



Fossils distribution from Garagu Formation (Early Cretaceous), diversity and Paleoenvironmental conditions, Kurdistan Region, North Iraq

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Abstract

The most recent studies reformed the occurrence of Garagu Formation, Dohuk area, Kurdistan Region, Northeastern Iraq. The present paleontological study, in the type locality, aids the recognition of the formation. Recognizing forty nine genera and species of the; Benthonic and Planktonic Foraminifera, Ostracods, Calcareous Algae, and Coral, with other fossils such as ; Gastropoda shell, Echinodermata spine, Pelecypoda shell, Spone spicules and Brachiopds shell, which are described and figured. The stratigraphic distribution and diversity of these fossils assemblages indicate the Hauterivian-Barremian age of the Garagu Formation. The fossil assemblages in the Garagu Formation are characteristic for a shallow marine setting with local transitions to continental facies, shelf lagoonal environment and open platform.

Introduction

The Gara anticline is one of the most interesting geologic areas in Kurdistan, Amedi District; Dohuk Governorate (Figure: 1). The type localities of the Chia Gara, Garagu and Baluti Formations located within the core of the anticline (Bellen et al., 1959; Hanna, 2007; Aljumaily, 2013). One of these rock units is the Garagu Formation (Valenginian-Hautervian) which was studied for the first time by Wetzel (1950 in Aljumaily, 2013). The Garagu Formation in this area (Gara anticline) is composed of a series of limestone beds with oolitic limestones, siltstones and sandy limestones. Some of the beds are rich in iron oxides, while others are not. Unlike in other nearby formations, bivalves and other fossils are abundant in some horizons (Mirza et al., 2016). The age and stratigraphic position of it is determined as Hauterivian- Barremian (Buday, 1980; Aljumaily, 2013).

The lower contact is with the Chia Gara Formation (Tithonian-Berriasian) and is gradational and conformable. The contact is at the beginning of the oolitic sandy beds of the Garagu Formation and above the dark limestone beds of the Chia Gara Formation (Mirza et al., 2016) (Figure: 2). The upper contact with the Sarmord Formation (Valanginian – Aptian) is also gradational and is placed at the top of the oolitic

limestone and the beginning of the yellowish marl beds (Bellen et al., 1959). The common occurrences of microfossils in Garagu sediments encourages studying these microfossils in detail. These sediments not studied since Wetzel (1950 in Bellen et al., 1959). Hence, the main objective of this study is to re-evaluate the microfossils distribution within the formation in order to deduce the diversity and Paleoenvironmental conditions at the time of deposition of Garagu Formation.

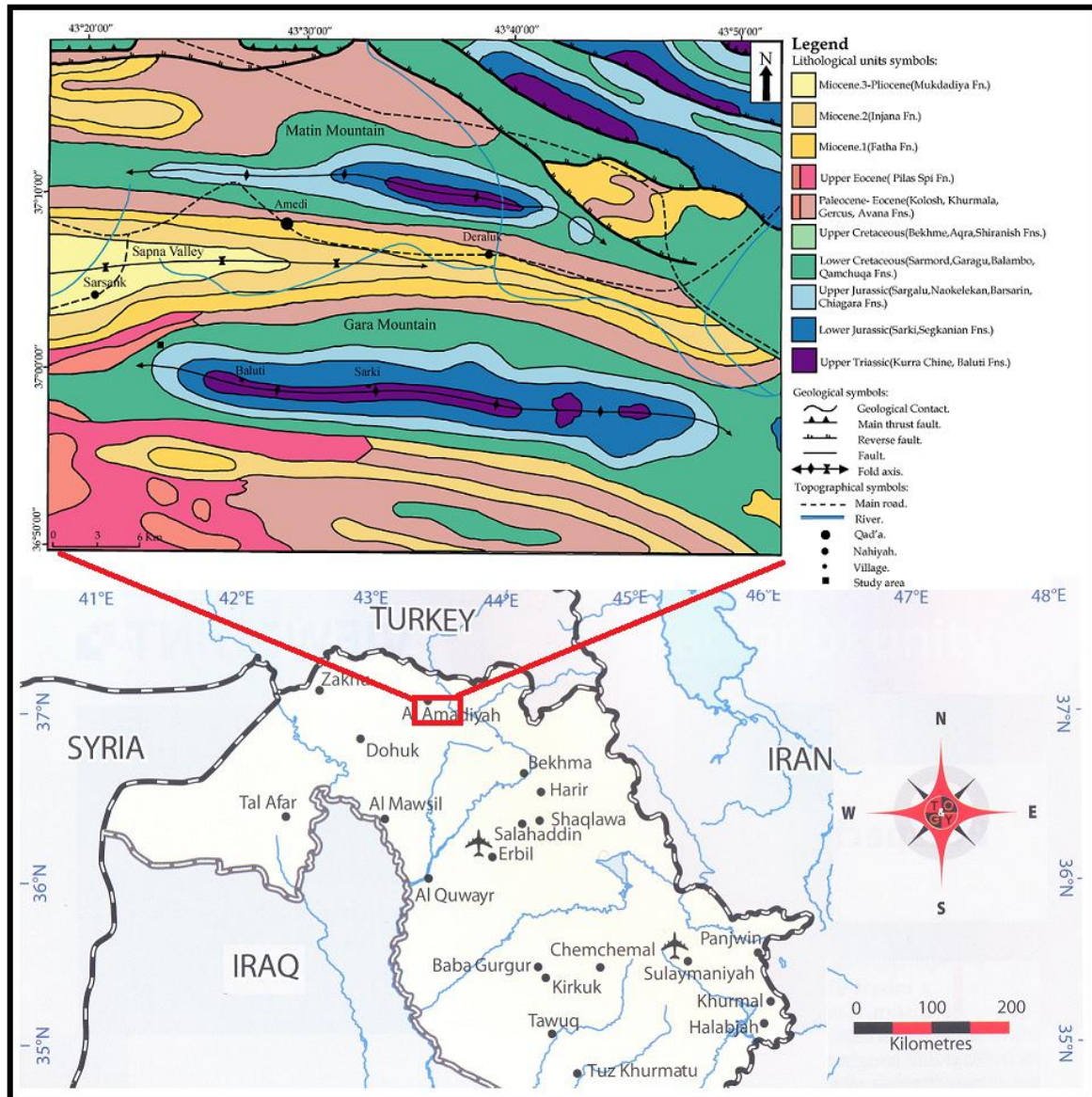


Figure-1: Geological map of Gara anticline and the surrounding areas (after Sissakian, 2000; Hanna, 2007).

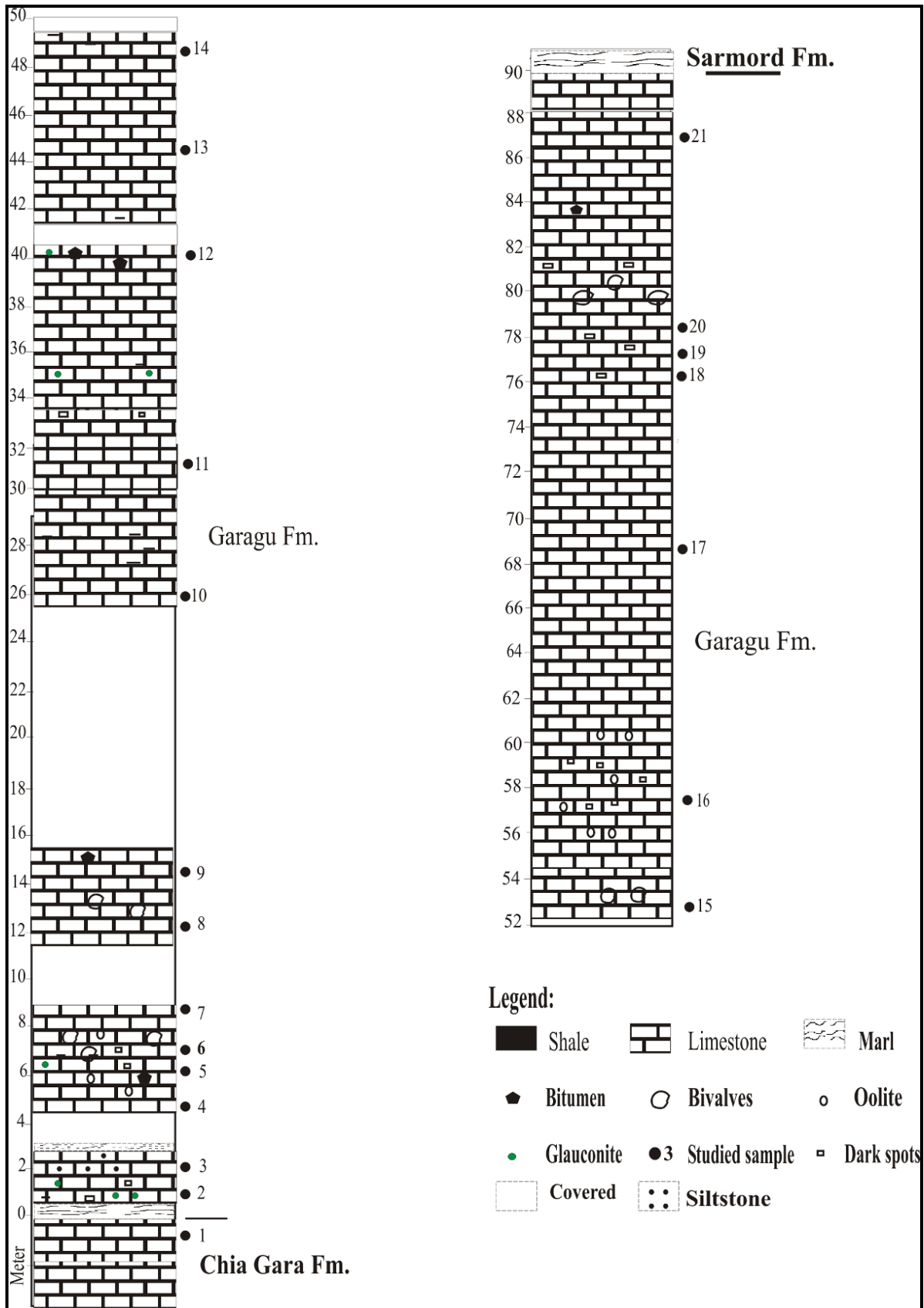


Figure-2: Stratigraphic column and the location of studied samples of the Garagu Formation, Gara Anticline, Amedi District, Dohuk Governorate, Kurdistan (after Mirza et al., 2016).

Geological Setting

The studied section of Garagu Formation (type locality) is located along the Gali Garagu Valley at N 37° 1' 06" and E 43° 23' 24.1", approximately 600m north of Garagu Village (Figure: 1). This is the exact section studied by Wetzel (1950 in Bellen et al., 1959). The studied area is a part of High Folded Zone of Iraq (Jassim and Goff, 2006). The succession comprises limestone beds with different colours and different fauna contents (Mirza et al., 2016). The total thickness measured in this section is 89.9m (Figure: 2), which is nearly 3 m less than the measured section by Wetzel. Some parts of the studied section were covered by thick soil sediments, hence not studied (Figure: 2).

The lower contact is with the Chia Gara Formation (Tithonian-Berriasian) and is gradational and conformable (Bellen et al., 1959). The contact is at the beginning of the oolitic sandy beds of the Garagu Formation and above the dark limestone beds of the Chia Gara Formation (Figure: 3). The upper contact with the Sarmord Formation (Valanginian - Aptian) is also gradational and is placed at the top of the oolitic limestone and the beginning of the yellowish marl beds.

Materials and Methods

Twenty one samples were collected from unbroken succession of the Garagu Formation at Garagu Valley, the type locality of the formation (Figure: 2). However, the section in some parts covered with recent and collapsed sediments, but still there are enough outcrops for collecting samples. Twenty five thin sections were prepared, and then studied under polarizing microscope.



Figure- 3: The boundary between Chia Gara Formation and Garagu Formation at the type locality of the Garagu Formation, Gara Mountain, Amedi District, Dohuk Governorate, Kurdistan (after Mirza et al., 2016).

Previous works

Bellen et al., (1959) studied the Garagu Formation in different well north Iraq, that the formation in the well Kirkuk-109 composed of clastic rocks with coral - algal banks and as a tongue within the Sarmord Formation and gives the following fossils in the type area:-

Stylina subtabulata Gregory; *Calamophyllia* sp.; *Pseudocyclammina litus* (Yokoyama); *Terebratula* cf. *waldensis* de Loriol; Gastropods; Lamellibranchs sp., *Cuneolina* sp.; *Cyclamminids* sp/, *Ticichites* aff. *Suprajurensis krumbeck*, *Subthurmannia* (Pictet); *Neocomites* sp. ; Hexacorallia, including *Axosmia*

neocomiensis Gregory, *Lochameosmia* sp.; *Stylina* sp.; *Corbulomina* cf. *aligera* (Hamlin); *Eonavicula* cf. *whitfieldi* Vokes; *Thracia neocomiensis* D'Orbigny, *T. russellensis* De oriol; *Trocholina* cf. *elongate* (Leupold); *Nautiloculina oolithica* Mohler. Chatton and Hart (1960) showed that the Garagu Formation is a unit with the Yamama Formation.

Hart (1962) identified the following fossils in the lower part of the Garagu Formation in the well-Awase1-5:- *Pseudocyclammina kelleri*; *Haurania* sp.; *Cyclammina gregi*; *Nautiloculina oolithica*, *Trocholina* spp. , and the following fossils in the well-Samara-1:- *Hensonella cyclindrica*; *Pseudocyclammina* sp.; *Nautiloculina oolithica*; *Choffatella decipiens*, *Cuneolina* sp.; *Trocholina* spp.; *Orbitolina* sp.

Hart (1962) showed the following fossils in the Garagu Formation, North Iraq:-

Primitive cuneolina var. *Parvo*. *Pseudocyclammina* spp.; *Cyclammina* cf. *gregi*, *Terebratula waldensis*; *Pseudocyclammina lituus*; *Trocholina* cf. *elongate*; *Groebericeras* sp. nov., *Subthurmannia occitanica*

Elliott (1968) gave the *Coptocampylodon lineolatus* in the Faluja well No.1., but Elliott (1968) showed these species of algae in different places in Iraq:- *Actinoporella podolica*; *Acroporella assurbanipali*; *Clypeina parvula* Garezzi; *Acicularia antique* Pia; *Salpingoporella dinafica* Radoicic; (*Hensonella cylindrical* Elliott. In the Makhol-1 well shows *Triploporella* and in Makhol well-2, *Cylindroporella barensi* Johnson. With the species *Pianella pygmaean* (Gumbel).

Ditmar (1971) refused the idea of the combination Garagu Formation with the Yamama Formation and showed that the garagu Formation is over the Zanqura Formation. However, Buday (1980) refused the name of Zanqura Formation and used Garagu for the sequences (Late Bereassian-Hauterovian) that composed oolitic and pseudoolitic and organic detrital Limestone with pelitic to psamitic. Buday (1980) identified the following fossils in the lower part of the Garagu formation:-

Pseudocyclammina kelleri; *Pseudocyclammina* sp; *Trocholina* sp. ; *Haurania* sp. ; *Glomospira* sp. ; *Nautiloculina oolithica*; *Astarte* sp. ; *Exogyra* sp.; *Aptyochus* sp. And these fossils from the upper part of the formation:- *Pseudocyclammina lituus*; *Trocholina elongate* (Leupold); *Nautiloculina oolithica*; *Terebratula careteroniana*; *T. russelensis*; *Ampullina syriaca*; *Thracia neocomiensis*; *Eonavicula whitfieldi*; *Corbulonia* cf. *aligera*; *Stylina* sp.; *Lochameosmia* sp.; *Axosmia neocomiensis*; *Subthurmannia occitanica*; *Trichites* aff. *suprajurensis*;

Al-Abawi (1984) determined the following fossils from the upper part of the Garagu Formation in Khabaz Well-1: *Cuneolina* aff. *Pavonia*; *Orbigny*; *Nautiloculina oolithica* Mohler; *Hensolena cyclindrica* Elliott, *Cuneolina* aff. *pavonia*, *Nautiloculina oolithica* and *Hensonella cylindrical* .

Amin (1989) studied the biostratigraphy of the Garagu Formation in subsurface sections from different oilfields in Iraq (Qarachauagh, Bai-Hassan, Khabaz and Jambour), and subdivided into four zones (*Pseudocyclammina litus*, *Orbitolina lenticularis*, *Choffatella decipiens* and *Hensonella cylindrical* zones) and suggested that the age of the Formation is Valanginian-Aptian. He recognized these fossils in the Garagu Formation, *Pseudocyclammina litus* (Yokoyama); *Cyclamina griegi* Henson; *Cyclamina* sp.; *Everticyclammina contrata* Redmond; *Litusepta* sp.; *Trocholina elongata* Leupold.; *Trocholina alpine* Leupold; *Nautiloculina oolithica* Mohler; *Mesoendothyra izumiana*; *Sabaudia minuta* Hofker; *Gyroidinoides* sp.; *Choffatella decipiens* Schlumberger; *Orbitolina lenticularis* Blumenbach L, Miliolids; Rotalids; Textularids; *Folygonella incrusata* Elliott; *Salpingoporella muehlbergii* Lorenz; *Salpingoporella annulata* Carozzi; *Amicualria* sp.; *Acicularia jurassica* Johnson; *Acicularia comanchence* Johnson; *Macroporella embergi* Booroullgc et Deloffre; *Cylindroporella arabica* Elliott; *Cylindroporella sugdeni* Elliott; *Cylindroporella barnesi* Johnson; *Carpathoporella occidentalis* Dragstan; *Coptocampylodon linolatus* Elliott; *Cooscinoconus* sp.; *Permocalculus* sp. ; *Permocalculus irenae* Elliott; *Araicodium aegagrapiloides* Elliott; *Hensonella cylindrical* Elliott. He concluded that the formation deposited in an open platform (shelf lagoon) and a restricted platform.

Al- Khashab et al. (2011) examined the ostracoda assemblages from the Garagu and Ratawi Formations (Lower Cretaceous) from the Makhul-2 (Mk-2) and East Baghdad-1 (EB-1) boreholes and concluded that the Garagu Formation deposited under a shallow marine sublittoral environment with normal salinity and warm water.

Recently, geochemical study has been carried out on the same section of Garagu Formation by Mirza et al., (2016). They deduced that the formation is rich with iron oxides in some parts and the sediments are deposited in shallow marine agitated water conditions. Different iron-rich minerals are present within these beds like hematite, goethite and magnetite. The origins of iron mineralization were considered depending on type of iron mineralization, texture and microstructure such as supergene, hypogene and sedimentary-diagenetic origin, it means that the iron ore has syngenetic and epigenetic origins.

Finally, the Garagu Formation at the same section (type locality) is also studied by Balaky et al. (2016) from microfacies analysis and depositional environment points of view. They concluded that there are three different microfacies which were subdivided according to their environmental interpretation into one basic type of facies association (lagoon association). Generally, the Garagu Formation represents shallow lagoonal environment with two high energy belts in the lower and upper parts.

Paleontological Studies and Fossil Distribution

The abundant well preserved forms within the studied samples, including different groups of microfossils are studied. Forty nine microfossils (Foraminifera, Ostracodes, Algae, Echinoid spines, microscopic parts of Gastropods, Brachiopods and pelecypods shells are identified and recorded in the studied section (Figures: 4 and 5).

The recorded foraminiferal species are characteristic for the early Hauterivian-Barremian age, namely *Cribellopsis elongate* Dieni, *Cribellopsis schroederi*, (Arnaud-Vanneau), *Orbitolinopsis buccifer* Arnaud-Vanneau & Thieuloy, *Paleodictyoconus actinostoma* Schroeder, *aracoskinolina* sp. *Choffatella decipiens* Schlumberger, *Globigerinolioides* sp, *Urgonina* sp., *Palorbitolina lenticulari* (Blumenbach), *Globigerinolioides* sp., *Hedbergella* sp.₁ *Rotalip.* sp., *Hedbergella* sp.₂ *Trocholina alpine*, Leupold *Hedbergella washitensis* Carsey, *Paleodictyoconus arabicus* Henson, and *Rehacythereis* sp. (Schroeder, 2010; Granier, 2013).

Several Ostracod taxa are also indicative for an early Hauterivian-Barremian age, namely *Neocythere* (*Centrocythere*) sp., *Hehticythere hehti* (*Cytherella ovata*, *Dictyothyris elongate* Smirnova, (Babinos and Colin, 2011). The Coral taxa are also indicative for an early Hauterivian-Barremian age, regarding with *Stylangia neocomiensis* de Fromental, *Stylina urgonica* Dietrich, *Alpillina antique*, *Planomalina buxtorfi*, *Sewllithyris sella*, *Letusepta* sp., *Actinoporella podolica* sp. (Kay and Barker, 1966; Löse et al., 2013).

The Calcareous Algae are also indicative for an early Hauterivian-Barremian age, regarding, *Paracoskinolina* sp, *Macrocypris* aff. *Siliiqua* (Abad et al., 2010), *Pseudoactinoporella fragillis* alga, and *Falsolikanelia danilovae* alga *Schuleridea* cf. *obtabilis*.

The recorded other fossils, such as Brachiopoda shells, Echinoid spines, Pelecypods shell, Gastropoda shell, and Calcareous spicules of sponges are characteristic for the early Hauterivian-Barremian age.

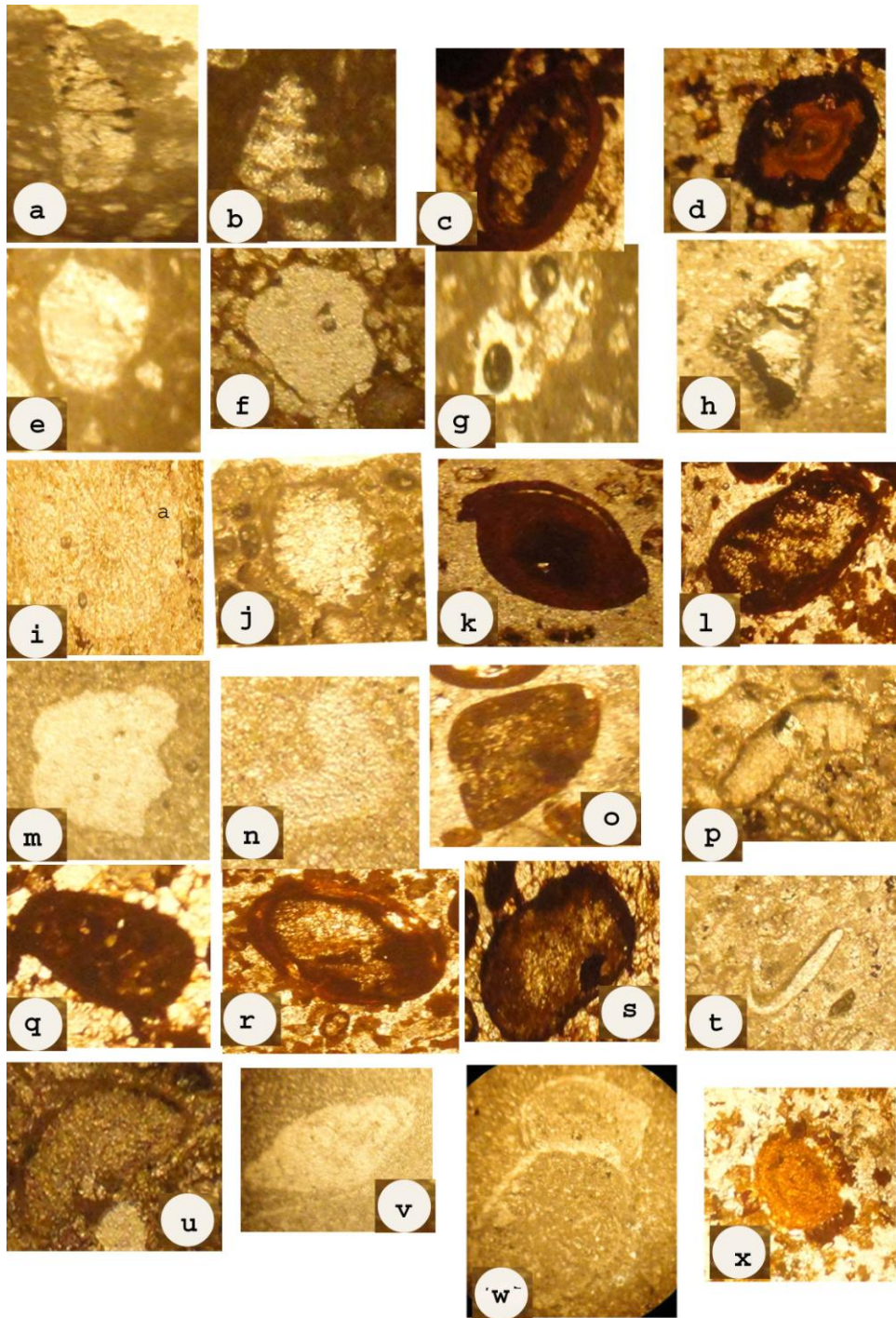


Figure-4: a- *Paracoskinolina* sp. (X80), sample No.1, ChiaGra Formation, b- *Trocholina alpine* Leupold (X80), sample No.4, , c- *Cytherella* sp. (X100) sample No.3., d- *Cytherella ovata* (Rö mer) Jones 1849 (X80), sample No.6, e- *Trocholina* sp. (X100), sample No.8, f- *Hedbegella washitensis* (Carsey) (X80), sample No. 6, g- *Hedbegella* sp. (X80), sample No. 12, h- *Cribellopsis schroederi* (Arnaud-Vanneau) (X80), sample No. 15, i- *Stylina urgonica* (Dietrich, 1926) (X100), sample No.16, Garagu Formation , j- *Rotalipora* sp.(X80), sample No.18, k- *Dictyothyris elongata* Smirnova.(X100) samle No. 19, l- *Hechticythere hechti* (X100), sample No. 10, m- *Rotalipora* sp. (X100), sample No. 16, ,n. *Paleodictyoconus arabicu* Henson(X80), sample No. 18, o- *Orbitolinopsis buccifer* Arnaud-Vanneau & Thieuloy (X80) (X100), sample No. 13, p- *Eopalorbitolina transiens* (Cherchi & Schroeder, 1999b) (X80), sample 11, q- *Patellacythere* sp.(X100), sample No. 18, r-*Protocythere* sp.(X100), sample No. 17, s- *Macrocypris* aff. *Siliqua* (X100), sample No. 16, t- Ecchinoid spine (X80), sample No. 1, u-*Palorbitolina lenticularis* (Blumenbach, 1805) (X80), sample No. 10, v-*Orbitolinopsis buccifer* Arnaud-Vanneau & Thieuloy(X80), sample No. 20, w- Gastropoda shell (X100), sample No. 1, x- *Pseudoactinoporella fragillis* (X80), sample No. 19, Garagu Formation, Amedi District, Dohuk Governorate, Kurdistan, Iraq.

Microfossil Assemblages and Paleoenvironments

Microfossil assemblages along the sampled section provided valuable information on the paleoenvironmental evolution. Our interpretations are based on the estimated autecology of several taxa assemblages (Figure: 5):-

A. Foraminifera assemblages:

The opportunistic foraminiferal species are detritivorous and able to dwell in very unstable nearshore environments with fluctuating salinities (Walton and Sloan, 1990) are indicators of almost normal marine conditions and quite stable environments. Miliolid foraminifera (epifaunal detritivorous and/or herbivorous) are characteristic for very shallow waters with normal marine to hypersaline conditions (Łuczkowska, 1972; Łuczkowska, 1974; Murray, 1991). The rotaliids are represented by opportunistic epifaunal or infaunal dwellers, all other foraminiferal species good indicators for shallow marine to shelf lagoonal environment and open platform.

B. Ostracod assemblages:

The ostracods are dominated by *Miocyprideis* spp, refer to highly fluctuating salinities, as suggested by the comparison with modern *Cyprideis*. Frequently these dominate in marginal marine, brackish waters. Other ostracods species are of shallow marine, local transitions to continental facies, shelf lagoonal environment and open platform. *Cytherella* with *Cythereis* are good indicator of shallow water environments (Löser, 2013).

C. Coral assemblages:

The identified coral species are *Stylangia neocomiensis* and *Stylina organica* which are of shallow marine environment, with local transitions to continental facies, and open platform (Bremner, 1976).

D. Calcareous Algae assemblages:

Calcareous algae involves *Actinoporella podolica*, this species is good indicator of shallow water environments (Abad et al., 2010) the others calcareous algae which are distributed are also of shallow marine environment.

E. Other fossils assemblages:

Different fossils were identified, such as Brachiopoda shell, Echinoid spines, Gastropoda shell, Pelecypods shell and Calcareous spicules of sponges, which are poorly preserved. All these bioclasts are characteristic for shallow marine environment.



Figure-5: Stratigraphic distribution of the fossils in the Garagu Formation, Gara Anticline, Amedi Distyric, Dohuk Governorate, Kurdistan Region, Iraq.

Conclusions

This study has the following conclusions:

- 1- The Garagu Formation is characterized by different assemblages of microfossils (fossil-rich sediments).
- 2- Forty nine genera and species of Foraminifera, Ostracoda, Calcareous Algae and others microfossils were identified and distributed in the Garagu Formation.
- 3- The identified fossils in the Garagu Formation extend from the Hauterivian to Barremian in age.
- 4- The depositional environment of the Garagu Formation may be a part of an open marine of shallow water with local transitions to continental facies, shelf lagoonal environment and open platform.

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