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Biostratigraphic Analysis of Middle to Late Eocene Palynomorphs from the Upper Gercus Formation, Dohuk Area, Northern Iraq

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ABSTRACT

The current study focuses on the palynological study of the upper part of the Gercus Formation of (Middle to Late Eocene) age in northern Iraq. Fifteen samples were collected from the studied outcrops. The studied section is about 57 meters. Twelve species belonging to eleven genera of spores and pollen grains are identified as follows: Sphagnum triangularum, Polypodiaciesporites retirugatus, Verrucatosporites usmensis, Monoporites annulatus, Perfotricolpites nigerianus, Tricolpites cf. brevicolpus, Retitricolporites irregularis, Psilatricolporites crassus, Psilatricolporites cryptoporus, Gemmastephanocolporites brevicolpites, Pinus sp, and Cycas sp. Based on the stratigraphic distribution of the identified palynomorph species, three palynological zones have been recognized, arranged in ascending order from the lowest (oldest) to the uppermost (youngest) part of the section as follows:

1- Monoporites annulatus-Gemmastephanocolporites brevicolpites interval Biozone (M1)
2- Gemmastephanocolporites brevicolpites Range Biozone (M2)
3- Perfotricolpites nigerianus Range Biozone (L)

These biozones are correlated and compared with other studies outside Iraq. The biostratigraphic analysis conducted in the present study indicates that the Gercus Formation is of Middle to early Late Eocene age.

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التحليل الحيوي الطبقي لأنواع الباليnomورف من منتصف إلى أواخر عصر الإيوسين من تكوين جركس العلوي، منطقة دهوك، شمال العراق

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الملخص

تركزت الدراسة الحالية على تصنيف حبوب اللقاح للجزء العلوي من تكوين جركس (الإيوسين الاوسط – المتاخر) في شمالي العراق. تم جمع خمسة عشر نموذجا من المقطع االمختار من محافظه دهوك والذى يبلغ سمكه حوالي 57 مترًا. تم تشخيص اثنى عشر نوعًا وهى تنتمي إلى أحد عشر جنسًا من الأبواغ وحبوب اللقاح على النحو التالي

Sphagnum triangularum : ،Polypodiaciesporites retirugatus ، Verrucatosporites usmensi

،Monoporites annulatus ،Perfotricolpites nigerianus ، Tricolpites cf. brevicolpus ،Retitricolporites irregalis ، Psilatricolporites crassus ،Psilatricolporites cryptoporus ، Gemmastephanocolporites brevicolpites،sp Pinus ،Cycas sp.

استنادًا إلى الامتدات العامودية الحياتية للأنواع المحددة، تم تحديد ثلاثة انطقة حياتية لل باليnوسبورومورفات ، من الأسفل (الأقدم) إلى الأعلى (الأحدث) من المقطع:

1-Monoporites annulatus-Gemmastephanocolporites brevicolpites (M1)النطاق الحياتي

2- Gemmastephanocolporites brevicolpites (M2) النطاق الحياتى

3- Perfotricolpites nigerianus(L) النطاق الحياتي

الانطقة الحياتية المحددة تمت مضاهاتها ومقارنتها مع الانطقة المكافئة لها عالميا أخرى خارج العراق. حددت دراسة الانطقة الحياتية عمر من الإيوسين الأوسط إلى المتأخر لتكوين جركس في الدراسة الحالية.

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Introduction

This study primarily deals with the identification and determination of biozonations in pollen and spores from the upper part of the Gercus Formation. The study samples have been collected from the surface section within the High Folded Zone, within Dohuk Governorate, Kurdistan region (N-Iraq). The studies of the Gercus Formation represent a significant geological interval, renowned for its diverse sedimentary sequences and paleontological content. Despite extensive studies on its sedimentology, stratigraphy, and fossil assemblages, the microfossil record, particularly that of pollen and spores, was absent in Iraq. The type locality of the Gercus Formation is situated at the Gercus area, approximately 12.5 miles north of Midyat in Turkey. A supplementary type section was established by Wetzel in Bellen *et al*. (1959) in the Duhok area, Iraq. The lithology of the Formation predominantly consists of red and purple shale, mudstone, and sandy, gritty marl, with occasional pebbles. (Bellen *et al*., 1959). The rock successions of the Gercus Formation crop out in northern and northeastern Iraq. The location of the geological sections is chosen based on the presence of outcrops of the

Gercus Formation, as well as the presence of evidence of plant leaves in the studied area. The main aim of this study is to identify and classify the pollen and spores in the upper part of the Gercus Formation, as important Molasses deposits in the Kurdistan foreland basin. Another target oriented towards the biozonation of the identified species with international standard biozones, which have not been recorded before in this unit. The correlation of the study result with the international biozone was also delineated, demonstrated, and calibrated with other studies worldwide to determine. Furthermore, the study aims to clarify and provide a detailed field description of the diagnostic lithological and stratigraphic characteristics of the Gercus Formation.

Geological Setting and Stratigraphy

From Geographic point of view, the studied area located within Dohuk Governorate, in Besre with GPS reading (36°52'01.8"N 43°03'36.4" E) and (36°51'34.2"N 43°03'44.6" E) in, Kurdistan region, Northern Iraq (Fig. 1). From structural point of view, the measured and sampled section is located at the Bekhair anticline, which is entirely asymmetrical double plunging fold, located within the High folded zone (Fouad, 2015), (Fig. 1) It represents the molasse deposits within Kurdistan foreland basin (Lawa, 2004, Lawa, 2018). Bekhair extends about 72 Km from Zawita/Besari area (the southeastern plunge) to Deraboon village near the Iraqi Syrian-Turkish border (the northwest plunge). The Gercus succession of northern Iraq was developed in a passive marginal basin, and belongs to the middle-late Eocene sequence, which is a part of the middle Paleocene-Eocene Megasequence AP10 (Sharland et al.,2001) cited in (Hussain, 2012). The Mid-Late Eocene sequence is represented by the Dammam, Ratga, Avanah, Jaddala, Pila Spi, and Gercus formations (Jassim and Goff, 2006). (Fig. 2).

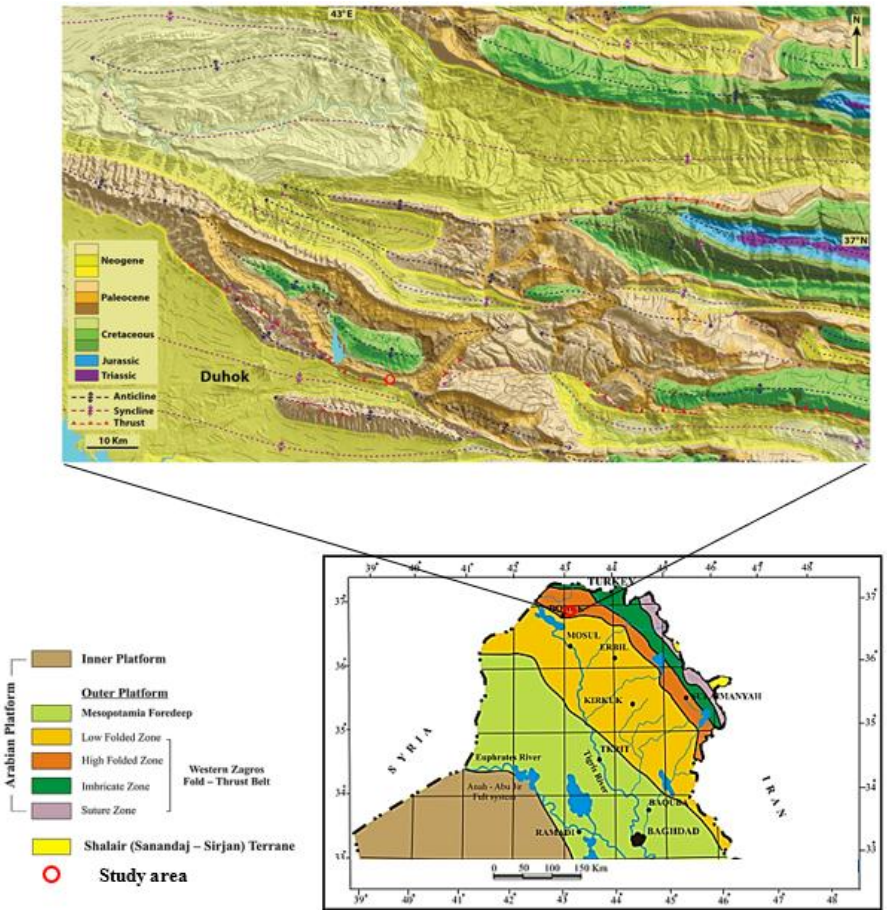

Fig. 1. Tectonic divisions of Iraq (after Fouad,2015). with a geological map showing the studied section, from (Doski, 2022).

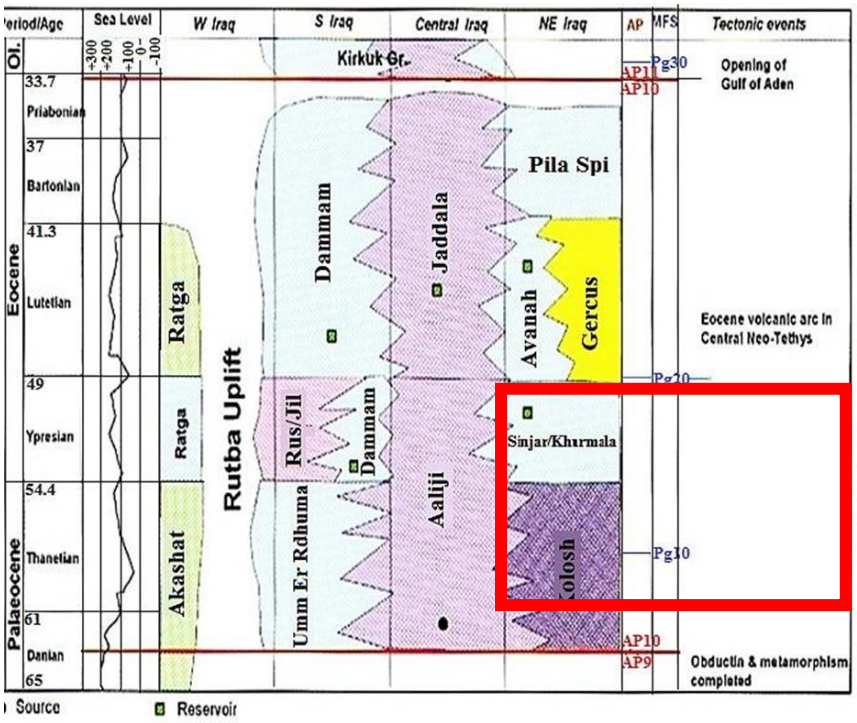

Fig. 2. Stratigraphic correlation of the formations of Megasequence AP10 (Jassim and Goff, 2006).

The studied section

The lithology of the formation in the studied area consists of a combination of clastic, carbonate, and evaporite sequences, particularly prominent in the middle and upper parts. However, in this specific section, the formation is mainly composed of interbedded clastic sediments and carbonate rocks, as illustrated in Fig. 3. Various sedimentary features are present, along with plant leaves and leaf impressions, which are commonly found within the carbonate rocks. Fifteen samples were collected from the outcrop of the upper part of the Gercus Formation, whose thickness is about 57 meters (Fig. 3).

Previous Studies

The previous palynological studies of the Gercus Formation are very rare in Iraq and neighboring areas, so the present study is the first palynological study to focus on the identification of pollen and spores within the studied section, in addition to determining the age of the Gercus Formation according to pollen and spores. The Gercus Formation has been subjected to several geological studies focusing on sedimentology, stratigraphy, and geochemistry; some of these studies are summarized as follows:

- Ameen (2006) studied the sequence stratigraphy of the Gercus Formation in the Suleimani area.
- Al-Hameedi (2007) studied the rock successions of the Gercus Formation in the Shaikhan area.
- Al-Aany (2010) studied facies analysis and sedimentological Model of Gercus Formation succession in selected locations, northern Iraq.
- Malak (2011) studied sedimentological and stratigraphical successions of the Paleocene-Eocene deposits from selected areas, North Iraq.
- Hussain (2012) studied facies analysis and the sedimentary environment of the Gercus Formation in northern Iraq.

- Awad and Alsultan (2020) carried out a stratigraphic analysis of the Gercus Formation in the Dohuk area, highlighting its lithological characteristics and vertical distribution.
- Ammar et al. (2025) studied the mineralogy of the Gercus Formation in Darbandi Basara Anticline, Sulaymaniyah Area, northeastern Iraq.

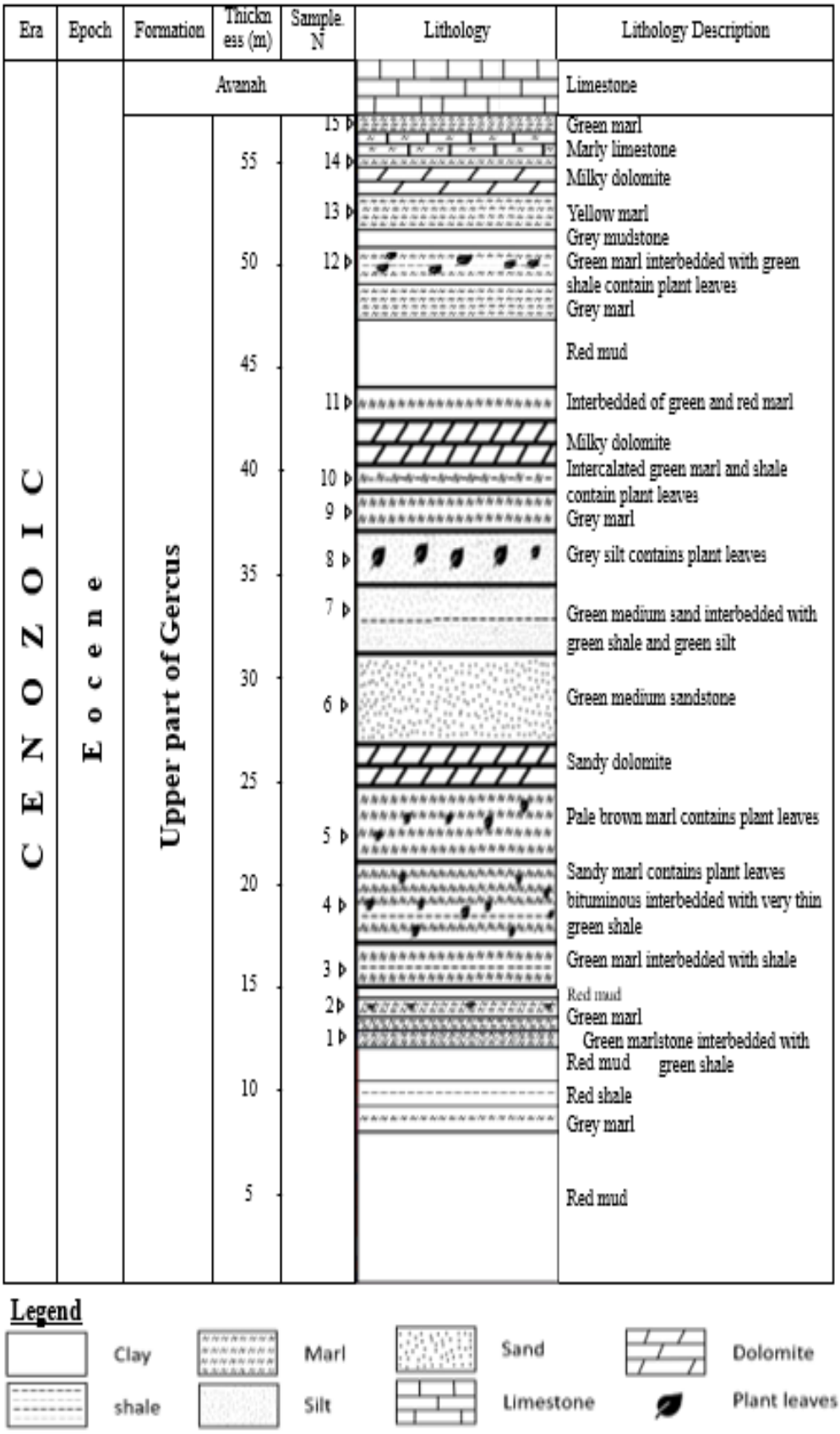

Fig. 3. Lithological section of the upper part of the Gercus Formation at the Besere section.

Materials and Methods

Fifteen samples were collected from the upper part of the Gercus Formation, which is approximately 57 meters thick. Standard palynological methods are implemented following Faegri and Iversen (1989) and Traverse (2007) for the study purpose. About 10–20 grams of sediment or rock per interval were treated with 10% HCl to remove carbonates, followed by 40% HF to eliminate silicates, and thoroughly rinsed. For samples rich in organic matter, 10% KOH was used to remove humic substances, while oxidizing agents were avoided to preserve palynomorphs. Residues were sieved through a 15 µm mesh and purified using zinc bromide ($ZnBr_2$, specific gravity 2.0). Final residues were mounted in glycerin jelly and examined under a transmitted light microscope (Olympus BH-2) at 400x–1000x magnification. Photomicrographs were taken with a Canon camera. All work was conducted at Hassan Jan Private Laboratory, Ankara, Turkey.

Results

A total of fifteen samples from the studied section are analyzed to investigate the spores and pollen grains. A total of twelve species, representing eleven genera, are identified, as summarized in Table 1. These twelve species are carefully selected based on their significance and preservation within the samples. The identification is based on the Smith and Butterworth (1967) and Potonié (1970) classifications. This research provides the first palynological record of Middle Eocene to Late Eocene spores and pollen grains within the studied section. The identified reworked Middle to Late Eocene spores and pollen grains identified include:

1- *Sphagnum triangularum* (Mamczar) Frederiksen, 1980.
2- *Polypodiaciesporites retirugatus* Kedves, 1961.
3- *Verructosporites usmenis* (van Hammen) Germeraad et al., 1968.
4- *Monoporites annulatus* van der Hammen, 1954.
5- *Perfotricolpites nigerianus* Takahashi and Jux, 1989.
6- *Tricolpites cf. brevicolpus* Couper, 1960.
7- *Retitricolporites irregularis* Van der Hammen and Wijmstra 1964.
8- *Psilatricolporites crassus* Van der Hammen and Wijmstra, 1964.
9- *Psilatricolporites cryptoporus* Boltenhagen, 1976.
10- *Gemmastephanocolporites brevicolpites* Jan du Chêne et al., 1978.
11- *Pinus* sp.
12- *Cycas* sp. Bouchal et al., 2024.

Table. 1: The taxonomic classification of the species studied. (Smith and Butterworth 1967, Potonié, 197

Anteturma	Turma	Subturma	Infraturma	Species
Proximegerminantes	Triletes	Azonotriletes	Laevigati	*Sphagnum triangularum*
		Cingulati	Murornati	*Polypodiaciesporites retirugatus*
	Monoletes	Azonomonoletes	Sculptatomonoletl	*Verrucatosporites usmensis*
Varigerminantes	Poroses	Monoporines	Wetzelielloideae	*Monoporites annulatus*
	Plicates	Tricolpate		*Perfotricolpites nigerianus*
		Tricolporates		*Tricolpites cf. brevicolpus*
				Psilatricolporites cryptoporus
				Retitricolporites irregularis
				Psilatricolporites crassus

	Stephanocolporatae		*Gemmastephanocolporites brevicolpites*
Saccites	Disaccites		*Pinus sp*
Monosulcates		Quasilaevigati	*Cycas sp.*

Biostratigraphy

A total of fifteen samples were analyzed. Twelve species of sporomorphs (pollen grains and spores) belonging to eleven genera are identified. Based on the stratigraphic distribution of the identified species as shown in Figure 4, three palynological zones are established, labeled M1, M2, and L. The M1 and M2 zones correspond to the Middle Eocene, while the L Zone represents the Late Eocene. The palynozones are established based on the stratigraphic distribution of marker sporomorph species. To further confirm the age and support the biozonation, these biozones are compared with previously published palynological studies. The palynozones correlated with their equivalent palynozones proposed by Ikegwuonu et al. (2020) from southeastern Nigeria and with the tropical palynozones described by Germeraad et al. (1968). These comparisons help reinforce the age assignment of the biozones within the Gercus Formation as summarized in Table 2.

Three Palynozones are recognized in this study as follows:

1-Monoporites annulatus - Gemmastephanocolporites brevicolpites interval Biozone (M1)

Definition:

The base of this zone was defined by the disappearance of Early Eocene index species. This biozone begins with the first appearance of the Middle Eocene index taxa *Monoporites annulatus*. (Fig. 4), while the top of the zone is marked by the first appearance of *Gemmastephanocolporites brevicolpites*. Furthermore, the zones show the abundance occurrences of Psilatricolporites crassus.

Assemblage: *Psilatricolporites crassus, Pinus* sp., *Tricolpites cf. brevicolpus, Psilatricolporites cryptoporus, Cycas sp., Monoporites annulatus*.

Range of zone: from sample 1 to sample 5

Discussion:

The Monoporites annulatus were first described from Middle Eocene sediments in tropical areas Germeraad *et al*., 1968. The Gemmastephanocolporites brevicolpites were described from the Middle Eocene in the Niger Delta Basin, southeastern Nigeria, Ikegwuonu *et al*. (2020).

The present zone (M1) is correlated with the upper part of the *Monoporites annulatus* Zone (Middle Eocene age), that established by Germeraad *et al*. (1968) in tropical areas. This zone also equates to the pollen Zone (P430) by Evamy *et al*. (1978) in the Niger Delta Basin, and compared with the middle part of Zone D by Ikegwuonu *et al*. (2020) in southeastern Nigeria, as shown in the table. (2) studies

Age of Biozone: Middle Eocene

2- *Gemmastephanocolporites brevicolpites* Range Biozone (M2)

Definition:

The base of this zone is defined by the appearance of Middle Eocene index species *Gemmastephanocolporites brevicolpites*. Ikegwuonu et al. (2020). And the top of the biozone is defined by the last occurrence of the species Gemmastephanocolporites brevicolpites. (Fig. 4)

Assemblage: *Psilatricolporites crassus, Polypodiaciesporites retirugatus, Psilatricolporites cryptoporus, Monoporites annulatus, Verrucatosporites usmensis, Gemmastephanocolporites brevicolpites.*

Range of Zone: from sample 5 to sample 8

Discussion:

The *Gemmastephanocolporites brevicolpites* was first described from Middle Eocene sediments around southeastern Nigeria Jan du Chêne *et al*., 1978 and from the Middle Eocene in the Niger Delta Basin, southeastern Nigeria Ikegwuonu *et al*., 2020. The base of this zone was defined by the appearance of Middle Eocene index species *Gemmastephanocolporites brevicolpites*. Additional biostratigraphic support for the base of the zone was delimited by the appearance of *Verrucatosporites usmensis* species within (late Middle Eocene).

The present Range zone (M2) is correlated with the *Verrucatosporites usmensis* Zone within (late Middle Eocene) age, which was established by Germeraad *et al*. (1968) in tropical areas. This zone also equates to the lower part of Zone (P450) by Evamy *et al*. (1978) in the Niger Delta Basin, and compared with the Uppermost of Zone D by Ikegwuonu *et al*. (2020) in southeastern Nigeria (Table 2) studies

Age of Biozone: late Middle Eocene.

3- *Perfotricolpites nigerianus* Rang Zone (L) (Part)

Definition:

The base of this zone was defined by the appearance of *the Perforatricolpites nigerianus* species. The top of the zone is not clearly defined due to a marked reduction in both species abundance and diversity beginning from sample 12 onwards. (Fig. 4)

Assemblage: *Verrucatosporites usmensis, Retitricolporites irregularis, Sphagnum triangularum, Psilatricolporites crassus, Monoporites annulatus, Cycas sp, Perfotricolpites nigerianus.*

Range of zone: from sample 8 to sample 12.

Discussion:

The base of the *Perfotricolpites nigerianus* Zone was defined by the disappearance of the middle Eocene index *Gemmastephanocolporites brevicolpites* species, and the first appearance of late Eocene *Perfotricolpites nigerianus* species in Nigeria, Ikegwuonu *et al*. (2020). Furthermore, along with the continued presence of *Verrucatosporites usmensis*. Additionally, the abundance occurrence of *Monoporites annulatus* recorded within this zone in southeastern Nigeria by Ikegwuonu *et al*. (2020). The top of the zone is not clearly defined due to a marked reduction in abundance and diversity of the species beginning from sample 12 onwards. (Fig. 4). The present Range Zone (L) is correlated with the lower part of the *Verrucatosporites usmensis* Zone within (Late Eocene age) that was established by Germeraad *et al*. (1968) in tropical areas. This zone also equates to the upper part of Zone P450 (late Eocene age) by Evamy *et al*. (1978) in the Niger Delta Basin, and compared with the lowermost part of Zone E (Late Eocene age) by Ikegwuonu *et al*. (2020) in southeastern Nigeria (Table 2) studies

Age of Biozone: early Late Eocene.

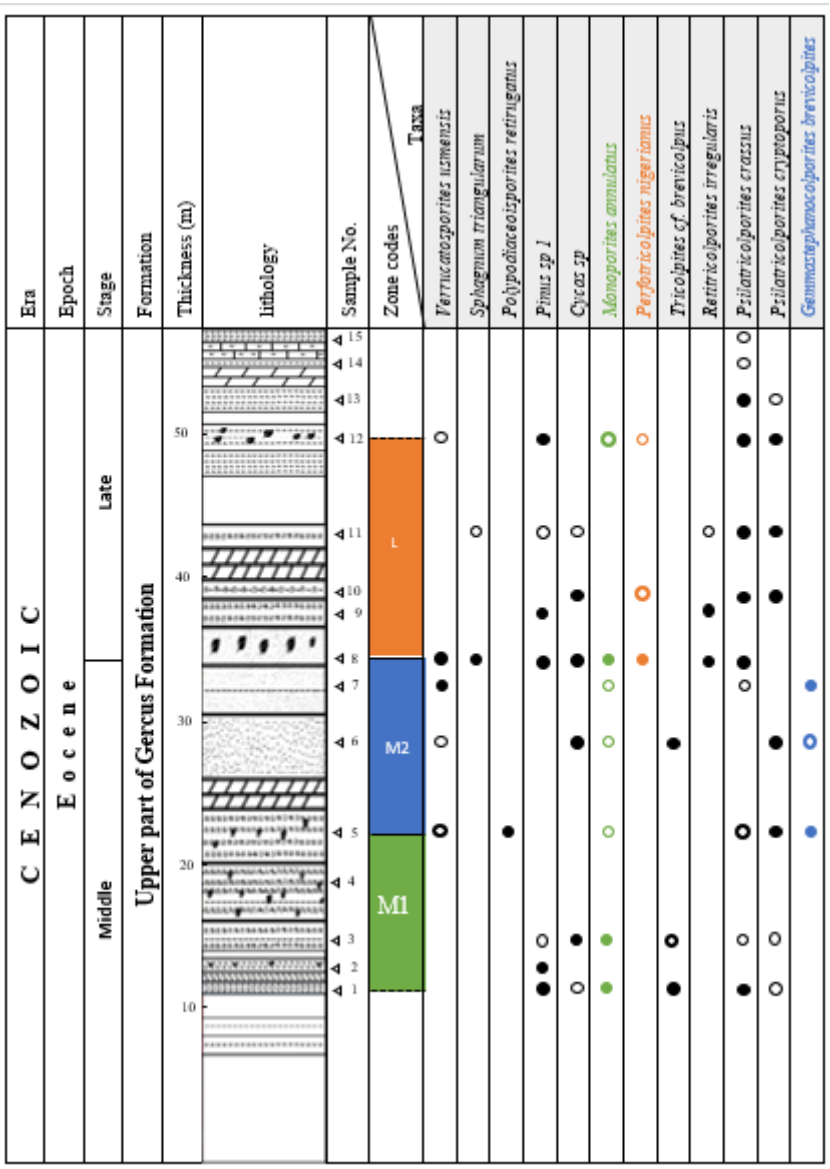

Fig. 4. Biostratigraphic Range chart of selected spores and pollen species in studied section. (Palynomorphs abundance ○ 1-5%, ◎ 5-25%, ● >25%).

Table 2: The correlation chart illustrates the relationship between the biozones and palynological zones identified in the study area.

Era	Epoch	Stage	Formation	Pollen Zone by (Evamy *et al.*, 1978) (Niger Delta Basin)		Tropical areas Germeraad *et al.*,1968 Pantropical zone	Palynological assemblage zone (Ikegwuonu *et al.*, 2020) (southeastern Nigeria)	Palynological zones (this study)
CENOZOIC	Eocene	Late	Not study	P400	P 480	*Verrucatosporites usmensis* Zone	Zone E	
					P 470			
			Upper part of Gercus		P 450			Zone L
		Middle			P 430	*Monoporites annulatus* Zone	Zone D	Zone M 2
			Not study		P 420			Zone M 1
		Early		P300			Zone C	Not study

Conclusions

The analysis of pollen and spore species in the Upper part of the Gercus Formation, northern Iraq, highlights the potential of these fossils as reliable indicators of Middle to early Late Eocene age. Notable discoveries include *Monoporites annulatus*, whose initial appearance

indicates the middle Eocene, *Gemmastephanocolporites brevicolpites*, which is characteristic of the late middle Eocene, and *Perfotricolpites nigerianus*, whose first occurrence is indicative of the late Eocene. The identification of *Verrucatosporites usmensis* species further corroborates these age assignments. These results underscore the significant role of fossil pollen and spores in stratigraphic correlation and age determination.

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Plate 1

1- *Sphagnum triangularum* (Mamczar) Frederiksen, 1980. (G5L1.9;124.2)

2- *Polypodiaciesporites retirugatus* Kedves, 1961. (G8L0.7;107.1)

3- *Verrucatosporites usmensis* (van der Hammen) Germeraad, et al., 1968. (G8L3.2;123.2)

4- *Monoporites annulatus* van der Hammen, 1954. (G8L-0.1;109.5)

5- *Perfotricolpites nigerianus* Takahashi and Jux, 1989. (G8L5.4;111.2)

6- *Tricolpites cf. brevicolpus* Couper, 1960. (G1L0.5,103.9)

7-*Retitricolporites irregularis* Van der Hammen and Wijmstra, 1964. (G8L7.1;102.9)

8- *Psilatricolporites crassus* Van der Hammen and Wijmstra, 1964. (G1R8.1,126.1)

9- *Psilatricolporites cryptoporus* Boltenhagen, 1976. (G5L0.1;111.1)

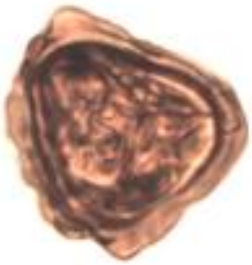
10- *Gemmastephanocolporites brevicolpites* Jan du Chêne, et al. 1978. (G5L3.1;107.3)

11- *Pinus* sp. (G2L1.7,126.8)

12- *Cycas* sp. Bouchal, *et al., 2024.* (G5L11.2;118.9)

Plate 1

1



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