Journal of Applied Research in Science and Humanities

Geological studies of the coastal plain of Egypt

Names: Alaa Atef Salem, Bassant Rushdy Baseet, Mariam Refaat Lotfy, Mira Gerges Ezat , Nardeen Boules Ayoub, Viola Zareif Saeed, Youstina Gaber Shafeek

Supervisor: Dr. Mariam Yehia Zakaria, Lecturer of geology, Biological and Geological department, Ain Shams University, Faculty of Education, Program Science

Abstract

The coastal plain is locally backed by limestone ridges and calcareous sand dunes, and is therefore characterized by markedly different coastal morphologies and sediment sources than found on the Nile Delta. The rock covered by a veneer of carbonate sand mostly consists of carbonate oolitic grains, the source of this carbonate from the cliffs and seabed are completely of Pleistocene limestone ridges. Geologically, the coastal plain is mainly dominated by sedimentary rocks of Quaternary age. Quaternary coastal plain of North West Egypt is bordered to the south and to the west by the outcropping Middle Miocene Marmarican Limestone which forms a tableland. Petrographical characters of samples reveal that they can be classified as oomicrite. The samples exhibit intergranular porosity, with less frequent vuggy porosity. These characteristics are indicative of a shallow marine environment. While the X-ray diffraction data of the Romel boulder samples consist of less aragonite than the Romel ridge, but don’t contain magnesium calcite, indicating recent environment in addition, to halite due to weathering.

Key Words:

Geomorphology – Coastal ridges- Oolitic limestone

1. Introduction:

Egypt is located on the northeastern coast of Africa and borders the Mediterranean Sea between Libya and the Gaza Strip. Egypt is a desert nation; only four percent of the country's total land area of 1 million km ^{2} is arable with over 80 million inhabitants.

The Northwest Coast of Egypt forms a belt about 20 Km deep, which extends for about 500 km between Amria (20 Km west of El-Alexandria) and El-Salloum near the borders with Libya.

The climatic conditions of the study area are typically arid to semi-arid, distinguished by a long hot dry summer, mild winter with little rainfall, high evaporation with moderately to high relative humidity.

The northern part of Egypt (the north Western Desert, the Nile Delta and north Sinai) lie in the unstable shelf area. The main part of Egypt west of the river Nile is covered by thick sequences of relatively undisturbed sedimentary strata of Paleozoic, Mesozoic and Cenozoic age (Said, 1990). The geology surface of the study area is mainly dominated by sedimentary rocks of Tertiary and Quaternary ages.

The North Western coastal zone of Egypt may be distinguished into two main physiographic provinces; an eastern province between Alexandria and Ras El-Hikma (about 230 km West of El-Alexandria) and a western province between Ras El-Hikma and Salloum. The landscape is differentiated into a northern coastal plain and a southern tableland.

2. The Theoretical Framework

- El Asmar's (1994) research suggests that the coastline might not always show signs of receding water levels (regression). These low water periods often coincide with dry climates. Studies of windblown sediments (aeolian sediments) revealed evidence for at least four major periods with increased humidity and high sea levels. Separating these humid phases were drier times with high positive oxygen-18 (O18) and carbon-13 (C13) values. These drier periods were identified across the Gebel Maryut ridge and the Coastal ridge, suggesting a trend towards increasing aridity with occasional short, wet intervals. During these wetter times, reddish-brown fossil soils (paleosols) formed, characterized by their lower O18 and C13 values.

- EL Shahat (1995) examined the Egyptian Mediterranean coast between Alexandria and the Egyptian-Libyan border (Salum). This region is known for its abundant production of carbonate sediments during the Quaternary period. These carbonates appear as parallel limestone ridges influenced by windblown carbonate deposits (dunal carbonates). The first and second ridges are dominated by a type of rock called oolite, formed from tiny, rounded grains. The third and fourth ridges contain mainly bioclastic facies, a type of rock rich in the remains of marine life like coralline algae, benthic foraminifera, mollusks, echinoderms, and rock fragments.

- Rashed (1998) studied the Pleistocene-era limestones (calcarenites) of the northwest coastal region. These limestones are covered by a hardened layer of calcium carbonate (calcrete) primarily made of low-magnesium calcite micrite. This calcrete layer may or may not include fragments of the underlying limestone. The calcium carbonate likely originated from the limestone bedrock, soil cover, and some windblown sea spray.

- Two main processes influenced the formation of this surface calcareous crust: Breakdown (alteration) of the Pleistocene limestone and Precipitation of new carbonate minerals to form crusts and nodules.

The breakdown of the limestone involved processes like recrystallization, fracturing (brecciation), turning the rock into tiny grains (micritization), and organisms boring into the rock. The negative C13 and O18 values of the studied calcretes indicate that they formed above ground (subaerial conditions) under the influence of rainwater and soil processes. The Pleistocene oolitic limestone in the northwest desert of Egypt likely developed in a semi-arid environment with some exposure to the air.

3.Methods of Research and the tools used

Sample Selection and Preparation:

Four rock samples were chosen from the Romel boulder and ridge for analysis using X-ray diffraction (XRD). To identify the minerals in each sample, a separate sample mount was created for XRD testing.

X-ray Diffraction Analysis:

The XRD analysis was performed using a BRUKER D8 Advanced diffractometer located at the Central Metallurgical Research and Development Institute in Egypt. This diffractometer operates at 40 kilovolts (kV) and 40 milliamps (mA). The scanning speed was set at 2 degrees per minute (2θ/Min) within a range of 2 to 30 degrees for the oriented mount samples and 2 to 70 degrees for the bulk samples (starting at 2.4 degrees).

Carbonate Content Measurement:

The analysis revealed that calcite and dolomite were the primary carbonate materials binding the sample aggregates together. The amount of carbonate content was determined by taking a specific weight of a dry, fragmented sample exposed to fresh air. The sample was completely dissolved in a heated 10% hydrochloric acid solution. The remaining residue was then washed with distilled water, dried, and weighed.

The percentages of carbonate content and residue were calculated using the following formulas:

- Carbonate (%) = ((Total Weight - Residue Weight) / Total Weight) * 100
- Residue (%) = ((Residue Weight) / Total Weight) * 100

4. Results of Research

X-ray Diffraction Analysis:

The X-ray diffraction patterns of the bulk samples are illustrated in Figures (1 - 2), and their chemical composition is detailed in Table (1).

Mineral Identification:

By comparing the data to reference materials like ASTM cards (Table 2), we can determine the mineral makeup of the samples. The analysis clearly reveals that the following minerals are present in the samples, listed in order of decreasing abundance: aragonite, magnesium calcite, and halite.

Analysis of the Romel ridge sample using X-ray diffraction (Table 3) shows that the most common carbonate minerals are magnesium calcite and aragonite, with aragonite being more abundant.

The X-ray diffraction data for the Romel boulder samples indicates less aragonite compared to the Romel ridge sample, and unlike the ridge sample, it does not contain magnesium calcite. Weathering processes are likely responsible for the presence of halite in the Romel boulder samples.

Carbonate Content:

The samples contain calcite, a carbonate mineral that acts as a binding agent (cement). Table (4) shows that the average carbonate content in the Romel section is 100%.

Petrographic Characteristics of Romel Ridge:

Table (5) details the petrographic properties of the Romel ridge. The main components are ooids (both true and coated) and intraclasts (50-70%), calcareous algae (10-15%), and echinoderm fragments (10%). Gastropods and miliolids are present in minor quantities. Based on Folk's classification system (1959), this unit can be classified as oomicrite (Figures 3 ,4 and 5).

The samples exhibit intergranular porosity, with less frequent vuggy porosity. These characteristics are indicative of a shallow marine environment.

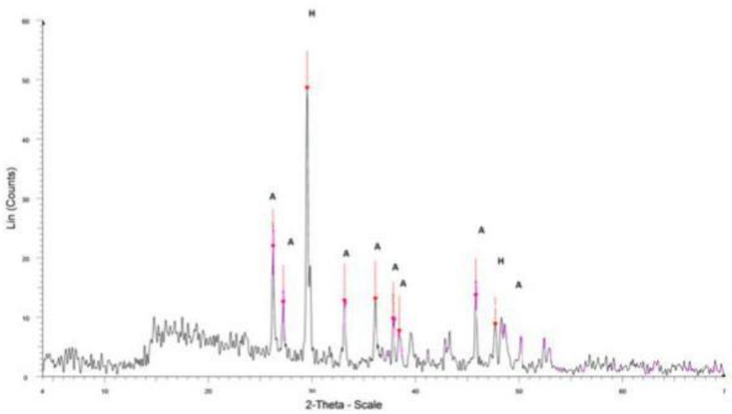

Figure (1): X-Ray diffractograms showing mineralogical composition of Romel boulder samples; Aragonite (A), Magnesium calcite (M) and Halite (H).

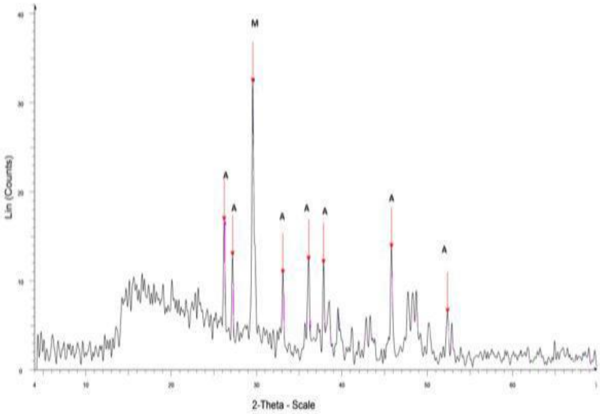

Figure (2): X-Ray diffractograms showing mineralogical composition of Romel ridge samples; Aragonite (A), Magnesium calcite (M) and Halite (H).

Table (1): X-ray diffraction data of Romel samples.

Romel ridge(R11)		**Romel boulder**	
d	**i%**	**D**	**i%**
3.40	51.70	3.40	44.50
3.28	39.50	3.28	25.00
3.02	100.00	3.02	100.00
2.71	33.20	2.70	25.40
2.49	37.90	2.49	26.10
2.38	36.70	2.38	19.00
1.98	42.30	2.34	14.80
1.75	19.70	1.98	27.30
		1.90	17.20
		1.82	14.10

Table (2): The characteristic identified lines of the main non-clay minerals in the examined samples.

Mineral	Characteristic (d) Spacing (Å)	ASTM Card NO.
Aragonite	3.40,3.27,2.70,2.48,2.37,2,34,2.33,1.977	41-1475
Mg-calcite	4.03, 4.69,3.70 ,2.886, 2.670,2.540,2.405,2.192,2.0192,2.066,2.015,1.848,1.804,1.787	43-0697
Halite	2.82, 1.99, 1.63	5-0628
Anhydrite	3.50, 2.85, 2.33	6-0226
Gypsum	7.56, 3.06, 4.27	6-0046

Table (3): X-ray diffraction analysis of the Romel ridge sample.

Location		Aragonite%	Magnesium calcite %	Halite%
Romel	Ridge	72.28	27.71	
	Boulder	62.6	0	37.39

Table (4): Carbonate and residue contents of the studied samples.

Section	Sample	Carbonate %	Residue %
Romel	1	100	0
	2	100	0
	3	100	0
	4	100	0
	5	100	0
	6	100	0
	7	100	0
	8	100	0
	9	100	0
	10	100	0
	11	100	0
	12	100	0
	13	100	0
	14	100	0
	15	100	0
	16	100	0
	17	100	0
	18	100	0
	19	100	0
	20	100	0
	21	100	0
	22	100	0

Table (5): Petrographical characters of the Romel ridge.

Samples	Total components		Total carbonate						Porosity
			Ooids		Inter-clasts	Fossils			
	Quartz and lithoclasts	Total carbonate particles	True Ooids	Coated ooids		Echin-oderm	Algae	Molluscs and Foraminifera	
R3	0	100%	35%	10%	10%	10%	5%	Few	30%
R8	0	100%	25%	15 %	15 %	15%	10%	Few	30%
R12	0	100%	30%	15 %	10 %	10%	15%	5%	30%
R17	0	100%	45%	10 %	15%	10%	Few	Few	40%
R21	0	100%	45%	10 %	10%	10%	10%	5%	40%

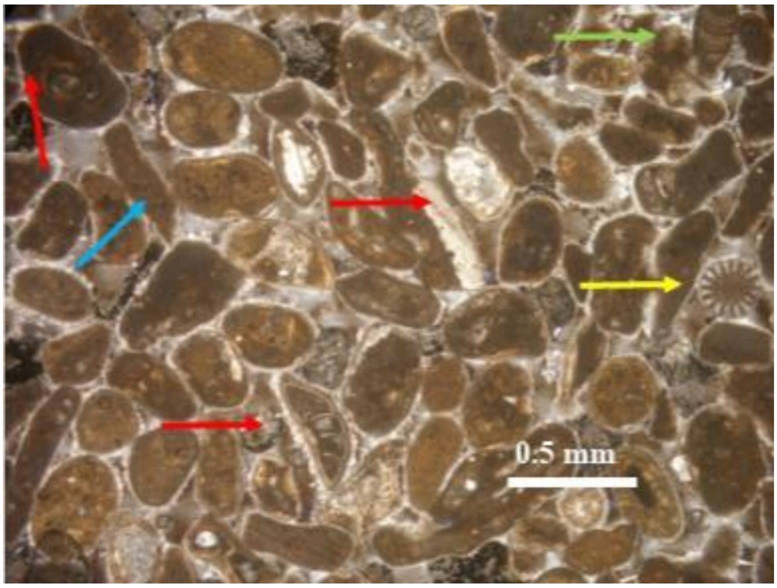

Figure (3): Oolitic limestone consists of ooids (blue arrow), coralline algae (green arrow), echinoderm (yellow arrow) and gastropod (red arrow) (Sample R12, PP).

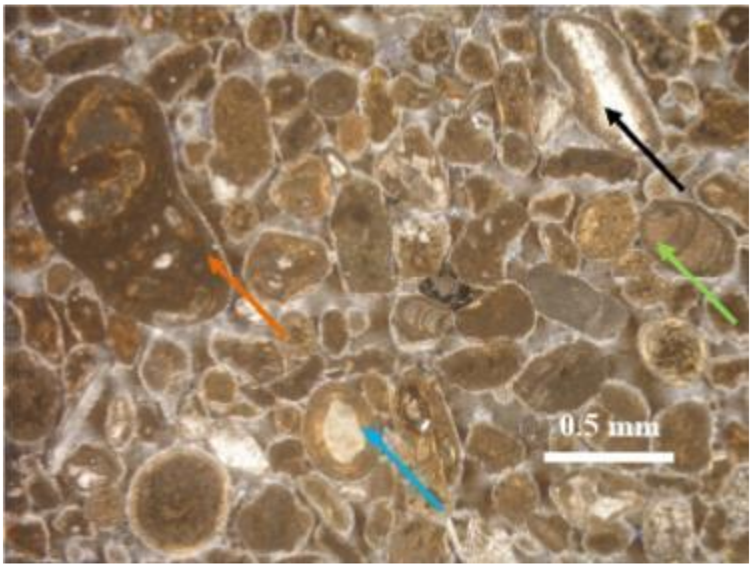

Figure (4): Oolitic limestone consists of ooids (blue arrow), coralline algae (green arrow), brachiopod (black arrow), echinoderm (yellow arrow) and intraclast (orange arrow) (Sample R17, PP).

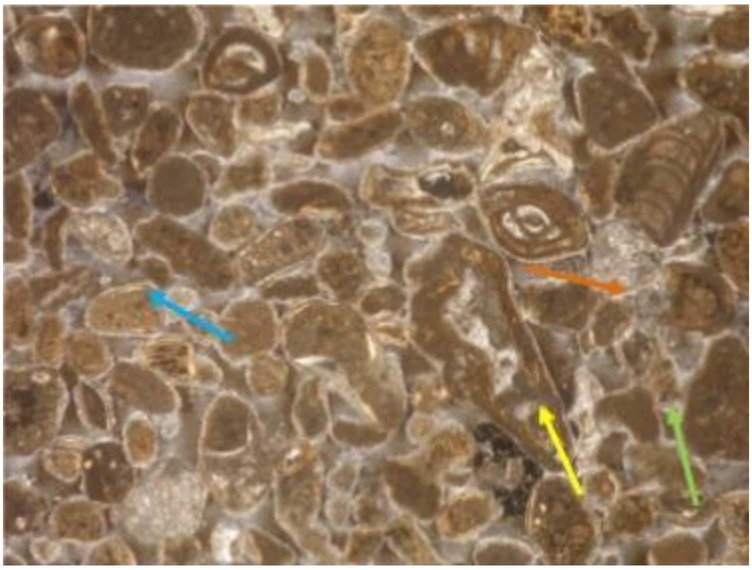

Figure (5): Oolitic limestone consists of ooids (blue arrow), coralline algae (green arrow), echinoderm (yellow arrow) and intraclast (orange arrow) (Sample R 21, PP).

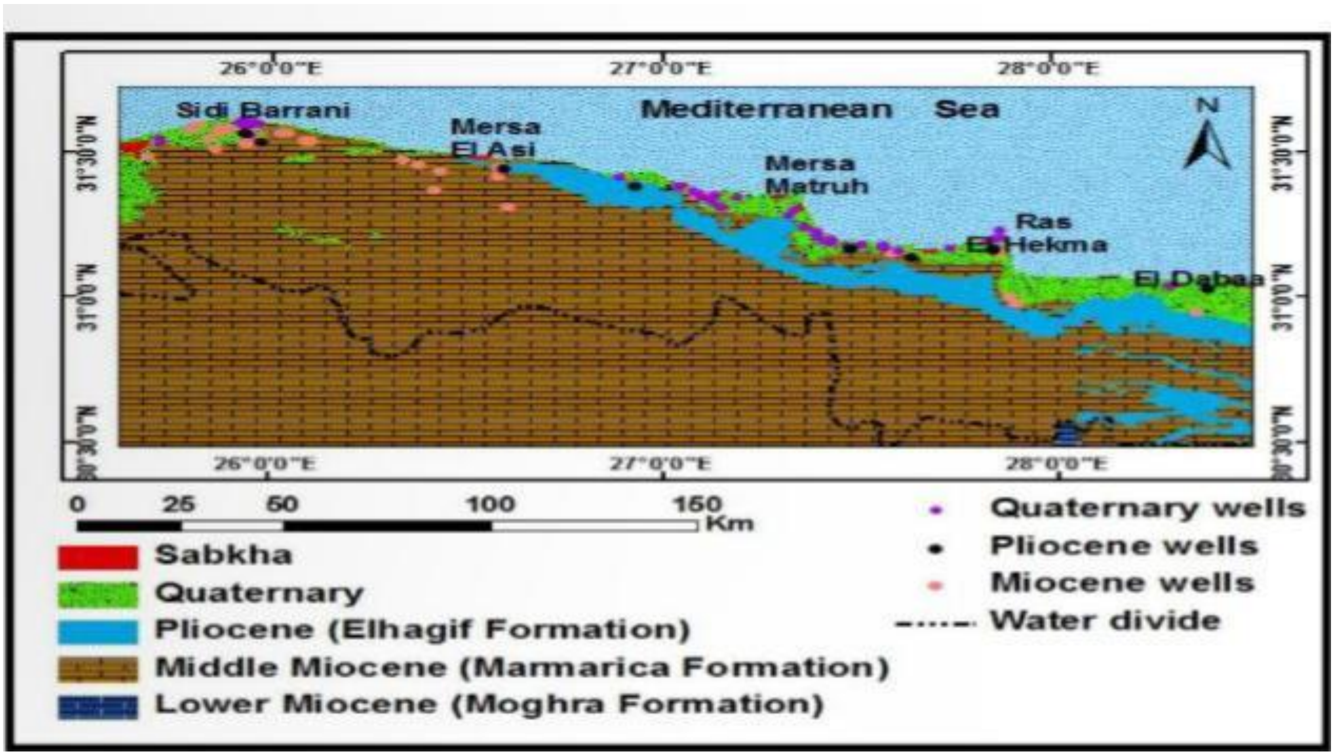

Figure (6): The main geological units of North West coastal zone.

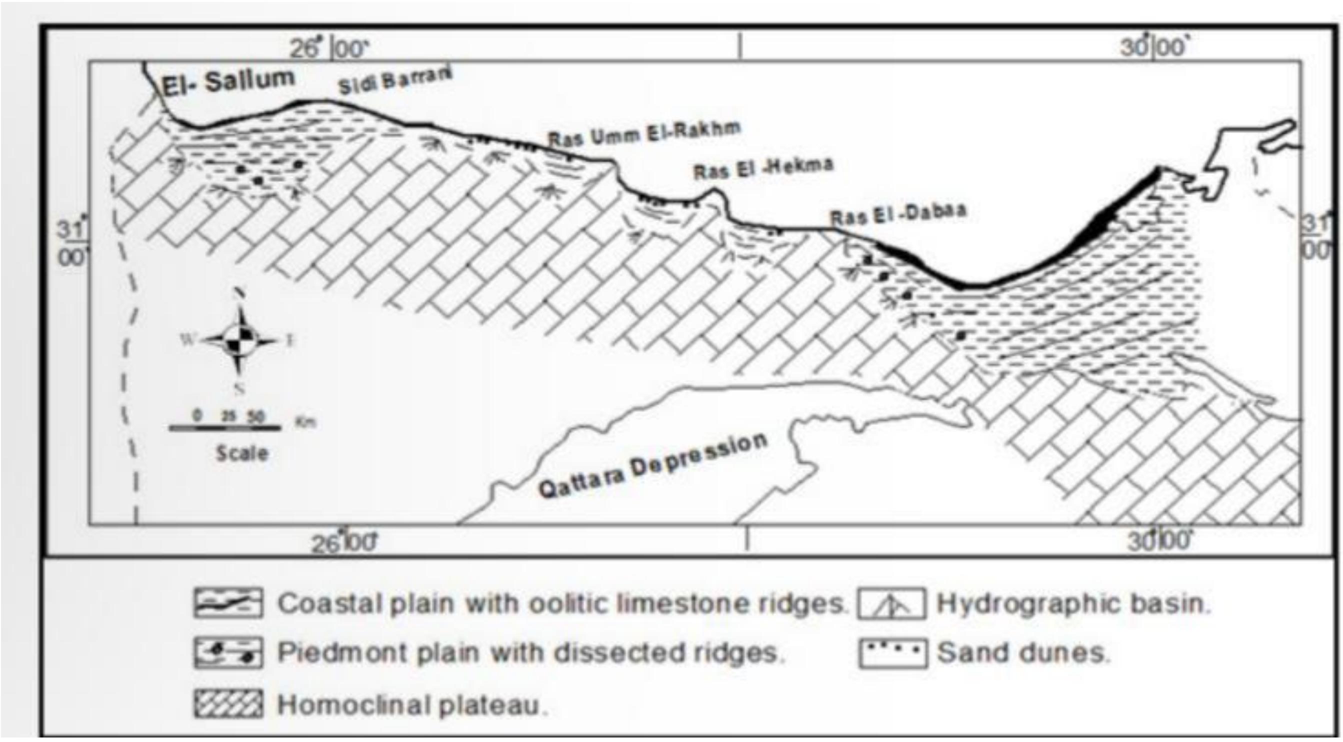

Figure (7): The main landforms along the Mediterranean Coastal Zone (Raslan, 1995).

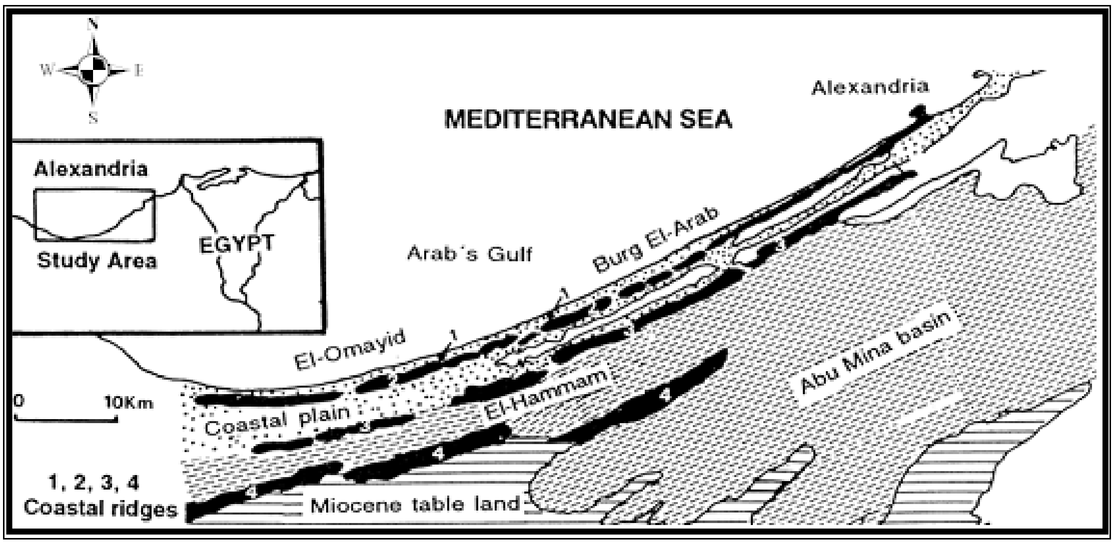

Figure (8): Coastal ridges of the studied area (El-Asmar and Wood, 2000).

5. Interpretation of Results

The northern part of Egypt (the north Western Desert, the Nile Delta and north Sinai) lie in the unstable shelf area. The main part of Egypt west of the river Nile is covered by thick sequences of relatively undisturbed sedimentary strata of Paleozoic, Mesozoic and Cenozoic age (Said, 1990) (Figure 6). The coastal zone of Egypt extends from the western side of the Nile valley and delta in the east to El-Salum in the west and the Mediterranean coastal plain in the north to the Qattara and Siwa depression in the south (El-Bastwasy, 2008). The geology surface of the study area is mainly dominated by sedimentary rocks of Tertiary represented by Moghra and Marmarica formations and Quaternary age represented by sand sheets, sand dunes and beach sands.

The North Western coastal zone of Egypt may be distinguished into two main physiographic provinces; an eastern province between Alexandria and Ras El-Hikma (about 230 km West of El-Alexandria) and a western province between Ras El-Hikma and Salloum. The landscape is differentiated into a northern coastal plain and a southern tableland (Figure 7). The following geomorphologic units can be represented as follows:

The coastal plain is locally backed by limestone ridges and calcareous sand dunes, and is therefore characterized by markedly different coastal morphologies and sediment sources than found on the Nile Delta. The rock covered by a veneer of carbonate sand mostly consists of carbonate oolitic grains, the source of this carbonate from the cliffs and seabed are completely of Pleistocene limestone ridges (Frihy et al., 2010).

The famous beaches along the Mediterranean Sea are normally between headlands, facing the synclinal embayments. They are covered by loose carbonate sands which are concentrated eastward of respective headlands (e.g: Romel beaches). The beaches are 500 m to more than 1.5 km long; the sandy beaches along shorelines are mainly composed of loose sands eroded in oolitic limestone ridges.

The coastal dunes exist close to the beaches. They cover portions of the near shore ridge that runs parallel to Mediterranean Sea. These Dunes involved of loose oolitic carbonate sands derived from the lying beaches by on- shore wind.

The North West coastal plain of Egypt consists of a sequence of carbonate ridges. The coastal plain is characterized by a series of at least eight elongated parallel carbonate beach-dune ridges. A coastal beach-dune ridge mainly composed of oolitic and biogenic calcareous sand with a coastal sabkha to land ward. These ridges are developed along the receding Quaternary shore-lines of an embayment of the Mediterranean Sea (Hassouba, 1995). The coastal ridge is weathered completely where the headlands exist. It is well developed along the synclinal embayment. This ridge consists of white, cross bedded, friable oolitic limestone. Locally this ridge is covered by snow white carbonate sand.

Accordingly, three formations are determined, these are from younger to older; the Alexandria Oolitic Limestone Formation of late Pleistocene to Holocene age, the Burg El-Arab Limestone Formation, and the El-Hammam Bioclastic Limestone Formation of middle to late Pleistocene age (Fig, 8). The Burg El-Arab Fossiliferous Limestone Formation presents the marine shelf platform and beach deposits exposed at the drainage ditch of Bahig. The El-Hammam bioclastic limestone Formation was suggested to comprise the aeolianites at the third ridge and the paleosols at the top of the fourth ridge with total average thickness of 50 m (El-Asmar, 1994) and (El-Asmar and Wood, 2000).

So, The Mediterranean coast of Egypt consists of a series of eight linear ridges that run parallel to the west coast of Alexandria and range in elevation from below sea level to higher than 100 meters (Hassan et al, 1982) (Figure 8).

The X-ray diffraction data of the Romel boulder samples consist of less aragonite than the Romel ridge, but don’t contain magnesium calcite, indicating recent environment in addition, to halite due to weathering.

6. Conclusion

The research sheds light on the Geologic and geomorphologic settings along the northwest coast of Egypt. Here's a summary of the key findings:

The coastline boasts a series of eight parallel ridges made primarily of carbonate minerals like aragonite and calcite.

These ridges likely formed along receding shorelines over long periods.

The oolitic limestone in these ridges originated in a shallow marine environment.

Weathering processes play a role in shaping the coastline, with erosion being more prominent near headlands.

Windblown sand contributes to the formation of coastal dunes adjacent to the beaches.

This study enhances our understanding of the geological history**.** The geology surface of the study area is mainly dominated by sedimentary rocks of Tertiary and Quaternary ages.

The X-ray diffraction analysis of the bulk samples from Romel ridge and Romel boulder revealed the presence of aragonite, magnesium, calcite, and halite, with varying abundances. The petrographical characteristics of Romel ridge in Marsa Matruh indicate a shallow marine environment.

Acknowledgement

We would like to express our sincere gratitude to the following individuals and organizations for their invaluable support and assistance in the completion of this research project:

First and foremost, we would like to express our deepest appreciation to our supervisor, [Dr. Mariam Yehia], for her guidance, support, and encouragement throughout the entire research process. Her insights and feedback have been instrumental in shaping the direction and scope of this study.

Also, we would like to express our gratitude to the [National Authority for Remote Sensing and Space Science (NARSS), Egypt] for providing the resources and facilities necessary to carry out this research.

Thank you all for your invaluable contributions to this project.

References and Sources

El Asmar, H. M. (1994): Aeolianite sedimentation along the Northwestern coast of Egypt; evidence for middle to late Quaternary aridity, Quaternary Science Reviews, Vol.13, pp.699-708.

El Asmar, H. M. and Wood, P. (2000) : Quaternary shoreline development: the northwestern coast of Egypt, Quaternary Science Reviews, 19(11), pp.1137-1149.

El Bastwasy, M. A. (2008): The Use of Remote Sensing and GIS for Catchments Delination in Northwestern Coast of Egypt: An Assessment of water Resources and Soil Potential, Egypt, Remote Sensing Space Sci., pp. 3-16.

El Shahat, A. (1995): Quaternary dune carbonates from the Mediterranean Coast ,of Egypt: petrography and diagenesis Facies 33, pp.265-276.

Folk, R., and Ward, W. C. (1957): Brazos River Bar: A study in the significance of grain size parameters, Jour. Sed. Petro., 27, pp. 3-27.

Frihy, O.E., Deabes, E.A. and El Gindy A.A. (2010): Wave Climate and Near shore Processes on the Mediterranean Coast of Egypt, Journal of Coastal Research, 261, pp.103-112.

Hassouba, A. (1995): Quaternary sediments from the coastal plain of northwestern Egypt (from Alexandria to El ,Omayid), Carbonates and Evaporites pp. 8-44 ,(1)10**.**

Hassan, F. (1982): The geological history of the River Nile, Book review, Quarterly Review of Archeology, 3(4), pp.5-6.

Mariam, Yehia Zakaria (2017) Sedimenological and Geohazards Studies ,of The Coastal Plain, Marsa Matruh Area Egypt., Msc, Faculty of Education, Ain Shams University, Egypt.

Raslan, S. M. (1995): Geomorphological and hydrogeological studies on some localities along the Northwestern Coast of ,Egypt, M.Sc. Thesis, Faculty of Science Menofia Univ., pp. 172.

Rashed, M. (1998): Calcrete On Pleistocene Coastal Ridges, West Alexandria, Egypt**,** sedimentary nature and applications, sedimentology of Egypt,Vol.6, pp.113-128**.**

Said, R. (1990): The Geology of Egypt Balkema, p.734.