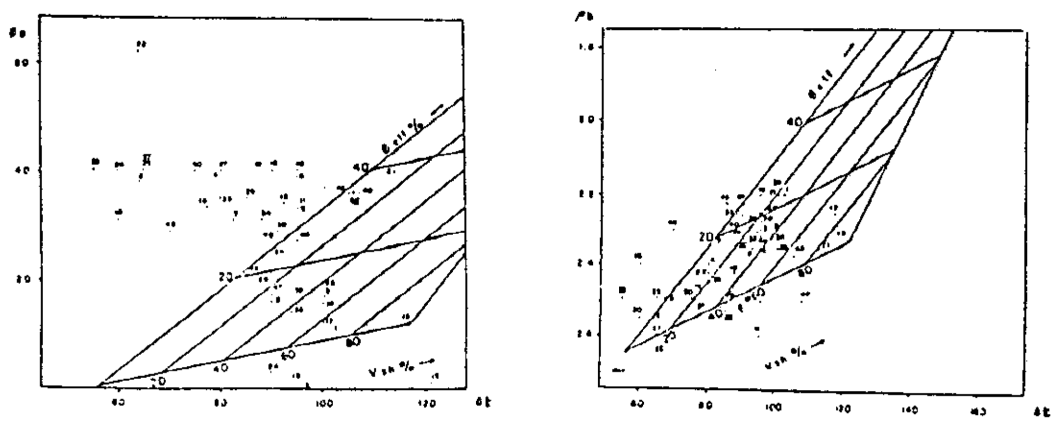


FIG. ( 8 ) DIA-POROSITY CROSS-PLOTS , KANAYIS WELL-IX

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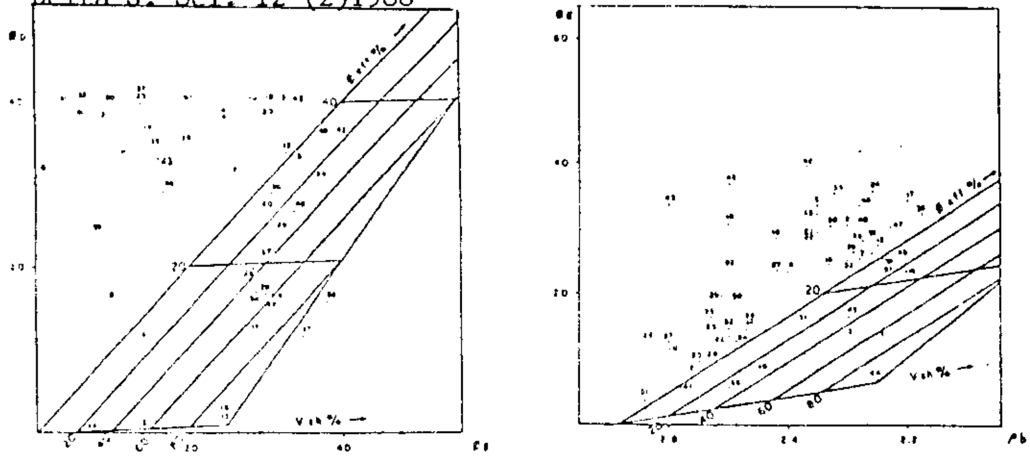

FIG. ( 9 ) DIA-POROSITY CROSS-PLOTS , KANAYIS WELL-1X

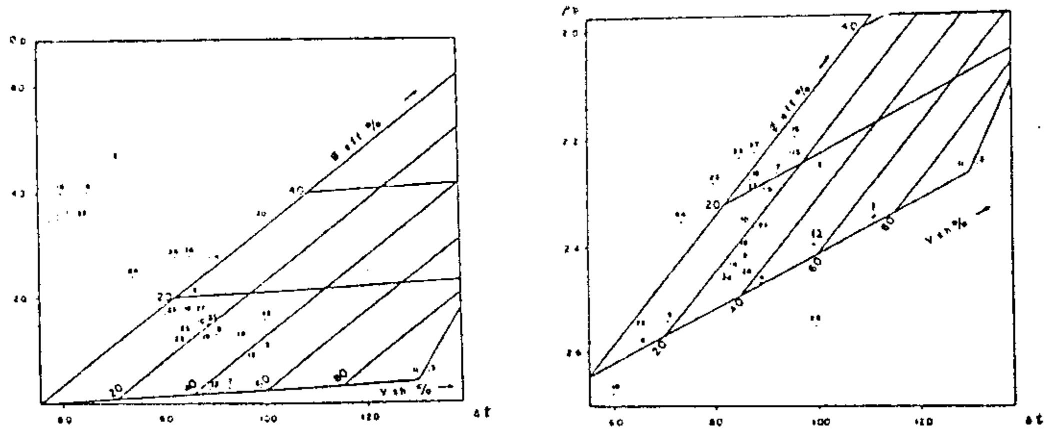

FIG. (10) DIA-POROSITY CROSS-PLOTS , MINQAR WELL-1X

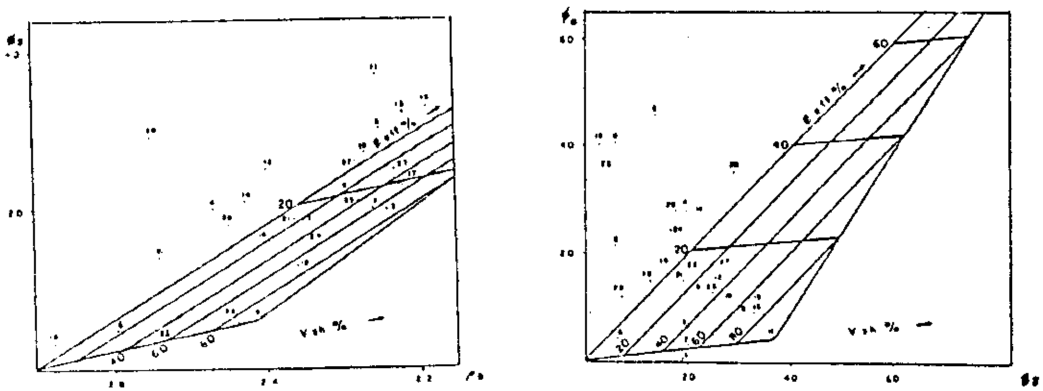

FIG (11) DIA-POROSITY CROSS-PLOTS , MINQAR WELL-1X

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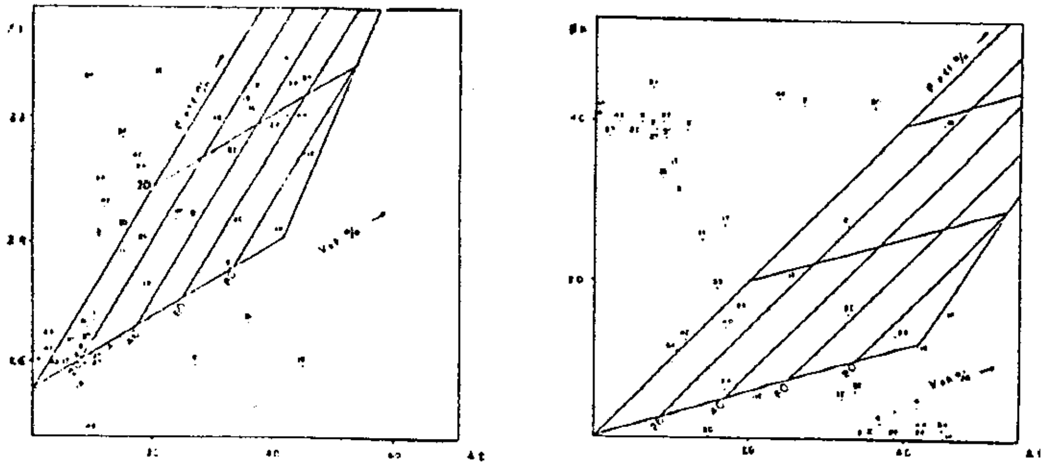


FIG. (12) DIA-POROSITY CROSS-PLOTS , FADDA WELL-1

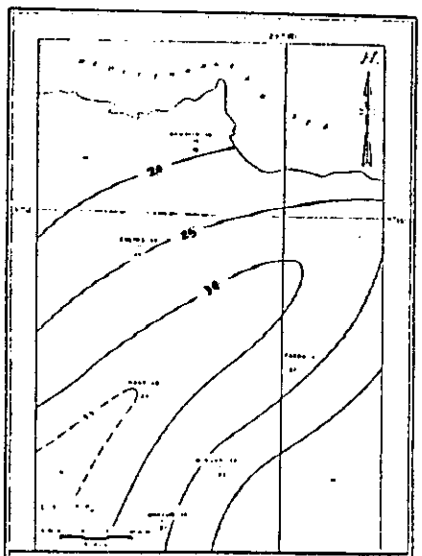


FIG (13) DISTRIBUTION MAP
OF SHALE CONTENT IN BAHARIYA FORMATION

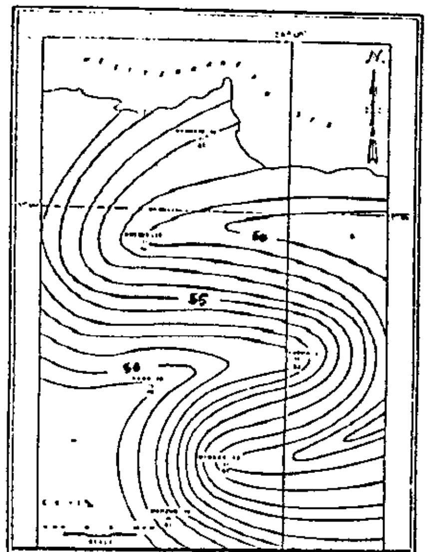


FIG (14) DISTRIBUTION MAP
OF MATRIX CONTENT IN BAHARIYA FORMATION

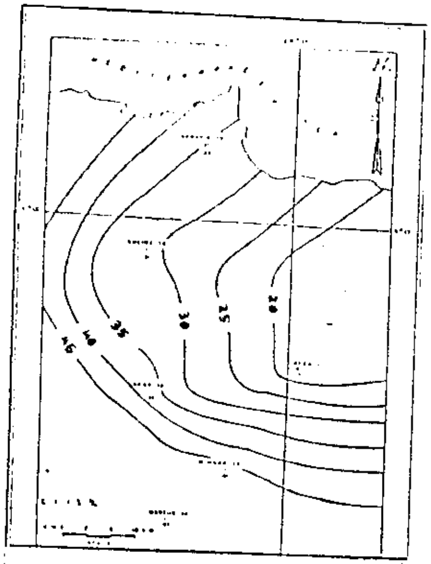


FIG (15) DISTRIBUTION MAP
OF SANDSTONE CONTENT IN BAHARIYA FORMATION

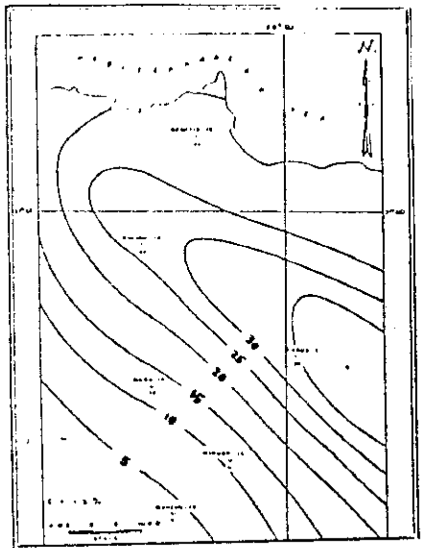


FIG. (16) DISTRIBUTION MAP
OF CARBONATE CONTENT IN BAHARIYA FORMATION

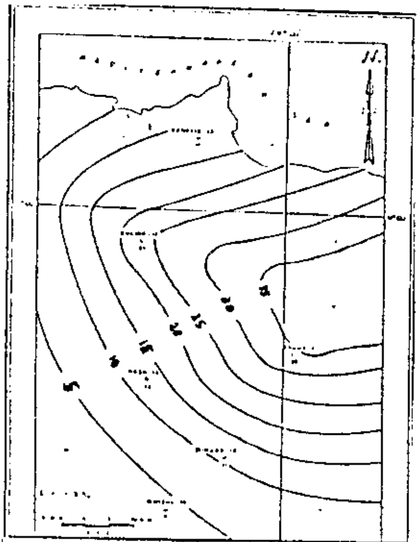


FIG (17) DISTRIBUTION MAP
OF LIMESTONE CONTENT IN BAHARIYA FORMATION

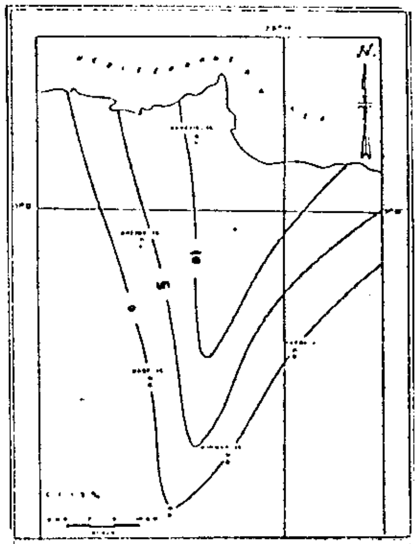


FIG (18) DISTRIBUTION MAP
OF DOLOMITE CONTENT IN BAHARIYA FORMATION

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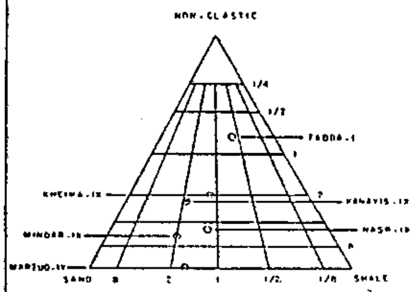


FIG. (19) LITHOFACIES ANALYSIS OF BAHARIYA FORMATION

# المدلول الجيولوجي لمكونات الطفل والمحتوى الصخرى المستنتج من تسجيلات الآبار الخاصة بتكوين البحرية منطقة كنايس ـ الصحراء الغربية ـ مصر

أحمد على حسن – شادية عبد الرحيم

تختص الدراسة بتحديد البيئة الترسيبية لتكوين البحرية فى المنطقة الواقعة تحت الدراسة والخاصة بمنطقة كنايس فى الصحراء الغربية • وقد استخدم فى الدراسة سجلات الآبار الكهربية والصوتية والكثافة لستة آبار وهى كنايس ، منقار ، فضة ،نصر خيمة ومرزوق •

ومن تحليل تلك السجلات أمكن تحديد المحتوى الطفلى وكذلك المحتوى الصخرى وقد أمكن أيضا رسم خرائط توضح التغيير الجانبى لكل سحنة صخرية حيث تم من خلالها استنباط البيئة الترسيبية ورسم شكل ثلاثى يوضح ذلك •