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Geological, geomorphological and structural characterization features of Al Bordi area, Libya

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Highlights

- **The exposed rocks of Al Bordy area are characterized by carbonate sequences of Late Eocence to Middle Miocence age.**
- **Various geological factors have affected the area structurally and geomorphologically.**

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ABSTRACT

This study has been conducted on Al Bordy area, which lies between latitudes N31°48'16.51 N31°43'14.91and E25°00'18.09 E25°06'55.07 on the sea coast of eastern Libya, The area has specified geological features, where the different rock formation exhibit good exposures that give a clear view about the stratigraphic column. The exposed formations are Al Gaghbub, Al Faidiyah and Al Khowaymat.

The target of study is to evaluate some characterization features e.g. lithology, stratigraphic analysis, fossil distribution, structural and tectonic setting.

The technical simulation models and geographic information system (GIS) software have been applied to interpret some geologic structures such as faulting, fractures, cracks and folding as well as the effect of stresses on formation strata.

The field observations and the obtained data revealed that the area has affected by variable geological factors and changes in depositional environments, in addition to tectonic movements that led to the formation of various structures such as anticline and syncline folds, normal faults and unconformities.

1. Introduction

Al Bordy area received many geological attention since the last century. Being located on the northeast part of Libya between Egypt in the east, the Mediterranean coast in the north and traversed by the crossroads leading to the spiritual Al Jaghbub Oasis in the south is a unique position for the present area. The earliest geological work in the area was made by Schweinfurth (1883a) who visited Tobruk and Al Bordy. He described a Miocene fauna identified by Beyrich from the limestone beds in the area. Much work on the nearby Egyptian outcrops has also led to a better understanding of the geology of Al Bordy area. of importance is Said's work (Schweinfurth, 1883b) who classified the Miocene rocks in the western desert of Egypt. Gindy (1970), Gindy and El Askary (1970), Gindy *et al.* (1972) discussed the stratigraphy, structure, microfacies, petrography and heavy mineral detritals of the Miocene section north Salum.

Al Bordy area is divided into two main geomorphic units; a southern flat surface and a northern-scarped physiographic terrain. This study is concerned with the second unit. The northern part of the area is marked by the rise of several prominent scarps running in an east southeast–west northwest direction. It comprises several scarps one of them overlooks the Mediterranean Sea, is the lowest of averages 90 m above sea level and extends for 85 km in Al Bordy area (Anthony and Athol, 1994).

2. Study Objectives

This study has been carried out on this area aiming to evaluate some characterization parameters e.g. lithology, stratigraphic analysis, fossil distribution, structural patterns.

3. Materials and Methods

The methodology of the study has been carried out through the repeated field trips, a collection of different rock samples that represent the different formations beds, as well as paleontological study throughout tracing the distribution of various fossil types in the different formation beds. In addition to determining the various structural types using measuring tools and determination their main directions and identifying their magnitudes as well as the main forces that lead to form these structural patterns.

4. Location of the Area

The studied area lies at the eastern of Libya on the coast Mediterranean Sea, between N31°48'16.51 N31°43'14.91 and E25°00'18.09 E25°06'55.07 .The area characterized by its elevation location, where the elevation above sea level is ranging from 80-120 m. The area comprises three main wadis namely, Wadi Al Rahib, Wadi Al Rezg and WadiBordi (Fig. 1). The study was concentrated on these wadis due to their location importance and their good exposures of rock formations (Industrial Research Centre Tarabulus, 1984).

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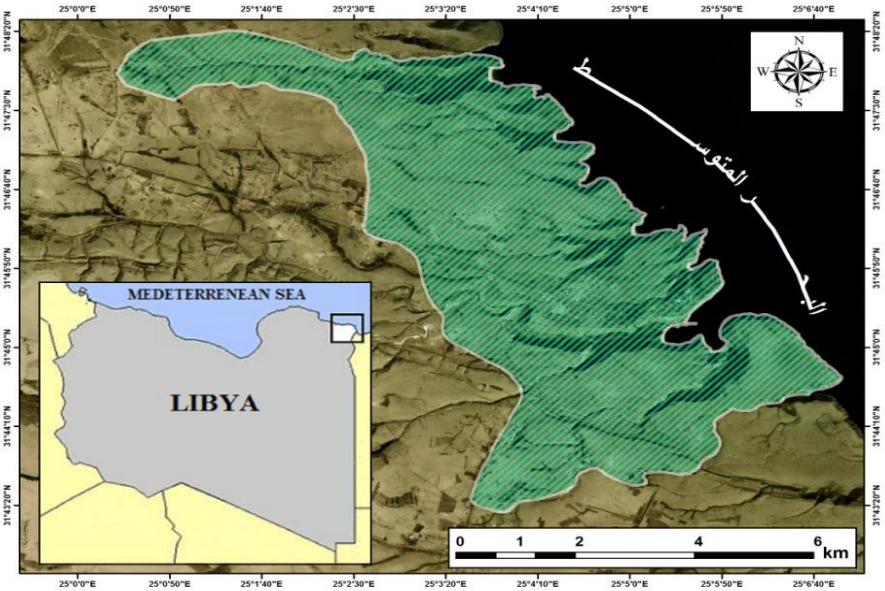

Fig. 1. Satellite map depicts Al Bordi area and the investigated locations

5. Results and Discussion

5.1. Lithology and Stratigraphy

In general, the characterization lithology of the studied area is encountered in a few rock types that represented by calcareous fossiliferous rocks, shale, sandy shale and conglomerate (Syamadas Banerjee, 1980; Megerisi and Mamgainn, 1980). The stratigraphic succession shows some variation from wadi to another in thickness and extent due to the variation of depositional factors and the tectonic movements. The thick sedimentary section exposed in Al Bordy area, especially noticed along the cliffs overlooking the Mediterranean Sea (Fig. 2) are classified into three main stratigraphic formations belonging to Early Tertiary. Besides, several, four in number, quaternary deposits were recognized near the foot slopes of the cliffs and inward covering older units. The following units were recognized in the field as given below:

Fig. 2. Anticline fold and rock avalanches at the coastal area

Quaternary:

Alluvium deposits.
Beach and coastal sand dune.
Sabkha sediments.
Eolian deposits.

Tertiary:

Lower-Middle Miocene: Al Jaghbub Formation
Upper Oligocene-Lower Miocene: Al Faidiyah Formation
Upper Eocene-Lower Oligocene: Al Khowaymat Formation
The section exposed at Wadi al Rahib; latitude 31° 48' 15" N and longitude 25° 03' 15" E described as following:

Al Khowaymat Formation: dolomitic limestone, yellowish white, hard compact, fossiliferous including; Globgerina spp., Globorotalia spp. and Nummulites.

Al Faidiyah Formation: limestone, faint brown to dark yellow, sandy and marly.

Lithologically the formation is made of alternating limestone, marly limestone and clay beds. The beds are nearly horizontal, thin to thin-bedded and highly fossiliferous (Fig. 3). It is including the following assemblage of macrofauna: Cardiumgallicum, Strombus sp. Worm tubes, Brissoposisfrassiand Tllina lacunose.

Al Jaghbub Formation: marly limestone, dark yellow and moderately hard. It is including the following assemblage of macrofauna: Ostreaverleti, Ostreadigitalina, Cardiumerinaceum and Pectencristato.

Fig. 3. Fossiliferous limestone

5.2. Geological Structures and Simulation Model analysis

The structural patterns of Al Bordy area are mainly determined by tensional faults. Faults planes are steep 75˚ to 80˚ and their extension are widely varied from one to another. It is seamed from the investigated area that it has been exposed to high tectonic movement and suffering from high stresses. The tectonic movement leads to the formation of different structural patterns represented by faulting, folding, fractures and cracks. On the other hand, another geologic structure formed later through depositional younger strata to yield disconformity and angular unconformity structures. However, the software technical simulation models have been applied to interpret some geologic structures e.g. faulting and folding to give us clear pictures of the tectonic movements and the effect of stresses on formation strata. Figs. from 4 to 7 show the mechanisms of faulting formation with time.

5.3. Geomorphological Features of Sea Coast

The coast of the studied area varies in its morphological aspects; this is due to different factors involved variation in lithology and the weathering due to wave's action. The rock type mainly formed of calcareous and soft rocks that highly affected by chemical and physical weathering owing to the formation of different types of Geomorphological features.

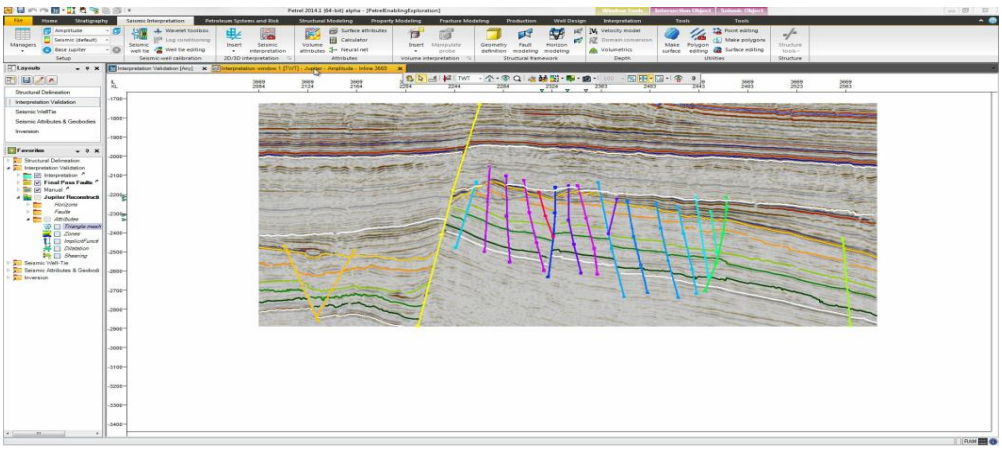

Fig. 4. Geological Rules (sequences) applied: Conformable, Erosional, Discontinuity

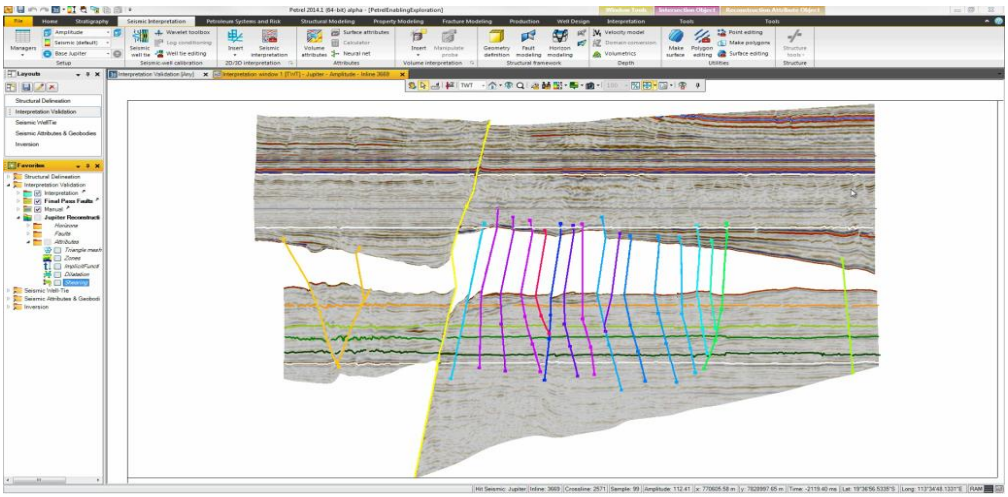

Fig. 5. Interpretation of geological structures

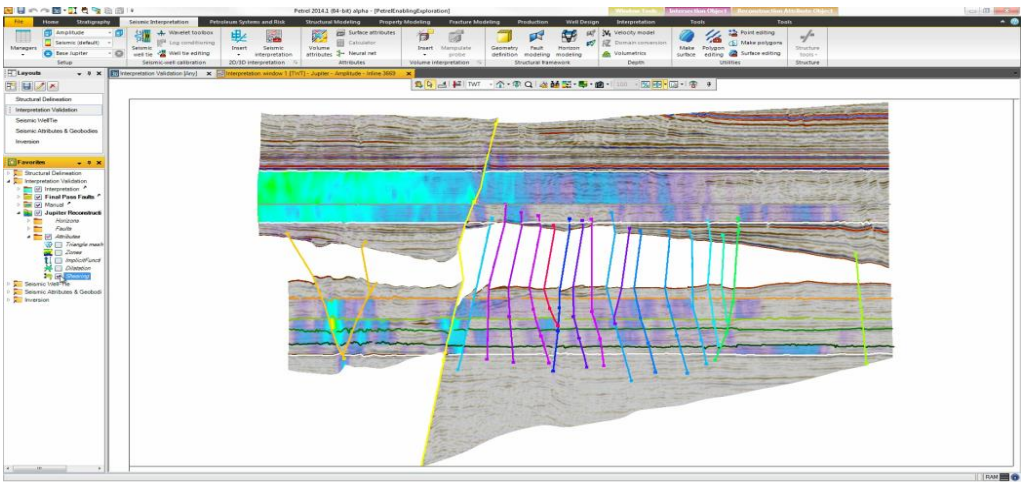

Fig. 6. Understand structure through time (Look for areas of high stress)

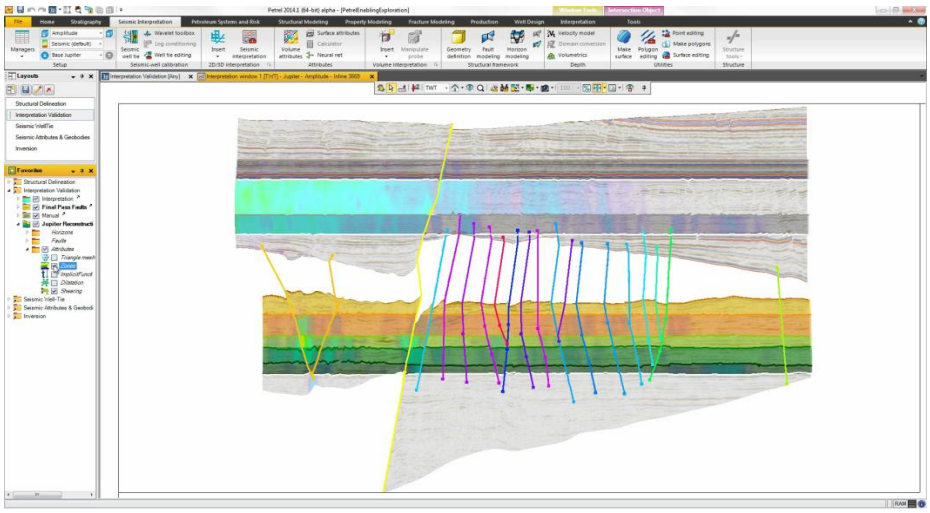

Fig. 7. Understand structure through time

5.3.1. Weathering Pits

These pits outcrops at rocks exposures on the slopes formed by calcareous rocks all over the area and usually associated joints and cracks, and also what is called taffonis pits that arises due to the solution solubility (Fig. 8)

Fig. 8. Weathering pits at the eastern ends of Wadi Al Jarfan

5.3.2. Honey Comb

These are holes and small pits are adjacent together, and characterized those small sizes compared with taffonis pits and formed due to chemical processes (Fig. 9)

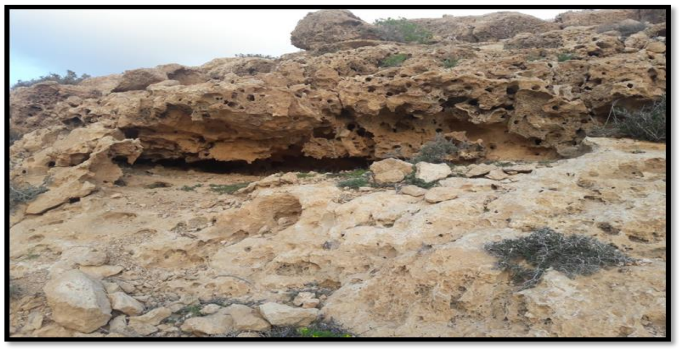

Fig. 9. Honeycomb due to weathering

These features include sea bay, sea caves, cliffs, sea plateaus and steep slopes as illustrated in Figs. from 8 to 10.

5.3.3. Coastal Cliffs

The edges that overlooking to the sea called coastal cliffs with slope ranging from 45-90° and affected by waves motions. These geomorphological aspects show a widespread on the coastal of study are with an elevation ranging from 50 to more than 100 m (Fig. 10).

Fig. 10. Coastal cliffs

The coastal cliffs include different geomorphological e.g. rock sliding and sea platforms, which appear at the foot of cliffs due to wave, cut platforms (Fig. 10).

5.3.4. Coastal Caves

The coastal caves and voids show a wide spread in the area, that indicate the active erosion process at cliffs feet due to wave actions. These caves ranging from 1.5 to 5.0 m with an average of 2 m, while its elevations ranging from 0.75 to 4.0 with an average of 0.50 to 4.0 m (Fig. 11).

Fig. 11. Coastal caves

5.3.5. Sedimentary Platforms

They are regarded as the most predominant Geomorphological features in the different valleys that indicate the variation in climatic conditions and amount of rainfall. Their elevations ranging from 0.20 m to 1.50 m above valleys drainage (Fig. 12).

Fig. 12. Sedimentary platforms at Wadi Al Jarfan

5.3.6. Coastal area and coastal sand dunes

The downstream of wadis covered by coastal sand dunes with very fine-grained (Fig. 13), where they are formed of fine sands and calcareous deposits in addition of medium to coarse-grained of sands and remains of detrital shells. The mechanical analysis of hand specimens revealed that the dominant sand deposits have an average value 25.8% very fine sand, 35.7% medium sand, 7.6% coarse sand and 4.6% very coarse sand.

Fig. 13. Coastal sand at Wadi El Rahib

5.3.7. Coastal Lagoons and Swamps

Swamps and Sabhka are subjected to all changes affecting on the coastal area. They are represented by clay, sand and silt deposits. Sabhka includes evaporite deposits that made up of gypsum and halite minerals (Fig. 14).

6. Conclusion

The geology of the exposed rocks in Al Bordy area dated back to the Late Eocen-Middle Miocene times. The deposits of the area were correlated with Al Khowaymat Formation, Al Faidiyah Formation and Al Jaghbub Formation. They exhibit similarity between lithology, stratigraphy, structures and fauna distribution. Earth movements that forming normal faults, anticline folds and joints that show variable trends have affected the area. AlFaidiyah Formation shows a major anticline trend north south. The unconformable relationship between Al Khowaymat and the overlying Al Faidiyah is also revealed by different joints sets observed in both units. Al Jaghbub Formation covers most of the area studied and thick sections were measured from the scarps overlooking the coast. The fauna of Al Jaghbub Formation belongs Lower Miocene to Middle

Miocene. The area deposits show more or less a variation in lithological distribution that reflects the variety of marine environment under the oscillation of sea level. Software programs were used to the simulation of some geological structures such as faulting to interpret the mechanism of movements affected on the area.

Fig. 14. Swamps and sabhka along the coastal area

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