

Late Middle Miocene (Serravallian) of the Fat'ha Formation, Northern Iraq: Palynofloral Evidence

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Received: 23 February 2025

Received in revised form: 29 April 2025

Accepted: 07 July 2025

Available online: 01 October 2026

Abstract

This study represents the first palynological investigation conducted on the Middle Miocene Fat'ha Formation in Northern Iraq. Twelve samples were collected from an outcrop section of the Fat'ha Formation in Zawita, Northern Iraq. These samples yielded well-preserved and well-diversified palynomorph assemblages. Three species of spores related to three genera and nine pollen species related to nine genera were investigated and identified, as follows (*Spirosyncolpites bruni*, *Pinuspollenites* Subgenus *Strobilus* sp, *Abies* sp.1, *Arecipites pflugii*, *Monocolpopollenites tranquillus*, *Tubulifloridites* sp, *Quercus* sp.2, *Trivestibulopollenites betuloides*, *Carya* sp, *Polypodiaceisporites fossulatus*, *Baculatisporites primarius*, *Camarozonosporites rarus*). Analysis of palynomorph species assemblages from the Fat'ha Formation at the Zawita section shows no significant variations throughout the entire section, suggesting a single palynomorph assemblage biozone. This biozone was correlated with its equivalent in neighbouring Turkey, Iranian realms, and other sections around the world. The stratigraphic distribution of the identified species confirms, for the first time, that the Fat'ha Formation was assigned to the late Middle Miocene (Serravallian).

Keywords:

Serravallian age, Fat'ha Formation, Palynomorphs.

DOI: [10.33899/injes.v26i4.60927](https://doi.org/10.33899/injes.v26i4.60927), ©Authors, 2026, College of Science, University of Mosul.This is an open-access article under the CC BY 4.0 license (<http://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Gachsaran Formation, formerly known as the Lower Fars series (Gill and Ala, 1972; Kashfi, 1980; Tucker and Shawket, 1980; Mahdi, 1983; Aqrabi, 1993; Tucker, 1999; Bahrudi and Koyi, 2004; Seyrafian and Mojikhalifeh, 2005; Habibi and Ruban, 2017; Sakhavati et al., 2020; Tavakolian et al., 2022) was first described from its type locality, the Fars Province NW Iran, by Busk and Mayo (1918) and van Bellen et al., (1959). Jassim et al. (1984) described the equivalent of the Lower Fars series and were the first to propose the name Fat'ha Formation and define its type section in the Fat'ha Gorge, 10 km north of Beji town in Iraq. The formation consists of anhydrites, gypsum, salt interbedded with limestones and marls (Al-Juboury and McCann, 2008; Al-Jaberi and Salim, 2022). The formation is widely distributed across Iraq, mainly in the

Foothill Zone and Mesopotamian Basin, but it is absent in some areas (Aqrabi, 1993). The formation continues into the Jazira area of Syria, along the Turkish-Syrian border (Weber, 1963), Iran, Kuwait, and Saudi Arabia (Powers et al., 1967). The formation was originally subdivided into an informal unit in Bellen et al. (1959) and Ditmar et al. (1971). Later, Jassim and Buday (2006) and Al Juboury and McCann (2008) subdivided the Fat'ha Formation into two members from the base to the top: 1) the Lower Member consists of organo-detrital limestone and anhydrite (or gypsum), green dolomitic marl, and thin limestone and cyclically interbedded gypsum; and 2) the Upper Member consists of red and green mudstone and gypsum, a few recrystallized shelly limestone beds and thin oolitic limestone beds, with calcarenite beds at the top. The formation thickness varies greatly, reaching a maximum of 900m. In the Kirkuk Basin, it reaches 600 m, whereas in the Sinjar Basin, it thins out markedly

near the AboJir high. The sedimentary facies of the Fatha Formation differ from one place to another, depending on its location in the sedimentary basin (Al-Taiyy and Al-Badrani, 2025). The fossils are very rare and mainly include foraminifera (Miliolids), with ostracods also common, assigned to the middle Miocene of the Fat'ha Formation in southern Iraq (Shareef et al., 2023). However, recent biostratigraphic studies based on nannofossils suggest an early Miocene – Aquitanian age for the Fat'ha Formation in northern Iraq (Kharajany, 2023). The depositional environments are interpreted as restricted hypersaline to continental and open marine settings (Bellen et al., 1959; Al Juboury and McCann, 2008). Palynology is a useful tool in evolutionary, ecological and biostratigraphic studies (Germeraad et al., 1968; Muller, 1981; Traverse, 2007; Jaramillo et al., 2010) because the palynomorphs, including pollen, spores and dinoflagellates, are among the most abundant fossil groups found in sedimentary rocks (Pardo-trujillo et al., 2003; Traverse, 2007; Jaramillo et al., 2010; Rodríguez-Forero et al., 2012). These microfossils span a wide temporal range, from millions of years ago to the present, and occur in all types of environments (e.g., freshwater lacustrine deposits and deep-marine sediments), reflecting both forest- and grass-dominated ecosystems of the past (Boucot, 1999; Traverse, 2007). Many previous studies focus on the Fat'ha Formation because of its widespread distribution and provides a regional seal to numerous oil reservoirs. In addition, the formation yields economically important deposits of sulfur found in evaporite beds in Iraq (Al-Sawaf, 1977; Jassim et al., 1997; Jassim et al., 1999).

Several studies have been conducted on the Fat'ha Formation (Middle Miocene), focusing on various aspects including ostracod palaeoecology, foraminiferal biostratigraphy, and sedimentology. Kharruffa (2008) studied the distribution of ostracods within the formation. Al-Hadithi and Aziz (2019), Khalaf and Kharofa (2020) Ostracods within the same formation. Al-Shareefi et al. (2022) nanobiostratigraphy and ostracod paleoecology of the Fat'ha. Additionally, Aziz and Kasim (2023) studied ostracods from the Takia area in the Darbandi Bazian Anticline. Shareef et al. (2023) studied ostracoda and foraminifera of the Fat'ha Formation across. Furthermore, Abdulla (1994) studied the Fat'ha Formation from a selected well. Al-Taiyy and Al-Badrani (2025) studied the

lithofacies and Age Determination of the Fatha Formation in Mushak. Mohammed and Al-Shareefi (2021) studied some records of ostracods from the Middle Miocene.

This work aims to determine the age of the studied section and to constrain the age of the Fat'ha Formation by using the palynomorphs for the first time. The results are then compared with other local and regional age-equivalent pollen and spore assemblages and corresponding zonal schemes to solve the problem of the unconstrained age of the studied formation. This study also aims to update the stratigraphic framework of the Fat'ha Formation by providing a detailed field description of the studied section, including its facies characteristics.

2. Geological Setting

The studied section is located in the Dohuk area, Zawita Valley, where the Fat'ha Formation is exposed in the Bekhair Anticline (Fig. 1A), with coordinates (43°09'05.8"E) and (36°55'28.2"N) within the High Folded Zone in northern Iraq (Jassim and Buday, 2006) (Fig. 1B).

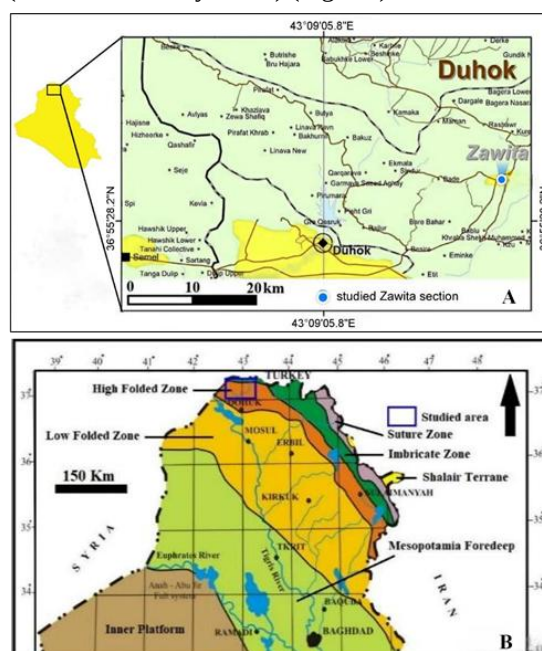


Fig. 1: Location map of the studied section and area. A: Satellite image from Google map© showing the study section in the Bekhair anticline, Northern Iraq. B: Structural map of N Iraq (Jassim and Buday, 2006; modified).

The Fat'ha Formation is part of the AP11 Megasequences, which span the latest Eocene to the Recent and include the middle Miocene sequence (Bellen et al., 1959; Sissakian et al.,

2016; Ameen, 2022). This formation was formerly assigned to the Lower Fars Series (Gill and Ala, 1972), whose equivalent in Iran is the Gachsaran Formation. The Middle Miocene sequence was deposited during a period of marine transgression and significant subsidence within a large, extensive basin that overlapped the margins of an older Oligocene–Early Miocene basin (Fig.2). The AP11 megasequence is associated with the collision of Neo-Tethyan terranes along the northern and eastern margins of the Arabian Plate, as well as with the initiation of rifting in the Gulf of Aden and Red Sea along its southern and western boundaries. The development of these rift systems was accompanied by thermal doming, extensive flood basalt volcanism, and crustal extension. The Gulf of Aden began opening during the Oligocene, followed by the onset of Red Sea rifting in the Early Miocene (Makris and Henke, 1992). The northward and northeastward movement of the Arabian Plate, coupled with the closure of the Neo-Tethys Ocean, resulted in folding and thrusting of the Neo-Tethyan terranes along the plate's northeastern edge (Jassim and Goff, 2006).

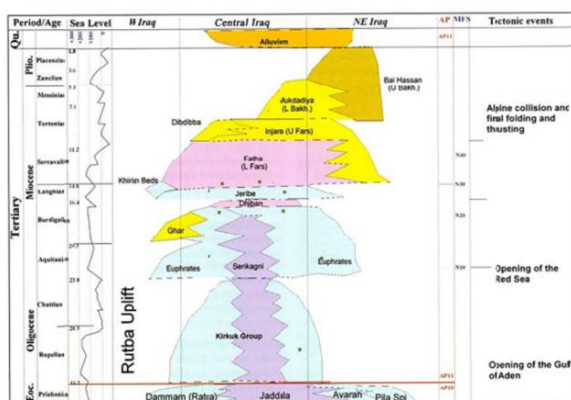


Fig. 2: Stratigraphic chart of AP11 megasequence (Jassim and Goff, 2006).

Stratigraphic Description of the studied Section

The Fat'ha Formation is composed of alternating sequences of green and red claystone and limestone. The base of the Fat'ha Formation overlies a 1.4-meter-thick layer of light brown, hard, well-bedded limestone enriched with iron oxides. This interval corresponds to an unconformity that typically underlies the top of the Pila Spi Formation. The Fat'ha Formation begins with a conglomerate layer, 60 centimeters thick (Fig. 3), followed by a brecciated limestone, 2 meters thick, and fossiliferous siltstone, 90 cm thick. Next, a 1 m-thick green soft marl, followed

by marly limestone, 2m thick, and then 2 m-thick red claystone. These successions are overlain by a yellow soft marl layer, 50 cm thick. Next, a 2 m-thick dark blue soft marl layer, overlain by a 4 m-thick yellow limestone layer. This interval is followed by a hard, light brown marl limestone layer, 5 meters thick, succeeded by a well-bedded, light brown limestone layer, 60 cm thick. Above this, a boudin-bearing soft marl limestone, 1 m thick, is followed by a yellow marlstone, 70 cm thick, and then 2.5m thick red claystone. Then, a 40 cm-thick layer of green siltstone rich in fossils (Gastropods), which is overlain by a 60 cm-thick layer of fossiliferous limestone. Then, a 70 cm-thick interval of gray marly limestone, followed by a 5 m-thick marl interbedded with mudstone. This interval is succeeded by a 1-meter-thick layer of hard brown marl limestone, followed by a 3-meter dark gray marl. The sequence ends with a 1-meter-thick sandstone belonging to the Injana Formation. (Fig. 4). The total thickness of the formation is approximately 22 meters (Fig. 5).

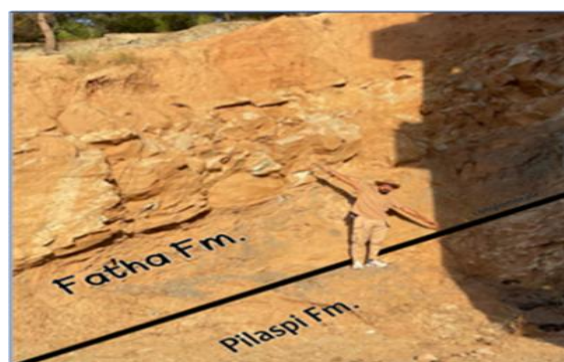


Fig. 3: Field photos show the lower contact between Pila Spi and Fat'ha Formation.



Fig. 4: Field photos show the upper contact between the Fat'ha and Injana formations.

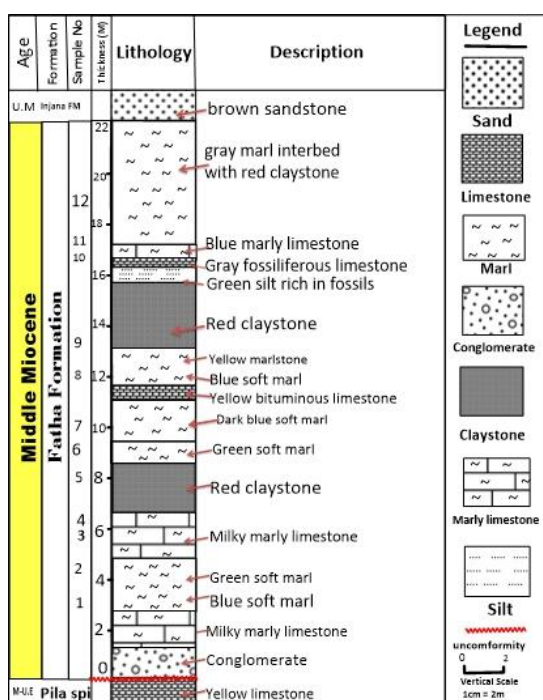


Fig. 5: Stratigraphic column of the Fat'ha Formation in the studied section.

3. Methodology

A total of twelve outcrop samples were collected from the studied section. These samples were processed in the laboratory following the preparation method developed by Barss and Williams (1973), with modifications introduced by Al-Ameiri (1986). The procedure was conducted with careful attention to preserve palynomorph grains for palynological analysis. The preparation process involved treating the samples with hydrochloric acid (HCl) to remove carbonates, followed by hydrofluoric acid (HF) to dissolve silicates. The remaining residues were sieved, thoroughly cleaned, and mounted on slides for microscopic examination. Microscopic observations were performed at a private laboratory in Ankara (Hasan Can laboratory) using an Olympus CX22 microscope, according to standard palynological techniques. The accompanying image illustrates the laboratory setup and the hands-on procedures involved in the sample preparation.

Identification of Spores and Pollen Grains in the Studied Section

Twelve samples from the studied section were analyzed to investigate spores and pollen grains. A total of twelve species were identified, as summarized in Fig. 6. These species were carefully

selected based on their significance and preservation in each sample.

The percentage compositions of pollen and spores are defined as follows:

- **Osmundaceae, Pteridaceae, and dinocyst assemblage (at the base of the formation).**
(Gymnosperm: 10%; Angiosperms:18%; Fern: 25%)
- **Juglandaceae, Fagaceae, and Asteraceae assemblage (in the middle of the formation).**
(Gymnosperm: 8%; Angiosperms:30%; Fern: 18%)
- **Pinaceae, Fabaceae and dinocyst assemblage (at the top of the formation).**
(Gymnosperm: 23%; Angiosperms:22%; Fern: 17%)

Anteturma	Turma	Subturma	Species
VARIGERMINANTES	SACCITES	DISACCITES	<i>Pinuspollenites</i>
			Subgenus <i>Strobis</i> sp.
			<i>Abies</i> sp. 1
			<i>Arecipites pflugii</i>
	PLICATES	MONOCOLPATES	<i>Monocolpopollenites</i> <i>tranquillus</i>
		STEPHANOCOLPITES	<i>Spirosyncolpites bruni</i>
		TRICOLPORATES	<i>Tubulifloridites</i> sp.
		TRIPTYCHES	<i>Quercus</i> sp. 2
POROSES	TRIPORINES	<i>Trivestibulopollenites</i> <i>betuloides</i>	
		<i>Carya</i> sp.	
PROXIMERMINANTES	TRILETES	ACAVATITRILETES	<i>Polypodiaceoisporites</i> <i>?fossulatus</i>
		AZONOTRILETES	<i>Baculatisporites</i>
			<i>Camarozonosporites</i>
			<i>rarus</i>

Fig. 6: The taxonomic classification of the species studied used here according to Burger (1994) and Smith and Buttworth (1967), modified from Traverse (1988).

4. Results

The analyzed samples contained well-preserved pollen grains and spores, making them suitable for a comprehensive appraisal of the palynology of the Fat'ha Formation (Plate 1). A

total of 12 species are identified, belonging to twelve genera within the studied section

A single palynomorph assemblage biozone (F1) is recognized:

***Carya* sp. – *Quercus* sp., Assemblage Biozone (F1).**

This biozone is characterized by the absence of an Oligocene –Miocene sporomorph assemblage including *Engelhardia*, Arecaceae, and *Castanea*, *Castanopsis* (Bozukov et al. 2009; Akkiraz et al., 2012). Additionally, no Early Miocene sporomorph assemblage, including Myricaceae, *Castanea*, *Engelhardia*, Sapotaceae and *Quercus*, is found within this biozone (Akgün et al. 2007).

This biozone is also characterized by the occurrence of middle Miocene age index species, including *Carya* sp., *Fagus* sp., *Quercus* sp. and *Pinus* spp. (Bouchal et al., 2018).

We point out the absence of *Cedrus* spp. in the studied section, which is considered an index species for early middle Miocene (Langhian) age, as noted by Bouchal et al. (2019).

We have noted, in addition, the occurrences of late middle Miocene (Serravallian) sporomorphs in a mixed assemblage including Juglandaceae, *Carya*, *Fagus*, and Asteraceae (Akgün et al., 2007).

Age estimates: Serravallian (Late Middle Miocene) age

Assemblage: Juglandaceae, *Carya*, *Fagus*, Asteraceae, *Quercus* sp. and *Pinus* spp., *Carya* sp.

5. Discussion

We point out, through the analysis of the samples of the studied section, the absence of genera such as *Engelhardia*, Arecaceae and *Castanea*–*Castanopsis* that were documented at the Oligocene –Miocene transition (Bozukov et al. 2009; Akkiraz et al., 2012).

According to Akgün et al. (2007), the Early–Middle Miocene age is characterized by the dominance of Myricaceae, *Castanea*, *Engelhardia*, Sapotaceae and *Quercus*. This assemblage was absent in the studied section except for *Quercus* sp., suggesting that the studied interval is younger than the Early- Middle Miocene age.

The dominant occurrences of *Fagus* sp., the occurrences of *Quercus* sp. and *Pinus* spp. index species indicate an age of Middle Miocene (Bouchal et al. 2019). These occurrences were

observed in the studied section; therefore, our sporomorph assemblage is designated as Middle Miocene age.

According to Javadi and Abassi (2024), the taxa *Inuspollenites* subgenus *Strobilus* and *Pinuspollenites* Subgenus *Pinus* sp. are assigned to the Middle Miocene age, which is in agreement with current biostratigraphic constraints of the studied assemblage.

Yavuz-Işık (2007) suggested that *Quercus* spp. is abundantly recorded within the middle Miocene strata. The aforementioned taxa have indeed been recorded in the studied section.

The mixed occurrences of Juglandaceae, *Carya*, *Fagus*, and Asteraceae in this study point to a late middle Miocene (Serravallian) age. These findings are consistent with palynomorph data from the Turkish realm, as reported by Akgün et al. (2007), who highlighted that the Serravallian is mainly characterized by mixed forest taxa, including Juglandaceae, *Carya*, *Carpinus*, *Pterocarya*, *Alnus*, Asteraceae, and *Fagus*. Furthermore, the absence of *Cedrus* spp. in the studied section supports a Serravallian (Late Middle Miocene) age, as noted by Bouchal et al. (2019). The accepted age for the investigated plant-bearing successions recovered from the Fat'ha Formation studied section is late Middle Miocene (Serravallian), in particular spanning from the top of early Middle Miocene (Langhian) into the late Middle Miocene (Serravallian) age.

6. Conclusion

The palynological content of the Fat'ha Formation, exposed at the Zawita section, near Dohuk City, Northern Iraq, has been studied to constrain its age. The formation yields a diverse palynofloral assemblage, with twelve species identified: three fern species (representing three genera) and nine pollen species (representing nine genera). This study shows that pollen grains are reliable microfossils for age diagnostics of the Middle Miocene (Serravallian), particularly indicating the limited nature of continental environments in comparison to macrofossils. The key findings concern the index genus *Quercus* that occurs in the Middle Miocene. Additionally, we also note the mixed occurrences of a late Middle Miocene (Serravallian) sporomorph assemblage (including Juglandaceae, *Carya*, *Fagus*, and Asteraceae), which closely resembles the early

Middle Miocene palynoflora assemblage previously documented in the Turkish realm. This study confirms, for the first time in Iraq, that the Fat'ha Formation can be dated to the Late Middle Miocene (Serravallian).

7. Acknowledgements

The author would like to express sincere gratitude to the staff of Hassan Jan Private Laboratory (Ankara, Turkey) for their assistance in sample preparation and laboratory analysis. Appreciation is also extended to colleagues and supervisors for their valuable support and scientific guidance.

8. Conflict Of Interest

The author declares no conflict of interest regarding the publication of this paper.

9. Funding Statement

This research received no external funding.

10. Author Contributions

Maha A. Al-Hasson: Conceptualized the study, provided writing guidance, and supervised the project.

Ahmed S. Qulmani: Conceived the study, collected samples, analyzed data, and was responsible for manuscript writing, data visualization (tables and figures), and final editing.

11. References

Abdulla. R., 1994. Sedimentology of Fat'ha Formation from selected well in northern Meshraq area. (In Arabic).

Akgün F, Kayseri MS, Akkiraz M.S., 2007. Palaeoclimatic evolution and vegetational changes during the Late Oligocene–Miocene period in western and central Anatolia (Turkey). *Palaeogeography, Palaeoclimatology, Palaeoecology* 253: pp. 56-90.

Akkiraz.M., Akgün.F., Utescher.T., Wilde.V., 2012. Paleo-flora and Climate of Lignite-bearing Lower–Middle Miocene Sediments in the Seyitömer and Tunçbilek Sub-basins, Kütahya Province, Northwest Turkey (Turkish J. Earth Sci.), Vol. 21, pp. 213–235. DOI: <https://10.3906/yer-1007-45>

Al-Ameri TK, Al-Najar, T.K., Batten, DJ. 2001. Palynostratigraphy and palynofacies indications of depositional environments and source potential for hydrocarbons: the mid-Cretaceous Nahr Umr and lower Maaddud formations, Iraq. *Cretac Res* 22:735–742. (In Arabic).

Al-Hadithi, Z., and Aziz, N. 2019. Paleoeecology and Statistical Study of Ostracoda, Fat'ha Formation (Middle Miocene) from Bazian Anticline, Al-Sulaymaniyah Area, Kurdistan Region, Iraq. *Iraqi National Journal of Earth Science*, 19(2), 119-0. (In Arabic). DOI: <https://10.33899/earth.2019.170284>

Al-Jaberi, M.H., and Salim, L. N., 2022. Depositional Properties of the Middle Miocene Fat'ha Formation in K Oilfield, Southern Iraq. *The Iraqi Geological Journal*, 139-152. (In Arabic). DOI: 10.46717/igj.55.2B.12Ms-2022-08-28. DOI: <https://10.46717/igj.55.2B.12Ms-2022-08-28>

Al-Juboury, A.I., and McCann, T., 2008. The Middle Miocene Fat'ha (Lower Fars) Formation, Iraq. *GeoArabia*, 13(3), 141-174. DOI: <https://10.2113/geoarabia1303141>

Al-Sawaf, F.D.S. 1977. Sulfate reduction and sulfur deposition in the Lower Fars Formation, Northern Iraq. *Economic Geology*, Vol. 72, pp. 608-618.

Al-Shareefi, I., Al-Badrani, O. and Kharofa, L., 2022. Nannobiostratigraphy and Ostracoda Paleoeecology of Fat'ha Formation, Bashiqa Anticline, Northeastern Iraq. *Iraqi Journal of Science*, Vol. 63, No.4, p. 1574 – 1590. DOI: <https://10.24996/ijs.2022.63.4.18>

Al-Taiyy A., Al-Badrani O., 2025. Lithofacies and Age Determination Study of Fatha Formation in Mushak, Salah Al-Din Government, Northern Iraq. *Iraqi National Journal of Earth Science*. DOI: <https://10.33899/earth.2024.147524.1242>

Ameen, F. A., 2022. Sequence stratigraphy of the Oligocene and Miocene successions from selected wells in Garmian district, Kurdistan region/Iraq. In *Recent Research on Geomorphology, Sedimentology, Marine Geosciences and Geochemistry: Proceedings of the 2nd Springer Conference of the Arabian Journal of Geosciences (CAJG-2), Tunisia 2019*, pp. 209-212. Springer International Publishing.

Aqrabi, A. A. M., 1993. Miocene evaporitic sequence of the southern Mesopotamian Basin. *Marine and Petroleum Geology*, 10(2), pp. 172-179.

Aziz, N., and Kasim, Z., 2023. Some New Ostracod Species of Genera *Schneiderella*, *Sulcostocythere*, and *Neomonoceratina*, from the Fat'ha Formation (Middle Miocene) in the Takia Area, Darbandi Bazian Anticline, Sulaimaniyah Area, Kurdistan Region, Northeastern of Iraq. *Iraqi Bulletin of Geology and Mining*, 19(1), pp. 49-59. <https://doi.org/10.59150/ibgm1901a04>

Bahroudi, A., and Koyi, H. A. 2004. Tectono-sedimentary framework of the Gachsaran Formation in the Zagros foreland basin. *Marine and Petroleum Geology*, 21(10), pp. 1295-1310.

Barss, M. S. and Williams, G. L., 1973. Palynology and nano-fossil processing techniques. *Geological Survey of Canada Paper*, 25 P.

Bellen, R.C., Van Dunnington, H.V., Wetzel, R., Morton, D.M. 1959. *Lexique Stratigraphique International*. Asie, Iraq, 3c (10a), 333 P.

Bouchal, J.M., 2019. The middle Miocene palynofloras of the Salihpaşalar lignite mine (Yatağan Basin,

- southwest Anatolia): environmental characterization and comparison with palynofloras from adjacent basins. *Palaeobiodiversity and Palaeoenvironments*, 99: 591-636. DOI: <https://doi.org/10.1007/s12549-018-0345-0>
- Bouchal, J.M., Zetter, R., Denk, T. 2016. Pollen and spores of the uppermost Eocene Florissant Formation, Colorado: a combined light and scanning electron microscopy study. *Grana*, 55(3): 1-67. <https://doi.org/10.1080/00173134.2015.1108362>
- Boucot, A. J., 1999. Southern African Phanerozoic marine invertebrates: Biogeography, paleoecology, climatology and comments on adjacent regions. *Journal of African Earth Sciences*, 28(1), pp. 129-143.
- Bozukov, V., Utescher, T., and Ivanov, D., 2009. Late Eocene to early Miocene climate and vegetation of Bulgaria. *Review of Palaeobotany and Palynology*, 153(3-4), 360-374. DOI: <https://doi.org/10.1016/j.revpalbo.2008.10.05>
- Burger, D., 1994. Guide to genera file of fossil spores and pollen of Jansonius and Hills (1976). Australian Geological Survey Organisation record 1994/46. 36 p.
- Busk, H.G. and MAYO, H.T., 1918. Some notes on the geology of the Persian oil fields: *Journal Institute Petroleum Technology*, v. 5, p. 5-26.
- Ditmar, V., 1971. Geological conditions and hydrocarbon prospects of the Republic of Iraq (Northern and Central parts), North Oil Company, Iraq.
- Germeraad, J.H. et al. 1968. Palynology of Tertiary sediments from tropical areas. *Review of Palaeobotany and Palynology* Vol. 6 # 3 P. pp. 189- 348
- Gill, W. D., and Ala, M.A., 1972. Sedimentology of Gachsaran Formation (Lower Fars Series), southwest Iran. *AAPG Bulletin*, 56(10): pp. 1965-1974.
- Goff, J.C., R.W. Jones and A.D. Horbury 1995. Cenozoic basin evolution of the northern part of the Arabian. Plate and its control on hydrocarbon habitat. In M.I. Al-Husseini (Ed.), *Middle East Petroleum Geosciences Conference, GEO'94*. Gulf PetroLink, Bahrain, Vol. 1, pp. 402-412.
- Habibi, T., and Ruban, D. A., 2017. Outstanding diversity of heritage features in large geological bodies: The Gachsaran Formation in southwest Iran. *Journal of African Earth Sciences*, 133, 1-6. DOI: <https://doi.org/10.1016/j.jafrearsci.2017.05.010>
- Jaramillo, C.A., and Dilcher, D. L., 2001. Middle Paleogene palynology of Central Colombia, South America: A study of pollen and spores from tropical latitudes, *Palaeontographica Abteilung B* 258 4-6, 87-213
- Jaramillo, C., 2010. The late Miocene paleogeography of the Amazon Basin and the evolution of the Amazon River system. *Earth Sci. Rev.* 99 (3-4), 99-124. DOI: [10.1016/j.earscirev.2010.02.005](https://doi.org/10.1016/j.earscirev.2010.02.005)
- Jassim, S. Z., Jibril, A. S., and Numan, N. M., 1997. Gypsum karstification in the middle Miocene Fat'ha Formation, Mosul area, northern Iraq. *Geomorphology*, 18(2), 137-149.
- Jassim, S.Z. and Goff, J.C., 2006. *Geology of Iraq*. Dolin, Prague and Moravian Museum, Czech Republic, 395 p.
- Jassim, S. Z., Karim, S. A., Basi, M. Al-Mubark, M.A., and Munir, J., 1984. Final report on the regional geological survey of Iraq. Vol. 3. Stratigraphy. Internal report. Geological Survey of Iraq.
- Jassim, S.Z. and Buday, T., 2006. Latest Eocene-Recent Megasequence AP11. In S.Z. Jassim and J.C. Goff (Eds.), *Geology of Iraq*. Chapter 14, p. 169-184. Dolin and Moravian Museum, Czech Republic.
- Javadi, F. and Abbassi, N., 2024. Miocene miospores in the Upper Red Formation, Zanzan, northwestern Iran. *Geopersia*, 14(1): pp. 199-212. DOI: <https://doi.org/10.22059/GEOPE.2024.365656.648730>
- Kashfi, M. S., 1980. Stratigraphy and environmental sedimentology of Lower Fars Group (Miocene), south-southwest Iran. *AAPG Bulletin*, 64(12), pp. 2095-2107.
- Khalaf, S.K., Kharofa, L.H., 2020. Paleontological study of Ostracoda in the Fat'ha Formation (Middle Miocene) Hammam Al-Alil area, northern Iraq. *Iraqi Bulletin of Geology and Mining*. (In Arabic)
- Kharajany, S. O. A. 2023. Calcareous-nannofossil biostratigraphy of the Miocene Fat'ha Formation at the Miryas section, Qaradagh Mountain Series, Sulaimaniyah, Kurdistan Region, Iraq. *Australian Journal of Earth Sciences*, 70(8), 1172-1183. DOI: <https://doi.org/10.1080/08120099.2023.2232436>
- Kharruffa, L.H., 2008. Systematic Study and Stratigraphical Distribution of Ostracoda in Fat'ha Formation (Middle Miocene) from selected locations; Northern Iraq, College of Science, University of Mosul. (In Arabic)
- Mahdi, A. H. I., 1983. Stratigraphical and palaeoenvironmental studies in the Lower Fars Formation (Miocene) of northern Iraq. University of London, Bedford College (United Kingdom).
- Makris, J., and Henke, C., 1992. Crustal structure of the Arabian Peninsula derived from seismic refraction data.
- Muller, J., 1981. Fossil pollen records of extant angiosperms. *Botan. Rev.* 47 (1), 1-142. Nesbitt, H.W., Young, G.M., 1982. Early Proterozoic climates and plate motions inferred from major element chemistry of lutites. *Nature* 299 (5885), 715-717.
- Mohammed and Al-Shareef, 2021. Some records Ostracod species of genus *Paichenborchellina* from the Middle Miocene Fat'ha Formation, Eastern Butmah Anticline, Northwestern Mosul City, Iraq. *Iraqi National Journal of Earth Science*. (In Arabic) DOI: <https://doi.org/10.33899/earth.2021.170377>
- Pflug H. 1953. Zur Entstehung und Entwicklung des Angiospermenpollens in der Erdgeschichte. *Palaeontographica B* 96: 60-171.
- Powers, R.W., Ramírez, L.F., Redmond, C.D., and Elberg, E.L. Jr. 1967. *Geology of the Arabian Peninsula: Sedimentary Geology of Saudi Arabia*. U.S. Geological Survey Professional Paper 560-D, 147 P.

Rodríguez-Forero, G., F.E. Oboh-Ikuenobe, C. Jaramillo-Muñoz, M.J. Rueda-Serrano, And E. Cadena-Rueda. 2012. Palynology of the Eocene Esmeraldas Formation, Middle Magdalena Valley Basin, Colombia. *Palynology* 36: 96–111. DOI: <https://10.1080/01916122.2012.650548>

Sakhavati, B., Yousefirad, M., Majidifard, M. R., Solgi, A., and Maleki, Z., 2020. Age of the Gachsaran Formation and equivalent formations in the Middle East based on foraminifera. *Micropaleontology*, 66(5), 441-465. DOI: <https://10.47894/mpal.66.5.06>

Seyrafian, A., and Mojikhalifeh, A., 2005. Biostratigraphy of the late Paleogene- early Neogene succession, north-central border of Persian Gulf, Iran. *Carbonates and Evaporites*, 20(1), pp. 91-97.

Shareef, N. F., Mahdi, M. M., and Mohamed, A. H., 2023. Combined Ostracoda and Foraminiferal Biozonation with Environment of Fat'ha Formation (Middle Miocene) in Different Oilfields, Southern Iraq. *The Iraqi Geological Journal*, 188-211. DOI: 10.46717/igj.56.1D.15ms-2023-4-24

Sissakian, V. K., Karim, S. A., Al-Kubaisyi, K. N., Al-Ansari, N., and Knutsson, S., 2016. The Miocene sequence in Iraq: a review and discussion on the stratigraphy, paleogeography and economic potential. *Journal of Earth Sciences and Geotechnical Engineering*, 6(3), 271-317.

Smith, V. H. and Butterworth, M.A., 1967. Miospores in the Coal seams of the Carboniferous of Great Britain. *Spec. Pap. Palaeont.1*, *Palaeont. Assoc.*, London, P. 1-324.

Tavakolian, I., Yassaghi, A., and Najafi, M., 2022. Structural style in the south Dezful Embayment, SW Iran: Combined influence of the Zagros frontal fault system and the detachment in the Miocene Gachsaran Formation. *Journal of Petroleum Geology*, 45(3), pp. 303-323. DOI: <https://10.1111/jpg.12821>

Traverse, A., 1988: *Paleopalynology*. Unwin, London. 600 P.

Traverse, A., 2007. *Paleopalynology* (Vol. 28). Springer Science and Business Media.

Tucker, M. E., 1999. Sabkha cycles, stacking patterns and controls: Gachsaran (Lower Fars/Fatha) Formation, Miocene, Mesopotamian Basin, Iraq. *Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen.*, 214(1).

Tucker, M. E., and Shawket, M. G., 1980. The Miocene Gachsaran formation (formerly lower Fars) of the Mesopotamian basin, Iraq: Sabkha cycles and depositional controls.

Weber, F., 1963. *Geologie des Irak: Beiträge zur regionalen Geologie der Erde*. Borntraeger, Berlin, p. 327

Yavuz-Işik, N. 2007. Pollen analysis of coal-bearing Miocene sedimentary rocks from the Seyitömer Basin (Kütahya), Western Anatolia. *Geobios* 40, 701–708. DOI: <https://10.1016/j.geobios.2006.11.006>

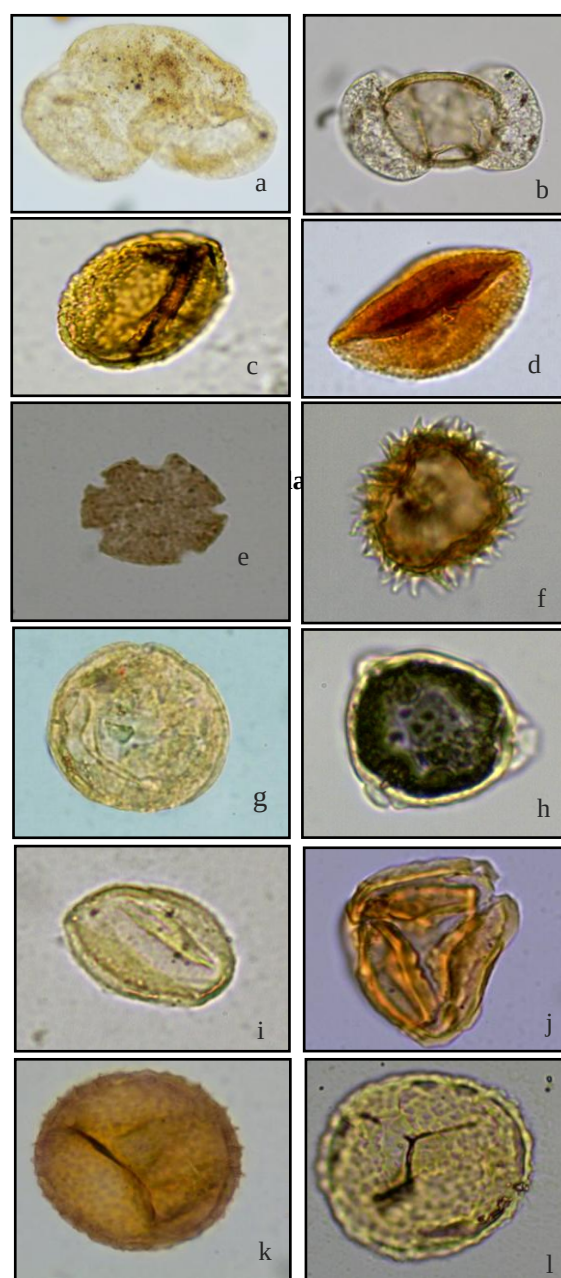


Plate 1: a. *Pinuspollenites* Subgenus *Strobilus* sp. (118 µm), b. *Abies* sp.1 (125 µm), c. *Arecipites pflugii* (28 µm), d. *Monocolpopollenites tranquillus* (30 µm), e. *Spirosyncolpites bruni* (29 µm), f. *Tubulifloridites* sp. (50 µm), g. *Quercus* sp. (28 µm), h. *Trivestibulopollenites betuloides* (32 µm), i. *Carya* sp. (27 µm) j. *Polypodiaceoisporites?* *fossulatus* (45 µm), k. *Baculatisporites primarius* (42µm), l. *Camarozonosporites* (*Hamulatisporis*) *rarus* (50µm).



المايوسين الأوسط المتأخر (سيرفاليان) لتكوين الفتحة، شمالي العراق: الأدلة

الباليونوفلورية

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تاريخ الاستلام: 23 شباط 2025 تاريخ المراجعة: 29 نيسان 2025 تاريخ القبول: 07 تموز 2025

تاريخ النشر الإلكتروني: 01 تشرين الأول 2026

الملخص

تُعَدُّ هذه الدراسة أول تحقيق بالينولوجي يُجرى على تكوين الفتحة من عصر الميوسين الأوسط في شمال العراق. تم جمع اثنتي عشرة عينة من مقطع سطحي لتكوين الفتحة في منطقة زاويتا، شمال العراق. وقد أظهرت هذه العينات تجمعات بالينومورفية محفوظة بشكل جيد ومتنوعة، إذ تم تحديد ودراسة ثلاث أنواع من الأبواغ تعود إلى ثلاثة أجناس وتسعة أنواع من حيوب اللقاح تعود إلى تسعة أجناس، وهي كما يلي:

Spirosyncolpites bruni, *Pinuspollenites* Subgenus *Strobus* sp., *Abies* sp.1, *Arecipites pflugii*, *Monocolpopollenites tranquillus*, *Tubulifloridites* sp., *Quercus* sp.2, *Trivestibulopollenites betuloides*, *Carya* sp., *Polypodiaceoisporites fossulatus*, *Baculatisporites primarius*, *Camazonosporites rarus*.

بينت تحاليل تجمعات الأنواع الباليونومورفية المستخلصة من تكوين الفتحة في مقطع زاويتا عدم تواجد فاختلافات كبيرة في محتواها، مما يشير إلى أنها تمثل تجمعا بالينومورفيا لنطاق حيوي واحد. وقد تمت مضاهاة هذا النطاق مع ما يُعادل في تركيا وإيران المجاورتين، وكذلك مع مقاطع أخرى حول العالم. وتؤكد التوزيعات الطباقية للأنواع المحددة، ولأول مرة، أن تكوين الفتحة يعود إلى أواخر الميوسين الأوسط (سيرفاليان).

الكلمات المفتاحية:

عمر سيرفاليان، تكوين الفتحة، بالينومورفات.

DOI: [10.33899/injes.v26i4.60927](https://doi.org/10.33899/injes.v26i4.60927), ©Authors, 2026, College of Science, University of Mosul.

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