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Microfacies and Paleoenvironment Conditions of Kometan Formation in Dokan area, Northeast of Iraq

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Abstract

The well-bedded and white chalky to white grey limestone of the Kometan Formation is Late Turonian – Santonin in age. The rock samples were taken from Qalat area in the Sulaymaniyah governorate in northern Iraq and studied under many different microscopes.

The main aims of the paper are to study the microfacies of the Kometan Formation and interpretation of the paleodepositional environment based on the detailed examination of thin sections prepared from samples selected from the Kometan Formation.

Muddy, marly, and brecciated limestone are the lithology of the Kometan Formation determined by petrographic studies based on the characteristics of grain and matrix types. The microfacies analysis of the samples from the Kometan Formation revealed three main microfacies and two submicrofacies. The first one is foraminiferal lime mudstone, these microfacies existed in the first part of the formation after the Shiranish Formation characterized by a significant amount of micrite with few amount of fossil content. The second one is wackestone microfacies, with two submicrofacies including Oligosteginal wackestone submicrofacies and *Globotruncana* wackestone submicrofacies. These microfacies are characterized by a considerable number of

skeletal grains and the groundmass consists of micritic materials. The microfacies are located in the center of the formation and contain the major stylolite with a high ratio of chert nodules. The third main microfacies is planktonic foraminiferal packstone microfacies, these microfacies are characterized by a high ratio of skeletal grain and a minor amount of micrite which form the groundmass of the facies. This microfacies is exposed at the adjacent zone to the major fault between Kometan and Qamchuqa formations. The paleoenvironment of the Kometan Formation is a deep-shelf marine environment passed to the continental slope environment based on the grain type characteristics and depositional textures identified in the present study.

Keywords: Kometan Formation, well-bedded limestone, deep shelf, microfacies, chert nodules.

Introduction

Kometan Formation was defined for the first time by [1] in northeast Iraq from Kometan village near the Endezah area. The lithology of the formation is well-bedded and white chalky to light grey limestone. The fossil contents are *Oligostegina; Gümbelina* spp.; *Globigerina cretacea;* rare Radiolaria; sponge spicules.

Many studies have been conducted on the Kometan Formation, which defined it as a well-bedded deep marine, and fine-grained limestone. Stylolite nets and chert nodules are distributed near bedding surfaces. Nannofossils and planktonic forms are the recorded fossils in the formation with rare benthic forams [2]. Knowledge of geological events and tectonic movements that occurred on the rock of formation in the Late Cretaceous (Late Turonian - Early Campanian sequence) is the one of requirements in this study. The study area is situated in the northeast of Iraq, Sulaymaniyah governorate, Dokan area near the Qalat village. The study area is located in the Unstable Shelf Unit, near the Kosrat anticline in the High Folded Zone according to the tectonic subdivision of Iraq [3] and [4]. The coordination of the study section is Latitude (35˚, 58′, 34″ N) and longitude (44˚, 53′, 83″ E) as shown in (Fig.1). Tectonically, during the Early Cretaceous, the area of the study is located in the NE margin of the Arabian Platform which became later as a foreland basin (Fig. 2) during the Late Cretaceous [5].

Subsurface data indicated that the Kometan Formation was divided into three stratified units in N of Iraq [6]. He suggested that the Kometan Formation is represented by the lower unit of the

formation. Tanuma Formation may be represented by the shaly succession in the middle unit of Kometan. The upper unit of the Kometan Formation represented a new rock unit. The paleodepositional environment of the three stratified units of the Kometan Formation indicated the upper slope shifting to the outer shelf environment. The lower unit belongs to Late Turonian due to the presence of *Marginotruncana sigali.* The shaley succession part in the middle unit of the formation was deposited during Coniacian due to the presence of *Dicarinella primitiva.* The upper unit of the Kometan Formation represented the Santonian age due to the presence of *Dicarinella asymetrica.*

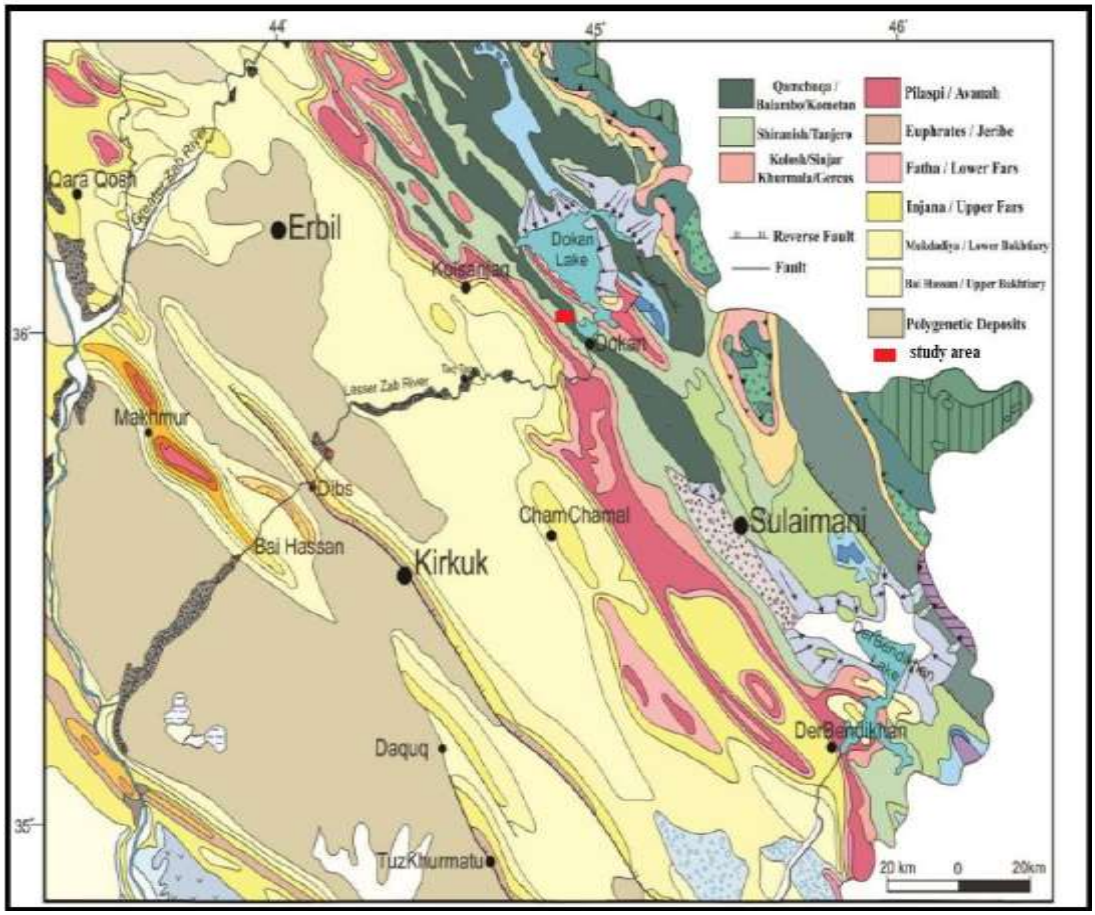

Figure 1: Location and geological map of the study area, modified after [17].

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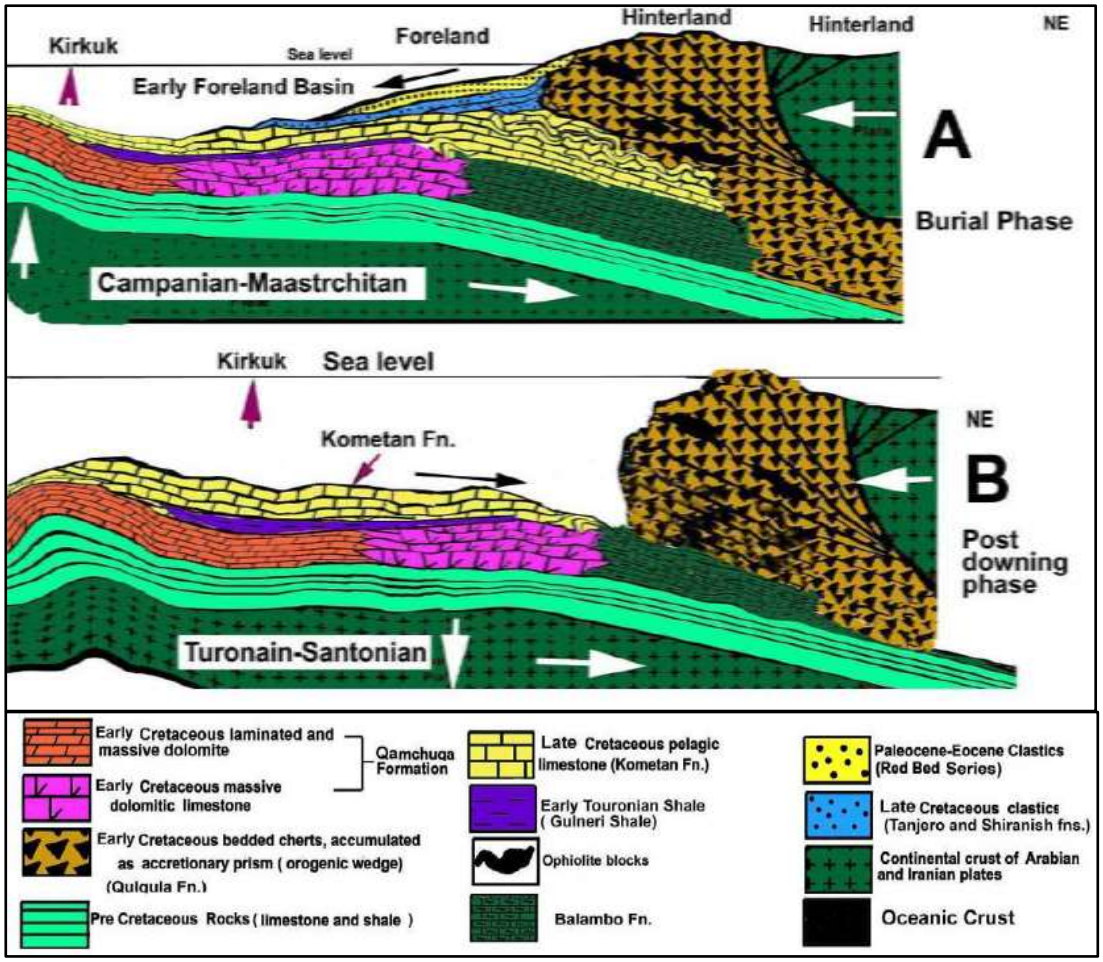

Figure 2: Tectonic events & history of deposits during Late Cretaceous deposits of NE margins of Arabian Pate after [5].

The paleoecology of the Kometan Formation in Qarachuq-1, Kirkuk-116, Najmah-29, and Demerdaq-1 boreholes in northern Iraq was studied by [7], which divided the formation into four biostratigraphic zones based on the genus *Globotruncana.* The project indicated that the Kometan Formation was deposited under a subequatorial climate, with water depth varying between (50-1500m) and temperature of surface water (25-32°c) and normal seawater salinity of (34-37%). Kometan Formation paleodepositional environments in the Zewa and Azmer, NE Iraq is deep marine, which was studied by [8] cited in [6]. The study stated that the existence of

Dicarinella primitiva (DALBIEZ) and *Dicarinella concavata* (BROTZEN) range zone and *Globotruncana elevata* (BROTZEN) range zone confirm the Coniacian-Campanian age to the Kometan Formation. The main goal of this paper is to study the microfacies present in the Kometan Formation based on the microscopic examination of thin sections prepared from the samples selected from the formation in the northeast of Iraq and determine the paleodepositional environment of the formation.

Material and Methods

In this study, the Kometan Formation has been investigated from Qalat section about 25 km northern of Dokan City located in Sulaymaniya province, NE of Iraq.

To perform this work, forty thin sections were prepared using different equipment. This equipment includes a rock cutter, automatic smoothing, and three methods of manual softening. In addition, glass slides and finally the two types of epoxy material are used at 3:1 time. On the first hand, thin sections were studied under binocular (Leica DM 500) and Optika microscopes. The classification of carbonate rocks by [9] has been used and the recognition of microfacies is based on depositional textures and grain types.

Paleoenvironmental interpretations often depend on detailed microfacies studies. To classify carbonate rocks, it is necessary to identify the types of particular grains, the frequency of their occurrence, and the depositional textures. The most important two microfacies models used in this study are those proposed by [10] and [11]. [10] proposed a conceptual model and identified nine Standard Facies Zones (FZ) that explained the facies belt along an abstract transect from an open deep marine basin, across the slope, through a platform marginal rim (including reef and sand shoals), and an inner platform, up to the coast. The rimmed carbonate platform model by [10] was revised and modified by [11]. In addition, [11] designated a conceptual model for the unrimed ramp carbonate platform and proposed 30 ramp microfacies (RMF), as well as 26 standard microfacies (SMF) for the rimmed carbonate shelves. This paper examines the types of sedimentation processes and types of sediments in the thin sections. On the first hand, this study explains microfacies types and paleoenvironment conditions in the Kometan Formation.

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Results

1. Microfacies analysis

Principally, microfacies are divided into two types which are carbonate and non-carbonate (Clastic or lithofacies) microfacies. There are three elements of microfacies characters which are; particles, pores, and the groundmass (Fig. 4). The particles include skeletal and non-skeletal frains, pores include fabric and non-fabric selective, and the groundmass includes micrite and sparite. Major skeletal grains represented by planktonic foraminifera were recognized after a detailed examination of thin sections and used in the description and identification of the petrography of carbonate rocks and the paleoenvironment interpretation of the studied Kometan Formation. The microfacies have been identified in the studied succession based on their petrographic characteristics (such as the relative abundance of major skeletal components, ratio of the matrix, and rock texture). They contain different skeletal and non-skeletal contents and reflect different environmental conditions in which they were deposited. In the studied section, three main microfacies types were recognized in the Kometan Formation according to [9] classification. These microfacies is divided into several submicrofacies based on the type of fossil, type of grains, and type of mud (matrix) that form the groundmass of the microfacies.

Forminiferal Lime Mudstone Microfacies

This microfacies is characterized by a significant amount of micrite with rare fossil content, commonly less than 10% in the micritic matrix. This microfacies is less common in the studied section of the Kometan Formation. The microfacies are affected by the neomorphism process of micrite to microsparite which is recognized in these facies. It is characterized by the rare presence of skeletal grains which are less than 10% according to the classification of carbonate rocks [9] except for a few planktonic forams and bioclasts. The planktonic foraminifera are the major skeletal grains present in the formation (Pl. 1). The skeletal grains are subjected to diagenetic effects. The micritic matrix forms the groundmass of the microfacies. According to the standard facies zones model [10] and model [11], these microfacies correspond to the standard microfacies (SMF3) deposited in the facies zone FZ3 (Toe of slope).

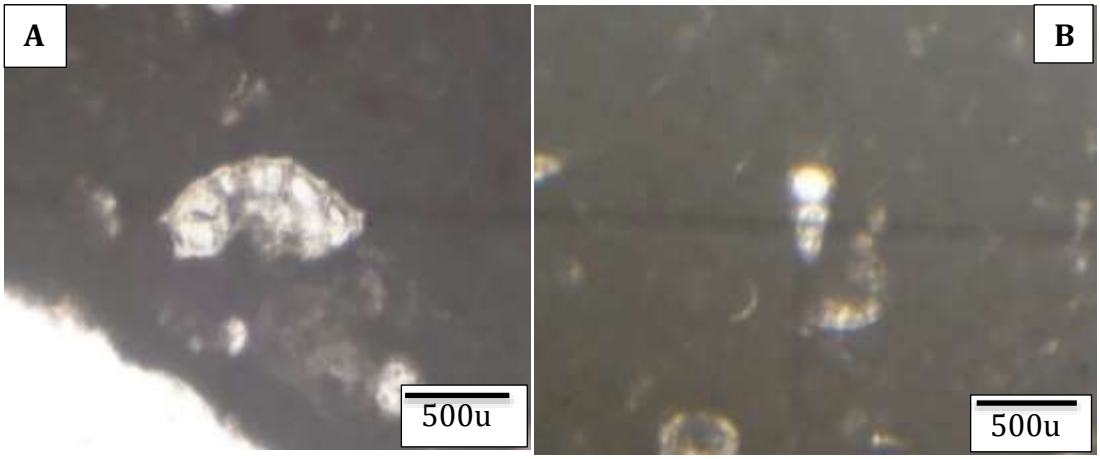

Plate 1: Foraminiferal Lime mudstone microfacies: (A) This facies is characterized by the dominance of micrites and few amount of fossils represented by planktonic foraminifera (A)- *Marginotruncana* and (B)- *Heterohelix.*

Wackestone Microfacies.

This is the major microfacies of the Kometan Formation in the studied section. It is recognized in many parts of the formation. The skeletal grains range between 10-40% with a micritic matrix form the groundmass. These microfacies in the Kometan Formation undergo different processes of diagenesis, such as micritization, compaction, neomorphism, and pyritization. Wackestone microfacies is divided into two submicrofacies.

- Oligosteginal Wackestone Submicrofacies.

The oligosteginal microfacies are widely distributed in the middle part of the studied section. The microfacies contains various proportions of skeletal grains and is characterized by a high content of *Oligostegina* with a percentage of more than 40% of the rock constituents with less presence of other unidentified grains because of the effect of the neomorphism process. Neomorphism and compaction are the diagenetic processes that affect these microfacies (Pl. 2). The tests are generally well-preserved. The matrix that forms the groundmass in this microfacies consists of micrite. The shell fragments of the fossils are varied in size, and the majority have a small size. According to the standard facies zones model [10] and model [11], these microfacies correspond to the standard microfacies (SMF10) deposited in the facies zone FZ2 (Deep shelf).

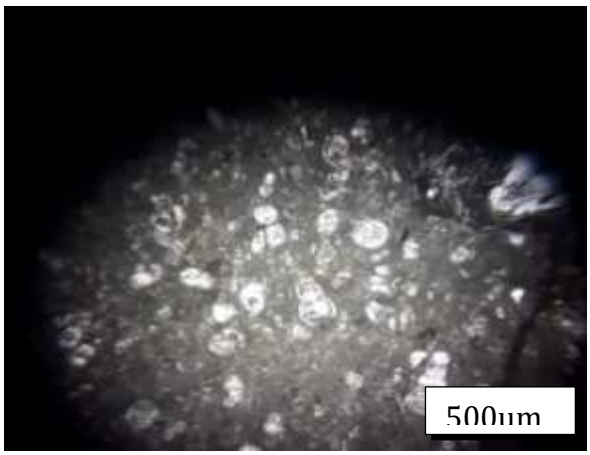

Plate 2: Oligosteginal Wackestone Submicrofacies: this microfacies is contains Oligostegana which is the main component of the facies. Micritic material forms the groundmass of the facies.

- Globotruncana Wackestone Submicrofacies.

The microfacies are characterized by the presence of *Globotruncana* in the micritic matrix in the upper part of the studied section. The dominant skeletal grains are planktonic foraminifera (*Globotruncana*) accompanied by other bioclasts. The skeletal grains are moderately preserved and affected by the diagenetic processes. The skeletal grains formed about 50% of the rock constituents. The micrite forms the groundmass of the microfacies. Neomorphism is the main diagenetic process that affects microfacies (Pl. 3). The characteristics of the wackestone microfacies have been compared with the standard microfacies of [10] and [11] models. It shows similarities and is compatible with standard microfacies SMF3, which is deposited in facies zone FZ3 (Toe of slope).

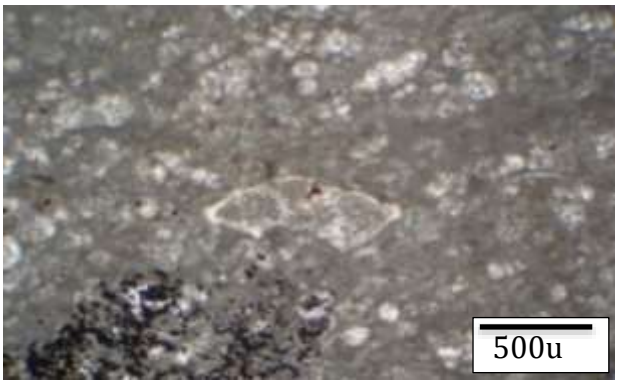

Plate 3: Globotruncana Wackestone Submicrofacies: This microfacies contains Globotruncana as the dominant skeletal grain accompanied by bioclasts. Micrite forms the groundmass of this facies.

- **Planktonic Foraminiferal Packstone Microfacies.**

In the studied section of the Kometan Formation, packstone microfacies is less distributed compared with the wackestone microfacies. It is characterized by high content of the skeletal grains which form about 60% of the rock constituents. A minor amount of micritic material exists in between the skeletal grain of the facies.

The planktonic foraminifera has an abundant amount in this microfacies (more than 60% of the grains) (Pl. 4). Some other bioclasts are associated with these planktonic foraminifera assemblages. The matrix present in this microfacies is less than 10% of the rock volume and consists of micrite. The shell fragments of the fossils are varied in size, and the majority are foraminifera, while other bioclasts occur in relatively low frequency. The presence of some minerals like pyrite with hydrocarbon criteria. The pyrite sometimes filled the skeletal grains. Kometan Formation is characterized by the presence of these submicrofacies, which is characteristic of a few meters far away towards the Shiranish Formation. The characteristics of the wackestone microfacies have been compared with the standard microfacies of [10] and [11] models. It shows similarities and is compatible with standard microfacies (SMF5) which is deposited in facies zone FZ4 (Slope).

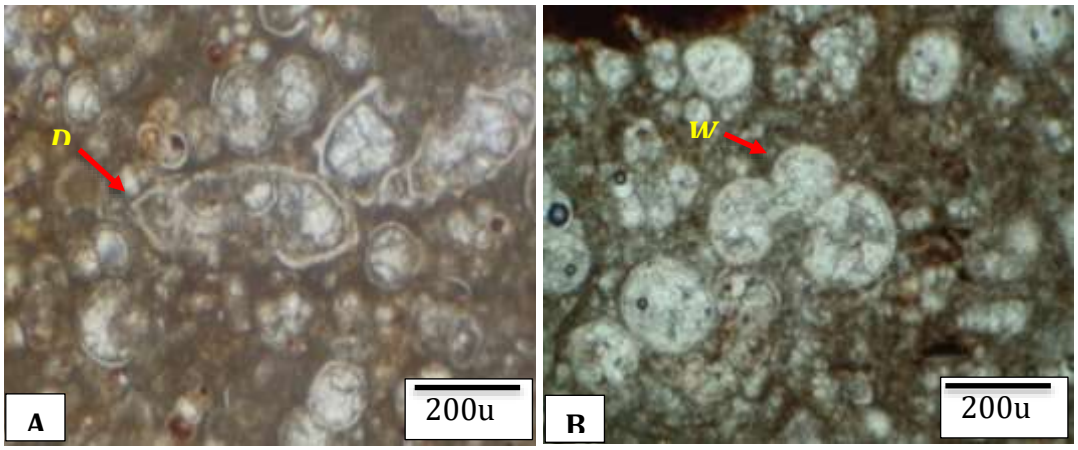

Plate 4: Planktonic foraminiferal packstone Microfacies: It is characterized by the dominance of planktonic skeletal grains and the micritic material in between the grains. The hydrocarbon trace is present in the facies. A-Dicarinella. B-Whiteinella.

2. Depositional paleoenvironment

The sedimentary environment is a geomorphic unit, in which the deposition takes place. The depositional system is affected by various conditions, such as sea-level fluctuations, water depths, salinity, temperature, water currents, light penetration, and water turbidity [12]. Common types of microfacies may indicate the environmental conditions controlling the depositional patterns and the organism's distribution.

According to Sharland et al 2001 [13], the Kometan Formation deposited at the lower part of Arabian Plate tectonostratigraphic megasequence AP9 (L. Cretaceous-E. Paleocene (92-63 Ma)). The deposition of the Kometan Formation followed the onset of the first obduction of ophiolite onto the NE margin of the Arabian Plate resulting in the fault activation and uplift of the Arabian Plate NE margin [13] (Sharland et al, 2001). Zagros Foreland basin forms as a result of crust loading by the thrust sheets created by compression [4] (Jassim and Goff, 2006). Kometan Formation was deposited in the Zagros foreland basin during the last stage of subduction of Neo-Tethys [14] (Lawa, 2018).

Detailed studies of grain-type characteristics and depositional texture allowed us to determine and diagnose the microfacies of the Kometan Formation. The identified microfacies have been compared with the standard facies zones model of [10], and with the modified standard microfacies models of [11]. The diagnosis of the microfacies of the studied formation, accompanied by studies of grain-type characteristics and depositional textures allowed us to determine the depositional environments. The distribution of the distinguished environments shows that the studied Kometan Formation was deposited in an open marine, deep environment. Microscopic examination of thin sections showed different types of facies and clear similarities in lithological and biological composition within the studied formations. This may indicate that both the facies and the environment in this section are homogeneous. According to the terminology of [9], in the rocks of the Komitan Formation in the studied area, four microfacies were identified ranging between mudstone, wackestone, and packstone. All of these microfacies are characterized by the presence of a fine micritic matrix, indicating a stagnant seafloor that is calm enough to allow the accumulation of lime mud.

According to [10] and [11] concepts of standard microfacies (SMF) and facies zone (FZ), the classified microfacies of Kometan Formation belong to standard microfacies SMF-10 that were deposited in the facies zones FZ-2 (Deep shelf), and standard microfacies SMF3 deposited in the facies zones FZ3 (Toe of slope). Pelagic-bearing microfacies found in the Kometan Formation indicate open marine and deep environments.

The prevalence of planktonic foraminifera, Oligostegina, and bioclasts in the examined samples indicate the environmental conditions of the deeper shelf with normal salinity and average temperature of 20°C. Planktonic foraminifera is more commonly found than benthonic foraminifera, suggesting a deep marine depositional environment in calm areas between the deep shelf and the continental slope [15] and [16].

Other evidence that supports the deposition of the Kometan Formation in deep, calm, and low-energy environments in the studied area includes the sandy to silty size of skeletal grains, the lack of detrital quartz, the existence of pyrite, the inclusion of all microfacies elements in a fine micritic groundmass, and the high-energy setting characteristics like oolite and coarse lithoclasts are not present in the formation.

Conclusion

The detailed examination of the microfacies of the Kometan Formation in the Dokan area, northeast of Iraq revealed that three principal microfacies and two submicrofacies are present in the formation. The first one foraminiferal lime mudstone microfacies dominated by micrite with less skeletal grain, second one is wackestone microfacies subdivided to two submicrofacies which are; Oligosteginal wackestone submicrofacies and *Globotruncana* wackestone submicrofacies, and the third one is planktonic foraminifera packstone microfacies.

Based on the present microfacies, the dominance of skeletal grains, and the texture of microfacies, the formation is deposited in a slope to deep shelf environment characterized by calm and low energy supported by the presence of pyrite, small skeletal grains embedded in micritic groundmass, and absence of high energy features like oolites and coarse lithoclasts.

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Conflict of interest: The authors declare that there is no conflict of interest.

Ethical clearance: Ethical approval was not required for this study.

References

[1] R. C. Bellen, H. V. Dunnington, R. Wetzel, and D. M. Morton, Lexique stratigraphique international Asia, fascicule, 10a, Iraq, (Center National de la Recherché Scientifique, Paris 333, 1959)

[2] H. K. Karim, S. T. Al-barzınjy, and A. K. Polla, Geology and critical review of the Upper Cretaceous zagros chalky limestone (kometan Formation) from Sulaimani governorate, Northeastern Iraq, Bulletin of the Mineral Research and Exploration, 157(157), 59-74(2018), DOI(http://dx.doi.org/10.19111/bulletinofmre.428342)

[3] T. Buday, and S.Z. Jassim, the Regional Geology of Iraq: Vol. 2, Tectonism, Magmatism, and Metamorphism. I.I. Kassab, and M. J. Abbas, (Eds.), (GEOSURV, Baghdad, 1987)

[4] S. Z. Jassim, and C. Jeremy, Goff, eds., (Geology of Iraq, DOLIN, sro, distributed by Geological Society of London, 2006)

[5] H. K. Kamal, and A. Zardasht, Tectonical history of Arabian platform during Late Cretaceous An example from Kurdistan region, NE Iraq, 1-14(2009)

[6] S. A. Hussain, and S. S. AL-Sheikhly, Paleoecology of Albian–Santonian succession of Surdash to Shaqlawa area, NE Iraq, Iraqi Journal of Science, 56(2A), 1076-1097(2015)

[7] F. M. D. Al-Tememmy, Micropaleontological study of the Kometan formation to determine its paleoecology, PhD diss., University of Baghdad, Baghdad, Iraq, 152(1986)

[8] T. A. Hashem, Biostratigraphy of the Late Cenomanian- Early Campanian Succession, Sulaimaniya, Iraq, M.Sc. thesis. Department of Geology, College of Science, Uni. of Baghdad, Baghdad, Iraq, 65(2010)

[9] R. J. Dunham, Classification of carbonate rocks according to depositional textures, 108-121(1962)

[10] J. L. Wilson, and J. L. Wilson, The stratigraphy of carbonate deposits, Carbonate Facies in Geologic History, (Springer, New York, NY, 1975)

[11] E. Flügel, and A. Munnecke, Microfacies of carbonate rocks: analysis, interpretation and application, Vol. 976, (Berlin: springer, 2004)

[12] A. D. Miall, Principles of Sedimentary Basin Analysis, 2nd edition, (Springer Verlag, New York, 1990), 668

[13] P. Sharland, R. Archer, D. M. Casey, R. B. Davies, S. Hall, A. P. Heward, A. D. Horbury, and M. D. Simmons, Arabian Plate sequence stratigraphy, GeoArabia SP2, (Gulf Petro Link, Bahrain, 2001), 371

[14] F. A. A. Lawa, Late Campanian–Maastrichtian sequence stratigraphy from Kurdistan foreland basin, NE/Iraq, Journal of Petroleum Exploration and Production Technology, 8, 713-732(2018), DOI(https://doi.org/10.1007/s13202-017-0424-1)

[15] P. A. Scholle, D. G. Bebout, and C. H. Moore, eds., 33, Carbonate depositional environments, (AAPG Memoir, 1983)

[16] Q. Li, and B. McGowran, Miocene upwelling events: neritic foraminiferal evidence from southern Australia, Australian Journal of Earth Sciences, 41(6), 593-603(1994)

[17] V. K. Sissakian, and S. Fouad, Geological map of Iraq, scale 1: 1000 000, 2012, Iraqi Bulletin of Geology and Mining, 11(1), 9-16(2015)