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STRUCTURAL ELEMENTS AND FORMATION PARAMETERS FOR SOME LOWER CRETACEOUS SEQUENCES IN THE WESTERN DESERT, EGYPT

By

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ABSTRACT

The Lower Cretaceous sequences in the northern part of the Western Desert has been penetrated by many of drilled bore-holes adopted by different oil companies. It was encountered at depths ranging from 1200 to 3500 m. The seismic data obtained for the study area have been interpreted. However, two structural elements are depicted. On the other hand, 11 core samples belonging to the Kharita Formation were used for studying some formation parameters such as rock porosity and permeability. Both the porosity and the permeability capacity of the Kharita Formation have been elucidated.

INTRODUCTION

The study area comprises about 45000 sq. km. being marked by latitude 29° 50′ and 31°40′ N and longitude 25° 00′ and 28° 00 ′E (Fig. 1). It is bounded from the north by the Mediterranean sea and delineated from the west by the Egyptian-Libyan border.

The surface of the study area is a featureless plain covered by the northerly gentle dipping Tertiary succession characterized by a wide regional extent and reasonable lithological uniformity (Zittel, 1883).

The subsurface stratigraphic sequence of the present area includes a sedimentary succession ranging in age from the Cambro-Ordovician to the Recent. The total thicknesses of the Lower Cretaceous increase progressively to

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the north and north–east range from about 2000 m in the south to about 7500 m along the coastal area. It overlies the Upper Jurassic in most of the drilled bore–holes except in some localities where it overlies the Paleozoic section (Table 1).

The present work represents a trial to throw more light on both the tectonic framework and the formation parameters controlling reservoir quality for some of the Lower Cretaceous sequences. These have been done through the interpretation of the available seismic reflection data as well as by measuring both rock porosity and gas–permeability for 11 core samples obtained from the Kharita Formation defined by El Gezeery and O'Conor (1975).

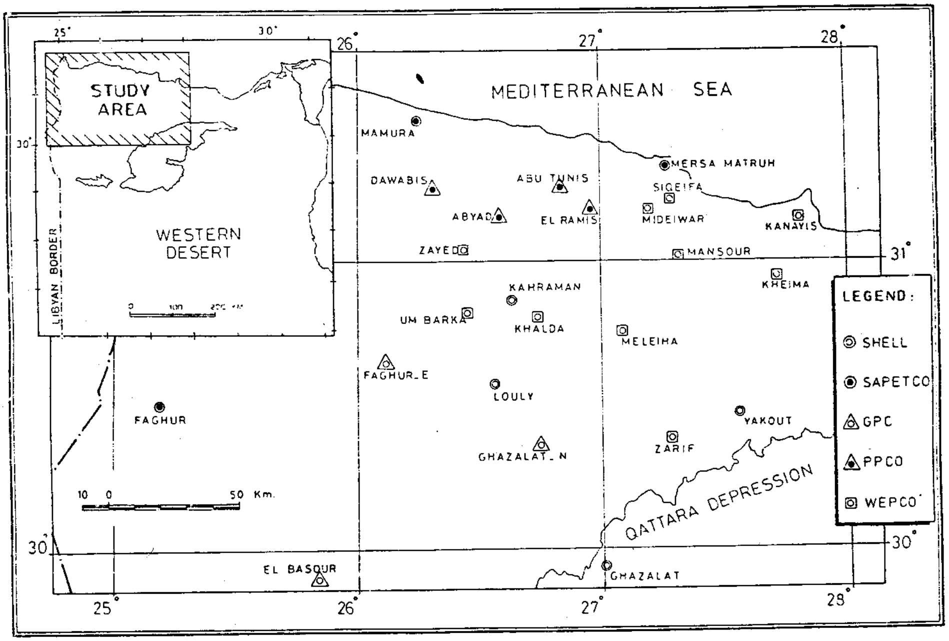

Fig. 1 : Location Map

Table 1

Lower Cretaceous Classification of different authors in the Western Desert

Chrono-stratigraphic units		BECKMAN, J. P. (1967)	NORTON, P. (1967)	AADLAND & HASSAN (1972)	ABDIEN & DEIBIS (1972)	EL-GEZEERY & O'CONOR (1975)	METWALLI et. al. (1980)	BARAKAT & DARWISH (1984)	
CENOMANIAN		BAHARIYA Fm.	BURG EL-ARAB FORMATION: Kharita Sandstone Member	BAHARIYA Fm.	CLASTICS	KHARITA Fm.: Meleiha Shaly Member	BAHARIYA Fm.	BAHARIYA Fm.	
LOWER CRETACEOUS	ALBIAN	MM 64 (MERSA MATRUH SHALES (Dark Shales))	BURG EL-ARAB FORMATION: Kharita Sandstone Member	KHARITA Fm	CLASTICS	KHARITA Fm.: Kheima Sand Member	KHARITA Fm.	KHARITA Fm.	
	APTIAN	APTIAN LIMESTONE (MERSA MATRUH SHALES (Dark Shales))	BURG EL-ARAB FORMATION: xx; Alamein Carbonate Member; xxx — MAMURA FORMATION; MERSA MATRUH FORMATION	ALAMEIN Fm.; UNNAMED UNIT	ALAMEIN Fm. (Upper Carbonate Unit); Intercarbonate Unit; Lower Carbonate Unit	KHARITA Fm.: Dahab Shaley Member; ALAMEIN Fm.; ALAM EL-BUIEB Fm.: Mireir Shaley Member	ALAMEIN Fm: Alamein Dolomite; Clastic Unit	DAHAB Fm.; ALAMEIN Fm.; MIDEIWAR Fm; ABYAD Fm.	
	BARREMIAN	BY 91 (MERSA MATRUH SHALES)	BURG EL-ARAB FORMATION: Alam El-Bueib Member; MAMURA FORMATION; MERSA MATRUH FORMATION	ALAM EL-BUEIB Fm.; MAMURA Fm.; MERSA MATRUH Fm.	APTIAN CLASTICS	ALAM EL-BUIEB Fm.: Umbarka Sand Member; MATRUH Fm.	ALAM EL-BUEIB Fm.	MATRUH Fm; ALAM EL-BUEIB Fm.	
	NEOCOMIAN	BY 103 Carbonate Shale facies of MAMURA (MERSA MATRUH SHALES)	BETTY FORMATION; MAMURA FORMATION; MERSA MATRUH FORMATION	BETTY Fm.; BETTY Fm.; MERSA MATRUH Fm.	APTIAN CLASTICS	ALAM EL-BUIEB Fm.: Basal Betty Member; MATRUH Fm.	BETTY Fm.	BETTY Fm.	
JURASSIC		LIMESTONE & SHALES	MASAJID Fm.	MASAJID Fm.	JURASSIC	MASAJID Fm.	MASAJID Fm.	MASAJID Fm.	

xx Undifferentiated Aptian Burg EL-Arab sandstones and shales (B. A. marker)

xxx Unnamed Unit

METHODS AND TECHNIQUES

The seismic survey (75 seismic profiles) have been conducted by the Geophysical Service International Corporation (GSI) using the geograph method. The recording in the field was carried out with digital recording system with sampling rate 4.0 m. sec. and with full resolution range of 78 db.

The seismic records have been processed by the GSI and several time variant filters (TVF) have been applied. These filters have different parameters relevant to different areas. The deconvolution which have been applied in the present seismic data processing was an attempt to creat new filters. These are the inverse of the unwanted earth filters, to remove approximately the effect of such unwanted filters.

The resultant seismic sections have been intepreted with the helpful of well velocity measurements (Table 2). Based on these available interpreted seismic data the evaluation of general structural setting at the studied area was possible.

The obtained core samples were cut into cubic shape samples of 2.5 cm. sides, in order to facilitate permeability measurements in both parallel and normal to the bedding plane direction. They are cleaned from the residual hydrocarbons by use of the extraction method with organic solvents adopted by Keelan (1972). The clean samples were dried to be ready for both porosity and permeability measurements. The sample porosity is measured by use of the saturation method (Koithara *et al*, 1965). However, gas−permeability is performed by use of the Ruska Gas Permeameter. The petrophysical data were statistically treated in order to throw light on reservoir characteristics of the Kharita Formation. The electrical resistivity of seven samples have been measured when the samples were 100% saturated with four different brine concentrations in four different measuring cycles.

Interpretation of Seismic Data

The study area could be considered as a part of the North African platform. It is unstable shelf area which had received sediments during several depositional cycles, from Cambrian to Quaternary and subjected to several tectonic movements. Several authors discussed these movements and gave an idea about different tectonism and structural framework of the northern part of the Western Desert.

Table 2
Formation velocity analysis

Well	Abyad		Mideiwar		Siqeifa		Kanayis		Khalda		Umm Barka		Louly		Yakout		Ghazalat-V		El Basour	
Formation	V_{av}	V_{int}	V_{av}	V_{int}	V_{av}	V_{int}	V_{av}	V_{int}	V_{av}	V_{int}	V_{av}	V_{int}	V_{av}	V_{int}	V_{av}	V_{int}	V_{av}	V_{int}	V_{av}	V_{int}
Kharita	3590	1555	3400	3720	3262	3567	2073	3706	3125	4000	3110	3963	3201	4290	2713	3277	2905	2810	2340	2735
Dahab	3620	1659	3460	3857	3308	3643	3026	4314	3247	4070	3192	4268	3232	4131	Missed	Missed	2970	2875	Missed	Missed
Alamein	3636	2027	3468	3963	3335	4070	3040	4869	3262	4726	3232	4558	3262	4619	Missed	Missed	2990	2895	Missed	Missed
Mideiwar	3651	1875	3476	3750	3373	3598	3095	3650	3293	4223	3247	4320	3323	4467	Missed	Missed	3010	2990	Missed	Missed
Abyad	3656	2666	3401	4756	3414	3506	3125	4131	3323	5031	3277	4605	3381	5534	Missed	Missed	3025	2000	2355	2750
Matruh	3584	1928	3506	3659	3445	3658	—	—	3400	4345	3323	3963	3415	4619	2774	3689	3065	3015	2395	2745
Alam El-Bueib	3700	1921	3529	3537	3460	3667	—	—	»3400	—	3354	4512	3582	4588	2912	3963	3130	3055	Missed	Missed
Betty	3710	1883	»3520	»3537	3476	3918	—	—	»3400	—	3415	3320	—	—	3040	4000	Missed	Missed	Missed	Missed

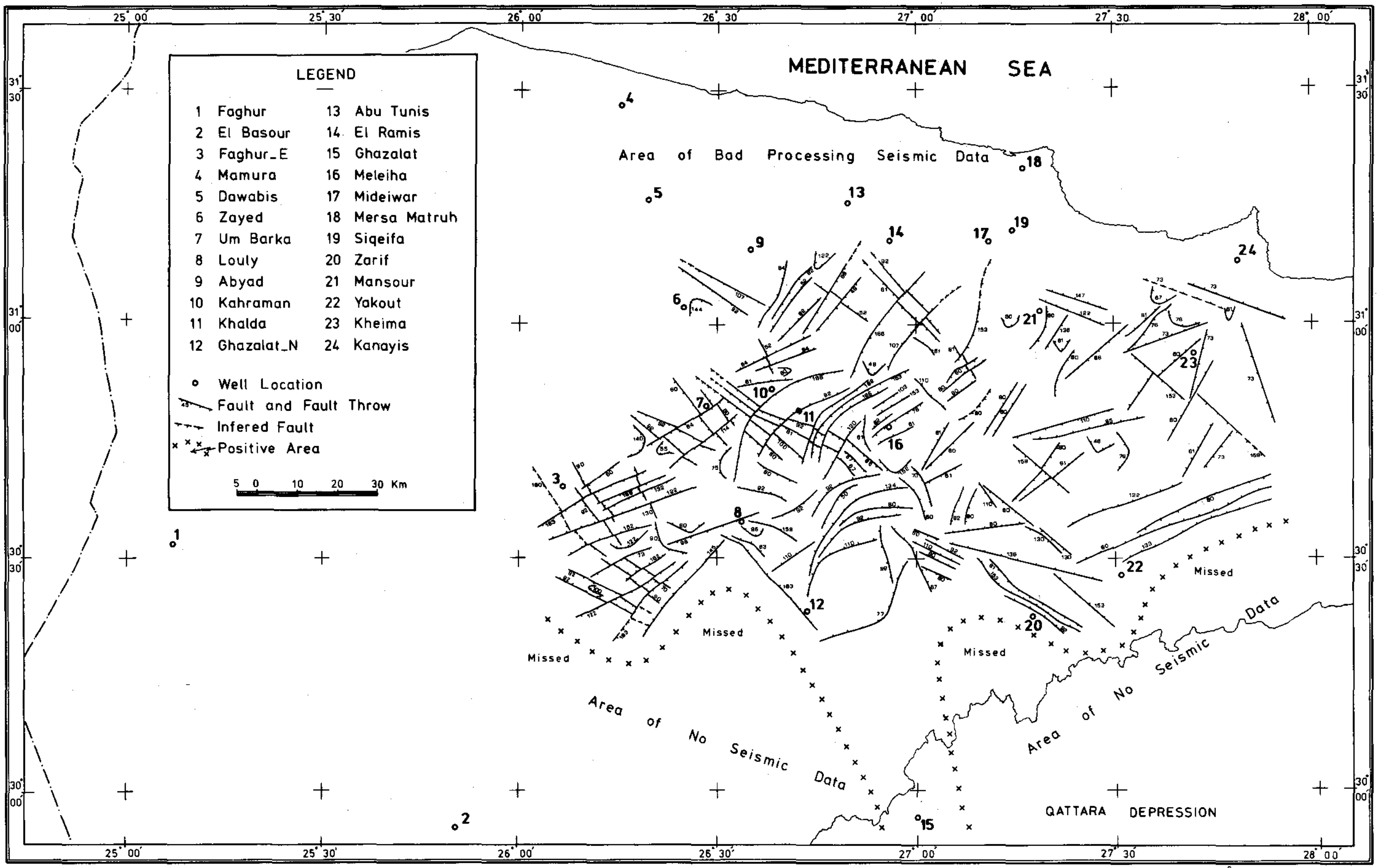

Fig. 2 : Faulting map on Top Alamein Formation

Scotti (1976) studied the tectonism of Matruh basin and concluded that its origin can be related to several Mediterranean plate tectonic models which indicated that the initial graben is a failed arm of the late Triassic or Early Jurassic crustal rift. He added that this rifting may be due to sea floor spreading between Turkey and North Africa.

Meshref (1982) studied the regional structural setting of the Northern Egypt using the concept of plate tectonics which proposed a model explaining the origin and the time of stresses that affected in this area.

Figure 2, shows the interpreted main structural elements in the concerned area from various seismic sections. This interpretation is deduced from detection of the Alamein Formation which is considered as a good reflector carbonate bed. Fault trends, throws, up and down thrown sides are recorded on this map.

The general prefered orientations of fault trends in the study area are:

1. ENE (Syrian Arc) and WNW trends are the strongest and most widely spread trends in the area. The rose diagram (Fig. 3), histograms (Fig. 4) and the tabulated statistical data (Table 3) confirmed this fact. This conclusion demonstrates an enormous harmony with Meshref's suggestion (1982) which stated that these two trends can be considered the two basic tectonic trends affecting northeast Africa and have the wide spread trends in Egypt as well as in the Arabian shield.

2. The NW (Suez) and NNE (Aqaba) trends are shown also relative strength but lesser in magnitude and extent, than the two previous mentioned trends (see Figs. 3&4). This can be correlated with the concept of Meshref (1982) which is based on the interpretation of the potential field data. He reported that the Suez trend shows in the northern portion of Egypt a stronger magnitude than the Aqaba trend.

3. The NE, NNW, E-W and N-S trends are also reported in the study area with very weak magnitude and limited extent.

4. The structural map shown in Figure (2) is characterized by a series of grabens and horsts crossing the area and have, in general, ENE trend (Syrian Arc).

Table 3
Distribution of the interpreted fault trends

Direction / Parameters	90°-75°	75°-60°	60°-45°	45°-30°	30°-15°	15°-00°	00°-15°	15°-30°	30°-45°	45°-60°	60°-75°	75°-90°
No %	2.34	6.10	10.32	16.90	13.15	1.41	3.28	7.50	9.85	15.10	10.79	3.26
L %	1.31	3.34	6.10	15.95	9.93	2.00	2.80	8.60	13.90	14.33	18.00	3.80
L/No	2.72	2.68	2.87	4.60	3.69	6.80	4.14	5.57	6.04	4.60	8.53	5.70
TH %	1.60	2.30	8.30	17.60	13.20	1.20	3.20	7.90	13.00	16.20	13.10	2.40
TH/No	58.40	33.00	66.41	85.55	82.86	75.00	83.38	86.75	87.54	88.47	104.60	63.57

No : is the number of faults in each direction. L : is the summation of fault lengths in each direction.

TH : is the summation of fault throws in each direction.

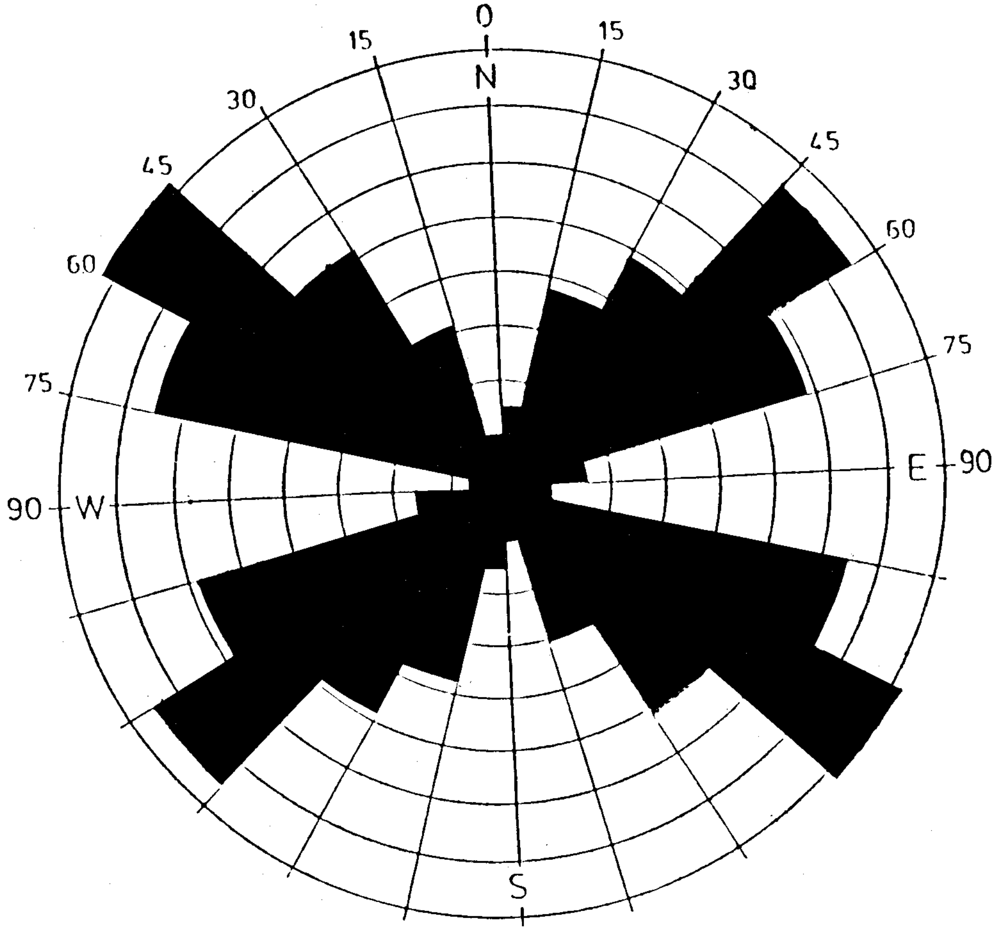

Fig. 3 : Rose diagram illustrating the structural pattern trends on Top of Alamein Formation.

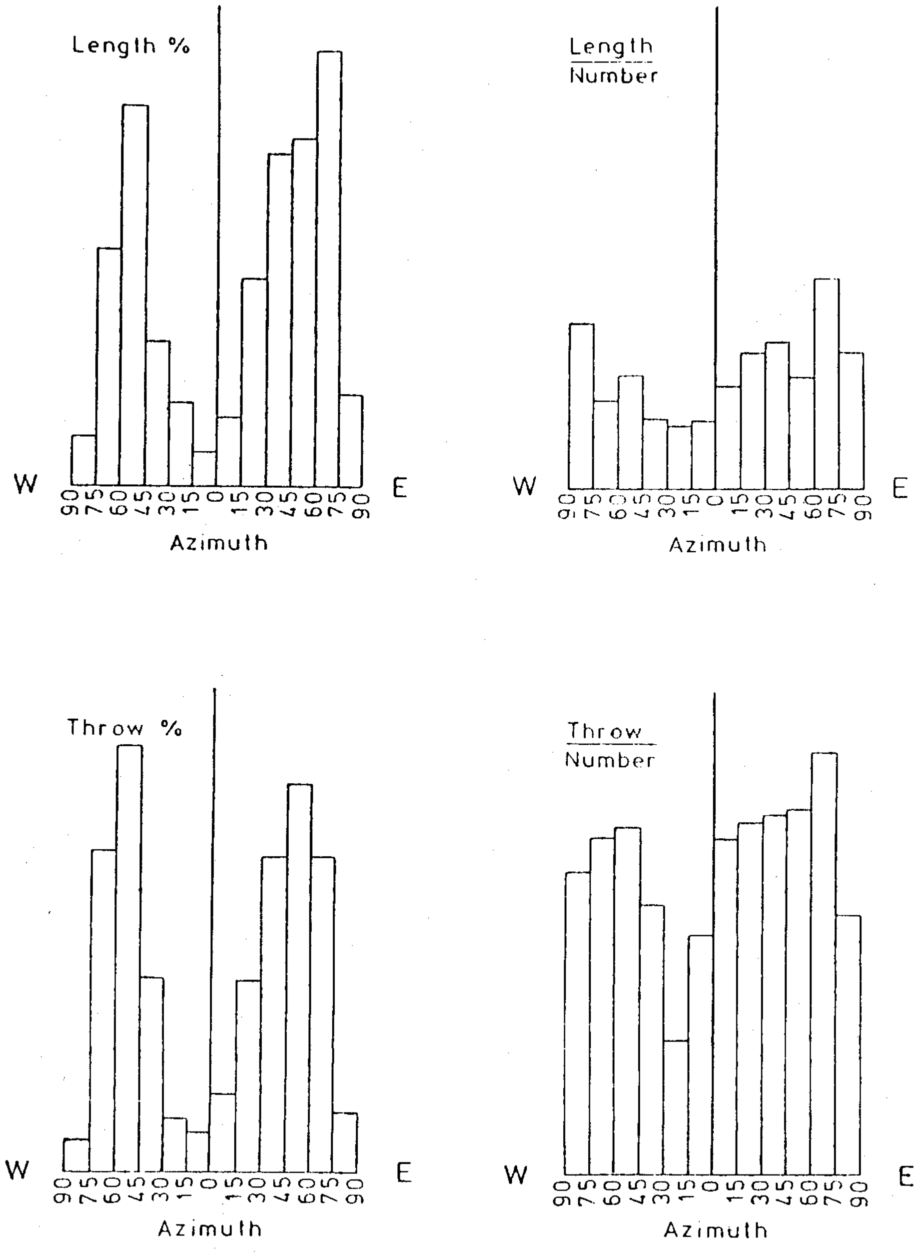

Fig. 4 : Histograms for faults interpreted from seismic data.

In some localities these structures illustrate an approximately NW trend. These grabens and horsts are crossed by oldest series of faults. The several trends of these structural elements at the concerned area were reported by several authors. El Gezeery *et al,* (1975) constructed a set of subsurface geological maps for the northern part of Egypt. Among them, the isopach map, during the Paleozoic Era, shows clearly NW trending basins and ranges, while the Jurassic age isopach map exhibits the beginning of deviation of the trend of these structural basins from NW to NE trends which is more pronounced during the Early and Late Cretaceous times.

Meshref (1982) reported that the northern part of Egypt seems to be affected with three tectonic events, the oldest one resulted in NW or WNW trending structure. This event was followed by another one, mainly of Cretaceous age and resulted in ENE trend (Syrian Arc). He refered these two events to the couple force affecting north Africa in that time. He added that the third tectonic event, most propably of late Eocene to Early Oligocene in age, resulted in the E-W, NW (Suez) and NNE (Aqaba) trending structures. He related this event to the collision of Africa with Asia which resulted in a northern horizontal compressive force.

Most of the southern portion of the concerned area (Yakout, Zarif and El Basour well areas) was uplifted during the deposition of the Alamein Formation (Aptian in age, Table 1). This can explain the absence of the Alamein Formation in these areas and is found to confirm the results obtained from the correlation schemes which they are based on bore-hole data and well logging tools (El-Dairy, 1986). This structural uplift is related to Qattara-North Sinai uplift which is proposed by Meshref (1982). This uplift seems to extend all the way across northern Egypt and confined basins of the Syrian Arc trend (mainly Cretaceous age), with increasing thicknesses towards the North and Northeast.

POROSITY

The measured rock porosity values (Table 4) are varied in a relatively wide range from 10.1% to 27.8% with mean porosity value equals 17.73%. The frequency distribution of the rock porosity (Fig. 5) depicts that the Kharita Formation is mainly of bimodal porosity type (may be primary and secondary porosity are coexist). Nevertheless, the calculated porosity standard deviation ($\sigma \emptyset$) was equal 1.8%, which seems of low value. It implies that the rocks consisting the Kharita Formation are more or less homogeneous.

Table 4
Measured rock porosity and gas permeability data for samples from the Kharita Formation

Well Name	Depth Int. m	Lithology	Porosity %	Permeability x 10^{-3}	
				Kh, μm^2	Kv, μm^2
Mersa Matruh	1591.0–92.0	Quartzarenite	25.00	1650.00	843.00
Mersa Matruh	1800.6–01.5	Quartzarenite	21.90	720.00	1.97
Mersa Matruh	1801.5–02.4	Calc. Quartzarenite	10.10	1.98	0.09
Faghur	1324.4–25.3	Silty Claystone	18.60	ipm.*	imp.*
Ghazalat	1222.0–23.0	Argil. Quartzarenite	10.30	10.00	7.98
Ghazalat	1352.4–54.0	Argil. Quartzarenite	27.80	1550.00	1540.00
Ghazalat	1355.0–56.0	Quartzarenite	28.30	3310.00	1700.00
El Basour	1230.0–34.0	Argil. Quartzarenite	22.30	67.00	27.00
Mersa Matruh	2046.6–47.5	Argil. Quartzarenite	10.10	2.97	1.98
Faghur East	2692.0–95.0	Argil. Quartzarenite	11.20	imp.*	imp.*
Faghur	1327.7–28.6	Quartzarenite	20.20	2420.00	964.00

* imp. = Permeability less than 0.0001 μm^2

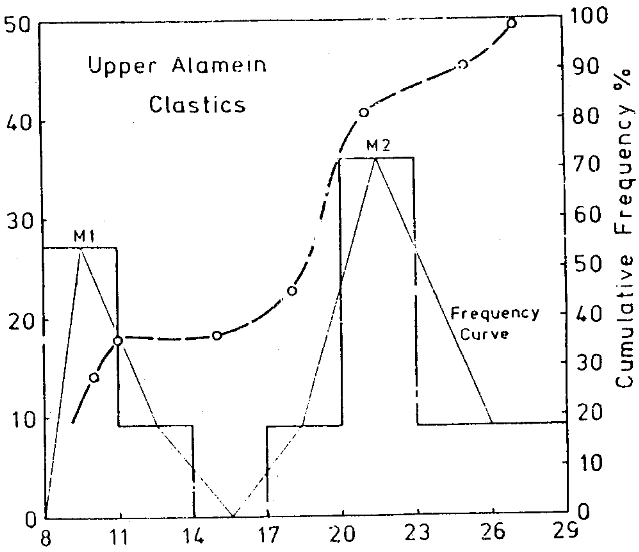

Fig. 5 : Porosity histogram and cumulative frequency curve.

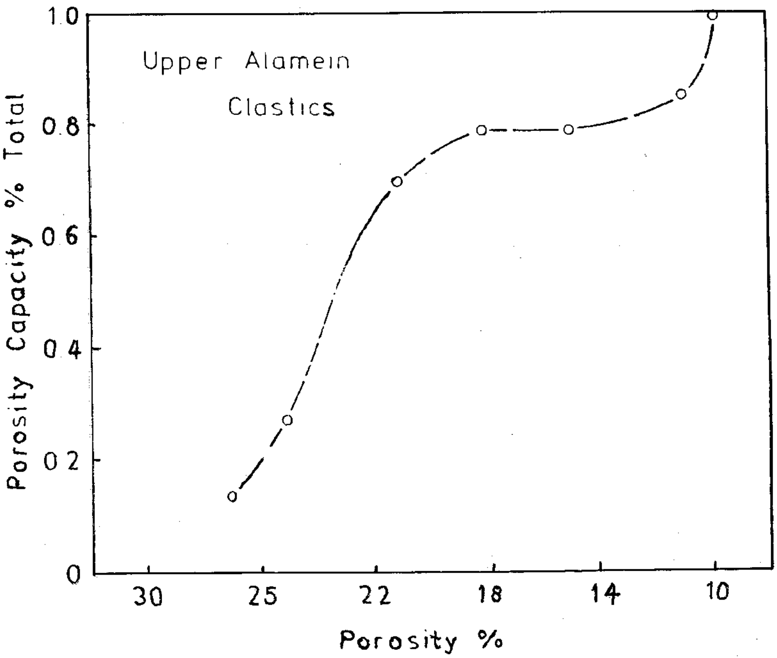

Fig. 6 : Distribution of porosity capacity.

Figure 6, exhibits the cumulative volume capacity versus rock porosity. It is easy to distinguish that 90% of the storage capacity of the Kharita Formation are represented by samples having porosity of 10.3% or greater. While 10% of the storage capacity are represented by samples having porosities of 27% or greater. So that, the porosity value of 10.3% could be considered as a porosity cut off value (Fig. 6) for fluid reserve estimation.

GAS - PERMEABILITY

The measured gas-permeability data (Table 4) of the Kharita Formation are found to be vary from $1.98 .10^{-3}$ to $33.5 .10^{-1}$ μm^2 and from $9.9 .10^{-5}$ to $17.0 .10^{-1}$ μm^2 for both the horizontal and vertical permeability respectively. Permeability histograms (Figs. 7A&B) show that both horizontal and the vertical permeability are characterized by unimodal distribution type (intergranular permeability type). In addition, the calculated permeability geometrical mean (K_{Gm}) values were equal $0.10995 \mu m^2$ and 0.2283 μm^2 for both the horizontal and the vertical permeability respectively.

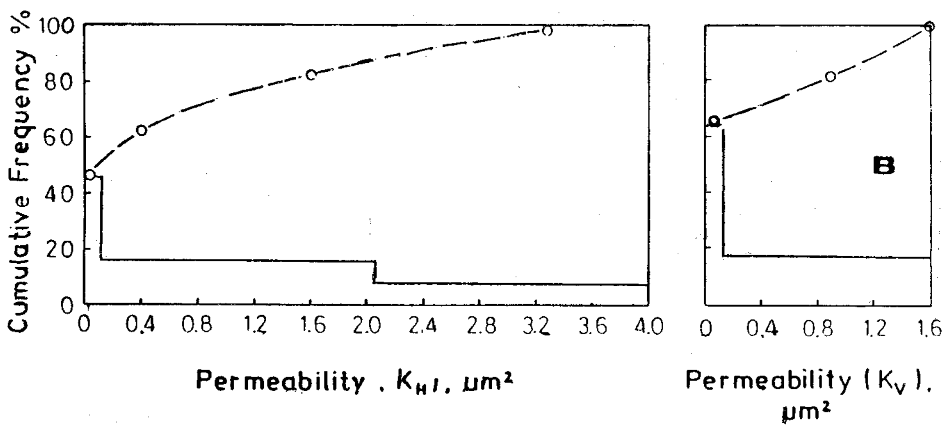

Fig. 7 : Permeability histogram and cumulative frequency curve of Upper Alamein Clastics.

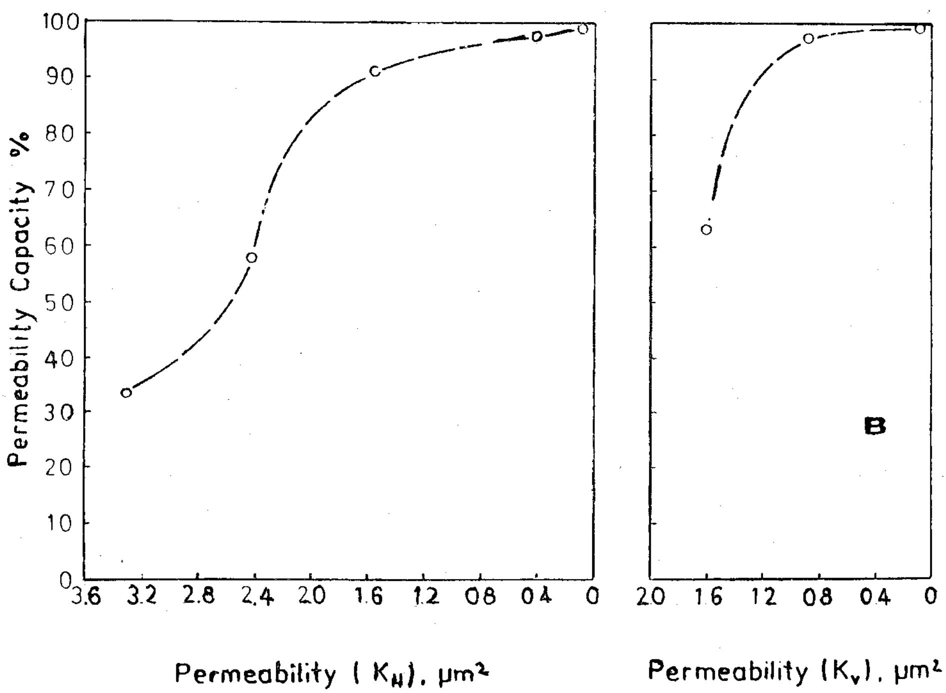

Fig. 8 : Distribution of permeability capacity of Upper Alamein Clastics.

The standard deviation (σ k) of the permeability data was found to be 1.26 μm^2 for the horizontal permeability and 1.09 μm^2 for the vertical one. It is easy to notice that there is no significant difference between the values of the standard deviation for the two measuring directions. This may implying certain homogenity in pore space framework characterizing the Kharita Formation.

Producing capacity was calculated (Amyx, et al, 1960) for the two measuring directions. Figures 8 A & B, reveal the relationship between permeability capacity and sample permeability. These plots show that 90% of the producing capacity of the Kharita Formation is represented by samples having permeability of 1.64 and 1.3 μm^2 or greater, for both horizontal and vertical directions respectively. Then, the permeability cut off value of 1.64 μm^2 can be used to calculate the net pay thickness of the Kharita Formation in the pilot area.

CONCLUSIONS

The interpretation of the available seismic reflection data have been done to demonstrate the subsurface structural elements of the Lower Cretaceous in the study area. However, a structural map on the top of Alamein Formation has been constructed. It includes a series of grabens and horsts having a general trend of ENE direction (Syrian Arc), while they crossed by oldest series of faults. In addition, it illustrates two major structural fault trends; ENE (Syrian Arc) and WNW trends. On the other hand, some minor trends have been detected; NW (Suez), NNE (Aqaba), NE, NNW, E–W and NS.

The statistical treatment of the core analysis data reveals that the samples belonging to the Kharita Formation are rather homogeneous in their pore space framework, especially in pore – throats which directly act on both permeability and effective porosity. In general, the study of the rock porosity and the gas–permeability (performed in two directions; parallel and normal to the bedding plane) data indicates that the samples of the Kharita Formation represent good reservoir characteristics. They have considerably high porosity and permeability mean values.

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العناصر التركيبية وبارامترات البنية لبعض تتابعات الكريتاوي الأسفل بالصحراء الغربية - مصر

ممدوح درويش الديري وحمود عبد المنعم الحفناوي
وعبد المقتدر عبد العزيز السيد

أمكن تحديد العناصر التركيبية الأساسية المؤثرة على تكوين العلمين باعتباره عاكس جيداً للموجات الزلزالية ، وقد رسمت هذه العناصر على خريطة تركيبية توضح اتجاهات الفوالق والخسائف والضهور وأحواض الترسيب في منطقة البحث بالاستعانة ببعض الخطوط السيزمية . ولقد أمكن تصنيف العناصر التركيبية إلى مكونات أساسية تتمثل في الاتجاهات شرق شمال شرق (القوس السوري) وغرب شمال غرب ، وعناصر فرعية تأخذ اتجاهات متعددة مثل شمال غرب (السويس) وشمال شمال شرق (العقبة) وشمال (العقبة) وشمال شرق وشمال شمال غرب وشرق غرب وشمال جنوب .

وقد تم قياس بعض بارامترات البنية مثل المسامية والنفاذية لصخور أخذت من متكون الخريطة (حسب تقسيم الجزيري وأوكونر سنة ١٩٧٥) بالتتابع الكريتاوي الأسفل . بمعالجة هذه القياسات احصائياً أمكن رسم مجموعة علاقات استخدمت في حساب مقدرة الصخور على اختزان الموائع (ماء - زيت - غاز) وكذلك أمكن التعرف على السمات المميزة للخزان من خلال حساب مقدرته الانتاجية .

وقد وصفت صخور خزان متكون الخريطة بأنها جيدة من حيث تخزين وتمرير الموائع خلالها .