# MINERALOGICAL AND GEOCHEMICAL STUDIES OF THE BLACK SHALES INTERCALATED WITH THE PHOSPHATE DEPOSITS ALONG THE RED SEA COAST, EGYPT



Thesis submitted to the
Faculty of Science, Ain Shams University

For the degree of
Doctor of Philosophy
in Geology



By
Ismael Sayed Ismael

M.Sc. Ain Shams University, 1990

*Cairo*

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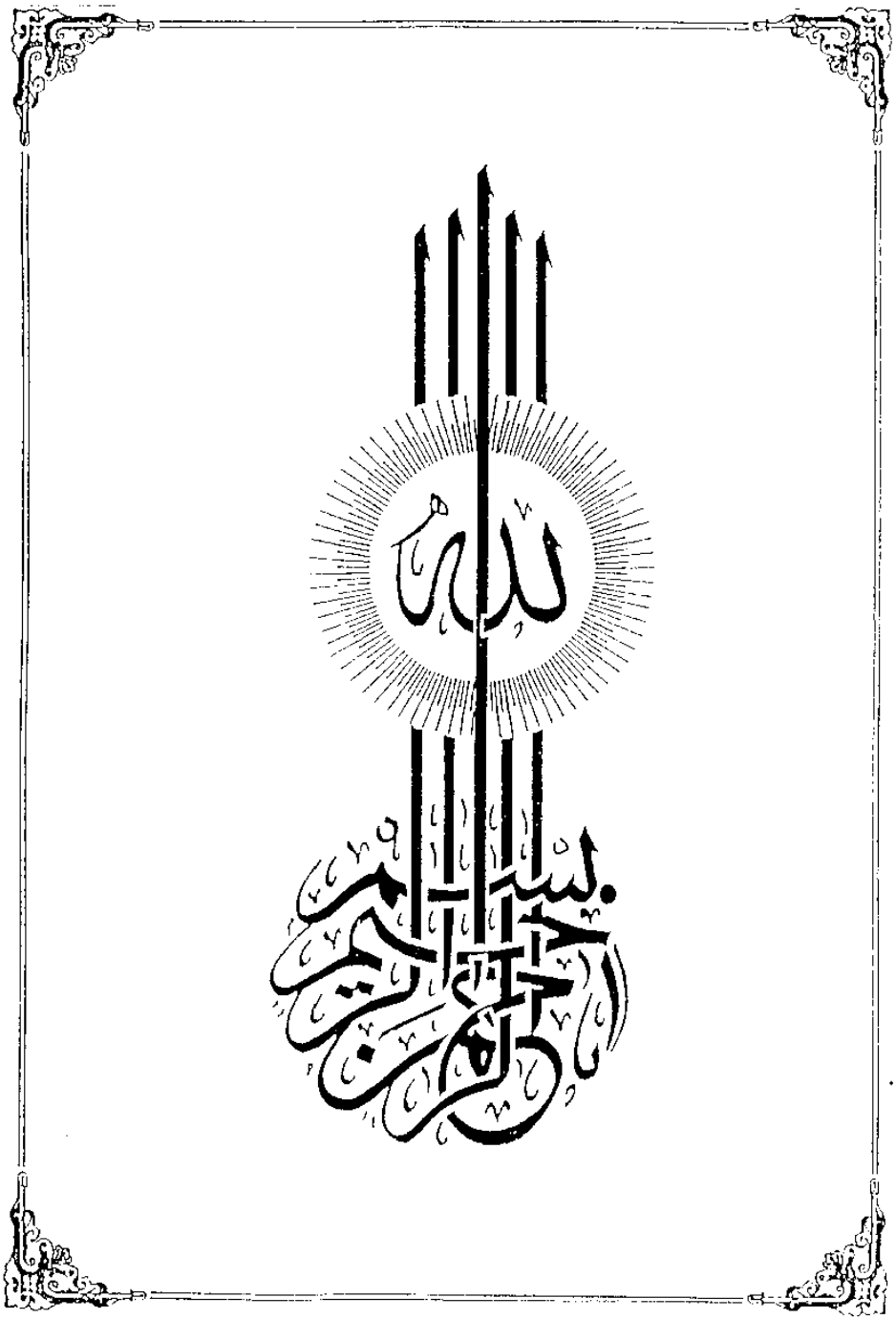

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# MINERALOGICAL AND GEOCHEMICAL STUDIES OF THE BLACK SHALES INTERCALATED WITH THE PHOSPHATE DEPOSITS ALONG THE RED SEA COAST, EGYPT.

By
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**Abstract**

The organic rich black shale (Upper Cretaceous-Lower Tertiary) intercalated with and capping the phosphate deposits along Red Sea Coast have been petrographically, mineralogically and chemically studied in details using the polarizing microscope, electron microscope, X-ray diffraction, infrared, differential thermal analysis, quantimeter arc spectrometer and inductively coupled plasma.

The study reveals the presence of four microfacies namely :

a) shaley microfacies b) phosphatic microfacies c) siliceous microfacies d) carbonate microfacies.

The almost perfect lamination of shales and its flexion around foraminiferal tests reveal that these foraminiferal tests were deposited in situ under calm water conditions. Pyrite associated with the organic matter reveal reducing conditions of deposition . The phosphatic particles occur in the form of uncoated and coated grains as well as skeletal debris (bones, teeth.....etc.) of variable sizes. Pyrite occurs as framboidals or disseminated euhedral grains normally resulting from the reaction of iron with $H_2S$, produced by bacterial reduction of sulfate in anaerobic environment. Gypsum occurs as baguette like form, randomly oriented fibrous, and very fine plates of irregularly closed small books. Gypsum might have been formed as a result of oxidation of pyrite. Halite recorded in some samples may be the result of evaporation of saline water formally present in the pore spaces of sediments. Smectite is mainly detrital in origin. It was mainly formed as a result of alteration of parent rocks

predominantly granitic to mixed granitic basaltic rocks in the presence of relatively moderate to bad drainage coupled with rapid deposition in calm water.

Authigenic kaolinite identified in a number of samples may be the result of the alteration of smectite. Apatite formed by the mineralization of the organic phosphorous from the soft parts of organisms. This mineralization occurs during very early diagenesis by microbial mediation.

The chemical composition of the bulk samples reveals that $SiO_2$, $Al_2O_3$, $Fe_2O_3$, $TiO_2$ and $K_2O$ are normally related to clays. However, part of $Fe_2O_3$ and $TiO_2$ may be related to pyrite and rutile respectively. No correlation was found to exist between the heavy metals ' V, Zn, Ni, Cu, Cr, Mo, Cd and U' and organic matter. This may be attributed to dissolution or migration of the organic matter, which loses part or all of its metal content on other phases ' e.g. clays or apatite'. The studied shales are normally enriched in ( Cd, Mo, U, Zn, V and Cr) compared to average shales. The long exposure of organic rich sediments to normal or abnormal sea water can lead to abnormality in the concentration of these metals.

**Key Words:**

Mineralogical - geochemistry - black shale - Red sea - Egypt - phosphate.

# CHAPTER ONE

# INTRODUCTION

Quseir and Safaga areas are parts of the Eastern Desert of Egypt at the Red Sea Coast (Fig. 1) , gained their importance since five decades when the phosphate deposits of Gebel Duwi Range were discovered and exploited. At the present time most of the mines are abandoned due to low grade of the remaining phosphate deposits and the effect of international competition of the Moroccan and Jordanian ores. The exploited phosphates in some mines are usually intercalated with and capped by shales.

The Egyptian phosphates are shallow marine deposits of a general Upper Cretaceous age. Their maximum intensity of deposition was associated with the transgressive shore line of Late Campanian or Early Maasterichtian sea which encoarashed from North to South over the northern slope of Africa.

The present study, deals with the geological, mineralogical and geochemical characteristics of shales ( including black shales) intercalated or capping phosphate deposits in Quseir and Safaga regions, which may throw more light on the depositional environment and diagenetic processes of these sediments.

## General geological and stratigraphical situation

The region extends in a north west direction along the western coast of the Red Sea from South of Quseir to Safaga in between latitudes 25° 50\' - 26° 67\' and longitude 33° 45\' - 34° 25\', covering an area of about 500 $Km^2$.

The complex geology and tectonics which characterize this region are attributed to its confinement to the boundary between the Arabo - Nubian massif and Gulf of Suez taphrogeosyncline. Faulting with dominating NW trend are the main features in the region and its complicated horest and grabens. Basement rocks form bold masses which cover the major parts of this stretch.

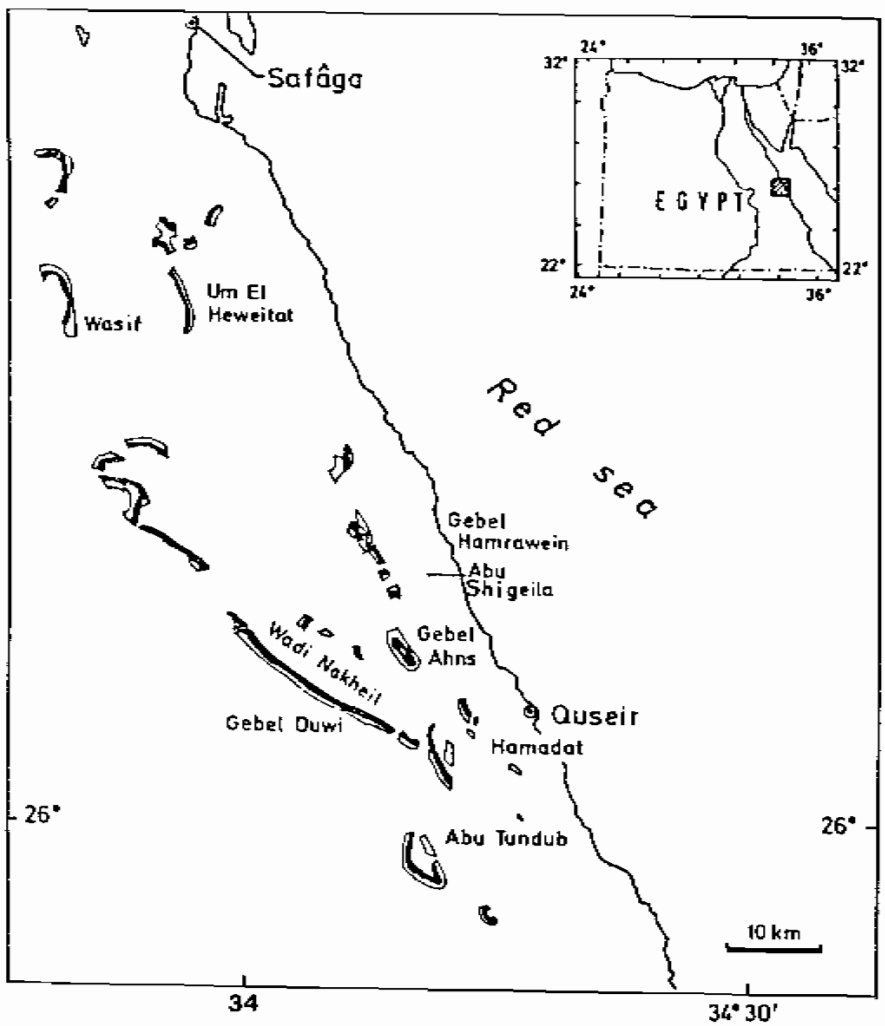


Fig. (1): Location map of the studied area.

The Upper Cretaceous and Lower Eocene sediments are preserved only in those tectonic blocks which have mostly synclinal structure. They form isolated hills of faulted elongated basin.

The sections at Quseir and Safaga areas were described by many authors including (Barron and Hume,1902; Ball,1913; Youssef,1957; Faris and Hassan,1959; El Akad and Dardir,1966; Abdel Razik, 1967 & 1972; Issawi et al., 1968 & 1971; El Tarabili, 1966 & 1969; Ginidy et al., 1973 & 1976; Hassaan et al., 1979; Mohammed, 1982; Saad, 1983; Hassanin et al., 1983; Philobbos et al., 1985; Hassaan et al., 1985 ; Ramadan, 1992).

The stratigraphy of the exposed sedimentary rocks was described under the following rock units according to the classification of Said (1962), from bottom to the top as follows;

1. Nubia Sandstone
2. Quseir Variegated Shale
3. Duwi "Phosphate" Formation
4. Dakhla Shale
5. Chalk (Tarawan Chalk)
6. Esna Shale
7. Thebes Formation
8. Nakheil Formation

**1 - Nubia Sandstone**

The term Nubia sandstone was first introduced to the Egyptian stratigraphy by Russegger (1837), who used the term " Sandstein Von Nubien" and was used to designate non fossiliferous sandstone section in Paleozoic or Mesozoic succession. It is the oldest sedimentary bed, rest unconformably over the basement complex. The bed occupies many of the topographic lows in Quseir area (Said,1962). It consists mainly of well sorted fine to coarse grains, brownish, yellow sandstone. It is weathered specially towards the upper part. The thickness of this unit is in the range of 130m in Quseir area (Issawi et al., 1968). According to Ward et al., (1979) and Van Houten et al., (1984), this unit can be divided into three members described as facies. This unit is assigned a Senonian age (Issawi et al., 1968).

## 2 - Quseir Variegated Shale

This formation was introduced by Ghorab, (1956), who considered it as a separate formation and named it " Quseir Variegated Shale". The variegated shale consists of varicoloured shale ( gray, brownish yellow, green, reddish, violet and blackish) alternating with yellowish sandstone at Gebel Duwi. The Quseir variegated shale is considered by earlier authors (Awad and Ghobrial, 1965; Abdel Razik, 1970 ; El Naggar and Ashor, 1983 and others) as a part of the Nubia Formation. The thickness of this unit is in the range of 70m in Gebel Atshan (Said, 1990). It is nonfossiliferous, with the exception of rare plant remains, bone fragments and fish teeth. Seward (1935) concluded that these plants must be grown in nearby places in humid tropical climate. The upper boundary of the Quseir Variegated Shale contains some phosphate bands. These phosphate bands range from 10 - 20 cm in thickness are found with indurated sandstone in Gebel Duwi, while they are associated with shale in Wasif section ( Glenn, 1980). Lithologically the upper part of Quseir Variegated Shale is very similar to the shale lithofacies of Duwi Formation (Glenn and Mansour, 1979). The age of this formation is regarded to be Senonian (Said, 1962).

## 3 - Duwi "Phosphate" Formation

In 1900, Barron noted the presence of phosphate beds in the Eastern Desert. Youssef (1949 & 1957) described the Duwi Formation and classified the exploited phosphate in Gebel Duwi into three beds, the upper Atshan bed, the middle or Duwi bed, and the lower or Hammadat bed. Said (1962) extended the use of Duwi Formation to laminated gray clays and chert phosphatic bands at Safaga and subdivided the whole section in the Red Sea area into three members (Atshan) or "A" member separated from the middle (Duwi) or "B" member by an Oyster limestone bed 6 - 16m in thickness and lower (Abu Shegala) or "C" member, separated from the middle member by shale unit of variable thickness 6 - 10m.

The Duwi Formation in the Quseir - Safaga coastal region comprises a heterogeneous suite of shallow marine rocks that lies stratigraphically above the Quseir Variegated Shale and below the Dakhla Shale. The rocks of the Duwi Formation are delineated into phosphorite, shale, siliceous claystone, gluconitic sandstone, chert, dolostone, marl and reefal limestone lithofacies ( Glenn and Mansour, 1979).

The Phosphate Formation can be subdivided into three members, the lower "C" member separated from the middle member by a section of variegated shale of non marine to marginal