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PALYNOMORPH BIOSTRATIGRAPHY OF THE SUBSURFACE DEVONIAN ROCKS, GHAZALAT BASIN, WEST QATTARA DEPRESSION, EGYPT

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ABSTRACT

Well–preserved palynomorphs dominated by miospores and subordinate acritarchs and chitinozoans are recovered from some cuttings of Ie 11 - 2 borehole drilled in the Ghazalat Basin in the west of Qattara depression, Egypt . A total of 36 species of palynomorphs (25species of spores, 8 species of acritarchs and 3 chitinozoan species) are identified. The palynological investigation of the studied stratigraphic interval enabled the recognition of three informal zones ranging in age from Lochkovian to Emsian. Most of the palynomorph taxa encountered are closely comparable with coeval assemblages recorded from North Africa, Saudi Arabia, Western Europe and Canada, indicating the close relationship of the present area to other parts of the western Gondwana and southern Euramerican provinces during that time interval. Frequent representation of marine taxa (acritarchs and chitinozoans) together with associated spores indicate near-shore marine depositional environment for the Lower and Middle Devonian (Zeitoun Formation) deposits in north Western Desert region of Egypt.

Keyword: Devonian**;** palynomorphs biostratigraphy; Ghazalat Basin; West Qattara Depression.

INTRODUCTION

The present study is based on investigation and palynological analysis of nineteen cutting samples obtained from an undifferentiated Palaeozoic sequence encountered in the Ie 11 – 2borehole drilled by Khalda Oil Company (2000) in the northern part of the Western Desert. It is located at Lat: 30˚ 28' 15.100" N, and Long: 26˚ 01' 01.600" E (Fig. 1). According to the composite log of this borehole, the Palaeozoic sequence attains a total thickness of 625ft from 12864 up to the total depth at 13489 ft. Nevertheless, the present study deals only with an interval attains 454 feet (13036–13490ft) representing the lower part of the Palaeozoic sequence in this borehole. Samples from the upper part (12864–13036ft) are unavailable, whereas the lower part is of unsuitable for palynological study that it is dominated by reddish yellow, coarse–grain sandstone beds. The drilling company introduced lithostratigraphic subdivision of Zahra, Safa and Zeitoun for the penetrated Palaeozoic sequence. However, the examined interval in this borehole is considered as the Zeitoun Formation, a widespread subsurface Devonian rock unit in the Western Desert. Lithologically, the examined interval is composed of alternating dark–gray shales and siltstones with few interbeds of sandstones.

The studied borehole situated within the Ghazalat Basin. This basin is located within the central Western Desert throughout Mid–Cambrian to Latest Devonian (Keeley, 1989, 1994). The Ghazalat Basin involved broad and persistent crustal downwarpand occupies a large area in the Western Desert (Fig. 1). It seems to believe that Ghazalat Basin was somewhat overlap or contact the eastern margin of Faghur–Siwa Basin; the remarkable Paleozoic basin, that cover the area along the Egyptian–Libyan border. Faghur–Siwa Basin is structurally oriented in north–south trend and may be connected to Al–Kufra Basin in southeast Libya (Palaeoservices, 1986). Throughout much of the Devonian time, Ghazalat Basin was semi–isolated with only a narrow marine connection to the north. The interplay between marine facies invading the depositional basin from the north located Paleotethys, and the continental facies mostly fine clastics, derived by presumed south–north and southeast–northwest river channels, resulted into the complex nature of this unit in their spatial distributions both in time and space (Issawi, 1996). All the prepared samples are palynologically productive yielding rich and diverse palynomorph elements,

although not in equal abundance. These well–preserved Devonian palynomorph assemblages comprise non–marine (spores) and marine (acritarchs and chitinozoa) elements. These assemblages contain several previously documented taxa as well as a number of stratigraphically important species that permit an assessment of their age from Early (Lochkovian) to Middle (Givetian) Devonian. Detailed stratigraphic information for the examined interval is shown in figure (2).

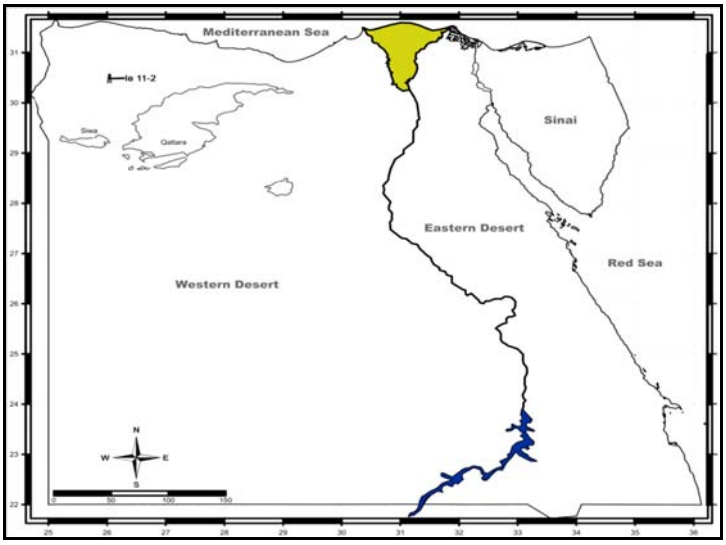

Fig. 1: Location map of the studied Ie 11-2 borehole.

Study of the Devonian spores is important for expounding the origin and evolution of land plants. The present palynomorph assemblages and location of the borehole have potential importance for the Devonian paleogeographic interpretations. Unfortunately, previously published palynological literatures on the Western Desert Devonian assemblages are rare. Indeed, the most relevant studies in relation to the present work are those of Schrank (1984, 1987), El-Ghazaly and Ali (1985), Gueinn and Rasul (1986), El-Menshawy (1989), Hosny (2001), and El-Shamma et al. (1998; 2011a; 2011b; 2012).

The present study represents a new attempt to evaluate and identify different palynomorph groups from some Devonian sediment recovered from the Ie 11 – 2 borehole. The present study aims to determine their stratigraphic ranges in response to the most closely comparable assemblages previously established, particularly throughout the North African and Arabian Basins as well as the Western Europe Province. Finally, this study attempts to elucidate the paleoenvironmental significance of such assemblages.

Material and methods

This investigation is based on nineteen samples recovered between 13045 and 13480ft in the borehole. Serial numbers of samples and their stratigraphic position are given in Figure (2). About 10 grams of each crushed sample were treated by the use of hydrochloric (HCl) and hydrofluoric (HF) acids to remove the mineral content of the sediments, followed by separation with heavy liquid using zinc chloride with specific gravity about 2. The residue was oxidized, as necessary, in nitric acid, and finally mounted in glycerin jelly. For each sample, two slides were prepared for the light microscopy. The quantitative analysis of the investigated taxa is based on about 200 palynomorphs count per sample at 250X and 400X magnifications.

PALYNOSTRATIGRAPHY

A total of 36 species are identified from samples of the studied interval. For the most productive samples, spores are by far the dominant element in the palynofloral content, together with frequent associated acritarchs and, in few exceptions, chitinozoans. The photomicrographs of the identified palynomorphs are arranged in plate 1. The organic–walled microfossils retrieved from the productive samples are, therefore, grouped systematically into three major categories; a) spores, b) acritarchs and c) chitinozoans. Since the majority of samples available for study are cuttings, the palynozones proposed in this study have been defined by the first downhole occurrence (highest appearance) of significant

palynomorph taxa. The quantitative distribution chart (Fig. 2) of the studied borehole shows a successive occurrence of different palynomorph species recorded at different stratigraphic horizons. These occurrences enabled the establishment of five assemblage zones covering the time interval from Lochkovian to Givetian.

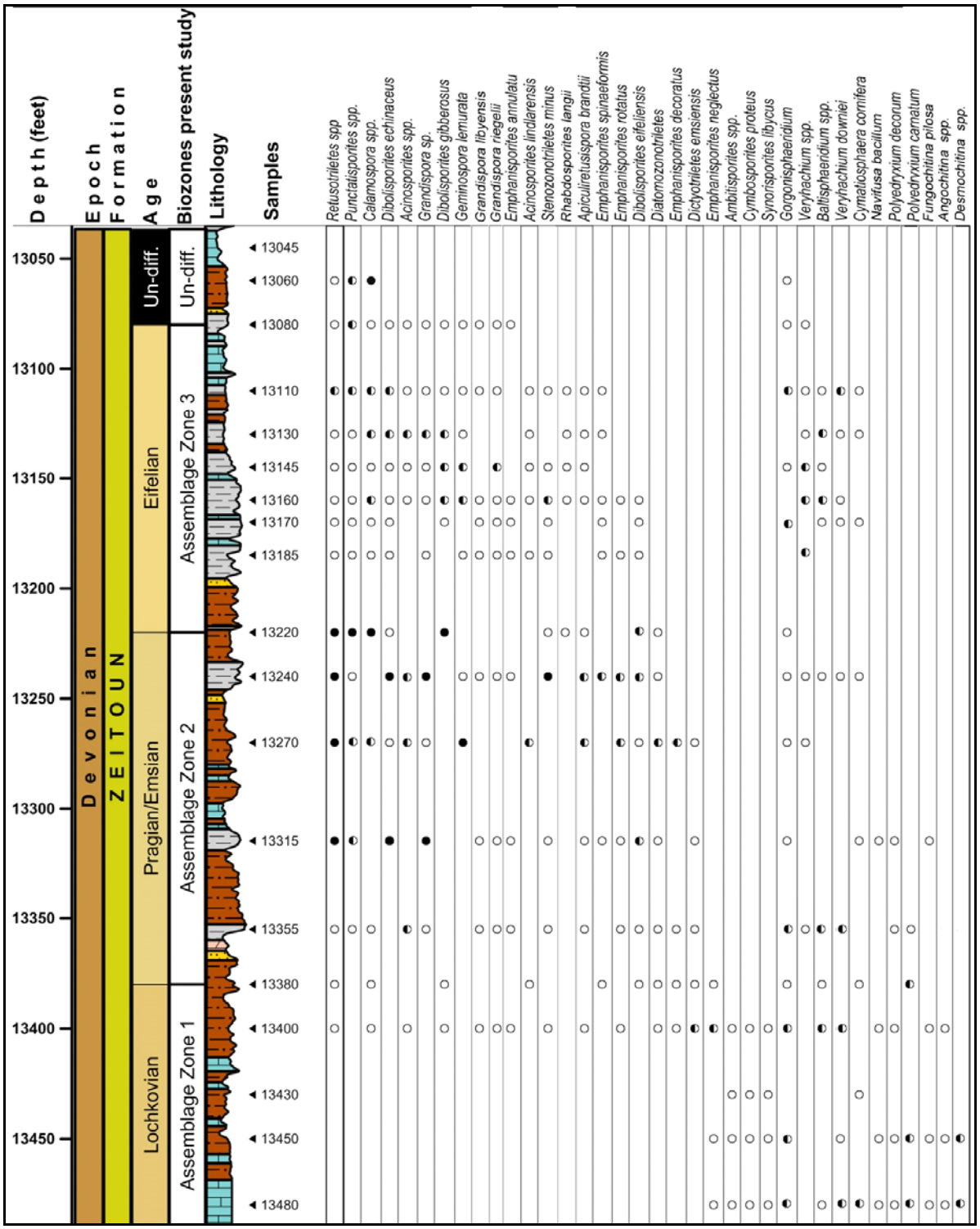

Fig. 2: Semi-quantitative distribution range chart of the identified palynomorphs from the studied section of the Ie 11-2 borehole.

The ages assigned to these assemblages have been determined by comparing the palynomorph assemblages of the present borehole with those known from previously dated sequences in North Africa, Saudi Arabia, Western Europe and Canada. The following comments summarize the characteristics of the proposed palynostratigraphic units in an ascending stratigraphic order. The differences in composition of their palynomorph assemblages have been noted and the age assignment of each assemblage is explained.

Lochkovian Assemblage Zone 1:

Interval: The productive interval between 13480–13380 ft.

Diagnostic Species: The assemblage of Lochkovian age is characterized by the occurrence of the following taxa: *Emphanisporites decoratus, Emphanisporites neglectus, Dibolisporites gibberosus, Ambitisporites* spp., *Synorisporites libycus,* and *Cymbosporites proteus*. Many marine palynomorphs (acritarchs and chitinozoan) are recorded in the present assemblage, Plate 1.

Age assignment: Many unequivocal Lochkovian miospore assemblages that have been recorded in different regions could be used to prove the existence of Lochkovian age in the present productive interval. Correlation with these assemblages is based on the general characteristics of the assemblages and the occurrence of certain taxa. For example, *Emphanisporitesdecoratus* is not previously recorded from sediments older than the Lochkovian age worldwide. The data concerning the Early Devonian of Egypt is relatively rare. A wide stratigraphic interval (Lochkovian–Givetian) has been assigned by Gueinn and Rasul (1986) for an acritarchs assemblage with *Polyedryxium fragosulum, Tunisphaeridium tentaculiferum, Polyedryxium carnatum and Diexallophasis remota*; and a reduced number of land–derived spores from the Western Desert.

El–Shamma et al., (1998) reported a probably Lochkovian undifferentiated assemblage zone (DV–1) from Faghur–1 well in the Western Desert with *Retusotriletes* sp., *Emphanisporites* spp., *Synorisporites papillensis, Apiculiretusispora plicata* and *Cymbosporites proteus,* based upon the stratigraphic position of the studied interval which lies below a determinable Pragian strata. 6

Ghavidel–Syooki (2003) studied the palynostratigraphy of Devonian sediments in the Zagros Basin, southern Iran. The author established spore assemblage zone I from the basal part of the studied succession. The miospore content of that assemblage, which dated as Lochkovian age, was definitely comparable with those assemblages recovered from several southern Euramerican and western Gondwanan regions. Both Iranian and Egyptian assemblages can be correlated easily when both contain the same diagnostic forms in general.

Recently, El–Shamma et al., (2011b) established a more distinctive Lochkovian assemblage (Sf–2) from the Sifa-1 borehole in the north Western Desert region. The present assemblage of Ie 11 - 2 borehole shows closely similarity with those of Sf–2 Assemblage Zone.

Pragian-Emsian Assemblage Zone 2:

Interval: The productive interval between 13380-13220 ft.

Diagnostic Species: This interval yielded an assemblage characterized by many useful miospores such as: *Emphanisporites spinaeformis, Dictyotriletes emsiensis, Emphanisporites annulates, Apiculiretusispora brandtii* and *Dibolisporites wetteldorfensis*.

Age assignment: The assemblage investigated is demonstrated by many species known to range from the upper part of the Early Devonian into the Middle Devonian and occasionally occur in even younger strata. Furthermore, zonate–camerate spores (e.g. *Camptozonotriletescaperatus*) have not been reported from well–dated strata older than Pragian. McGregor and Camfield (1976) indicated that *Dictyotriletes emsiensis* is represented among a typical upper Pragian–lower Emsian assemblage in Canada.

El–Shamma et al., (1998) reported *Verrucosisporites polygonalis–Dictyotriletes emsiensis* Assemblage Zone for the Pragian of the Western Desert with *Dibolisporites wetteldorfensis, Camptozonotrilete scaperatus, Synorisporites papillensis* and *Apiculiretusispora brandtii*. The present assemblage recovered

from the Ie 11 - 2 has almost the same palynofloral component of the above mentioned zone and, therefore, a Pragian age could be assigned to this interval.

El–Shamma et al., (2011b) recognized SF–3 Assemblage Zone from the Sifa–1 borehole in the north Western Desert of Egypt. The present assemblage of Ie 11 – 2 borehole closely resemble to the lower part, where the authors attribute their zone to the Pragian–Emsian age.

A Pragian age is also confirmed by comparing the present assemblage with similar ones described from southeast Libya (Grignani et al., 1992); Spitsbergen (Allen, 1967; 1973); central Poland (Turnau, 1986) and Canada (McGregor and Camfield, 1976). The present assemblage is also similar to the zone dated as Pragian (*polygonalis–emsiensis*) from the Old Red Sandstone Continent and adjacent regions (Richardson and McGregor, 1986).

The present assemblage can be correlated with the assemblage taxa of the Palynozone D4A of Pragian time in Saudi Arabia (Al–Hajri and Filatoff, 1999).

In support of this age is the presence of *Emphanisporites annulatus* which shows its first occurrence in the lower part of upper Emsian in the type area of southwest Eifel (Lanninger, 1968), or the upper part of lower Emsian in the Klerf beds (Schultz, 1968). At Gaspé Bay it first occurs in the mid–Emsian (McGregor, 1973). In the Dinant Basin of Belgium, it has been recorded probably in the lower Emsian (Streel et al., 1975). El–Shamma et al., (1998) reported *Emphanisporites annulates– Camarozonotriletes sextantii* Assemblage Zone to the Emsian age based on the presence of species recorded in the preceding zone in addition to *Dibolisporites eifeliensis, Grandispora douglastownense, Emphanisporites spinaeformis, Dibolisporites echinaceus* and *Grandispora* (= Ancyrospora) *nettersheimensis*.

The present assemblage is also similar to the zones dated as early and late Emsian respectively (*annulatus–sextantii and douglastownense–eurypterota*) from the Old Red Sandstone Continent and adjacent regions (Richardson and McGregor, 1986). Also, is similar to the Emsian miospore assemblage described by Paris et al. (1985) from northeast Libya. The Libyan assemblage contains *Dibolisporites eifeliensis, Grandispora douglastownense, Emphanisporites spinaeformis, Dibolisporites echinaceus* and *Grandispora nettersheimensis.*

Spores from the present stratigraphic interval closely resemble those from the Ghadamis Basin (Tunisia–Libya) described by Loboziak and Streel (1989). The authors identified a miospore assemblage rich in *Grandispora* spp. (*Grandispora velata*, *G. riegelii*, *G. douglastownense*, *G. inculta* and *G. naumovii*), *Acinosporitesacantho mammillatus*, *Emphanisporites annulatus* and *Ancyrospora nettersheimensis*.

Closely comparable Emsian assemblages are probably similar to the present assemblage based on their total spore content as reported from Algeria (Jardiné and Yapaudjian, 1968); Western Libya (Massa and Moreau–Benoit, 1976); Saudi Arabia “Palynozone D3/D4” (Al–Hajri and Filatoff, 1999) and Iran (Ghavidel–Syooki, 2003).

Eifelian Assemblage Zone 3:

Interval: The productive interval between 13220-13080 ft.

Diagnostic Species: The characteristic taxa of the Eifelian assemblage include *Grandispora libyensis, G. inculta, G. riegelii, G. tomentosa, G. velata, G. gabesensis, G. douglastownense, Verrucosisporites premnus, V. scurrus, Craspedispora ghadamisensis, Geminospora lemurata, Acinosporites lindlarensis, Rhabdosporites langii, Emphanisporites spinaeformis, Dibolisporites wetteldorfensis, D. echinaceus, Apiculiretusispora brandtii, A. plicata* and *Ancyrospora nettersheimensis.* Furthermore, this interval is characterized by the last occurrence of *Emphanisporites annulatus*. Many acritarchs and chitinozoan species are represented such as *Veryhachium downiei*.

Age assignment: The assemblage described herein is characterized by a proliferation of the spinosezonate–pseudosaccate spores (*Grandispora and Rhabdosporites*); first occurrence of irregular verrucate sculpture (*Verrucosisporites premnus and Verrucosisporites scurrus*) and a marked increase in the spore size. All of these features are typical for the Middle Devonian time. This is additionally

supported by the ranges of *Grandispora tomentosa* and *Ancyrospora nettersheimensis*. The presence of *Grandispora tomentosa* points to an age not older than mid–Eifelian (McGregor and Camfield, 1976).*Ancyrospora nettersheimensis* reaches its acme occurrence above the base of Eifelian in the type area (Riegel, 1982) and then disappeared during that age.

An Eifelian age could also be confirmed by comparing the present assemblage and those previously reported from Egypt by El–Shamma et al., (1998). They recorded the "*Grandispora douglastownense–Grandispora velata*" Assemblage Zone from the Western Desert of Egypt, and assigned it to the Eifelian age. The same conclusion can be extracted from El–Shamma et al., (2011b).

The present assemblage is also similar to the Eifelian miospore assemblages described from Libya by Massa and Moreau–Benoit (1976); Paris et al. (1985) and Loboziak and Streel (1989). The Libyan assemblages are rich in *Grandispora spp. (Grandispora velata, G. riegelii, G. douglastownense, G. libyensis, G. inculta, G. megaformis* and *G. gabesensis*) in addition to *Emphanisporties spinaeformis, Verrucosisporitesscurrus, V. premnus, Emphanisporites annulatus, Craspedispora ghadamisensis* and *Ancyrospora nettersheimensis*.

Loboziak and Streel (1995) recorded a tenuous miospore assemblage from a clastic section in Saudi Arabia. These beds are of uncertain age but are thought to be of Eifelian age based apparently on its stratigraphic position. The Saudi assemblage is rather simple in its composition though it is partly comparable to the assemblage recovered in this study in terms of the presence of *Grandispora riegelii, Emphanisporites annulatus, Acinosporites lindlarensis, Verrucosisporites premnus* and *V. scurrus.*

The palynomorph elements of Palynozone D3A and base of the Palynozone D2 of Saudi Arabia (Al–Hajri and Filatoff, 1999), which attributed to the Eifelian time, contain almost forms recorded in the present Eifelian assemblage of the Western Desert of Egypt.

McGregor and Camfield (1976) recorded an Eifelian miospore assemblage from the Moose River Basin in Canada. The base of this assemblage is characterized by the last occurrence of *Apiculiretusispora plicata*, while the upper limit is dominated by *Acinosporites lindlarensis, Dibolisporites echinaceus, Grandispora tomentosa, Densosporites orcadensis* and *Retusotriletes rotundus.* Although the present assemblage has less in common to the above one, the same age seems to be suggested.

The spore assemblage IV of an Eifelian age recorded in southern Iran (Ghavidel–Syooki, 2003) has nearly the same palynomorph elements as recorded from the Eifelian interval in Ie 11 - 2borehole in the northern part of the Western Desert of Egypt. The Iranian spore assemblage of Eifelian time showed great similarity with the Arabian (Loboziak, 2000) and North African (Richardson, 1985) assemblages.

PALEOENVIRONMENTAL ANALYSIS

The analytical quantitative data of the samples show occurrence of different species recorded at three biostratigraphic zones which enable to interpret their environmental settings. This analysis show abundant and diverse miospores in general and les abundance of acritarchs and rare chitinozoans.

The marine and nom-marine abundance reflect a number of sedimentary cycles related to the growth of lithology of this succession. These cycles are implied from the variation in the marine (acritarchs and chitinozoans) and terrestrial (miospores) palynomorphs abundance. ratio.

Regression setting during the zone 1 is mainly composed of claystone which represent the lower part of Zeitoun Formation. These rocks deposited under fluvio-deltaic conditions because of the sparse of marine taxa.

Transgression settings of zone 2 which contain dominated marine shale with sandstone and siltstone interbeds. The high frequency of acritarchs and chitinozoans (marine taxa) and low frequency of terrestrial miospores indicate shallow marine conditions.

Regression settings occurred during zone 3. Its lithology composed of sandstone with calcareous matrix which has been deposited in deltaic to continental condition because of less abundant marine taxa.

The Ie 11-2 borehole is studied in Ghazalat Basin in the west of Qattara Depression. This basin is structurally semi-isolated with a narrow marine connection to the north and interplay between the marine and continental facies derived by presumed north and southeast-northwest river channels resulted in the complex nature of this unit in their spatial distribution both in time and space (Issawi, 1996). The tectonic event during the Devonian Period led to the creation of many regressive settings and reduced thickness of strata possibly attributed to eustatic oscillation and periodic uplift of crust contemporaneous to periods of non-deposition and /or erosion (El Shamma, 2011).

The overall picture presented by recovered miospores from Ie 11-2 borehole seems to be consistent with the worldwide spore record.This can be explained in terms of the increase in their abundance and diversity coupled with a much more pronounced size difference reflect contemporaneous land plant evolution from the base of Devonian time upwards.

The sculpture of the exines of the miospore witnessed a complexity through the time, the less abundance and diversity in the base of this interval is due to evolution than that environmental control. The beginning with simple and psilate(*Retusispora*) then verrucate (*Grandispora*),striate (*Emphanisporites*)and anchor-spined spores (*Ancyrospora*).Simple and striate miospores do not provide any conclusive evidence on the palaeoclimate because of the spore-producing plants are largely unknown (Schrank, 1987). Richardson (1969) proposed that plant producing anchor-spined spores leave in the upper flood plan environment. The large diversity and increase of spore size during the Eifelian related to evolutionary phase from homospory to heterospory (Richardson and McGregor, 1986).

CONCLUSIONS

The palynostratigraphic study of the samples from Ie 11 – 2 borehole in Ghazalat Basin in the west of Qattara Depression in the Western Desert of Egypt leads to identify a diverse and abundant assemblage of the Lower and Middle Devonian (Lochkovian-Eifelian). The study enabled the recognizing three assemblage zones in this borehole. The Assemblage Zone 1 is distinguished with *Emphanisporites decoratus, Emphanisporites neglectus, Dibolisporites gibberosus, Ambitisporites* spp., *Synorisporites libycus,* and *Cymbosporites proteus* in the Lochkovian. The Assemblage Zone 2 is differentiated with *Emphanisporites spinaeformis, Dictyotriletes emsiensis, Emphanisporites annulates, Apiculiretusispora brandtii* and *Dibolisporites wetteldorfensis* in Pragian-Emsian). The Assemblage Zone 3 includes *Grandispora libyensis, G. inculta, G. riegelii, G. tomentosa, G. velata, G. gabesensis, G. douglastownense, Verrucosisporites premnus, V. scurrus, Craspedispora ghadamisensis, Geminospora lemurata, Acinosporites lindlarensis, Rhabdosporites langii, Emphanisporites spinaeformis, Dibolisporites wetteldorfensis, D. echinaceus, Apiculiretusispora brandtii, A. plicata* and *Ancyrospora nettersheimensis* in Eifelian. The three assemblage zones during this time interval are similar to the zones recorded from north Africa, Saudi Arabia, Western Europe and Canada and Southern Iran. Three sea level change cycles have been observed n the studied section. The earliest one is regression in the early Devonian, followed by a transgression cycle in the Middle Devonian and the latest one is regression cycle in the Late Middle Devonian. Mainly, the increase of spore diversity and their abundance in this studied interval is due to evolutionary significance more than environmental conditions.

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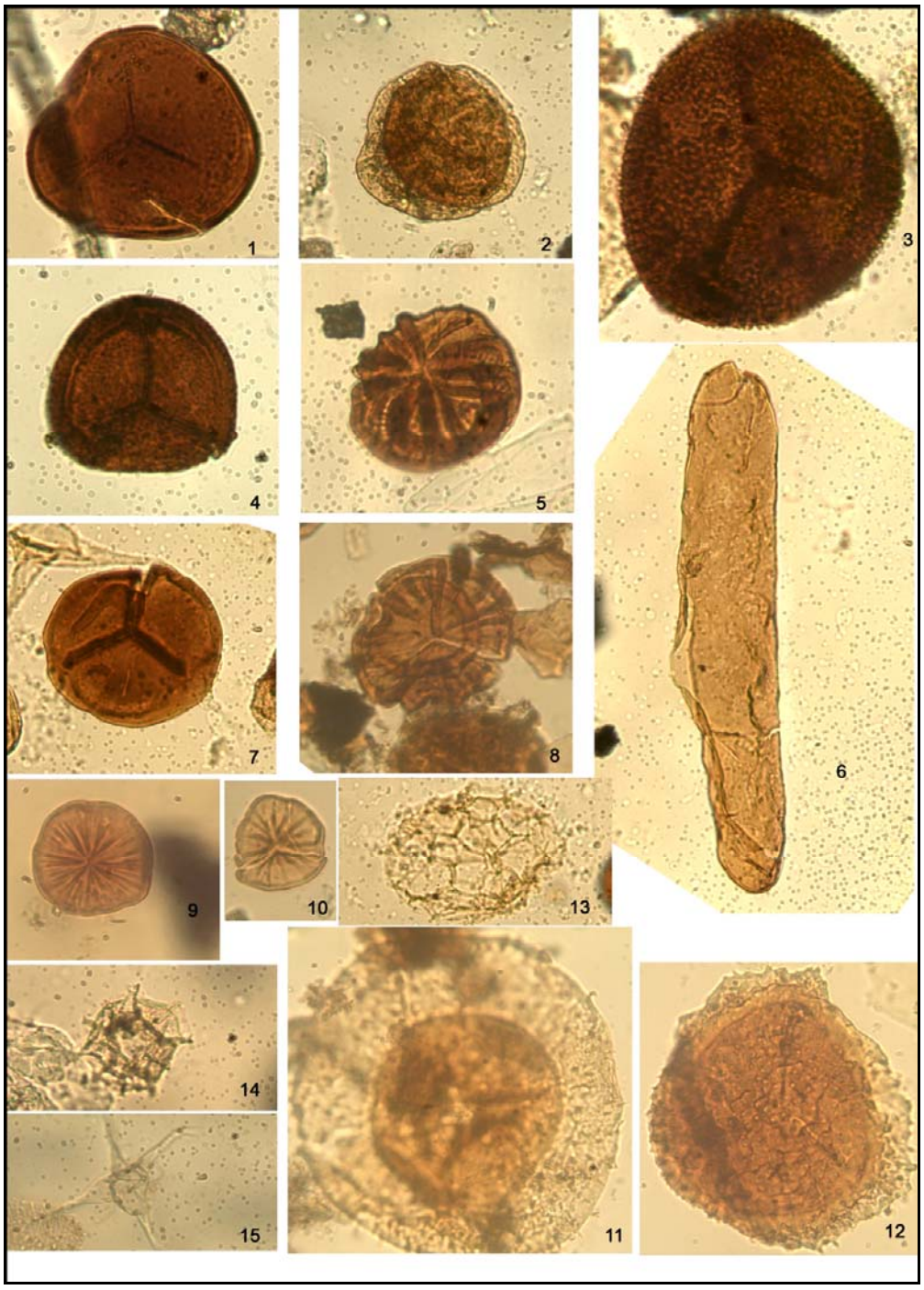

Plate 1

1,*Retusotriletes sp.* depth 13110 ft, dia. 130 um.2, *Rhabdosporites langii*, depth 13145 ft. dia. 118 um.*3, Apiculiretusispora brandtii*, depth 13240, dia. 110 um.*4, Geminospora lemurata*, depth 13160 ft, dia. 105 um.*5, Emphanisporites decorates*, depth 13270ft, dia. 75 um.*6, Navifusa bacillum*, depth13355ft, dia. 250 um. *7, Synorisporites libycus*, depth 13430, dia. 105 um.*8, Emphanisporites annulates*, depth 13270 ft, dia. 85 um.*9, 10, Emphanisporites neglectus*, depth 13380 ft, dia. 80um.11,*Grandisporalibyensis*,depth 13170 ft, dia. 190 um. *12, Grandispora riegelii*, depth13145 ft, dia. 185 um.*13, Polyedryxium carnatum*, depth 13450 ft, dia. 55 um.*14, Cymatiosphaera cornifera*, depth 13480ft, dia. 50 um.*15, Veryhachium downiei*, depth 13355ft, dia. 40 um.

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Palynomorph biostratigraphy of the subsurface Devonian rocks

بيواستراتجرافية بالينومورفات (الاحافير النباتية) لصخور الديفوني لتحت السطحية بحوض غزالات غرب منخفض القطارة بمصر

طارق فؤاد مصطفى

معهد بحوث البترول – مدينة نصر القاهره

الخلاصة

تهدف هذه الدراسة الباليناستراتجرافية لعدد تسعة عشر عينة فتاتية من بئر 2 – 11 le بحوض غزالات غرب منخفض القطارة بمصر . لتحديد انواع الباليناومورفات (الاحافير النباتية) و استخدامها في استخلاص النطق الحياتية للعصر الديفوني (السفلي والأوسط) من (Lochkovian – Eiflian). و اظهر التحليل الباليناولوجي للعينات وجود أحافير الأبواغ بكثرة و انتشار خلال العصر الديفوني للفترة الزمنية الخاصة بالدراسة مع بعض الاركيتاركات و الكيتيانات وتم استخلاص٣٢ نوع من الباليناومورفات

تتضمن خمسة وعشرين نوعا من الأبواغ و ثماني أنواع من الاركيتاركات و ثلاث أنواع من الكيتيانات . و ادي ذلك لتحديد ثلاث نطق حياتية باليناستراتجرافية مميزه للعصر الديفوني السفلي و الاوسط .

النطاق الاول يتميز بوجود *Emphanisporites decoratus*, *Emphanisporites neglectus*, *Dibolisporites gibberosus*, *Ambitisporites* spp., *Synorisporites libycus*, and *Cymbosporites proteus* وعمره(Lochkovian age) و يتميز النطاق الثاني بوجود *Dictyotriletes emsiensis*, *Emphanisporites spinaeformis*, *Emphanisporites annulates*, *Apiculiretusispora brandtii* and *Dibolisporites wetteldorfensis* و يتراوح عمره من (Pragian – Emsian) و النطاق الثالث يحتوي علي *Grandispora libyensis*, G. *inculta*, G. *riegelii*, G. *tomentosa*, G. *velata*, G. *gabesensis*, G. *douglastownense*, *Verrucosisporites premnus*, V. *scurrus*, *Craspedispora ghadamisensis*, *Geminospora lemurata*, *Acinosporites lindlarensis*, *Rhabdosporites langii*, *Emphanisporites spinaeformis*, *Dibolisporites wetteldorfensis*, D. *echinaceus*, *Apiculiretusispora brandtii*, *A. plicata* and *Ancyrospora nettersheimensis* و عمره (Eiflian) ووجد ان هناك تشاية كبير بين هذه النطق الثلاث مع النطق المسجلة سابقا في نفس الفترة الزمنية في كل من شمال افريقيا و السعودية و غرب اوربا و كندا و جنوب ايران .

و تتميز هذه الفترة الزمنية (Lochkovian – Eiflian) بوجود ثلاث دوارات لتغير منسوب البحر حيث حدث تراجع للبحر أثناء الديفوني المبكر تبعه تقدم للبحر في الديفوني الأوسط و أخيرا تراجع في نهاية الديفوني الأوسط و قد تم استنباط ذلك من نسبة تواجد الأنواع البحرية من الاركيتارك و الكيتيانات و الأنواع القارية من الأبواغ حيث يدل وجود الأنواع البحرية بكثرة علي تقدم البحر و الأبواغ تدل علي انحسار البحر .

و من دراسة الشكل الخارجي و حجم و تنوع الأبواغ دل علي أن المناخ السائد أثناء الترسيب كان رطبا خلال الديفوني المبكر والأوسط كما يدل تواجد الأنواع البحرية مع القارية علي أن العصر الديفوني الأوسط و السفلي ترسب في بيئة قريبة من شاطئ البحر هذا و يرجع تنوع الأبواغ في الحجم و الشكل و الإنتشار خلال هذه الفتره الي عوامل التطور أكثر منها بسبب الظروف البيئية .