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Microfacies Analysis of the Carbonate Rocks in Ora Formation (Late Devonian early Carboniferous) in North Iraq

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Abstract
The outcrop sections of Ora Formation (late Devonian-Early Carboniferous) in the Nazdor and Ora localities at the Northern Thrust Zone of Iraq were selected for this study. Lithologically the Ora Formation composed of clastic and carbonate rocks. The lower part in the Nazdor section cosists of crossbedded quartz arenite sandstone interbedded with successive laminated siltstone and shale. The lithology of the upper part in the Nazdor section and the upper part in Ora section, are composed of mixed silicalcastic (shale, siltstone and sandstone) and carbonate interbedded lithology. The petrographic study shows that the carbonate rocks consist of micrite and sparite groundmass. The skeletal grains include shallow water brachiopods, bryozoans , echinoderms , in addition to ostracods , trilobite , pelecepoda , gastropoda and calcispheres , while nonskeletal grains include peloids and lithoclasts of carbonate and noncarbonat. Ten microfacies types were identified. There are silty mudstone, laminated silty peloidal packstone, lithoclast breccia, wackstone, floatstone, bryozoa grainstone, sandy laminated grainstone, grainstone/rudstone and boundstone. Facies analysis of the upper part of the Ora Formation in Nazdor and Ora section indicate that the rocks were deposited mainly in inner margins of homoclinal carbonate ramp with minor units were deposited in middle of outer ramp margins.

Keywords: Ora Formation, Microfacies analysis

تحليل السحنات الدقيقة للصخور الجيرية في تكوين اورا (الديفوني االمتأخر الكاربوني المبكر) في شمال العراق

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الخلاصة
تقع المقاطع المنكشفة لتكوين اورا (الديفوني المتأخر – ا لكاربوني المبكر) في منطقتي نازدور و اورا ضمن نطاق الزحف الشمالي في شمال العراق . يتألف تكوين اورا صخاريا من صخور فتاتية و جيرية . يحتوي الجزء السفلي من التكوين في مقطع نازدو على صخارية مخلوطة من سحنات فتاتية سليكية (السجيل و الحجر الغريني و الرملي) وسحنات من الصخور الجيرية . تحتوي الصخور الجيرية على متحجرات تمثلت بهياكل: براكيوبودا، برايوزوا، اكينوديرم، اوستراكودا، كاستروبودا، بايفالفيا و كالسسفير، بينما ضمت الحبيبات غير الهيكلية حبيبات البلويد والفتات الصخري الجيري و غير الجيري و لقد تم تمييز عشرة سحنات دقيقة في الصخور الجيرية اشتملت على حجر جيري طيني غريني: حجر جيري بليودي متصحف مرصوص، حجر جيري واكي. حجر جيري مرصوص، حجرجيري برايوزوا حبيبي، حجر جيري حبيبي رملي متصحف، حجر جيري حبيبي رودست وحجر جيري كتلي و لقد اشار التحليل السحني للجزء العلوي من تكوين اورا في

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مقطعي نازدور واورا الى ان البيئه الرسوبية كانت في اجزاء متعددة من المسطح الداخلي بشكل رئيسي
اضافة الى اجزاء من المسطح الوسطي والخارجي.

Introduction

Paleozoic formations are cropping out in a restricted area from northern Iraq (Northern Thrust Zone). These outcrops occur at the core of faulted anticlines northwest of Amadia and Shiranish village. Ora Shale Formation was first recorded by Wetzel (1952) from the Northern Thrust Zone in Ora Fold (Amadia - North Iraq). The Ora Formation composed of black, fine micaceous calcareous shales, with olive green, blocky, silty marls with thin lentils of organic detrital limestone and fine grained sandstone occur intermittently through the succession; representing marine, shallow water origin [1]. The upper contact of Ora Formation is conformable and gradational with the overlying Harur Formation, which represented by dominated shale below grades upward to alternative shale/limestone beds, in which the top of the Ora Formation is marked by a break in sedimentation [1, 2]. The upper part of the Kaista Formation was added to the Ora Formation and the thickness has been increased to 256m at the type locality in the Ora anticline near the Iraq Turkey border [3]. The Arabian Plate has involved five tectonic phases which together contain eleven tectonostratigraphic megasequences [4]. Ora Formation has been deposited through the third phase (Late Devonian to mid-Pemian phase, (Ap4 and Ap5), when the plate was located in a general back-arc setting and in moderate southern latitudes and specifically through the AP4. This megasequence was dominated by Carboniferous silicaclastic sediments, which were deposited in an overall back-arc setting during Hercynian Orogeny over much of the Arabian Plate. This TMS is largely represented by erosional interval due to uplift of the underlying Paleozoic rocks. The preserved sediments are mostly from adjacent emerging structures and thus contain reworked flora and fauna [4]. The Maximum Flooding Surface (MFS) is represented in the geological succession of Arabian Plate by a variety of lithologies, but princely by either marine outer shelf or shallow marine limestons. These lithologies are largely controlled by paleo - bathymetry which is itself primarily carried out between subsidence, sea level, sediment supply and climatic environmental controls are also important. The relation of these components has varied through the time across the plate, resulting in each MFS potentially represented by a variety of lithologies. The Ora shale below the Harur Formation in Iraq which dated as the latest Devonian - Tournasian on the basis of the brachiopoda funa and gave its stratigraphic position is probably an equivalent of D30 MFS [1, 4]. The Ora Formation comprises black calcareous to micaceous shale interbedded with silty marls, thin lenses of bioclastic and fine grained limestone and occasional fine grained clastic beds. The total thickness is up to 220m [5, 6]. The Palynology studies indicate the age of Late Devonian- Early Carboniferous. It would be probably of marine to near shore environment [2, 7].

Geological Setting

According to the tectonic divisions, the study area is located at the Ora Thrust zone, north of Iraq. The area is a part of imbricated zone of the unstable shelf, located along the Turkey – Iraq border with E-W trending narrow belt. . Northern Ora Thrust Zone is widest in the west with three domes culminations (Sinat, Kaista and Ora). These domes are asymmetrical towards the south and occasionally the southern, limps are overturned and the northern limbs have low dips and erected by reverse faults [3]. Figure-1 represents the geological map of the Ora Formation and other Paleozoic rocks in the study area. Carbonate rocks in the Ora Formation are observed in the outcrop sections interbedded with shale in Nazdor section and in the upper part of Ora section. The studied sections depend on the field work of the Ora formation outcrops: (a) the first section lies at 37o 17´ 50´´N, 43o 20´ 15´´E, North Ora village, Amdia in Dohuk Governerate. The studied section was about 75m thickness, while some of the lower of upper parts of the formation were covered with recent sediments Figure-2. (b)The second section lies at 37o 18´ 10´´ N, 43o 08´ 15´´E, in Nazdor area west of the Ora section, reveals160m thickness Figure-3. Thin sections preparation of petrographic study for 32 limestone samples. These thin sections were later stained with Alizarin Red S for detecting the calcite and dolomite. Detailed petrographic description, along with microfacies analysis, is performed by using petrographic polarized microscope.

Petrography of Carbonate Rocks

The carbonate rocks are composed of depositional constituents which products from the depositional events and digenesis which result from post depositional processes. Petrographic study of carbonate rocks show skeletal and non skeletal grains, groundmass represented by matrix and cement.

Skeletal grains

The skeletal grains represent bioclast which includes fossils, fragments of well preserved shells. The size of the identified skeletal grains is varies in size and ranging from less than 1mm to more than 1cm. This reflects the growth size and size patterns of the whole fossil skeletal caused by the transport process that leading to the dimensions of fossils or their fragments depending on hydraulic modification [8].Varieties of fossil assemblages are observed within carbonate of Ora Formation, These are; brachiopods, bryozoans, echinoderms, ostracods, trilobites , calcispheres, bivalves and gastropods.

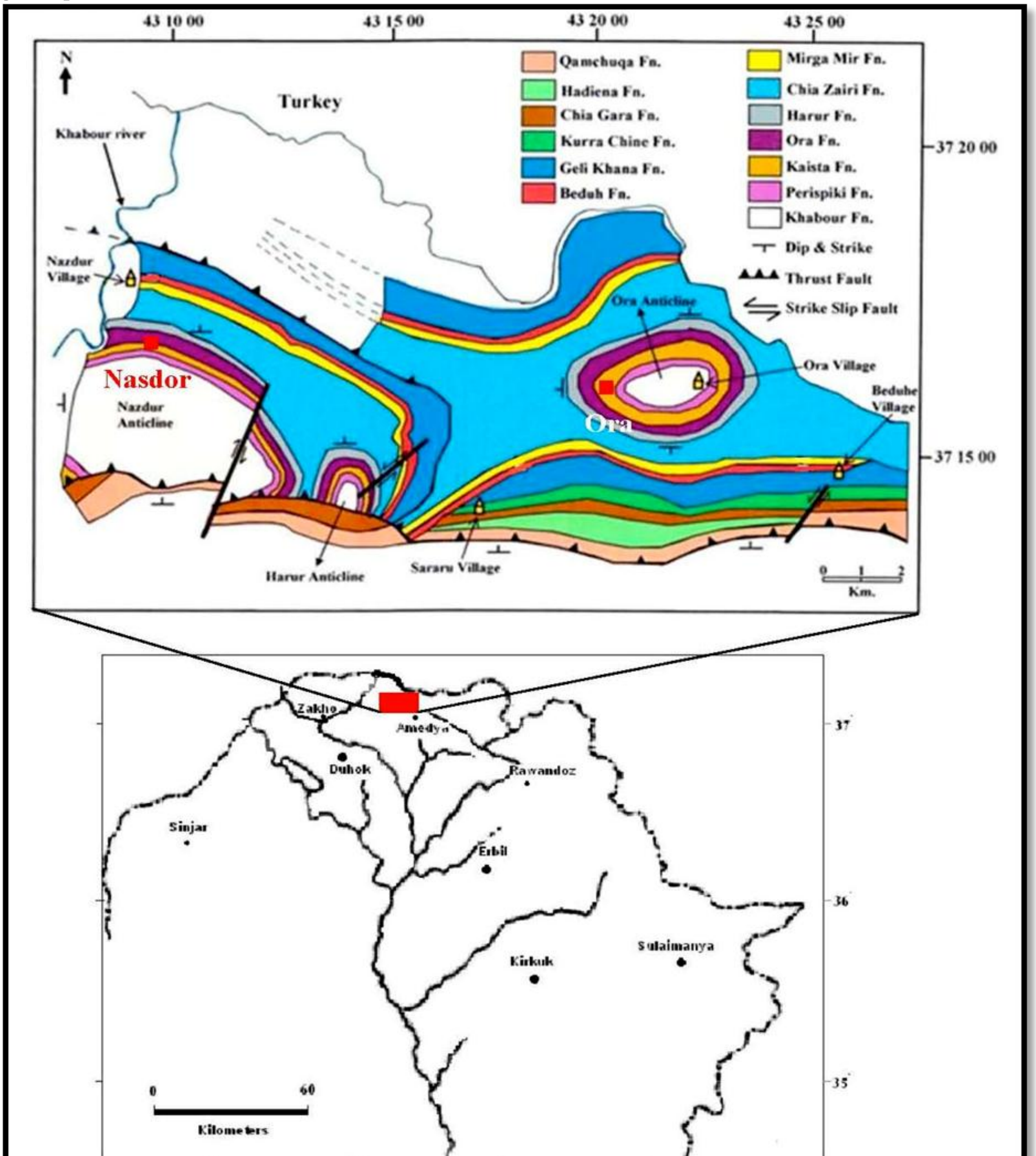


Figure 1-The location and geological map which shows Ora and Other Paleozoic formations, which are cropping out in the study area [9]

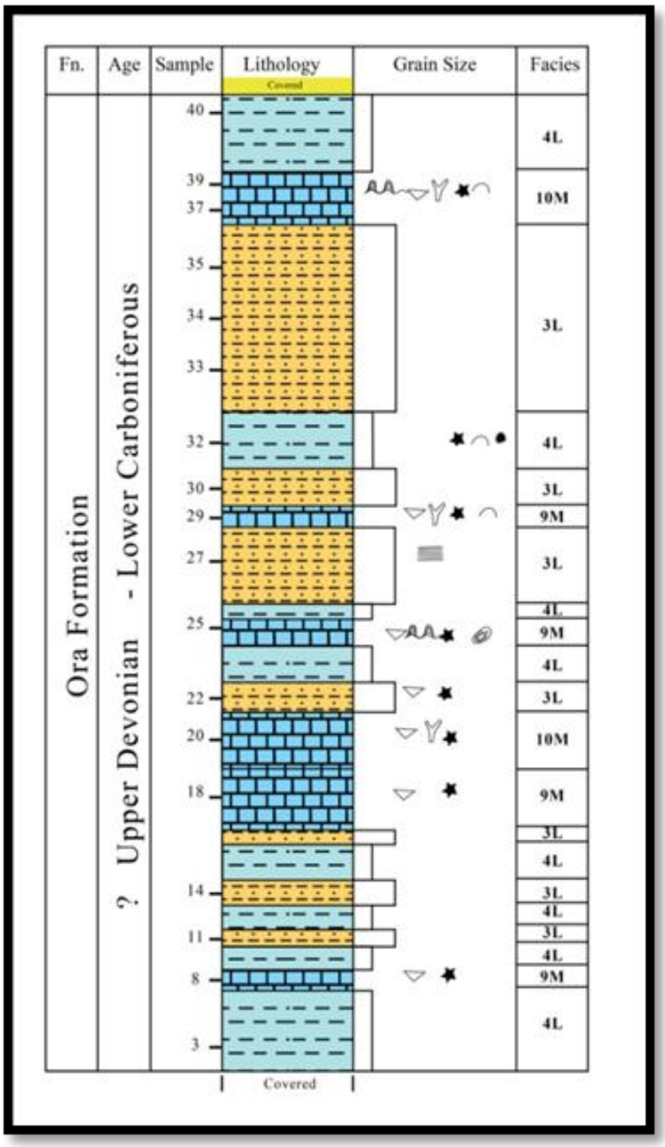
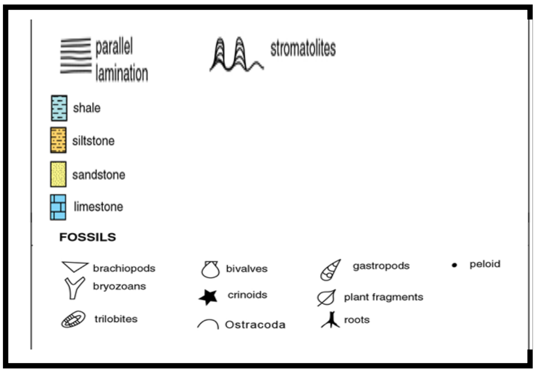


Figure 2- Graphic sedimentary log of the the upper part in the Ora section



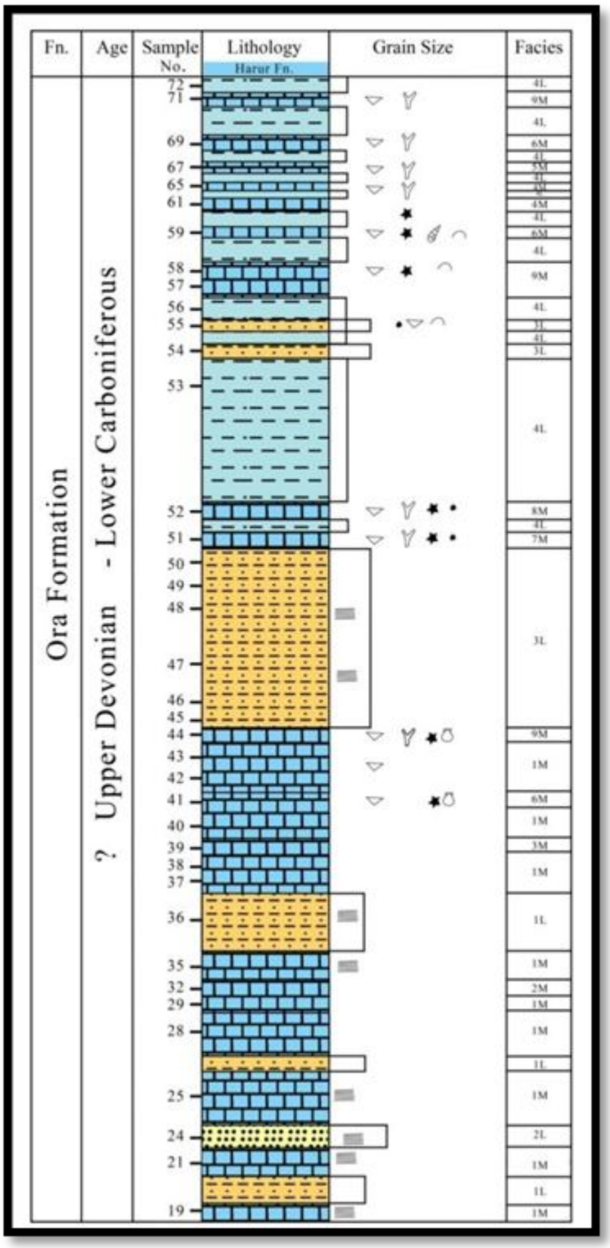
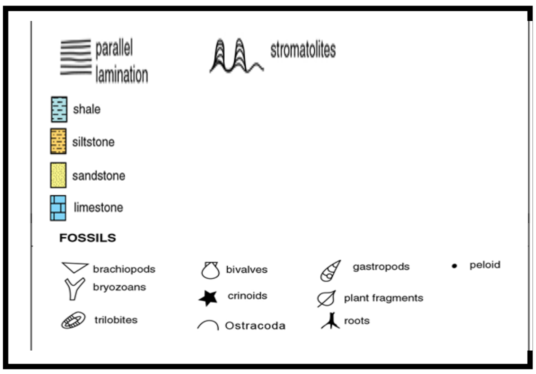


Figure 3- Graphic sedimentary log of the upper unit in the Nazdor section



Brachiopods

Brachiopods are major contributors to the biodastic content of shallow marine limestones particularly in the Paleozoic. Brachiopods consist of two unequal valves, are low Mg calcite there surface observed as smooth, plicated, corrugated and spinose. Figure-4.1, -17, -20. Brachiopods in limestone are present in different depositional environments (shelves ramp and slopes). Others are transported by currents within depressions and accumulate as dunes Figure-4.2 [8, 10].

Echinodermata

Echinoderms are marine invertebrates with a multi- plate calcareous internal skeleton, each plate acts as an individual high Mg calcite crystal, includes the echinoids and crinoids which are passive filter- feeding organisms. Stalked crinoids are abundant in shelf environments of the Paleozoic Era [11]. The common fossil record of crinoid's skeleton are dissociated elements. These elements of crinoidea fragments show the characteristic shapes at Ora carbonate rocks, some of them having an axial canal Figure-4.3, -4. The plates of criniod exhibit an open mesh work structure act as single crystal of calcites and display unit extinction. The occurrence of crinoid plates at Ora section is more abundante than in the Nazdor section, it is associated with the microfacies of large skeletal grains and the size of crinoid fragments ranging from less 1mm to 4mm. Echinoid spines are the common constituents of the echinoid, which appear as a single crystal of calcite with flower like appearance Figure-4.5. The occurrence of echinoids is very rare in Ora carbonat may be due to their rarity throughout Paleozoic. [8, 10, 11].

Bryozoans

Bryozoans reflect specific depositional setting and paleoclimate. Most of bryozoans are usually composed of low Mg calcite, predominantly marine condition, suspension feeders and forming colonies. Bryozoan in Ora Formation is observed in the carbonate rocks of the upper part at Nazdor section. The size of colony ranges from more than 1mm to 1cm, which attains in many shapes Figure-4.6, 7. The carbonate rocks of Ora section are rich in bryozoan's types, which indicate platform and ramp carbonate throughout Paleozoic shelf limestone and may contribute the formation of reefs [8, 12].

Ostracods

The Ostracods belong to the arthropoda which are characterized by segmentation. It is a good fossil record in carbonate rocks, belong to superclass crustacean,the ostracods are thin bivalve shell composed of low to high Mg calcite with chitin. The size of ostracods in the carbonate units of the Ora Formation is less than 1mm, with a smooth surface and typically ovate or kidney shaped Figure-4.8,-20, ostracoda commonly shows repeated shedding that result in accumulation of numbers of disarticulated valves Figure-4.9. Ostracoda lived in shallow depths marine brackish water from arctic to tropical latitudes [8].

Trilobite

The Trilobites fragments which are identified in thin sections are dissociated thorax fragments of high Mg calcite. The individual segments are 1mm to 1 cm length and it is less than 1mm in thickness. Trilobite fragments are sharply re-curved with characteristic hook or crook shapes Figure-4.10, the skeletal grains show sweeping extinction [10]. Trilobite is mobile benthonic, marine organisms, most common in shallow shelf setting [13].

Bivalves

The Bivalves are the important mollusks contributing in the bioclast content of the limestone, less common in carbonate rocks than brachiopods in the Paleozoic age. The size of shell is larger than Ostracods which has somewhat similarly shaped valves Figure-4.11. It composed of aragonite and less calcite. The bivalves are associated with other bioclast in wackestone and packstone microfacies. The vast majority inhabits shallow marine settings of intertidal and subtidal conditions [8, 11].

Gastropoda

The Gastropoda are less abundant constituents in the limestone of the Paleozoic rocks. They are the largest class of mollusks, and are rarely major rocks forming organisms composed of aragonite. In the carbonate units of Ora Formation, Gastropoda is characterized by small size (mm size), and thinner shells Figure-4.12, which refer to cold water environment. They are mostly mobile benthonic, detritus feeder live in fresh and marine water environments [8, 11].

Calcispheres

The Calcispheres are found in may thin sections of carbonate rock units in Nazdor section, observed as isolated cysts as small hollows spheres, have smooth surface and microgranuler wall. It consists of uniformed dark micrite with sizes of less than 0.5mm and may be calcified reproductive parts of alge. Their wall is composed of calcite and the hollow is filled with micrite or Sparry calcite Figure-4.13. Some calcisphere are restricted in the coastal lagoon setting and others are associated mainly with open shelf pelagic deposits. Paleozoic Calcisphere occurs in shallow marine platform and ramp carbonates. [8, 10, 11].

Carbonate Lithoclasts

The Carbonate lithoclasts are fragments derived from weakly consolidated carbonate sediments, eroded and redeposited within the same depositional environments, called intraclasts. It may be derived from lithified carbonate sediment outside of the depositional area, called extraclasts Figure-4.14. The distinction between these two types of clasts is often difficult [8].

Peloids are usually rounded, void rod like shapes, with size 0.1 - 0.3mm Figure-4.15. Peloids presents in rapid and low rate of sedimentation of low energy shallow marine subtidal and intertidal zones of inner platform or ramp [8]. Peloids are abundance in the Nazdor section at upper units of the sequence.

Non Carbonate Lithoclasts

Lithoclasts are rock fragments that are derived from erosion of ancient rocks on land. In carbonate units of the Ora Formation rocks, they are mainly composed of quartz grains of silt to medium sand size. The grains of quartz are rounded to angular shape Figure-4.16,-17 .Well rounded detrital quartz grains are scattered throughout carbonate rocks. The rounded quartz grains indicates long term abrasion in high energy setting, while the angular detrital quartz are more abundant as terrigenons contributers to carbonate rocks. Other kinds are phosphatic nodules of yellow – brown color and isotropic behavior Figure-4.18.

Groundmass

Groundmass is the material present between the grains, small size of the crystals or particle bordering interganular pores, which include fine grained material such as micrite and sparry calcite.

Micrite

Micrite is the former carbonate mud in limestone which occurs as microcrystalline calcite matrix. The crystal size of micrites ranges from cryptocrystalline to microcrystalline. Micrite in Ora carbonates rocks may be homogenous or inhomogeneous contain a few percentages of mud size non carbonate impurities such as clay minerals, quartz and organic matter. Micrite may be precipitated in cavities of shells Figure-4.20. Micrite matrix indicate deposition in quiet water conditions where little winnowing of fine mud took place in the shallow subtidal less agitated parts of the platform and lagoon [14].

Sparry Calcite

Sparry calcite occurs as cement filling the space among carbonate grains. The precipitation of sparry calcite take place in agitated water causes removing micrite and leaving the grains that may later become cemented by sparry calcite. This kind of sparry calcite is primary precipitated while secondary formed throw digenesis. In Ora carbonate rocks sparry calcite appears as patchy distributions crystal outlines tend to attains elongated loaf shape Figure-4.19. The identified sparry calcite in the carbonate units of the Ora Formation are most probably of diagenetic origin [8].

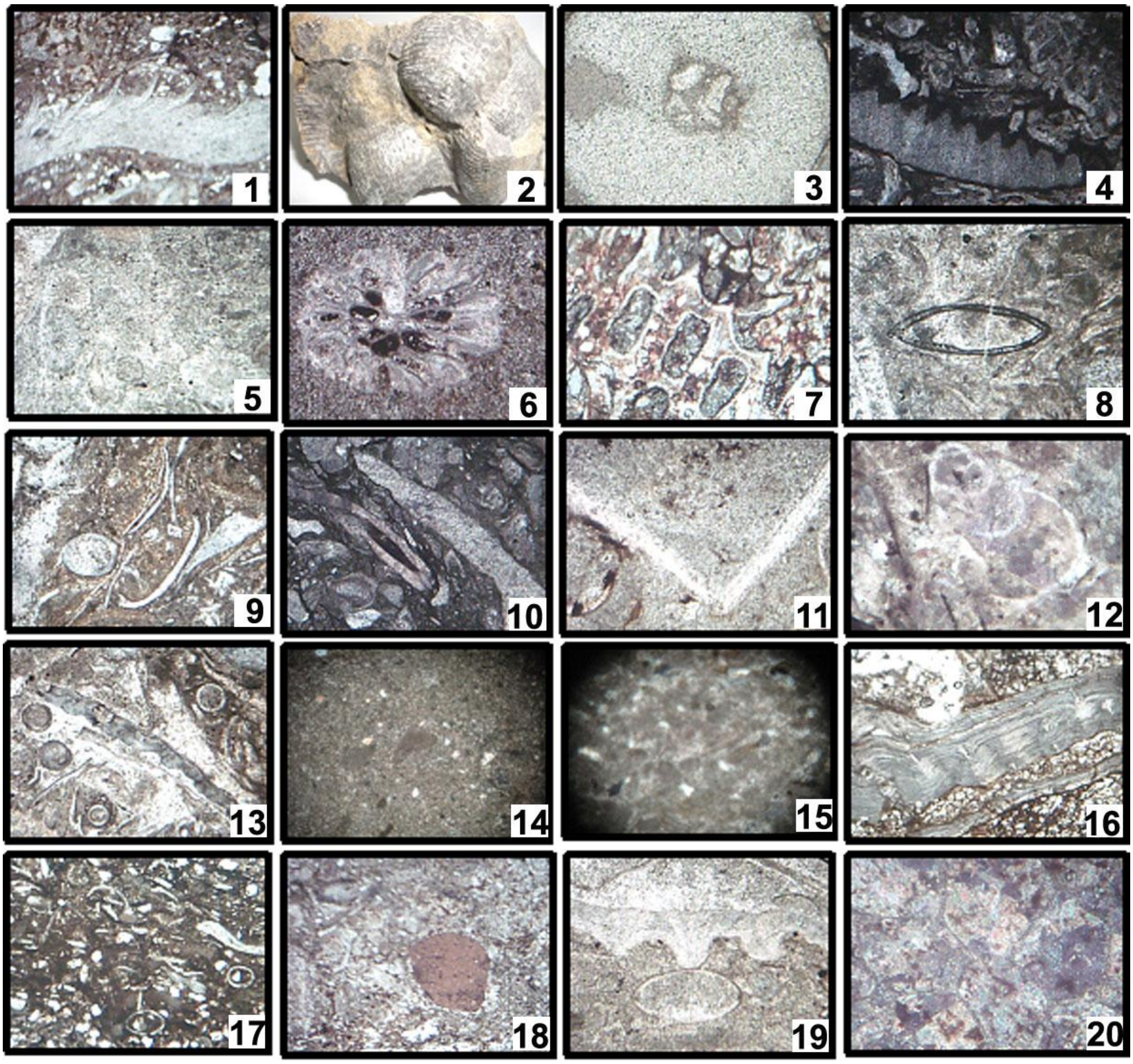


Figure 4.1- 4.20-Photomicrographs show the skeletal constituents of the carbonate units of the Ora Formation

(1) Brachiopoda with spines.57Nxpp, (2) accumulation of Brachiopoda shells as dunes. 67N, (3) Crinoidea fragments with axial canal. 25Oxpp, (4) one of the Crinoidea fragment. 20Oxpp, (5)Echiniod spines. 63Nxpp, (6) Bryozoans 59Nxpp, (7) Bryozoans rich microfiches 37Oxpp, (8) Articulated Ostracoda 44Nxpp, (9) Disarticulated Ostracoda 44Nxpp, (10) Trilobite 25Oxpp, (11) Bivalva 37Nxpp, (12) Gastropoda 51Nxpp, (13) Casispheres 41Nxpp, (14) Carbonate lithoclasts 19Nxpp, (15) Peloides lithoclasts 32Nxpp, (16) Silt size quartz grains lithoclasts 58Nxpp, (17) Sand size quartz grains lithoclasts 52Nxpp, (18) phosphate nodules 44Nlpp, (19) Micrite matrix 59Nxpp, (20) Sparry calcite cement 44Nxpp.

Microfacies of Carbonate Rock

The microfacies of carbonate rocks reflect the depositional and paleoecological conditions in a certain sedimentary environment. Ten microfacies are recognized in the carbonate units of Ora Formation followed the Dunham's classification (1962) and modified by Embry and Klovan (1971)[15,13]. According to the types of microfacies which were identified in this study, the interpretation of the sedimentary environment are depending on the distribution of the microfacies types of the Paleozoic and Mesozoic Eras using the microfacies types (RMF) suggested by Burchette and Wright (1992) [16].

Silty Mudstone Microfaies (1M)

This microfacies consists of micrite composed of detrital silty grains of quartz. At the lower part of the upper unit, this microfacies consists of very fine peloids grains with absence of fossils and characterized by existence of random accumulation in patches of very fine sand to silt size quartz grains which may indicate the spaces of previous roots occurrence Figure-5.1, -2, -3. Moreover its consist of intraclast derived by scouring of the lithified mudstone beds.

This microfacies was changed upward to consists mica and opaque grains which oriented in the direction of the lamination with few bioclasts of brachiopoda, ostracoda and peldoids grains . It is charaeterized by the parallal lamination of millimeter scale with parallal orientation of silt grains reflects short term depositional events [17].

This microsfacies in the Nazdor section is most probably belongs to the ramp microfacies (RMF 19, 22, 24) represents the peritidal and lagoon zone in the inner carbonate ramp.

Laminated Silty Peloidal Packstone Microfacies (2M)

This microfacies is characterized by peloids of different size of silt to fine sand grain size, which shows irregular distribution fine grained packstone. This microfacies consists of silt size, rounded to sub angular quartz grains. The peloids gives the laminated fabrics Figure-5.4. This microfacies may belong to the ramp microfacies (RMF4) peloiodal packstone represent the outer carbonate ramp [8].

Lithoclastic Breccia Microfacies (3M)

This microfacies consists of coarse micritic clast of angular pebble size edgwise arranged forming intraformational breccias Figure-5.5. The micrite clasts consist of skeletal grains and bioclasts which are cemented by sparry calcite Figure-5.6. This facies is interpreted as storm sediment deposited within tidal flats areas as lag deposits in tidal channels. The breccia is intraformational formed by syndepositional process and consist of clasts belived to have formed within depositional basin. This belongs to the ramp microfacis (RMF 10, 11) limestone conglomerate is interpreted as mid and outer ramp zones [8].

Wackstone microfacies (4M)

This microfacies show matrix support and consists of bioclasts mainly of ostracoda, few fragments of brachiopoda and crinoids Figure-5.7. This microfacies is observed only in the uppermost part of Nazdor section but it was not observed in Ora section. This microfacies belongs to the (RMF 18) bioclast wackstone with ostracoda represent shallow marine environment of restricted inner ramp zone. This microfacies is observed only in the uppermost part of Nazdor section and not seen in Ora section [8].

Floatstone microfacies (5M)

This microfacies consists of bioclasts grains (> 2mm in size) comprised of bryozoa, brachiopoda and bivalva with few plates of crinoids Figure-5.8,-4.11. This microfacies belongs to (RMF 28) bioclastic grain floatstone microfacies which is present in the banks of inner ramp zone. This microfacies is observed in the upper part of the upper unit in Nazdor section and not observed in Ora section [8].

Packstone microfacies (6M)

This microfacies consists of micrite matrix which is affected by neomorphism to microspar. Other diagenesis is cementation inside the space of skeletal grains like the spines of brachiopods, while dissolution caused channel porosity, stylolites and partially dolomitization in some crinoid's plates. The bioclasts is mainly comprised of brachiopods, crinoid's plates, bivalvia, ostracods and few peliods which reflect shallow marine environment of platform interior especially at open marine zone Figure-5.9. This microfacies is formed as a result of densly packing of the bioclasts with unidirectional orientation indicates the deposition by tempestite storm event. This microfaciesis observed only in the lower most part and in the upper part of the upper unit in Nazdor section and not seen in Ora section.

This microfacies belongs to (RMF 14) packstone/grainstone with various bioclasts interpret as open marine zone of inner ramp environment [12].

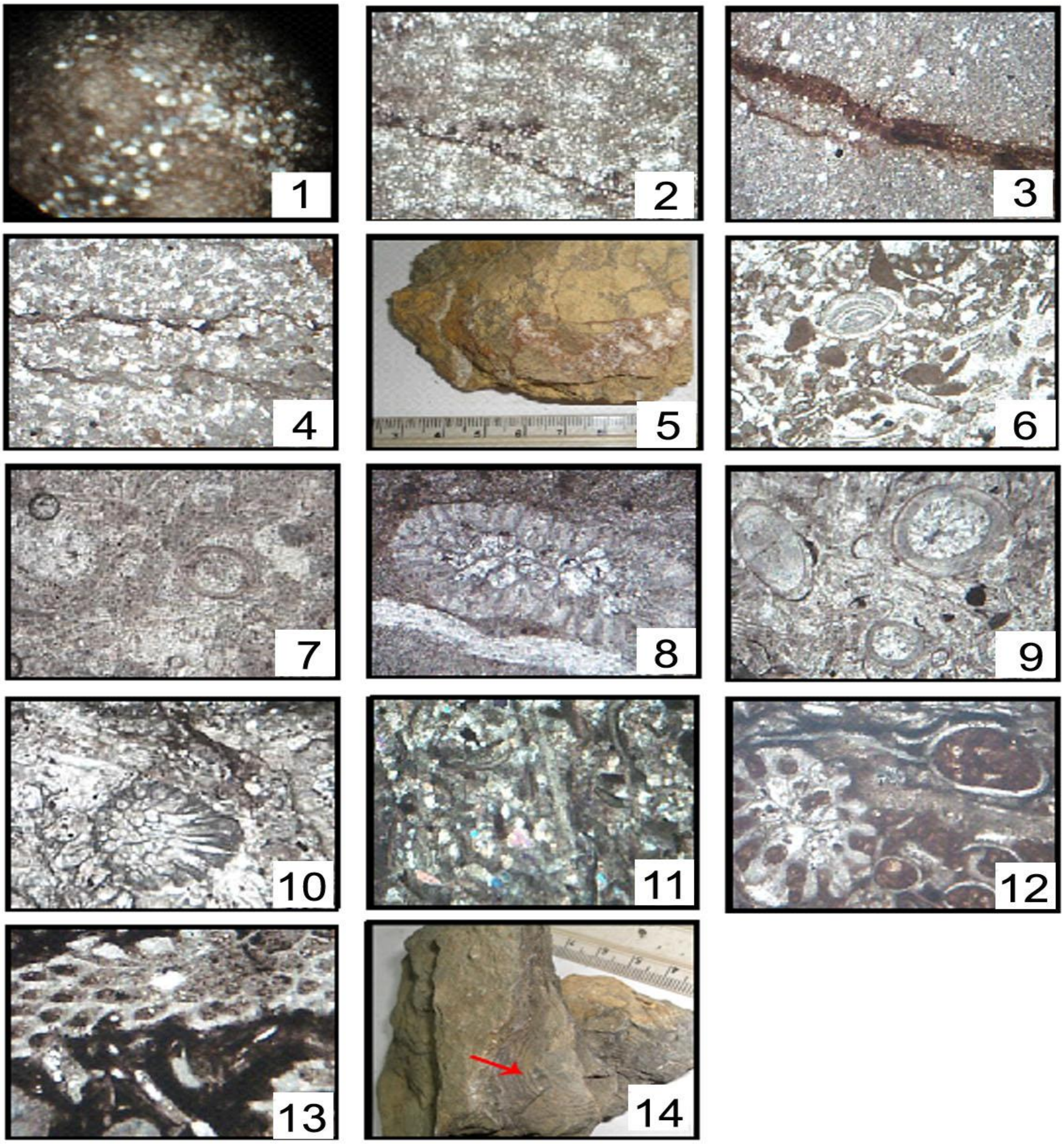


Figure 5.1-5.14-Photomicrographs show the microfacies of the limestone rock units of the Ora Formation

(1,2,3) Silty Mudstone Microfacies (1M) 28N-xpp, 29N-lpp, 30N-lpp. (4) Laminated Silty Peloidal Packstone Microfacies (2M) 32N-lpp, (5) Hand spasement of the lithoclastic breccias microfacies (3M) 39N, (6) Lithoclastic breccias microfacies (3M) 39N-xpp, (7) Wackstone microfacies (4M) 61N-xpp, (8) Floatstone microfacies (5M) 67N-xpp, (9) Packstone microfacies (6M) 65N-xpp, (10) Bryozoa grainstone microfacies (7M) 51N, (11) Sandy laminated grainstone microfacies (8M) 62N-xpp, (12) Grainestone/rudstone microfacies (9M) 72N-xpp, (13) Boundstone Microfacies (10M) 25O-xpp, (14) Spheroidal structure of stromatolite in the limestone of Ora section, sample no. 25 Ora section.

Bryozoa grainstone microfacies (7M)

The groundmass of this microfacies consists of sparry calcite cement. The bryozoa is the main abundent skeletal grains. Other bioclasts are ostracoda, crinoids plates and brachiopoda fragments, gastropoda and peliods. The diagenesis comprise cementation inside the skeletal grains; syntaxial cement, dolomitization and pressure solution patterns. This facies is characterized by abundance of syntaxial cement associated with crinoid's plates. Because of high compaction and cementation, there is no porosity were observed Figure-5.10.This microfaciesis observed only in the mid of the upper unit of Ora Formation in Nazdor section, and not observed in Ora section. This microfacies belongs to (RMF 27) bioclastic grainstone / packstone with few dominated skeletal grains interpret as shoals and banks zone in the inner and in the mid ramp [12].

Sandy Laminated Grainstone Microfacies (8M)

The groundmass in this microfacies consists of sparry calcite cement with diver's skeletal grains of ostracods, bryozoa and fragments of brachiopods. The laminated fabric is associated with the occurance of detritus fine to silt size quartz grains. Some of the bioclasts are coated and exhibited micrite envelopes or are completely micritized. Another identified grain types are rounded peloids Figure-5.11. This microfacies is characterized by lamination due to the current orientation of all elongated skeletal and sand grains. The fabric is characterized by densely packed, well sorted bioclast supported fabric deposited in storm conditions of tempestites above fair- weather wave base and at the storm wave base [12].

This microfacies is only observed in the mid of the upper unit in Nazdor section and not observed in the Ora section. This microfacies belongs to (RMF 26) grainstone / packstone deposited in the shoals and banks of inner ramp and in the mid ramp [12].

Grainestone / Rudstone microfacies (9M)

The groundmass of this microfacies is micrite and partially sparry calcite with some of the bioclasts which are characterized by coarse size (> 2mm). Many diagenetic processes are observed like dissolution, silicafication in the skeletal grains, pressure solution and neomorphism in some skeletal grains.The bioclasts are mainly composed of brachiopods, bivalva, large bioclasts of bryozoa colonies and large plates of cirinods as well as many grains of ostracods Figure-5.12.

This microfacies is identified in the upper unit of Nazdor section by the dissolution creats moldic porosity and intergranular porosity in the matrix. Some skeletal fragments are neomorphised to blocky sparry calcite cement and viens filled by calcite cement. The rudstone microfacies is observed commoly in the carbonate beds in the Ora and Nazdor section and is interbedded with other microfacies.

This microfacies is characterized by the occurrence of the tempestite storm deposition in some beds which was evident by the bioclast orientation. This microfacies may belong to (RMF 28) bioclastic floatstone and packstone exhibiting a strongly disorganized fabric, in shoals and banks of inner ramp [12].

Boundstone Microfacies (10M)

This microfacies is observed only in the Ora section. It consists mainly of bryozon colonies and other skeletal of very coarse crinoid's plates, brachiopods and ostracods. The zocia of bryozoa are filled with micrite matrix and is affected by dolomitization. The bryozon skeletals are composed of partially dolomitized calcite Figure-5.13, -4.7. There are stromatolites structures were observed in the hand specimens of this microfacies Figure-5.14. This microfacies represents the autochtonous reef rock formed by sessile benthonic organisms bounded at the time of deposition construct a rigid in three dimensional framwork [8, 18]. This microfacies belongs to (RMF 12) organic boundstone in the open marine inner ramp and in the mid ramp [15].

Sedimentary environment of the carbonate rock units of the Ora formation

The main depostational setting of the upper unit was the shallow marine carbonate environment. The evidences determined from types of organisms and the energy from wave and tidal currents. The source of the carbonate material is predominantly biogenic. The deposition was took place in the carbonate ramp model which are gently sloping platform on which shallow water deposits pass downslope with slight break in slope into deeper water facies. The facies belts are controlled by energy, levels fair weather wave base and storm wave base. The ramps are common during the phanerozoic in times when reef building organisms are missing or rare.The facies in this unit are distributed in three zone of ramp; inner, mid and outer. Inner ramp comprises the euphotic zone between the upper shoreface and the wave base, peritidel zone (Microfacies 1M), shoals and banks zone (Microfacies 5M, 7M, 8M, 9M), restricted zone (Microfacies 4M) and open marine zone (Microfacies 6M, 10M) . Mid ramp represents the zone lies below wave base and above storm wave base is characterized by the depositions of intraclasts and breccia (Microfacies3M). The outer ramp represents by the zone lies below storm wave base and characterized by the peloidal packstone (Microfacies2M). The interbedding of silicaclastic - carbonate facies, interprets lateral mixing facies, or sea level change and/or variations in sediment supply causing vertical variation in the lithological succession in shelf setting. Transitions from silicaclastic to carbonate sedimentation occur near coast inner shelf environment where rivers transport terrigenois material to the sea, and on low to high latitude shelves. This transition between the two depositional systems is largely controlled by climate, sea level and tectonic setting. The upper unit consists of carbonate rocks interbdded with siltstone and black shale. Areas of shallow marine carbonate are known as carbonate platforms occur in a wide various climatic and tectonic settings. The carbonate platforms have a different morphology and the carbonate units of the Ora Formation indicate that the deposition took place in carbonate ramp platform during period when reef development was not widespread, the tidal currents and waves are affected in all depths. The ramp can be divided into three depth zones; inner, mid and outer ramp. The inner ramp is the shallow zone mostly affected by waves and tidal action. Most of the microfacies of Ora Formatin in the study area were deposited in the inner ramp zone. Schematic block diagram shows paleoenviroment and the distribution of microfacies in the carbonate ramp platform Figure-6.

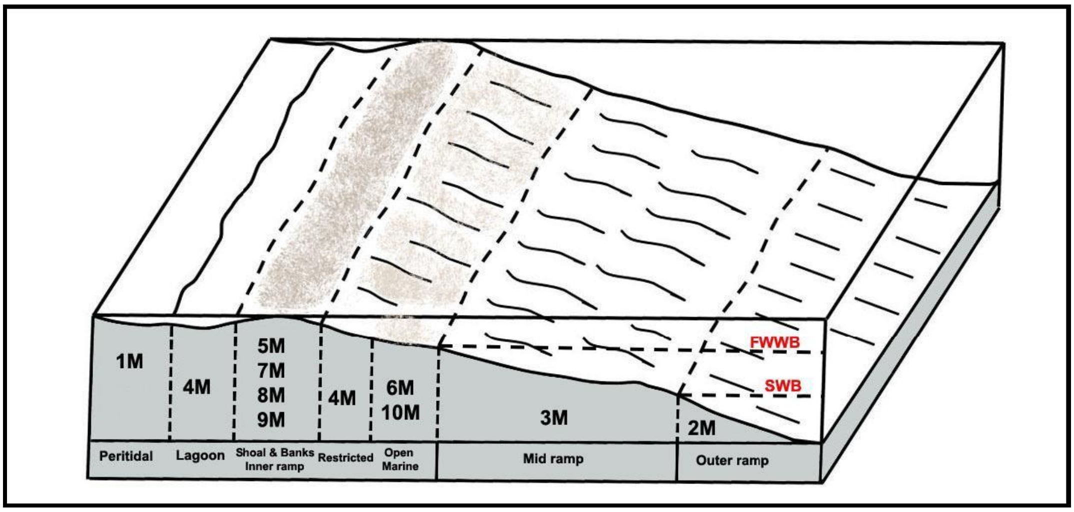


Figure 6- Schematic block diagram shows paleoenviroment and the distribution of microfacies in the carbonate ramp platform

Conclusions

Microfacies and environmental analysis of the late Devonian- Early Carboniferous Ora Formation, in Northern Iraq has been studied. Detailed field observation was carried out in Nazdor and Ora section and Petrographic studies and microfacies analysis have reveals the following conclusion.
Using Dunham's (1962) classification, and the modification of Embry and Klovan (1971). Ten microfacies types are recognizes; silty mudstone, laminated silty peloidal packston , lithoclast breccia, wackstone, floatstone, bryozoa grainstone, sandy laminated grainstone, grainstone/rudstoneand boundstone. Applying lithologic and paleontologic criteria; traditional and standard microfacies analysis, the depositional environment of the Ora Formation is concluded to be shallow marine environment. Facies analysis of the upper part in Nazdor and Ora sections indicates that the depositional environment is represented by different parts of the homoclinal carbonate ramp mainly in the inner ramp with little microfacies indicates mid and outer ramp.

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