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Depositional and Diagenetic Analysis of the Limestones in Iwerre Area, Part of the Afikpo Basin in the Southeastern Part of Nigeria

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Abstract The analysis of some limestone in Iwerre Area of Part of Afikpo Basin were undertaken to determine their depositional environment and diagenetic histories. Facies analysis and petrographic studies were employed to determine the depositional environment. Textural and mineralogical characteristics of the limestone were used to interpret the diagenetic histories. The result of the thin section revealed that allochems constitutes the major componenet ranging between 63% in location 2 to 82% in location 10; this corresponds to biosparite / packstone. The minimum value of allochems (27%) occurred at location 9 and is interpreted to be sparse biomicrite / wackestone. Other constituents such as micrite ranged between 5% at location 1 and 10 to 17% at location 2 with maximum high of 58% at location 9 while sparite range between 8% at location 10 and 20% at location 2. Biofacies identified in the study area include planktonic and benthonic foraminifera, ostracods, corals, peloids, oncolites, pellets and other shell fragments. From these, two microfacies types fossilferous packstone and micritic wackestone were inferred, and these were interpreted as restricted lagoon tidal flat.

Keywords Facies, allochems, fossiliferous, petrographic, micrite, sparite

Introduction

Depositional environmental interpretation is essential for the understanding of the ancient earth processes and in the reconstruction of the geologic past of any sedimentary basin. This is so because each rock strata (layer) is a repository of the physical, chemical and biological activities of geologic past with absolute and relative age signals. A diagrammatic illustration of the main sedimentary depositional environments is as shown in figure 1.

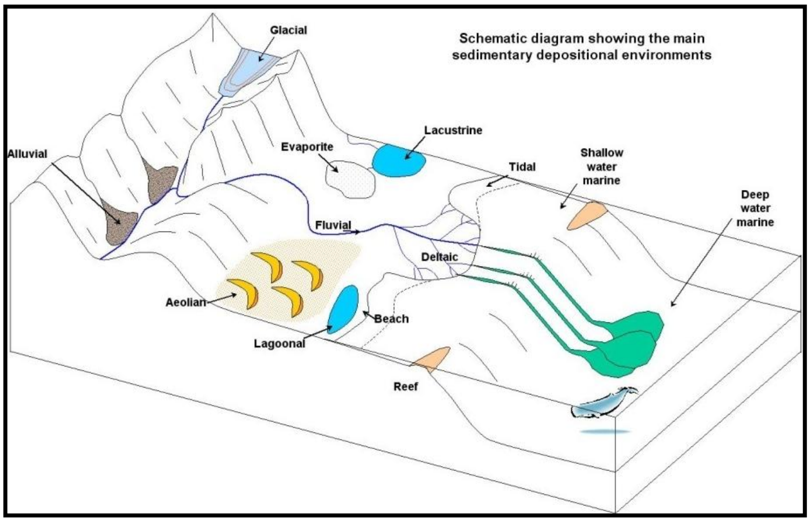


Figure 1: A Schematic Illustration of the Main Sedimentary Depositional Environments [1]

Diagenetic processes refers to all the processes, essentially physiochemical processes which sediments undergo after deposition before lithification takes place [2]. These processes are in responds to lack of chemical equilibrium of the mineral constituents in the rock which tends to alter physiochemically when there are changes in the interstitial water composition or temperature changes. Diagenesis differ from metamorphism in that diagenesis include relatively low pressure, low temperature alteration processes such as chemical alteration that replaces feldspar with a distinctly new mineral in its place while metamorphism is an alteration process that occur at a relatively high pressure and temperature.

Microfacies are characteristic and distinctive components of a sedimentary deposit that are only visible and identifiable under the microscope. The use of rock thin-sections are employed in the study of microfacies. The microfacies types in the rock thin section are largely descriptive and are defined on the basis of microfacies criteria whose presence and abundance are largely dependent on specific environmental factors that are linked to specific depositional settings; these include a combination of paleontology and sedimentology criteria.

Data for microfacies analysis and interpretation which included paleontological and textural data were interpreted in this study, based on the Standard Microfacies Types (SMF) and Standard Facies Zones (FZ) of the modified Wilson [3] model for depositional environment and diagenetic interpretation. The microfacies types were described and interpreted with emphasis on their depositional environment. The diagenetic characteristics of the studied rock samples were also inferred based on the textural relationships of the microfacies components while the different microfacies types identified in the studied rock samples were used for facies interpretation of the rock sequence for proper depositional environment interpretation. This work produced a relationship between the stratigraphic setting, microfacies types, and depositional environment of the studied rock units.

The studied area is located between latitudes 5° 24´N to 5° 28´N and longitudes 7° 49´E to 7° 52´E (fig. 2).

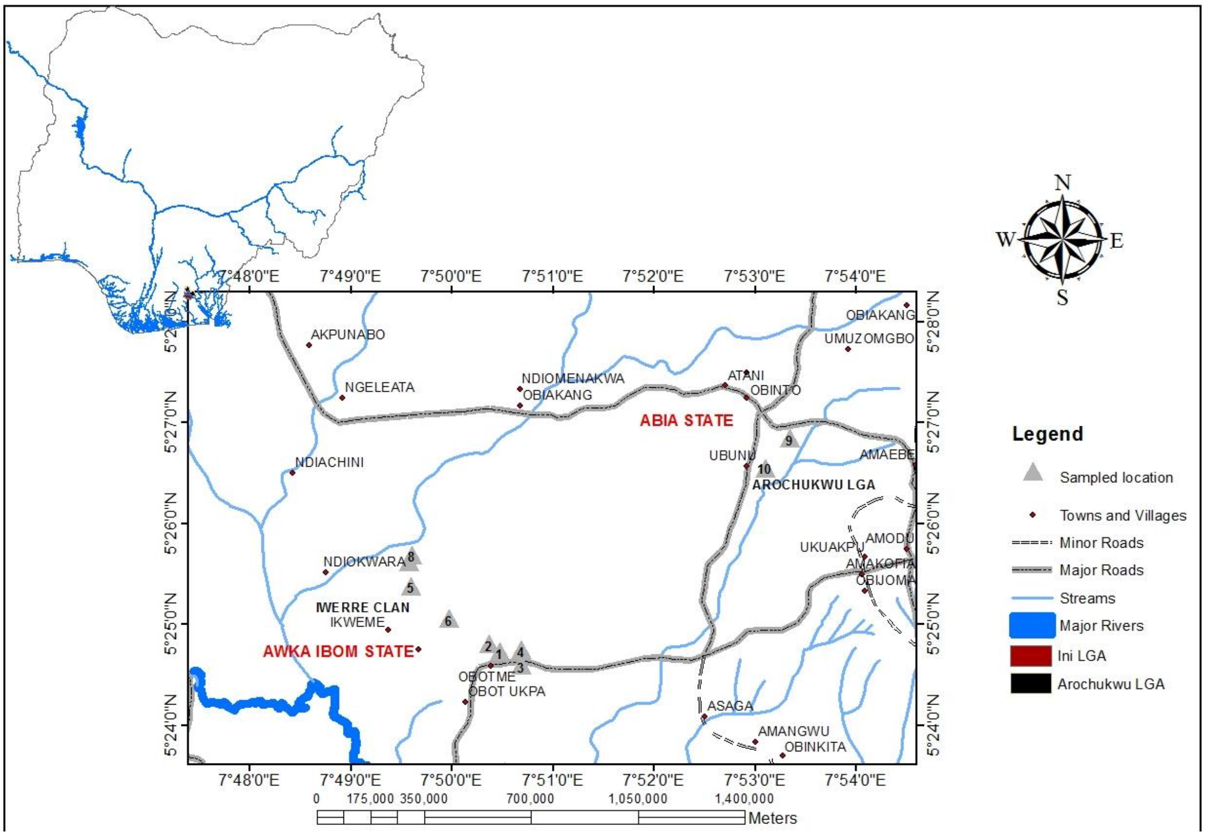


Figure 2: Location map of the study area showing sampled points

The study area (Iwerre) is part of the Afikpo basin in the southeastern part of Nigeria. The Afikpo basin was developed from the down warping following the Santonian tectonism according to Murat [4] and Peters [5]. After the uplift of the Abakaliki-Benue Trough as a result of the post Santonian deformation, sedimentation started in the Afikpo syncline with source sedimentary detritus from the Abakaliki uplift consisting of Campanian to Lower Maastrichtian deposits of the Nkporo Group which included Nkporo Shale, Enugu Shale,

Afikpo Sandstone and Owelli Sandstone. The lithological description of the Nkporo Group consists of dark gray shales, mudstones and occasionally thin beds of sandy shale, sandstone, shelly limestone and coal [6].
The stratigraphy of the Afikpo basin include the basal Campanian to Lower Maastrichtian Nkporo Group, overlain conformably by the Mamu Formation which consists of an intercalation of sandstones, shales, mudstones and sandy shale, carbonaceous shales and coal seams. The Mamu Formation is overlain conformably by the Mid-Maastrichtian Ajali Formation which consists of thick, friable, poorly sorted, medium to coarse-grained, smoky-white sandstones with distinctive mud drapes and burrows. The Ajali Formation is conformably overlain by the Late Maastrichtian to Danian Nsukka Formation which in turn is conformably overlain by the Paleocene Imo Formation. The stratigraphic chart showing the Afikpo basin is as shown in figure 3.

Age (my)		Abakaliki–Anambra Basin	Afikpo Basin
30	Oligocene	Ogwashi–Asaba Formation	Ogwashi–Asaba Formation
54.9	Eocene	Ameki/Nanka Formation/Nsugbe Sandstone	Ameki Formation
65	Paleocene	Imo Formation Nsukka Formation	Imo Formation Nsukka Formation
73	Maastrichtian	Ajali Formation Mamu Formation Nkporo/Owelli Sandstone/Enugu Shale (Including Lokoja Sandstone and Lafia Sandstone)	Ajali Formation Mamu Formation Nkporo Shale/Afik-po Sandstone
83	Campanian		
	Santonian	Agjbani Sandstone/Awgu Shale	Non–deposition/erosion
87.5	Coniacian		
88.5	Turonian		Ezeaku Group (Including Amasiri Sandstone)
93	Cenomanian–Albian	Ezeaku Group	
100		Asu River Group	Asu River Group
119	Aptian Barremian Hauterivian	Unamed units	
Precambrian		Basement complex	

Figure 3: Showing stratigraphic chart of Afikpo basin (after Nwajide, [7])

Method of Study

The methods adopted for the Depositional environment, diagenetic processes and microfacies analysis include

1. Systematic field investigation (both reconnaissance and detailed investigation),
2. Petrographic (thin-section) sample preparation and analysis.
3. Textural and mineralogical characteristics of the limestone were used to interpret the diagenetic histories.

Ten (10) samples collected from the Field investigation were subjected to thin section preparation. Sample locations 1 to 8 are within Iwerre in Ini Local Government Area of Akwa Ibom state while sample locations 9 and 10 are within Uburu Ihe area in Ihechiowa, Arochukwu Local Government Area of Abia state.
The thin section preparation was carried out in the laboratory where the rock samples were cut into 8 to 10 mm piece. The cut rock samples were mounted on already labeled glass slide using the epoxy resins. The rock set up is further cut into about 2.0 mm which is then grinded into 30µm, cleaned and ready for analysis.
Prepared thin section were analysis under a transmitted light microscope equipped with crossed polarizer. The carbonate rock constituent, which include grain size, texture, dominant groundmass constituent and depositional fabrics were recorded while the photomicrograph of the rock were also prepared.

Results and Discussion

Results

Results obtained include field photographs of outcrops (Figures 3 to 6), showing the field structural relationships and other depositional features that were recorded insitu at the time of field investigation. Other results generated included rock sample thin sections from where comprehensive petrographic analysis of each rock sample were carried out and presented in table.

The field investigation revealed that the limestone outcrops consist mostly of fossiliferous limestones with clastic (detrital) to non-clastic texture (Figure 4 and 5), the grains are of variable grain sizes, the limestones are consolidated but moderately hard, and light coloured.

Figure 4: Fossiliferous Limestone at Uburu Ihie

Figure 5: Scattered Limestone occurrences at Ekpreng

The limestone outcrops are widespread across the length and breadth of the studied area. The facies include bio-clastic to clastic limestones.

Bio-Clastic Limestone Facies:

Bio-clastic limestones include all the limestones formed from shells of dead marine organisms such as algae, coral and foraminifera (Figure 6). These bio-clastic limestones were seen at locations 1, 3, 5, 6, 8 and 10. The fossil contents included large benthonic foraminifera such as *Nummulites* and *Orbulina* species, other fossils included corals and shell fragments.

Clastic Limestone Facies:

Clastic Limestones are all the Limestones formed from cementation of sand and other weathered clastic materials by calcite (Figure 7).

Depositional features such as layering (bedding planes) are not conspicuous in most of the outcrop visited because of long time exposure of the outcrops, however, some of the outcrops showed clear and visible bedding planes.

Figure 6: Bio-clastic limestone (micritic) at Ikweme

Figure 7: Clastic Limestone at Edem Urua

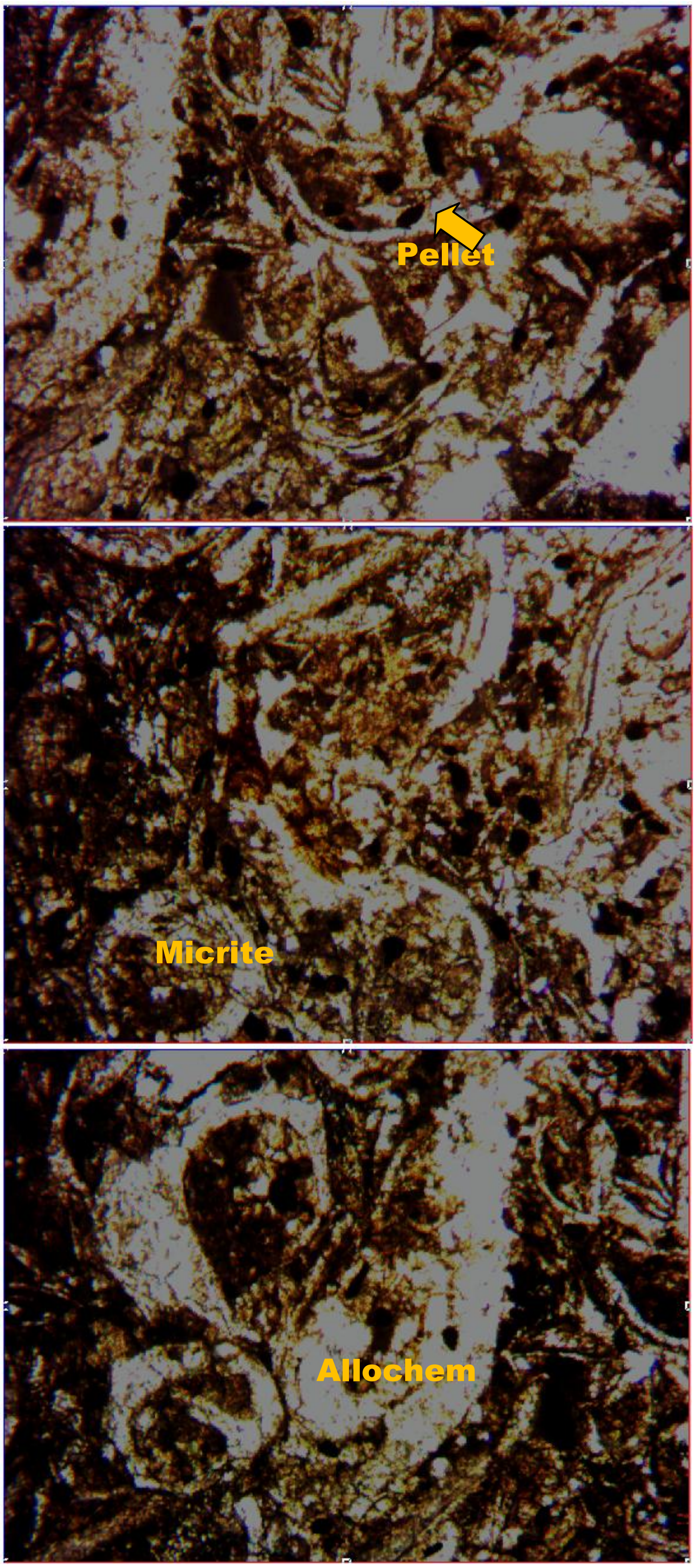


Figure 8: location 1 sample photomicrograph (magnification = 25x)

Petrographic Analysis Results

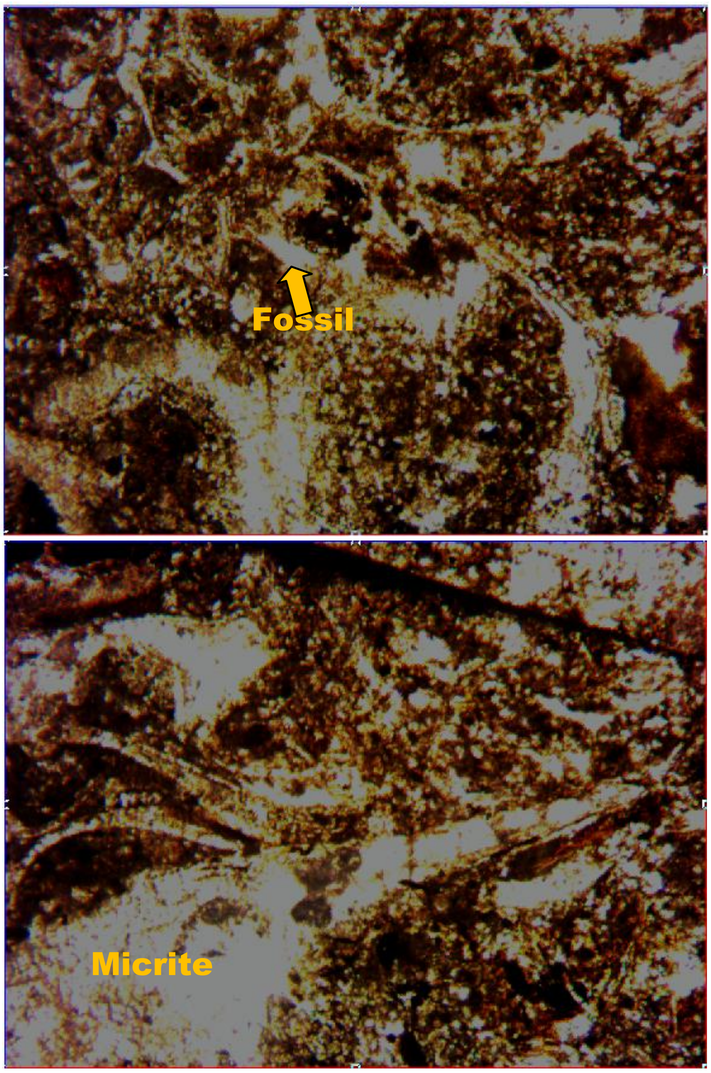
Three different types of limestones were identified in the study area following Folk [8] classification scheme, these include: - |Poorly washed biosparite, Packed biomicrite and Sparse biomicrite. They corresponded to two limestones types of the Dunham [9] classification scheme which are Packstone and Wackestone.

Poorly Washed Biosparite/Packstone Facies

This comprises of clastic, grain supported, brown to light coloured limestone, the grains are chiefly composed of fossils with shell fragments ranging in size between 0.02 to 1.3mm and burrows (trace fossils) which are rod – like, elongated structures. The inter and intraparticle voids (cavity porosity) are filled with lime mud (sparite). This limestone type was seen in locations 1, 3, 5, 6, 8 and 10.

In location 1, the limestone is made up of about 80% allochems comprising of 70% fossil, 15% sparite and 5% micrite. The fossils are recrystallized, brown with moderate relief and consists of mostly large benthonic foraminifera such as *Nummulites*, corals and other shell fragments. Other very conspicuous component identified include oncolite and peloids which appeared as opaque or black, isotropic grains with high relief and ranges between 0.03 to 0.07mm in size. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling as seen in figure 8.

In location 3, The limestone is made up of about 78% allochems comprising of 72% fossil, 15% sparite and 7% micrite. The fossils are recrystallized, brown with moderate relief and consists of mostly large benthonic foraminifera such as *Nummulites*, corals and other shell fragments. Other very conspicuous component identified include oncolite and few occurrences of peloids which appeared as opaque or black, isotropic grains with high relief and ranges between 0.03 to 0.07mm in size. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling as seen in figure 9.



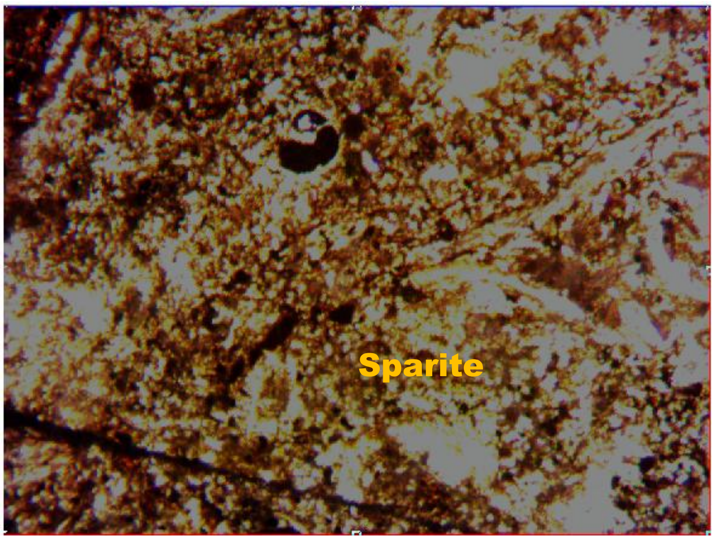
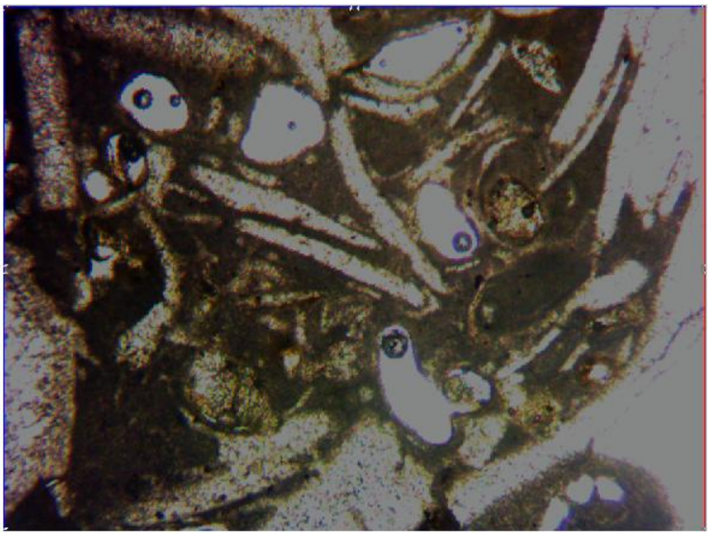


Figure 9: location 3 sample photomicrograph (magnification = 25x)

In location 5, The limestone is made up of about 80% allochems comprising of 83% burrow structures (trace fossil), 10% sparite and 7% micrite. The burrow structures (trace fossils) are recrystallized, brown with high relief. There is also presence of large benthonic foraminifera such as *Nummulites*, corals and other shell fragments. Other very conspicuous component identified include oncolite and peloids which appeared as opaque or black, isotropic grains with high relief and ranges between 0.03 to 0.07mm in size. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling as seen in figure 10.



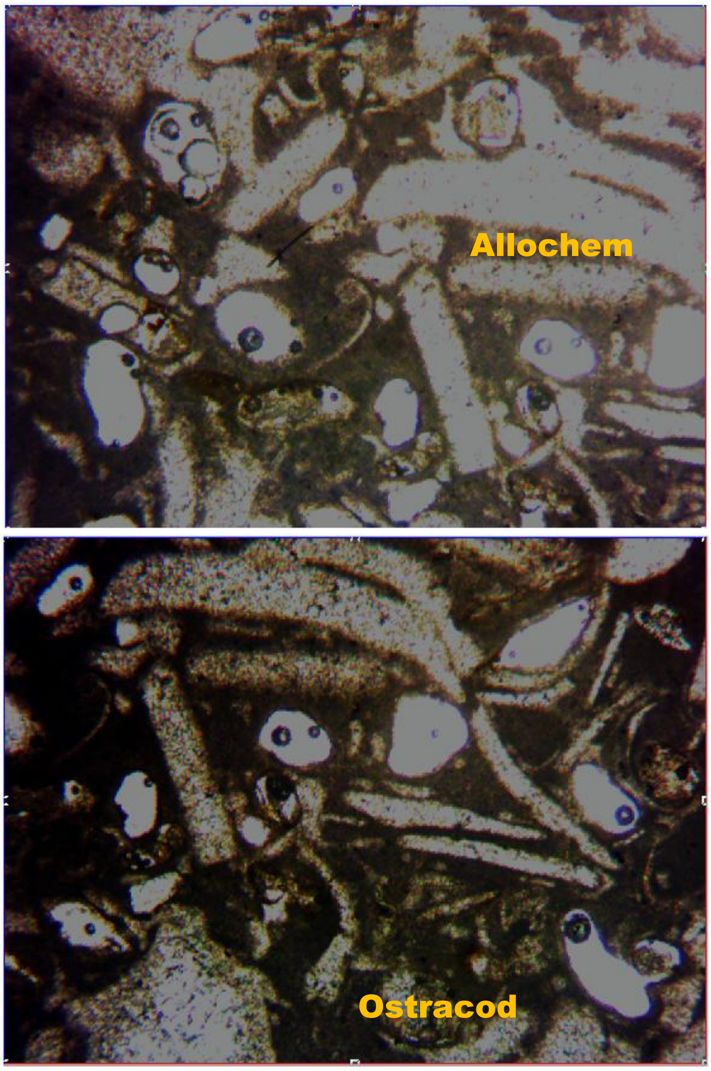


Figure 10: location 4 sample photomicrograph (magnification = 25x)

In location 6, the limestone is made up of about 78% allochems comprising of 63% burrow structures (trace fossil), 14% sparite and 8% micrite. The burrow structures (trace fossils) are recrystallized, brown with high relief. There is also presence of large benthonic foraminifera such as *Nummulites*, corals and other shell fragments. Other very conspicuous component identified include oncolite and abundant peloids which appeared as opaque or black, isotropic grains with high relief and ranges between 0.03 to 0.07mm in size. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling as seen in figure 11.

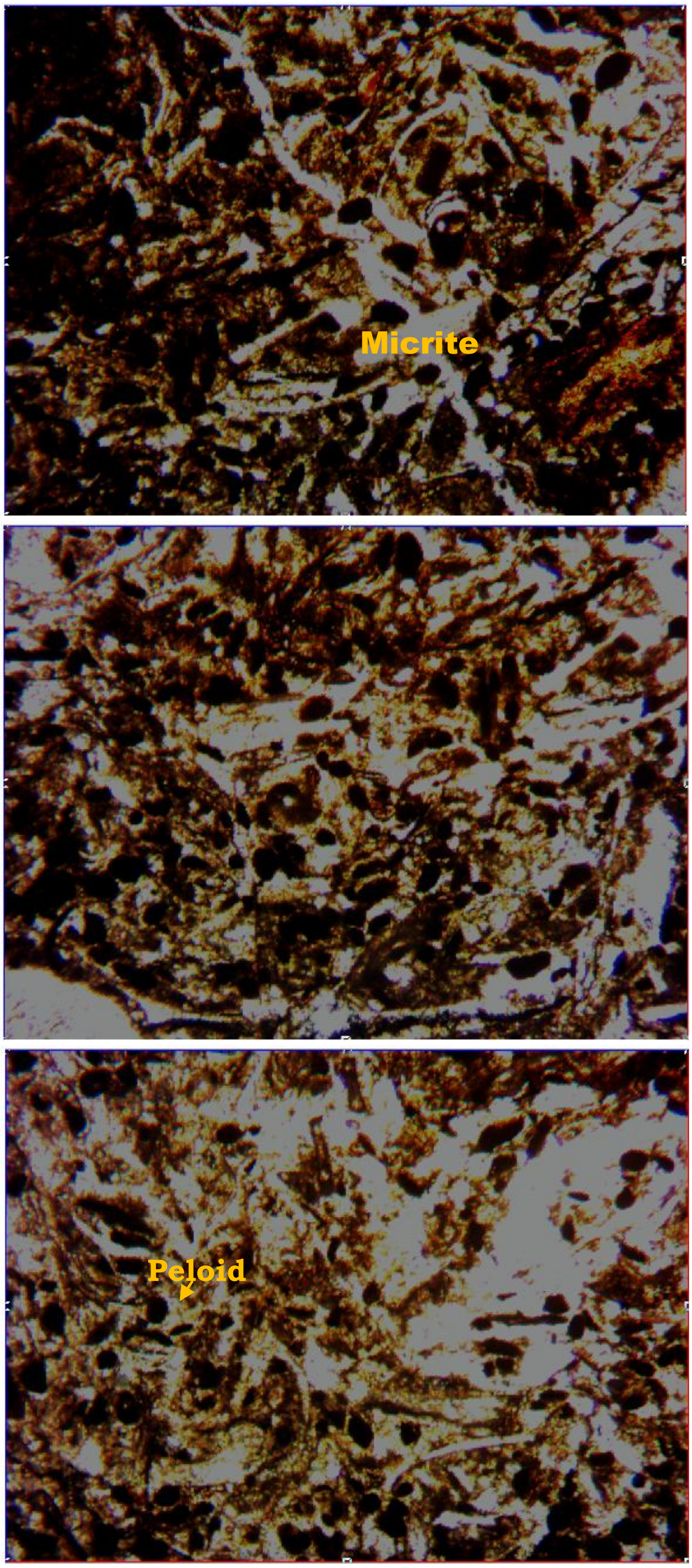


Figure 11: location 5 sample photomicrograph (magnification = 25x)

In location 8, the limestone is made up of about 81% allochems comprising of 74% burrow structures (trace fossil), 12% sparite and 7% micrite. The burrow structures (trace fossils) are recrystallized, brown with high relief. There is also presence of planktonic such as *Orbulina*, corals and other shell fragments. Other very conspicuous component identified include oncolite and rare occurrence of peloids which appeared as opaque or black, isotropic grains with high relief and ranges between 0.03 to 0.07mm in size. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling as seen in figure 12. The microfacies identified included *Orbulina*, corals, shell fragments and syntaxial overgrowth.

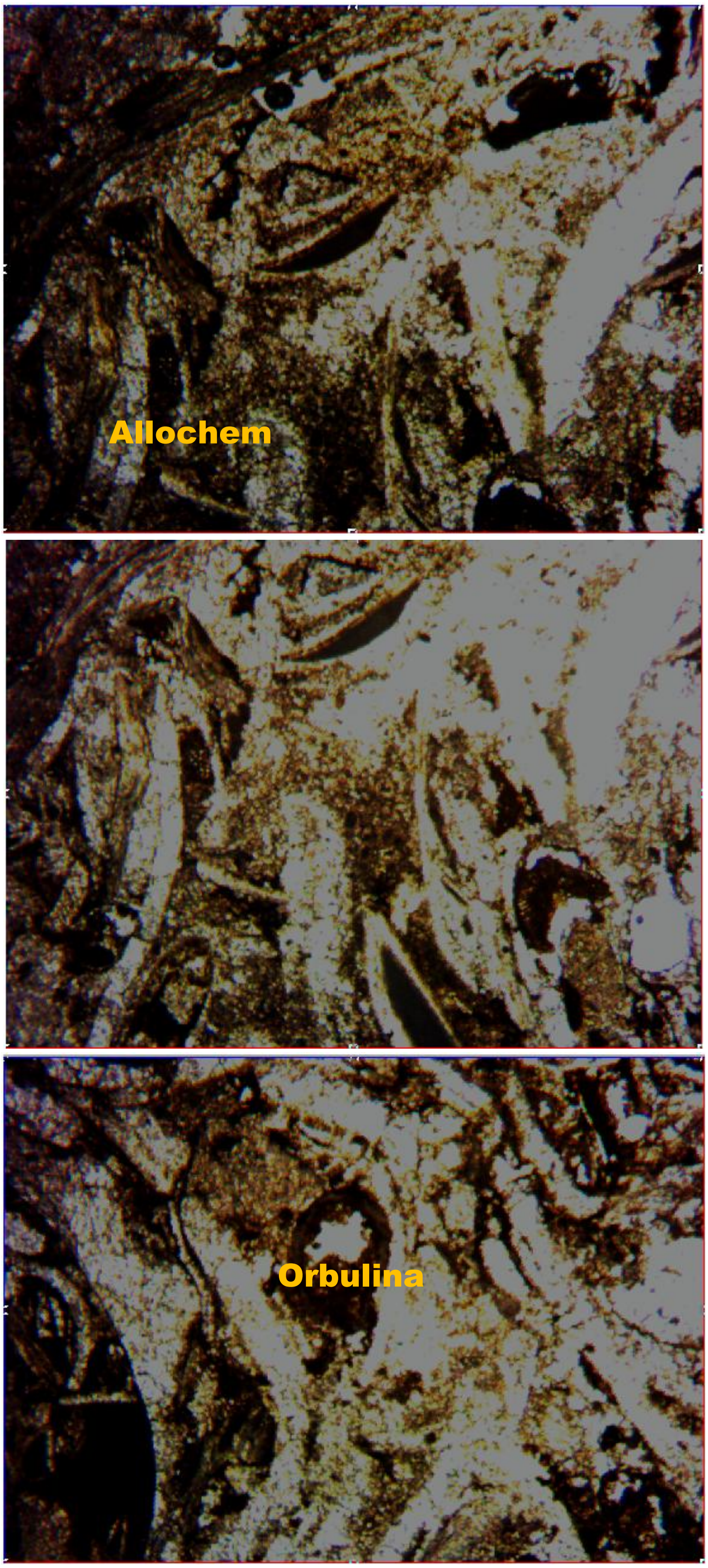
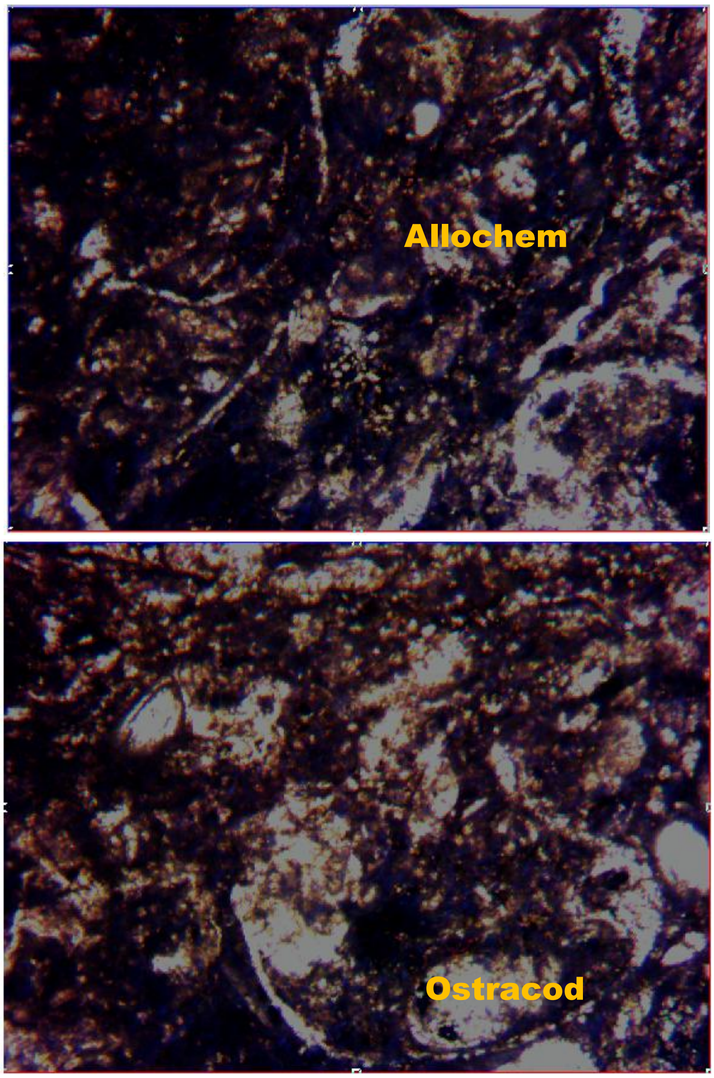


Figure 12: Location 7 sample photomicrograph (magnification = 25x)

In location 10, the limestone is made up of about 87% allochems comprising of 70% burrow structures (trace fossil), 8% sparite and 5% micrite. The burrow structures (trace fossils) are recrystallized, brown with high relief. There is also presence of large benthonic foraminifera such as *Nummulites*, ostracods, corals and other shell fragments. Other very conspicuous component identified include oncolite and rare occurrence of peloids which appeared as opaque or black, isotropic grains with high relief and ranges between 0.03 to 0.07mm in size. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling as seen in figure 13. The microfacies identified included *Nummulites*, Ostracods, corals and shell fragments.



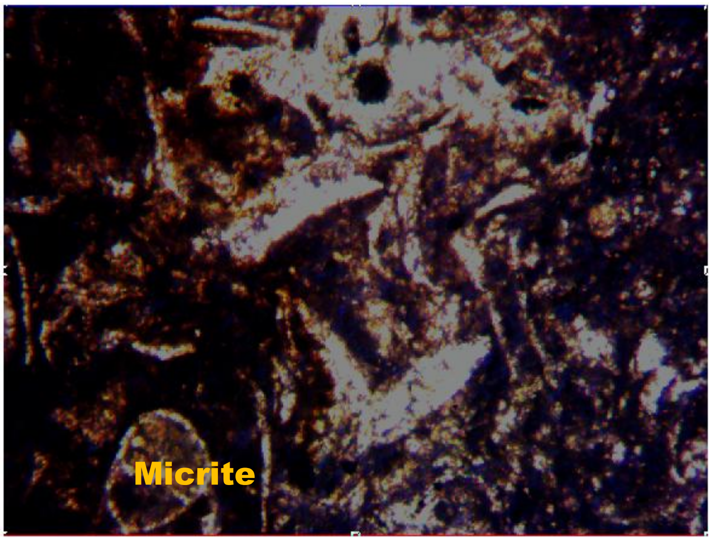


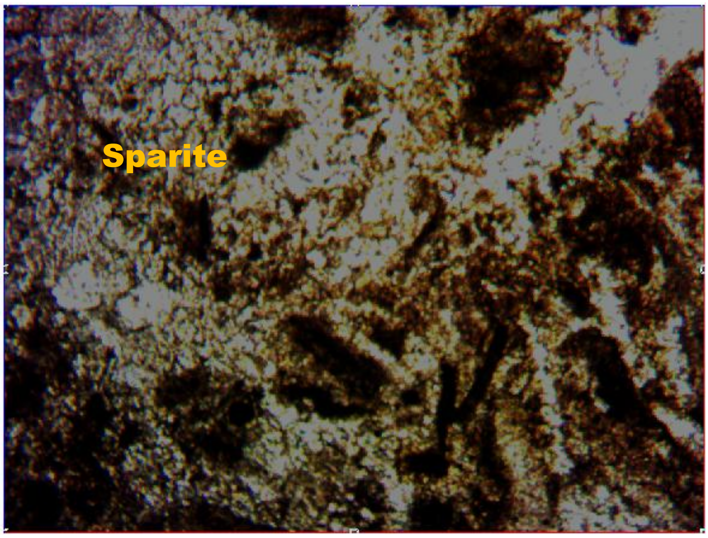
Figure 13: Location 9 sample photomicrograph (magnification = 25x)

Packed Biomicrite/Packstone Facies

The rock consists of clastic, grain supported, brown to light coloured limestone, the grains are chiefly composed of fossils with shell fragments ranging in size between 0.02 to 1.3mm and burrows (trace fossils) which are rod – like, elongated structures. the fossils appear to be in intact condition. The inter and intraparticle voids (cavity porosity) are filled with lime mud (sparite).

This limestone type was seen in locations 2, 7.2 and 11.1.

In location 2, the limestone is made up of about 80% allochems comprising of 63% fossil, 20% sparite and 17% micrite. The fossils are recrystallized, brown with moderate relief and consists of both planktonic such as *Orbulina* and large benthonic foraminifera such as *Nummulites*, corals and other shell fragments. Another very conspicuous component identified is the oncolites but with rare occurrence of peloids. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling as seen in figure 14.



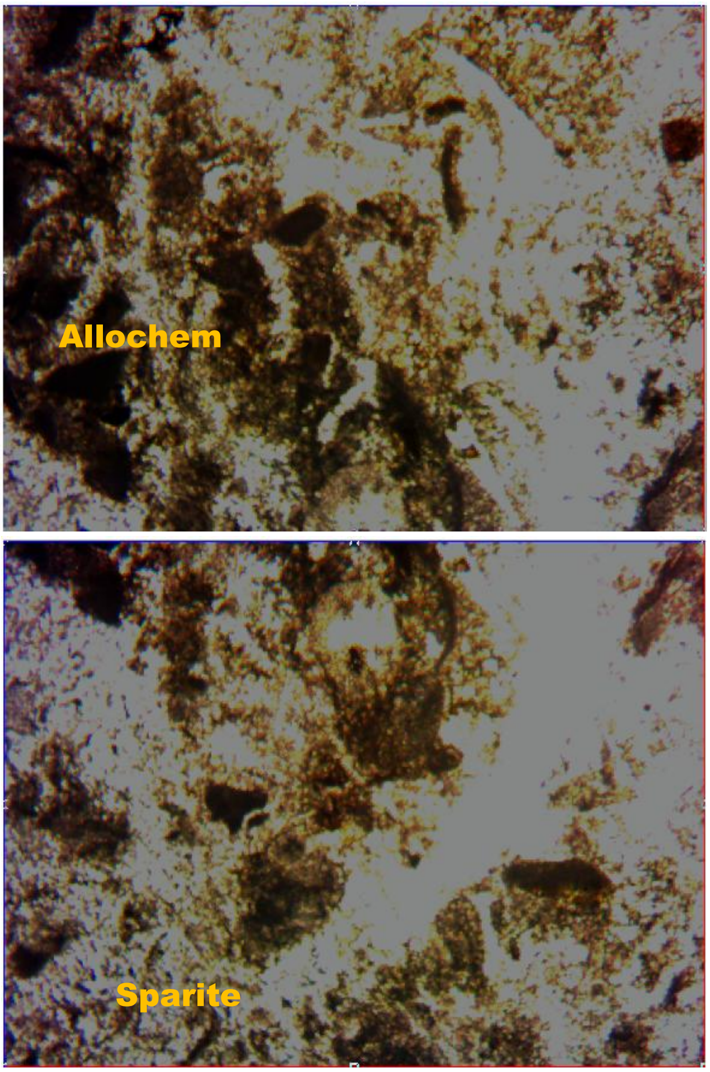


Figure 14: Location 2 sample photomicrograph (magnification = 25x)

In location 7, the limestone is made up of about 74% allochems comprising of 60% burrow structures (trace fossil), 16% sparite and 10% micrite. The burrow structures (trace fossils) are recrystallized, brown with high relief. There is also presence of large benthonic foraminifera such as *Nummulites*, corals and other shell fragments. Other very conspicuous component identified include oncolite and fairly abundant peloids which appeared as opaque or black, isotropic grains with high relief and ranges between 0.03 to 0.07mm in size. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling as seen in figure 15. The mictofacies are made up of *Nummulites*, corals and other shell fragments.

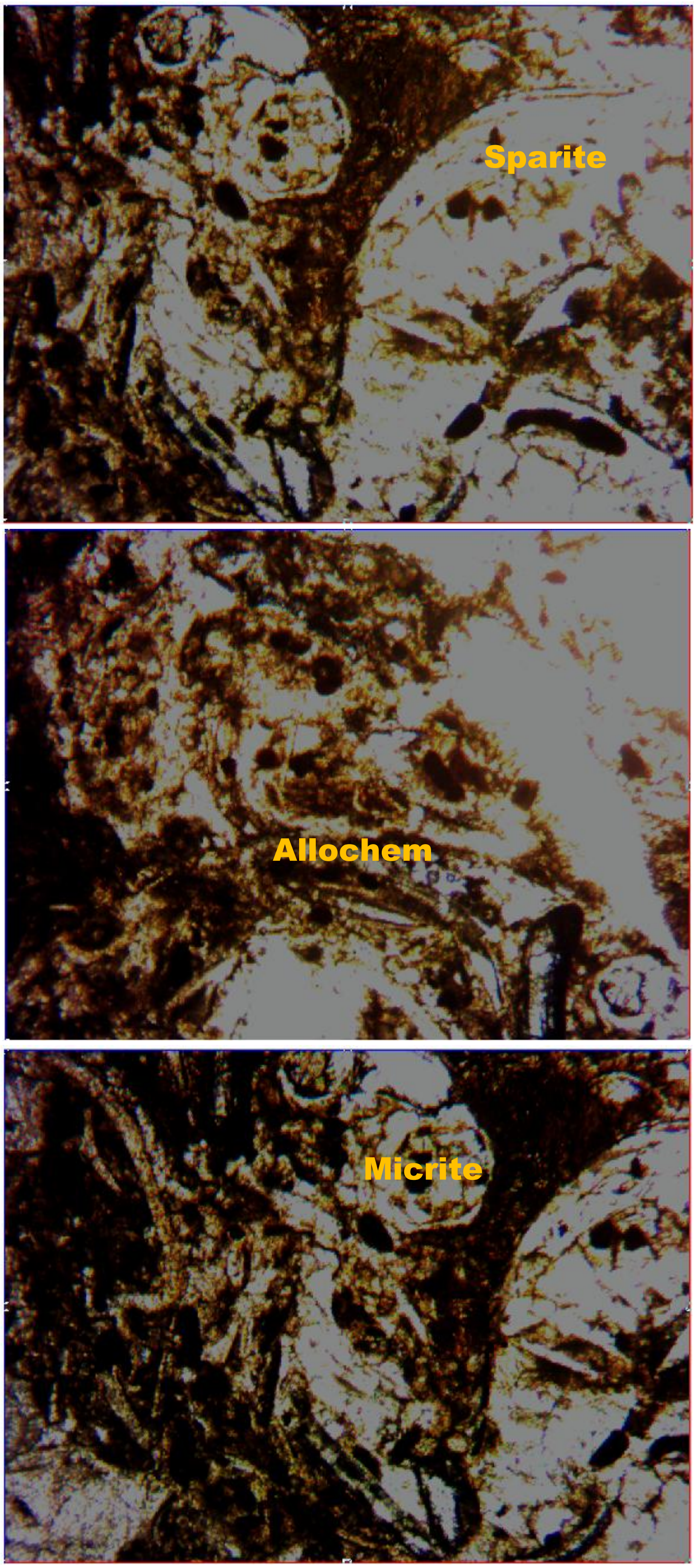


Figure 15: Location 6 sample photomicrograph (magnification = 25x)

In location 11, the limestone is made up of about 73% allochems comprising of 60% burrow structures (trace fossil), 17% sparite and 10% micrite. The burrow structures (trace fossils) are recrystallized, brown with high relief. There is absence of large benthonic foraminifera such as *Nummulites*, ostracods, but presence of corals and other shell fragments. Other very conspicuous component identified include oncolite and rare occurrence of peloids which appeared as opaque or black, isotropic grains with high relief and ranges between 0.03 to 0.07mm in size. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling. The photomicrograph of location 11 sample thin section is shown in figure 16.

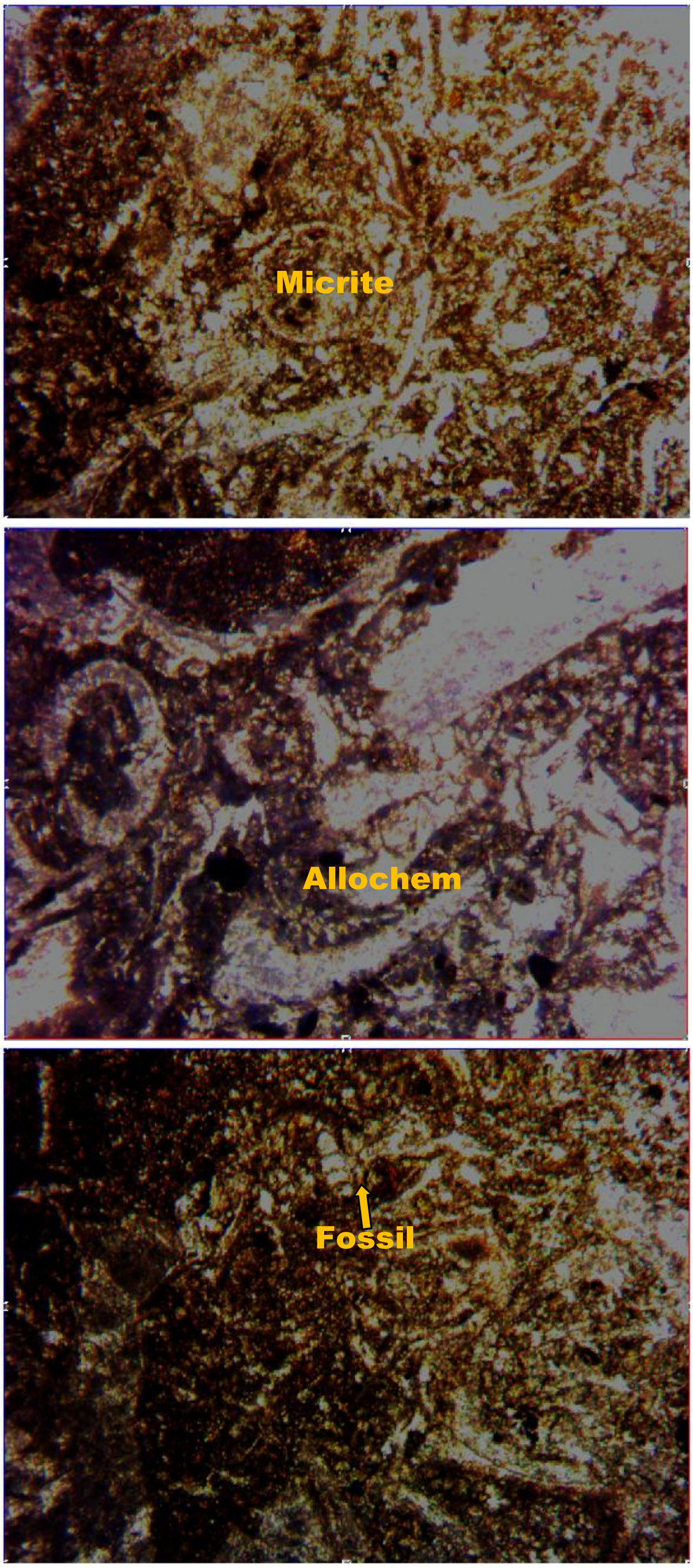
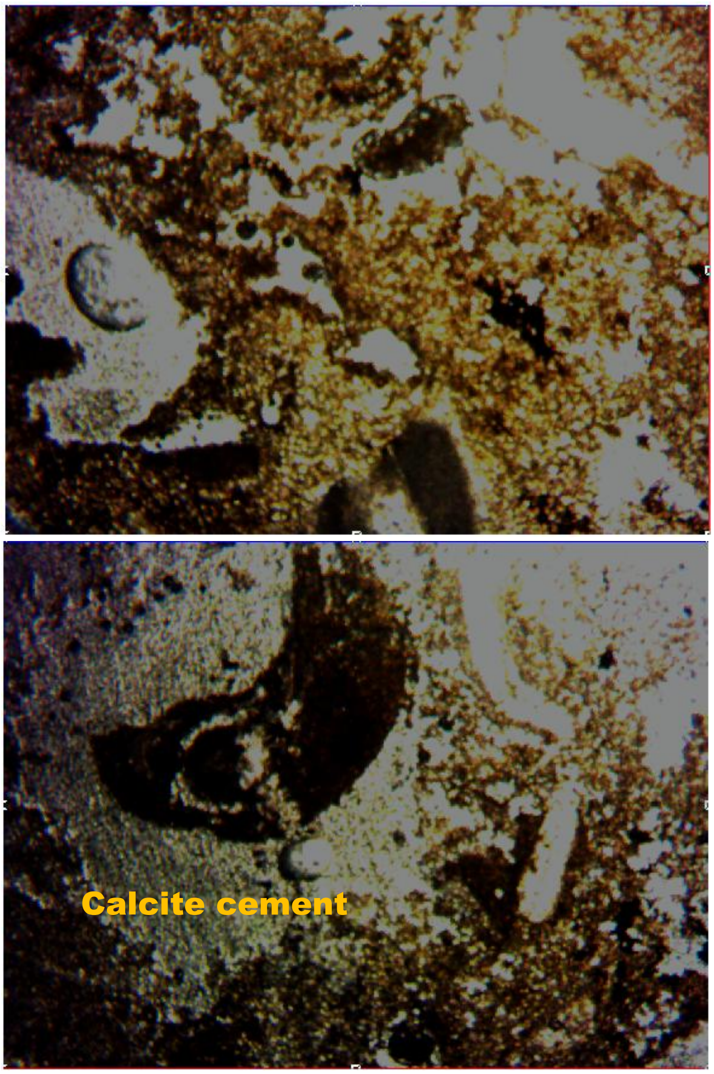


Figure 16: Location 10 sample photomicrograph (magnification = 25x)

Sparse Biomicrite/Wackestone Facies

This rock unit composed of clastic, grain supported, brown to white limestone, the grains are detrital made up of burrows (trace fossils) which are rod – like, elongated structures. The inter and intraparticle voids (cavity porosity) are filled with lime mud (sparite). It only occurred in locations 9.

The limestone is made up of about 27% allochems comprising of 79% burrow structures (trace fossil), 15% sparite and 58% micrite. The burrow structures (trace fossils) are recrystallized, brown with high relief. There is no presence of both planktonic such as *Orbulina* or large benthonic foraminifera such as *Nummulites*, but few corals and other shell fragments. Other very conspicuous component identified include oncolite and very few peloids which appeared as opaque or black, isotropic grains with high relief and ranges between 0.03 to 0.07mm in size. The micrite are colourless and appears with variable relief while the sparite are colourless but with moderate relief and appears to be cavity filling as seen in figure 17. The microfacies identified included *Orbulina, Nummulites,* corals and shell fragments.



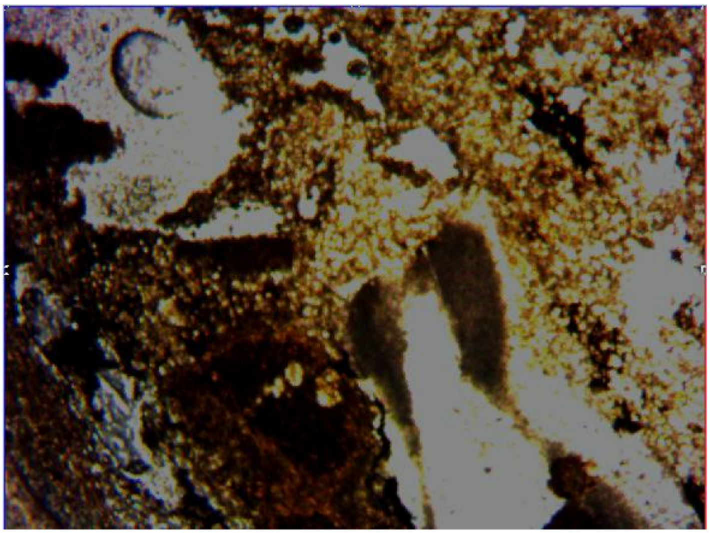


Figure 17: Location 8 sample photomicrograph (magnification = 25x)

The summarized petrographic analysis for all the sampled location with Folk [8] and Dunham [9] carbonate rock classification scheme is presented in table 1.

Table 1: The petrographic analysis of thin sections of the samples from the study area

Sample Location	Main components			Composition of the grains					Folk [8]	Dunham [9]
	Allochem	Micrite	Sparite	Ooids	Peloids	Oncolites	Pellets	Fossils		
1	80	5	15	0	8	14	8	70	Poorly washed Biosparite	Packstone
2	63	17	20	0	3	25	5	67	Packed Biomicrite	
3	78	7	15	0	4	18	6	72	Poorly	
5	83	7	10	0	1	10	3	86	washed	
6	78	8	14	0	30	3	4	63	Biosparite	
7	74	10	16	1	23	13	3	60	Packed Biomicrite	
8	81	7	12	0	2	21	3	74	Poorly washed Biosparite	
9	27	58	15	0	1	14	6	79	Sparse Biomicrite	Wackestone
10	87	5	8	0	2	23	5	70	Poorly washed Biosparite	Packstone
11	73	10	17	0	1	28	11	60	Packed Biomicrite	

Discussion

The petrographic analysis of the rock samples from the thin section revealed the sedimentary constituents of the limestone studied. In all the samples studied, allochems constitutes the chief component of the rock constituent ranging between 63% in location 2 to 87% in location 8 and its interpreted to be biosparite according to Folk [8] and packstone according to Dunham [9] classification. The minimum value of allochems (27%) occurred at location 7 which corresponded to Folk [8], sparse biomicrite and Dunham [9] wackestone. Other constituents such as micrite ranged between 5% at location 1 and 9 to 17% at location 2 with maximum high of 58% at location 8 while sparite ranged between 8% at location 9 and 20% at location 2. Fossil is the major constituent of the allochem in all the samples analyzed with few peloids, oncolites and pellets. The fossils included mostly burrows (which are traces of biological activities), foraminifera (mostly *Nummilites*), gastropods and bivalves shell fragments. The burrows are elongated tubular structures with recrystallized calcite crystals. The oncolites are spherical structures formed from cyanobacterial growth which were formed around the shell fragments. The pellets are spherical to ovoid but small rod like shaped and lacking radial structure with a remarkable uniform shape. The peloids are mostly of carbonate mud, most of which were micritized clastic materials and pebbles.

The results from field investigation as well as petrographic analysis of the limestone samples were essentially useful in discussing the depositional environment and diagenetic processes affecting the limestones. The depositional environments which are defined as specific place where sediments are deposited were discussed following the microfacies assemblages recognized within the rock samples.

Wilson [3] developed nine (9) carbonate facies belts as a results of changes in sedimentology and biology that cut across shore to basin, twenty-four (24) standard microfacies types which are results of combination of paleontology and sedimentology**.** These facies belt were identified in the study area from where the depositional environments were inferred. Allochem are the main constituent of the limestone samples which were mostly from paleontology (fossil) and partly from sedimentology (oncolites, peloids etc).

Diagenesis encompasses all the physicochemical, biological and physical processes affecting sediments between the times of deposition to lithification. Diagenesis in limestones are seen in the textural and mineralogical character of the constituent elements of the limestone. They occur in the form of cementation, micritization, neomorphism, dissolution, compaction and dolomitization.

Depositional Environment

The microfacies types identified in the limestone on which the depositional environment was delineated are based on the combination of paleontology which included the planktonic and benthonic foraminifera, ostracod, corals and other shell fragments, and those from sedimentology which include the peloids, oncolites and pellets. Two microfacies types were identified in the studied area, they are the fossiliferous packstone and micritic wackestone.

The Fossiliferous packstone microfacies association was recognized in locations 1, 2, 3, 5, 6, 7, 8, 10 and 11. It consists of brown to light coloured limestone. The paleontological component included foraminifera either planktonic (*Orbulina*), or large benthonic (Nummulites) or both with corals, ostracods and other shell fragments. The sedimentologic components were those that were originally bounded, such as peloids and pellets. It corresponded to Wilson [3] facies belt No. 8. This is interpreted to be a depositional environment of restricted lagoon tidal flat.

Thw Micritic wackestone microfacies association was recognized only in location 2 and 9. It consists of brown to light coloured limestone. The paleontological component include few corals and other shell fragments while the sedimentology components include those that were original bounded such as peloids. This microfacies type also corresponded to Wilson (1975) facies belt N0. 8, ant it is interpreted to be a depositional environment of restricted lagoon tidal flat as illustrated in figures 18 and 19.

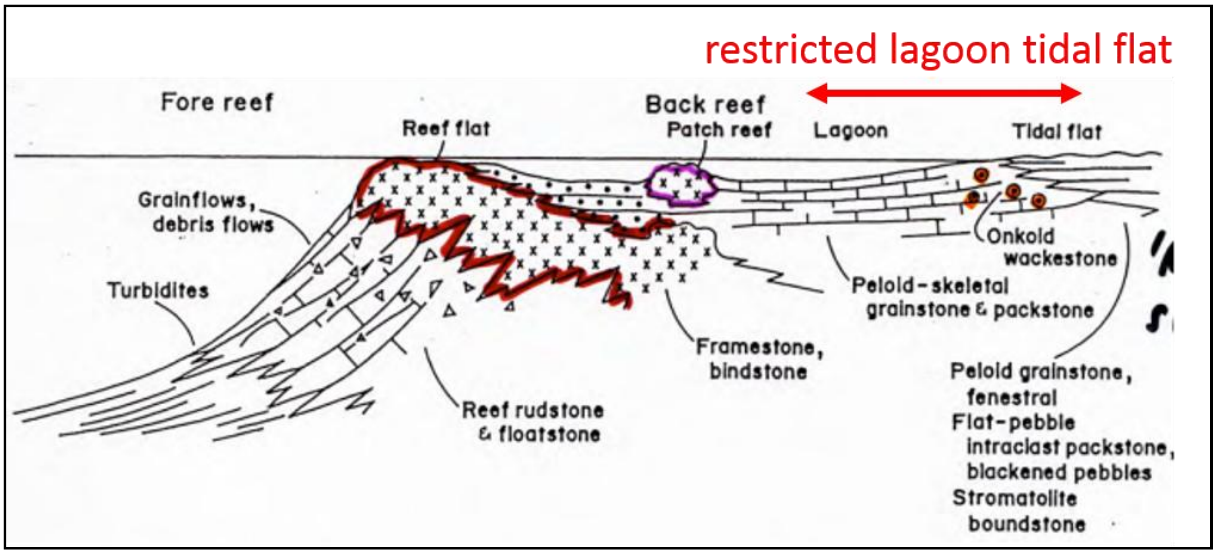


Figure 18: Carbonate models showing depositional environment modified from Tucker [1]

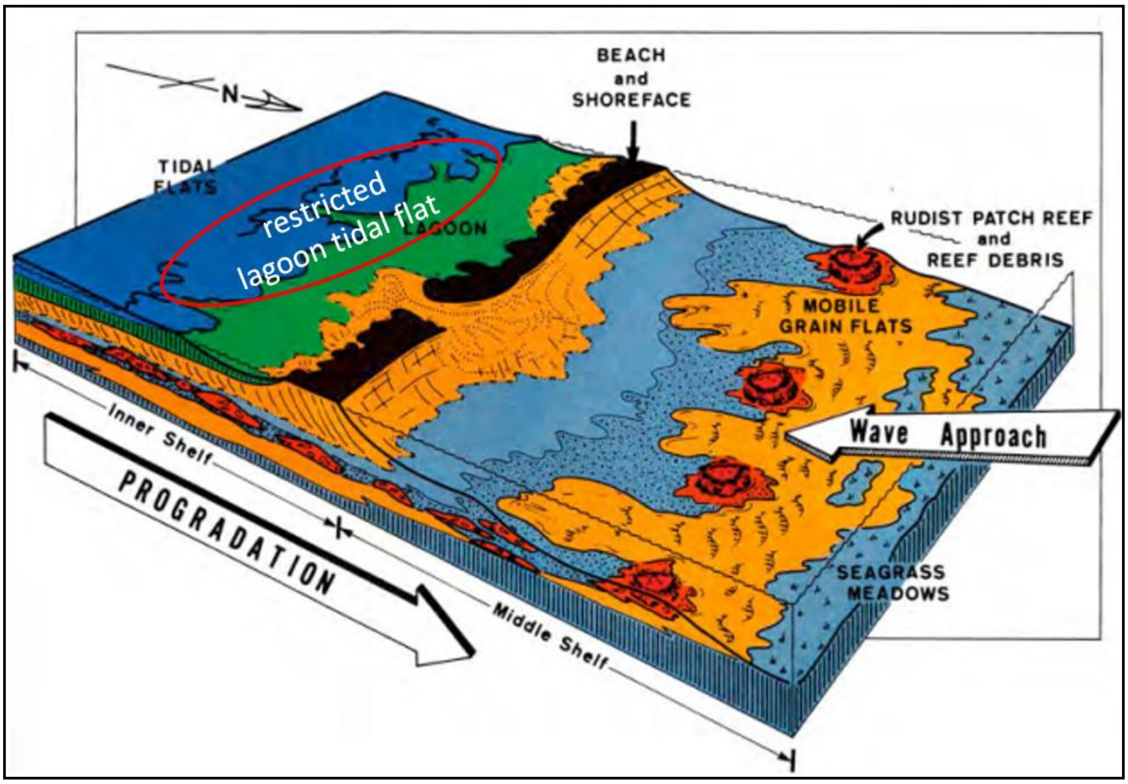


Figure 19: Showing depositional model modified from Kerr and Jirik [10]

Carbonate Facies Association

There are various depositional settings in which carbonate rocks accumulates forming specific carbonate facies characteristic of the depositional setting. These carbonate facies are essentially, the product of certain processes that are prevalent in the depositional setting at the time of deposition. Other natural occurring activities that affect the character of the carbonate rock formed include temperature, wind, water depth, waves, water chemistry, currents, and biological activities [3]. After the carbonate rocks are formed, diagenesis sets in to modify the carbonate rock facies in the subsurface. On the basis of depositional settings, carbonate facies are grouped in response to base level changes and type of sediment accumulation as shown in table 2, and figure 20.

Table 2: Depositional settings for carbonate facies with their corresponding sediment types

Depositional setting	Type of deposit
Basin and slope	Pelagic sediments.
	Turbidites and debris flows
Platform margin	Reefs and organic buildups
	Sand shoals
Platform interior	Epeiric sea, lagoon or bay
	Tidal flats
Terrestrial	Dunes, lakes, cave deposits, soils, fanglomerates

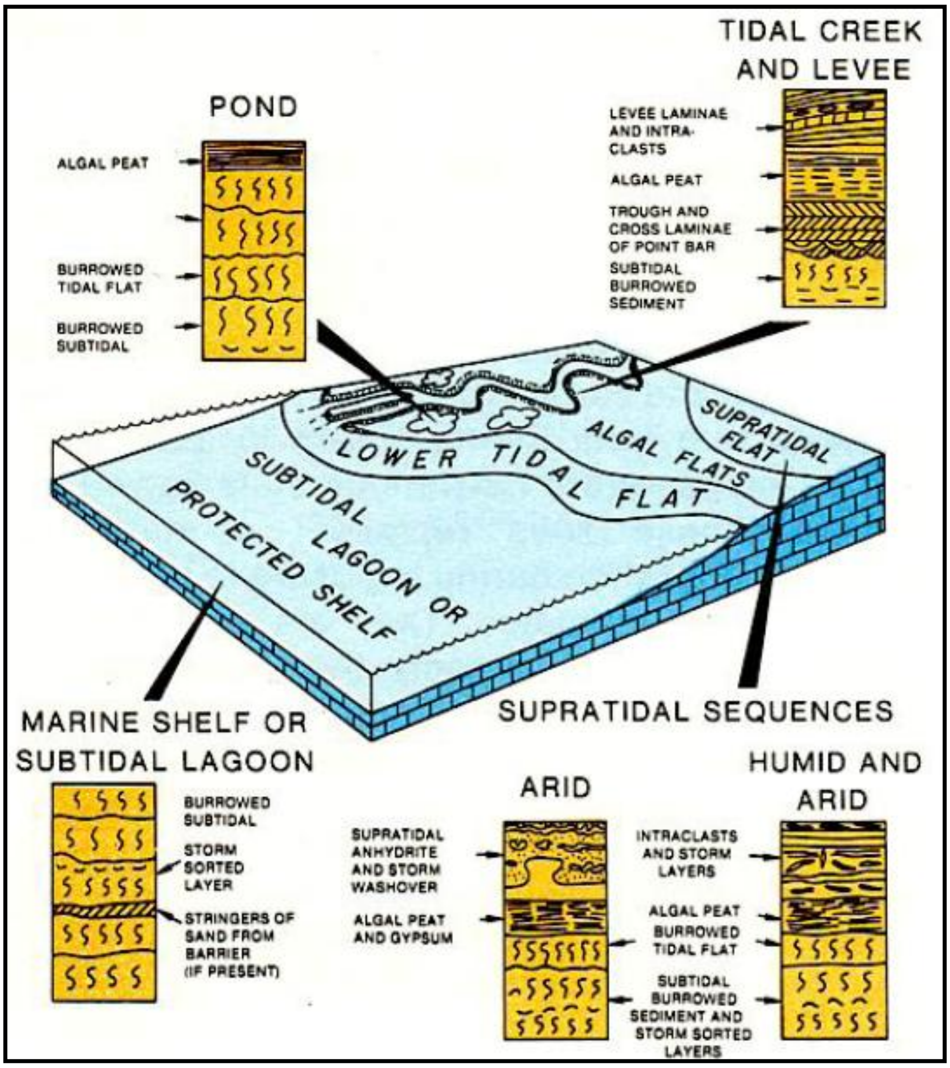


Figure 20: Depositional settings for carbonate facies with their corresponding sediment types after (Reading, [11])

Platform Interior

This microfacies type identified in the studied area compared favorably well with Wilson [3] facies belt No. 8 which is interpreted as a depositional environment of restricted lagoon tidal flat. This corresponded to the platform interior carbonate facies consisting of the Epeiric Sea, Lagoon or |Bay. The platform interior depositional setting is bounded by shallow sea, reefs or carbonate sand barriers. It is characterized by poorly sorted sediments with common occurrence of extensive burrows. These poorly sorted sediments are results of winnowing activities of wave current on insitu or transported materials. The faunal remains which form the microfacies components in the platform interior carbonate facies decreases from the normal marine setting due to high salinity to stromatolites and mats towards the landward margins of Epeiric Sea where there is highest salinity. The facies component identified in the studied area are lime muds, clean carbonate sands and muddy skeletal sands which are characteristic of the shallow water. The sand form the flat in which the lime mud is winnowed, the grains identified in the studied area are mostly pellets and oncolites. The faunal abundance is very low but a little diverse.

Diagenetic Processes

Diagenetic processes affecting the limestones in the study area can be observed in the textural and mineralogical characteristics of the limestone in the thin sections. Essentially, five diagenetic processes were observed affecting the limestones. There are cementation, micritization, neomorphism, dissolution and compaction.

Cementation

According to Adams and McKenzie [12], cementation is a process of precipitation of space by filling crystals. Safer et al [2] explained cementation as a very important diagenetic process that helps in transforming weak sediment to a hard limestone. The cement identified in the studied area consists of the early diagenetic cement known as the fibrous cement [13]. This type of cement occurs in packages of calcite crystals surrounded in micrite. In the studied thin sections, the fibrous aragonite cement is seen as been replaced by fibrous calcite cements (figure 21). The calcite cement formed meniscus between grains as very fine-grained micritic cement. Most of the spores that were not filled during the early stage were filled by sparry calcite.

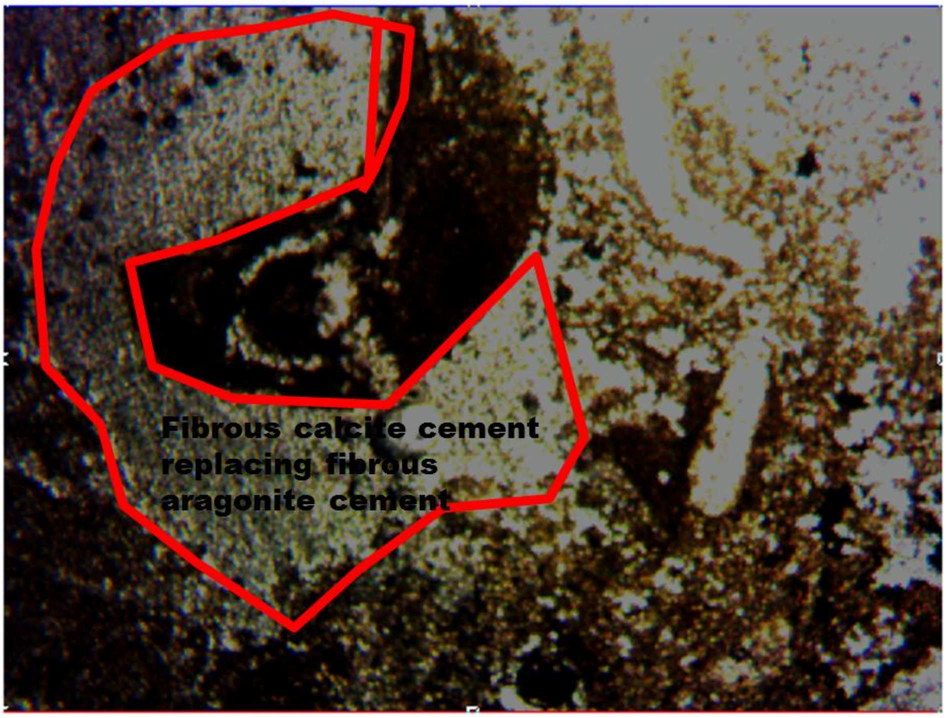


Figure 21: A photomicrograph of limestone of the studied area (loc. 9.2) showing the framework grains replaced with fibrous cement and relics of ooids and grains welded by sparry calcite

Micritization

This is the process whereby the carbonate grain margins are replaced by micrite around the sediment water interface, it occurs as an early stage diagenetic processes in marine sediments. According to Reid et al [14], it is the result of recrystallization of skeletal carbonate material contemporaneous with deposition. This is enhanced by boring activities of microorganism which enhances precipitation of inorganic materials in warm, saline shallow water under low energy condition [8]. This is dominant in all the sampled location following the high boring seen as trace fossils in the study samples (figure 22).

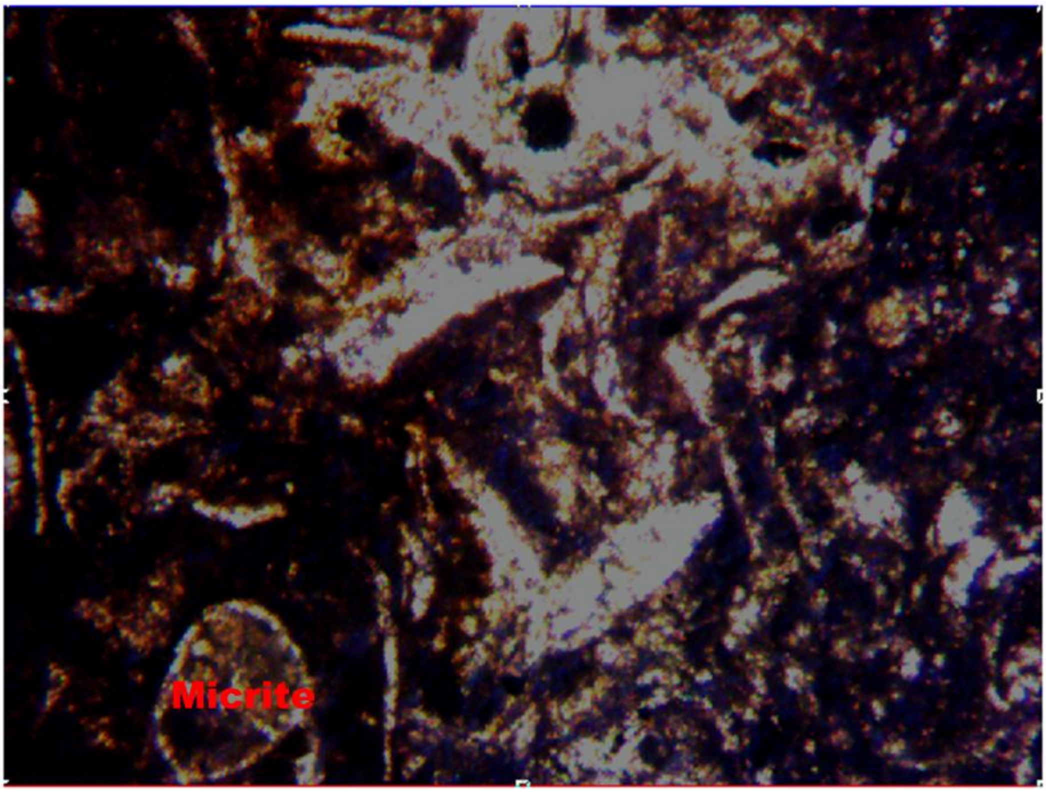


Figure 22: A photomicrograph of the limestone of the studied area (loc. 10.2) showing micritized framework grains.

Neomorphism

Neomorphism is a process of replacement by recrystallization of carbonate mud with resultant increase in crystal size of the microcrystalline sparry calcite formed. This is seen in the thin sections of the studied samples as microspars that occur as mass of fine grained crystalline materials with different birefringent colours under crossed nicol. The peloids are also replaced with coarser calcite grains of not very well ordered crystals (figure 23).

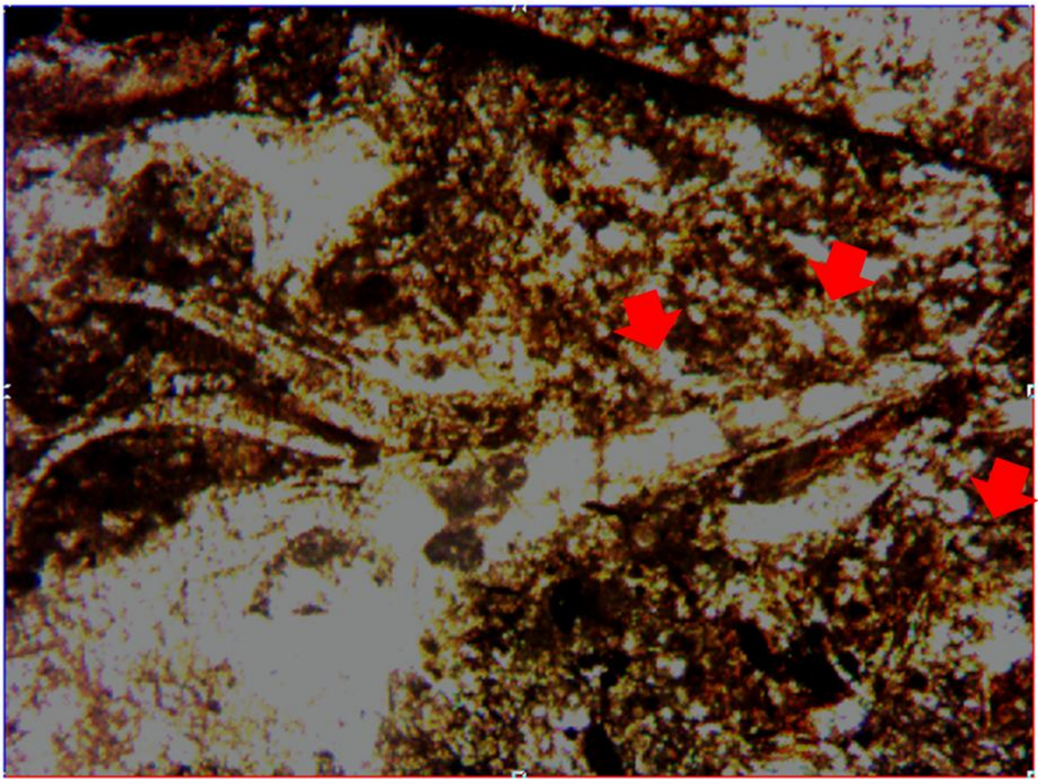


Figure 23: A photomicrograph of the limestone of the studied area (loc. 3.2) showing etched and replaced allochems by crystalline calcite.

Compaction

Compaction is the response of the limestone to overburden pressure. These were mostly seen in the thin sections as micro fractures (figure 24). Compaction affecting the limestone is also seen in the hand specimen as stylolites which are as a result of pressure dissolution by overburden, forming solution surfaces and bedding planes which are larger scale, pressure solution surfaces.

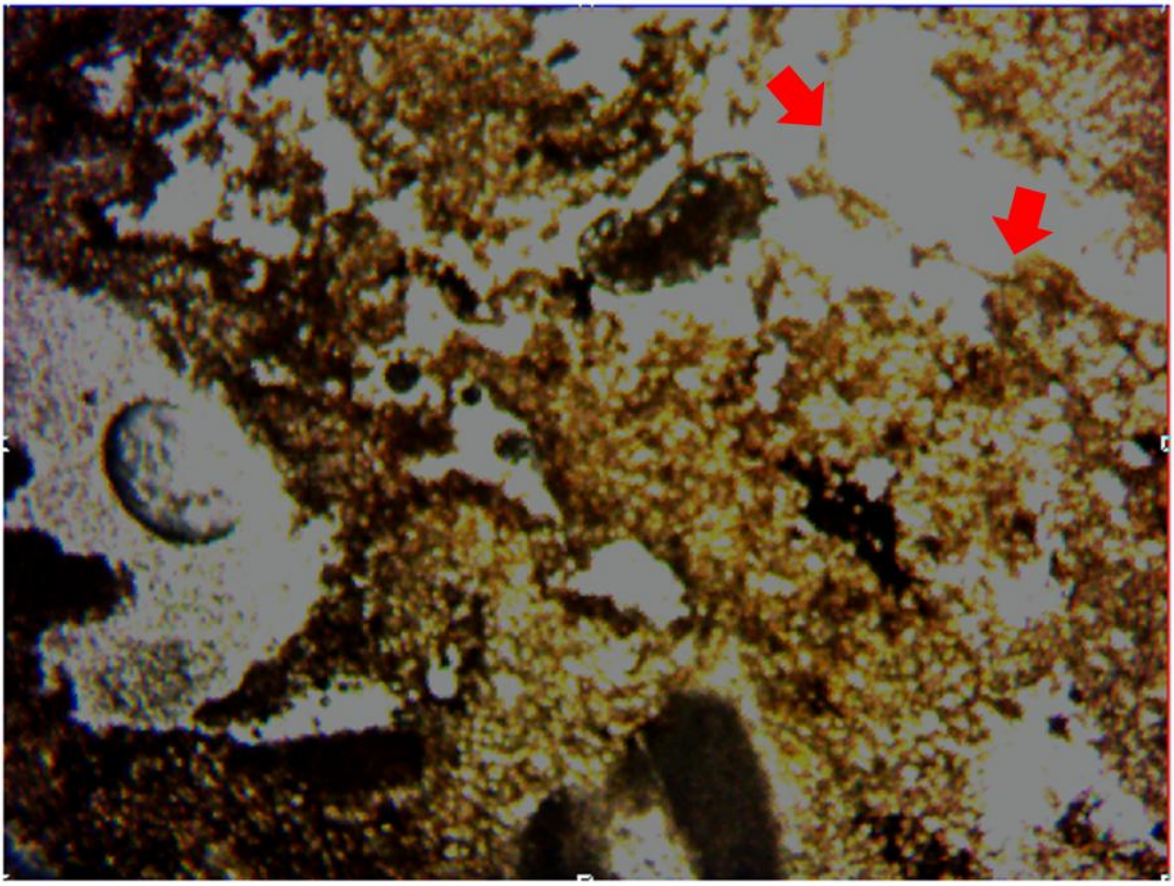


Figure 24: A photomicrograph of the limestone of the studied area (loc. 9.2) showing fractured micritized allochem due to compressional force of compaction

Dissolution

Dissolution are the results of inter and intraparticle voids (cavity porosity) filling with dissolved lime mud (sparite) which were seen in all the samples in the study area.

Conclusion

Fossiliferous packstone and micritic wackestone microfacies types were recognized in the study area were based on paleontology and textural components.

The microfacies were compared to Wilson [3] facies belt and the result suggests deposition within restricted lagoon tidal flat.

Five diagenetic processes were observed affecting the limestones in the study area; and they include cementation, micritization, neomorphism, dissolution and compaction.

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