PETROLOGICAL AND MINERALOGICAL STUDIES ON THE PALEOZOIC SEDIMENTS IN WESTCENTRAL SINAI

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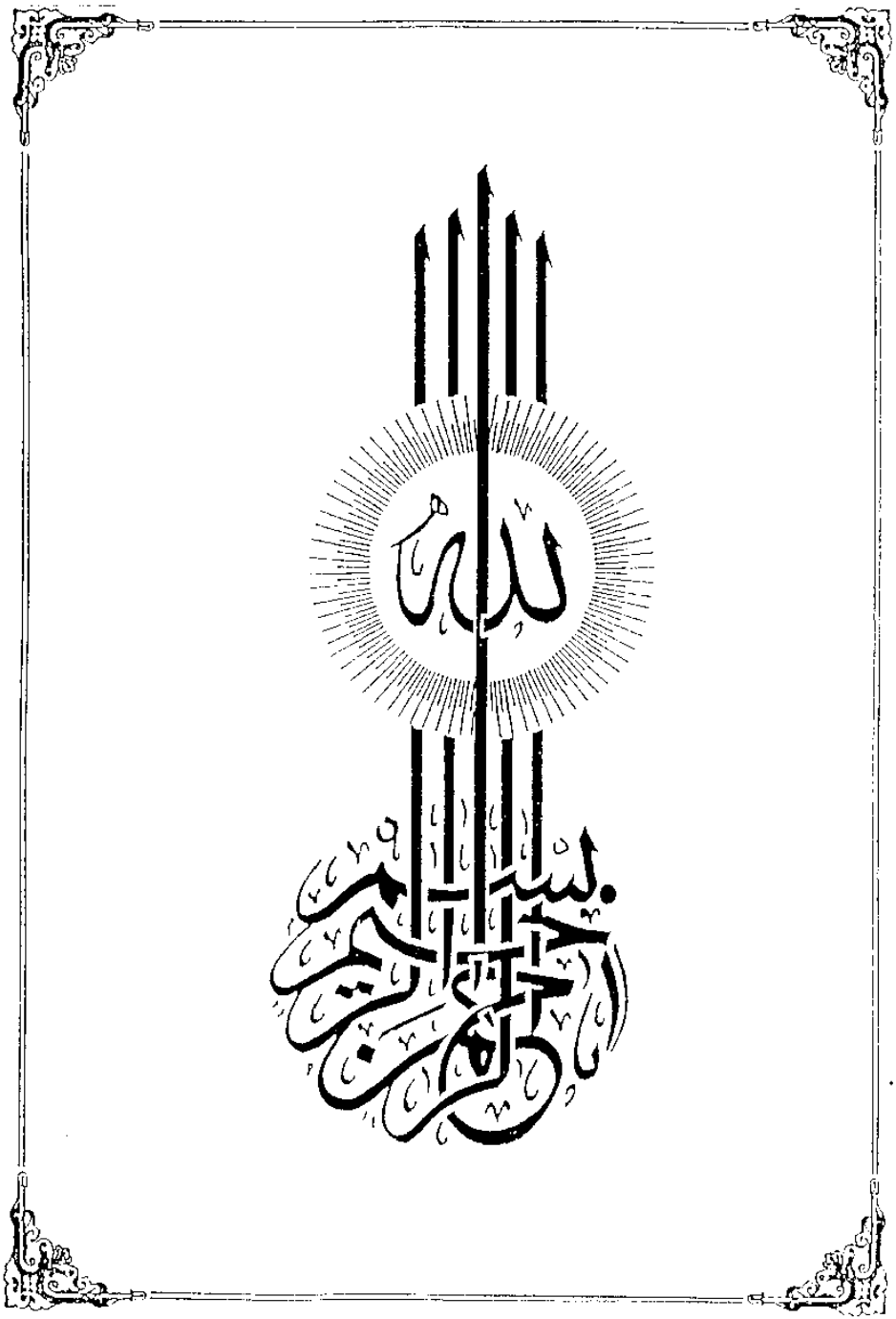
وَقُلْ رَبِّ زِدْنِي عِلْمًا



TO MY FAMILY

PETROLOGICAL AND MINERALOGICAL STUDIES ON THE PALEOZOIC SEDIMENTS IN WESTCENTRAL SINAI

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CONTENTS

Page

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

CHAPTER VI

CHAPTER I
INTRODUCTION

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INTRODUCTION

Geologically, the Sinai Peninsula is one of the most interesting regions in Egypt. Firstly, because within its relatively limited area almost all the salient features dominating the whole country are represented and, secondly, because it displays a variety of simple and complex structural forms. The westcentral part of the peninsula is particularly interesting. The Paleozoic sediments exposed in this region have attracted the attention of many workers due to their wide distribution as well as the economic importance of their manganese and iron deposits.

The Paleozoic sequence in westcentral Sinai is typically divided into three main units : a basal sandstone, a carbonate and an upper sandstone unit. Some of these units may be absent locally or change laterally. This presents a complex problem of nomenclature and correlation which is most intriguing to the stratigraphers.

Barron (1907) classified the Carboniferous section overlying the basement complex in southwestern Sinai into two sandstone series separated by a limestone unit. Pockets of manganese and iron ores exist at the boundary between the lower sandstone series and limestone unit. The Carboniferous sediments are topped by basalt flows. These basalts were found to be a very useful marker, for where it has been removed, a quartzitic bed is always present as a boundary line. The upper part of the Carboniferous sequence seems to pass conformably into the so-called "Nubian Sandstone Series".

Ball (1916 & 1939) adopted ***Barron's classification*** of the Carboniferous sequence and estimated its thickness in westcentral Sinai to be about 320 m. The same Carboniferous subdivisions have been recognized in the area, with only minor variations, by several other workers ***(e.g. Barthoux, 1923; Davey, 1948, Tromp, 1951; Said & Shukri, 1955; Attia, 1956; Kostandi, 1959; Said, 1962 & 1971; El Shazly et al., 1963 & 1974; Omara, 1971 & 1972; Robson, 1971*** and ***Garfunkel & Bartov, 1977).***

1. The Carboniferous Lower Sandstone Series

The Carboniferous Lower Sandstone Series directly overlies the basement complex. It consists mainly of sandstones (130 m thick) which are frequently intercalated with shaly beds. The series exhibits worm tracks and markings ***(Ball, 1916).***

Trials to establish a system of classification and terminology of the Carboniferous Lower Sandstone Series have been attempted by several investigators. ***Hassan (1967)***subdivided the series into the following formations (from base to top) :

(i) The Araba Sandstone Formation (Carboniferous or older); consists of nonfossiliferous sandstones (170 m thick) with vivid conspicuous violet, red and yellow colours. The sandstones are

generally cross-bedded, medium-grained, friable and contain sporadic rounded pebbles. The lower part of the formation is occasionally intruded by basaltic dykes.

(ii) The Naqus Sandstone Formation (Carboniferous or older); composed mainly of a sequence of sandstones (462 m thick) which are generally white, medium-to coarse-grained, moderately- to well - consolidated and commonly contain quartz pebbles.

Soliman & El Fetouh (1969) carefully investigated the Carboniferous Um Bogma Group which is equivelent to the Carboniferous Lower Sandstone Series. They subdivided the group into the following rock units (from base to top) :

(i) The Sarabit El Khadim Formation (18 m thick); consists of sandstones which contain thin bands of conglomerates, shales and siltstones. The sandstones are generally pink, occasionally yellow, creamy white or spotted white due to the presence of kaolinized orthoclase.

(ii) The Abu Hamata Formation (62 m thick); is formed of a rhythmic succession of sandstones with some siltstones and shales. The sandstones are fine-to medium-grained, partly pebbly and conglomeratic. The formation is easily distinguished by its colour, with conspicuous banded colouration (dark violet, green and blood red) and the presence of convolute and slump structures.

(iii) The Adedia Formation (131 m thick); is made up mainly of sandstones with subordinate siltstone and shale interbeds. The contact with the underlying formation can be recognized by its pink and red colours which are related to the introduction of manganese and iron oxides carried in hydrothermal solutions.

Weissbrod (1969) studied the Paleozoic outcrops in southwestern Sinai in an attempt to correlate them with those in southern Israel. He emphasized that the Carboniferous Lower Sandstone Series can be related to the Yam Suf Group and the Netafim Formation. The Yam Suf Group comprises the following formations (from base to top) :

(i) The Paleozoic Nubian Sandstone (Lower Cambrian,10-45 m thick); consists mostly of bedded arkose, arkosic sandstones and occasionally micaceous sandstones. The rocks are reddish brown with some white bands. They are generally fine-to coarse-grained, cross-bedded and show many sedimentary structures and internal truncations.

(ii) The Hakhlil Formation (Upper Georgian, 6-14 m thick); is made up of alternating facies of arkosic sandstones, micaceous shales and clays. The sandstones are thinly-bedded, red, brown, very fine-grained, contain a few bands of coarse sands and grits as well as clay lenticles. The micaceous shales are red, brown and green. Impregenations of manganese minerals appear in the middle and upper parts of the formation.

(iii) The Nimra Formation (Upper Georgian, 6 m thick); is composed of sandy dolomites and dolomitic sandstones alternating with arkosic sandstones and micaceous shales. The dolomites and dolomitic sandstones are hard, purple, red, white, grey with varying amounts of feldspar grains. The sandstones are intercalated with micaceous shales. They are greenish white, soft, very fine-grained

and contain bands of quartz granules. Slight copper mineralizations are encountered mainly in the middle part of the formation , the top of which is impregnated by manganese minerals.

(iv) The Mikhrot Formation (Upper Georgian, 2.6 m thick); consists of thin series of micaceous shales, generally violet and green, soft and fissile. Some prints and markings of unidentifiable organisms are found in the lower part of the formation.

(v) The Shehoret Formation (Cambrian, 30-70 m thick); is formed mainly of a sequence of nonfossiliferous arkosic sandstones which are thinly-bedded, white and brown. The lower part of the formation is characterized by the presence of shales and micaceous shale intercalations and impregenations of manganese and iron minerals. A few layers of quartz pebbles are noticed towards the upper part of the rock unit. ***Weissbrod (1969)*** divided the formation into the following three members (from base to top) :

- Multicoloured "Casata" Member (6.5 m thick); consists of brown, very fine-grained arkosic sandstones alternating with brown and green micaceous shales. Some very thin gypsum laminae and manganese mineralizations appear in the upper part of the member.

- White Member (27 m thick); is composed of thinly-bedded, soft arkosic sandstones which are pinkish white, fine-grained and occasionally coarse.

- Variegated Member (23 m thick); is formed of arkosic sandstones, reddish brown and fine-grained.

The Negev Group unconformably overlies the Yam Suf Group and consists of three rock units namely : the Netafim, Um Bogma and Ataqa Formations. The Netafim Formation (Pre-Carboniferous, 30 m thick) is composed predominantly of hard sandstones with some shale and ferruginous siltstone layers. The sandstones are brown, fine- to coarse-grained with some layers of quartz pebbles in the lower and middle parts of the formation. Some copper mineralizations (turquoise) appear towards the uppermost part of the rock unit.

Beyth (1981) subdivided the Paleozoic sequence at the Um Bogma area into six rock units. The Carboniferous Lower Sandstone Series is correlatable with the following formations (from base to top):

(i) The Amudei Shelomo Formation (Early Cambrian, 1-18 m thick); consists of grit and polymictic ferruginous, arkosic conglomerates in the east and well-bedded silt and grit with few beds of well-rounded pebble conglomerates in the west.

(ii) The Timna Formation (Late Georgian, 0-20 m thick); is composed mainly of silt, sandstone and grit interbedded with few dolomite beds.

(iii) The Shehoret Formation (Cambrian, 0-60 m thick); is characterized by the presence of subarkosic sandstones interbedded in its lower part with silts.

(iv) The Netafim Formation (Late Cambrian, 0-40 m thick); unconformably overlies the Shehoret Formation and is composed mainly of sandstones which are ferruginous at the top.

Issawi et al. (1981) emphasized that the Carboniferous Lower Sandstone Series can be related to the following formations (from base to top) :

(i) The Araba Formation (Early Cambrian); is made up of a sequence of cross-bedded, varicoloured and laminated sandstones (45 to 100 m thick). Sandy clays and ferruginous bands are common in the succession. Silty sandstone beds occasionally preserve ichinofossils among which *Cruziana* is the most significant.

(ii) The Naqus Formation (Cambrian-Early Carboniferous); consists of a sequence of white sandstones (260 m thick), coarse- grained, massive and cross-bedded. The most striking feature in the formation is the presence of quartz gravels to cobbles, mostly rounded to subangular, haphazardly distributed in a fairly well-sorted, fine-to medium-grained quartz arenite. Moreover, ***Issawi &Jux (1982)*** proposed a third rock unit (15 m thick) which is designated the Wadi Malik Formation. This unit overlies the Naqus Formation and is composed of dark brown to red sandstones and clays. It is separated from the underlying and overlying formations by two distinct paleosols.

El-Shahat & Kora (1986) , Kora & Jux (1986) and ***Kora & Schultz (1987)*** adopted the classification proposed by ***Beyth (1981)*** and used the formational names previousely suggested by ***Soliman & El Fetouh (1969)***. They defined four formations of Cambro-Ordovician age related to the Carboniferous Lower Sandstone Series as follows :

(i) The Sarabit El Khadim Formation (11-23 m thick); is formed of pink pebbly sandstone and grit interbedded with thin siltstone and fine-grained sandstone layers.

(ii) The Abu Hamata Formation (0-18 m thick); is composed mainly of laminated multicoloured siltstones, fine sandstones, micaceous shales and few grit beds.

(iii) The Nasib Formation (18-62 m thick); comprises fine-grained sandstones which alternate at the top with siltstones and micaceous green shales.

(iv) The Adedia Formation (0-36 m thick); consists of fine-grained, brown sandstones. Many pebbly sandstone and grit interbeds are observed particularly in the Um Bogma area.

2. The Carboniferous Limestone Unit

The Carboniferous Limestone unit (Early Carboniferous) conformably overlies the Carboniferous Lower Sandstone Series ***(Ball, 1916)***. It consists of greyish brown to pink, hard, crystalline dolomite alternating with ochreous earthy limestones. The unit contains characteristic species of *Orthis, Productus, Spirifer* and other brachiopods. It has a variable thickness and is best developed on the eastern side of Gebel Nukhul where it is about 41 m thick. The unit is thinner in the Um Bogma area (19 m thick). Further to the southeast at Gebel Riglein and Gebel Sarabit El Khadim, the unit is thinned out almost entirely but its level is marked by a thin band of iron and manganese minerals.

The Carboniferous Limestone Unit shows a remarkable lithologic variation in westcentral Sinai. It is made up of carbonates in the north, shales in the middle and sandstones towards the south. The carbonate facies was designated by ***Soliman & El Fetouh (1969)*** as the Khaboba Formation (40 m thick). The rock unit is formed mainly of dolomitized oolitic calcarenites with shale intercalations. It is characterized by the presence of manganese and iron ores and contain *Spirifer* and *Productus*.

Weissbrod (1969) and ***Beyth(1981)*** emphasized that the carbonate unit "Um Bogma Formation" consists of grey to pink, coarsely crystalline, bedded fossiliferous dolomites and dolomitic limestones interbedded with yellow marls. The thickness of the dolomites varies from zero in the southeast to 43 m in the northwest.

The Um Bogma Formation was subdivided into different members ***(Omara & Conil, 1965; Weissbrod, 1969; Mart & Sass, 1972*** and ***Kora & Jux, 1986).Saleeb-Roufaiel et al.(1987)*** recognized three main facies in the Um Bogma Formation namely: (i) Dolomite-ore-silt facies, its presence is restricted to the Um Bogma and surrounding areas and is characterized by the presence of manganese-iron ores in the form of lenticular bodies invariably flattened parallel to the stratification; (ii) Dolomite facies, which extents to the north and northwest of the Um Bogma area, and (iii)Ferruginous sandy facies which is encountered in the southwestern parts of the Um Bogma area.

The shale facies was refered by ***Hassan (1967)***as the Durba Shale Formation, in an area east of El Baleyim Bay. The rock unit (166 m thick) consists of shales, generally varicoloured, soft, fossiliferous and occasionally stained with iron oxides. Several interbeds of fine-grained sandstones are also recorded. ***Hassan (op.cit.)***emphasized that the outcrops run parallel and capping the underlying Naqus Formation wherever the latter occurs except in southeastern Sinai where the formation pinches out.

The sand facies was reported by ***Issawi et al.(1981)*** near Wadi Feiran area. They used the term Abu Durba Formation (60 m thick) which is represented mainly by ferruginous sandstones at the base and alternating thick sandstone beds and thin, dark grey fossiliferous clay layers at the top. In places, the clayey intercalations are massive, black, generally hardened by iron and manganese solutions.

Recently, ***El Wekeil (1989)*** used the same term "Abu Durba Formation" to distinguish the sand facies in Gebel Qattar near Wadi Feiran. The formation is composed almost entirely of sandstones (≃43 m thick) which are characterized by the abundance of ferromanganese nodules. The sandstones are violet, pink, brown, yellow, generally fine-grained, compact, hard and occasionally ferruginous.

3. The Carboniferous Upper Sandstone Series

The Carboniferous Upper Sandstone Series (150 m thick) consists of reddish brown, fine-grained and moderately hard sandstones ***(Ball, 1916)***. Thin bands of white to grey clays and red to purple shales are encountered in the upper part of the series. The series contains tree fragments (*Lepidodendron* type) and is capped in several places with olivine basalts. The Carboniferous Upper Sandstone Series is separated from the Cenomanian clays by the "Nubian Sandstone" (≃500 m thick; Late Carboniferous to Early Cenomanian).

Tentative classifications and terminology of the series have been proposed by several workers. ***Hassan (1967)*** used the term Huswa Formation (Permian ??). The rock unit consists predominantly of sandstones (148 m thick) with subordinate shale intercalations. The sandstones are generally dark red to multicoloured, medium-grained, moderately hard and nonfossiliferous.

Soliman & El Fetouh (1969) refered the series as the Ataqa Group which comprises the following formations (from base to top) :

(i) The Hashash Formation (59 m thick); consists predominantly of light-coloured, pink sandstones with subordinate claystone, green shale and siltstone bands near the base. The top of the formation is characterized by its gravelly and pebbly nature.

(ii) The Magharet El Maiah Formation (33 m thick); is characterized by the abundance of grey shales, carbonaceous shales, coal and sandstones. Veins of manganese oxides and plant remains are abundant.

(iii) The Abu Zarab Formation (100 m thick); is characterized by the presence of white glass sands and rare shales. The rock unit is capped by basalt flows of the Farsh El Azraq Formation.

Weissbrod (1969) and ***Beyth (1981)*** defined the Carboniferous Upper Sandstone Series as the Ataqa Formation (up to 200 m thick) which is of an Early Carboniferous (Visean) age. The formation consists mainly of sandstones intercalated with shales and contain local coal seams. The sandstones are pinkish white, generally fine-grained and show cross-bedding and ripple marks. The lower and middle parts of the sequence contain *Lepidodendron* as well as fragments and prints of fossil plants. The formation is topped by basaltic sills. In the absence of these basalts, the upper part of the formation is indicated by a thick layer of hard quartzite. The formation is overlain by a succession of sandstones and siltstones (more than 350 m thick) belonging to the Mesozoic "Nubian Sandstone".

Issawi et al. (1981) and ***Issawi & Jux (1982)*** recognized two formations which are stratigraphically equivelant to the Upper Sandstone Series namely : (i) The Aheimer Formation (Upper Carboniferous ,35-60 m thick) is made up of greenish grey, occasionally yellow shales with pale brown sandstone interbeds. Highly fossiliferous dolomitic limestone bands are also present; and