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PETROGRAPHY AND DIAGENESIS OF ABU DARAG LOWER CRETACEOUS SEDIMENTS, GULF OF SUEZ, EGYPT

Kolkila, A.* ; El Mansey, I.** ; El-Rahmany, M.***;
and Madani, M.**

* Al-Azhar University, Cairo, Egypt.
** Petroleum research Institute, Cairo, Egypt.
*** Ministry of Indistry, Cairo, Egypt.

ABSTRACT

This paper deals with Petrographical and diagenetic studies on some lower Cretaceous sediments of Abu Darag region, Gulf of Suez, Egypt Four columnar sections have been measured and sampled. Twenty seven samples have been selected for microscopic investigation. The study revealed that the investigated samples are composed of :- (1) Sand and sandstone, feldspatic sandstone and ferruginous sandstone (2) Shales and claystones. diagenetic processes are represented by silica overgowths, silica and iron-oxide cement, replacement by secondary inclusions, compaction, effect of pressure-solution, authigenic Kaolinite, sericitisation of feldspars, and authigenic gypsum (anhydrite). These sediments had been deposited not far from the source supply on the flood plain of alluvial environment by slow current velocity.

INTRODUCTION

The lower Cretaceous rocks exposed in many parts of Abu Darag region, are represented by non-fossiliferous vari-coloured sandstone underlying the Cenomanian and overlying the Jurassic sediménts (Abdallha and El-Adindani, 1963),

(Fig. 1). Structurally, the area is represented by an asymmetric anticlinal fold affecting the Late Carboniferous and Permo-Triassic rocks with an axis striking N64^{o}W (El-Kholy, 1987). These sandstones are termed as Lower Cretaceous Nubia Sandstone by Said (1962), whereas Abdallah and El-Adindani (1963) gave the formal name Malha Formation at the type locality of Wadi Malha. The sucession under study (about 21 to 30 meter in thickness) is composed of yellowish white to reddish brown, fine, medium to coarse grained sandstones with grey yellow to reddish clay intercalations.

The sandstone beds at Abu Darag exhibit number of primary sedimentary structures, i.e. fine stratification ripple marks stratification and gradded bedding. The Lower surface of the sandstone section is unexposed. However, the petrographic, mineralogical composition, and diagenetic studies were carried out on such Nubia Sandstone facies where they are exposed at Wadi Qiseibv only (Zaghloul et al., 1984). The object of the present work is to study the encountered lithological variations, mineralogical composition and to reveal the main diagnetic events which took place after deposition. To achieve such target, all the components encountered in thin sections

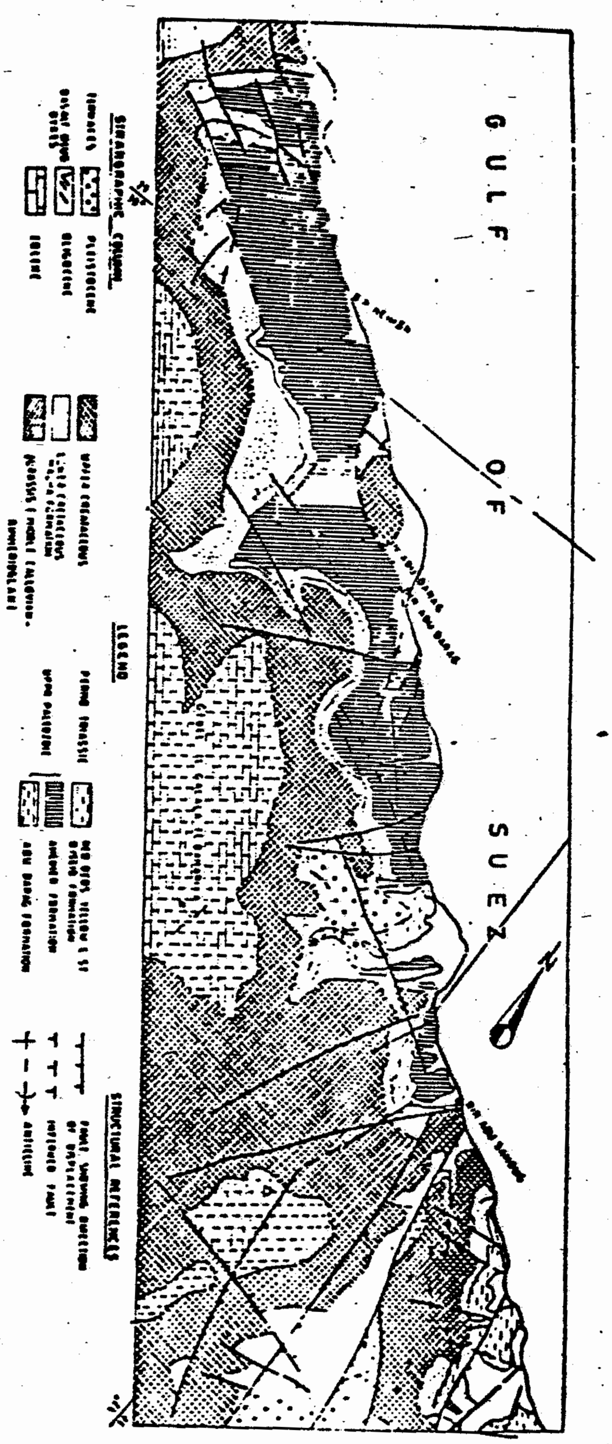

Fig.(1) - Geological map of Abu Darag area, Eastern Desert, Egypt after (Abdallah and El-Adindani, 1963).

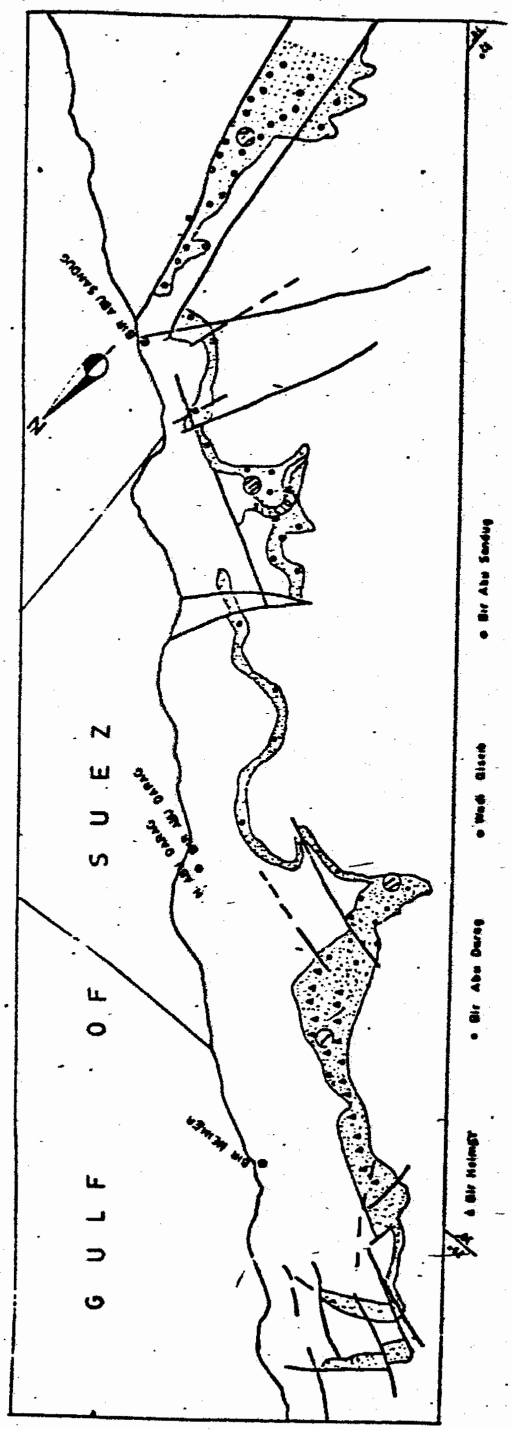

Fig.(2) - Location of sampling and the cross-sections sites in Abu Darag Region (after EL-Kholy, 1987).

Fig.(15): Feldspatic sandstone.
Photomicrograph showing angular, coarse and partly altered feldspar (albite) grain. x100: C.N.

Fig.(16): Feldspatic snadstone
Photomicrograph showing banded and curved coarse feldspar suffered from unstability of the depositional environment. x 70: C.N.

Fig.(17): Ferrugineous sandstone.
Photomicrograph showing hematitic cement and disseminated iron-oxides between quartz grains. x 70: P.P.L.

Fig.(18): Quartz arenite
Photomicrograph showing sutured quartz grain due to effect of pressure solutions. x 50: C.N.

Fig.(19): Sub graywacke.
Photomicrograph showing replacement by secondary inclusions (spotted clay materials) on quartz grains. x100: P.P.L.

Fig.(20): Sub graywacke.
Photomicrograph showing fine-liminations and alternation of fine and very fine quartz grains x 50: P.P.L.

Fig.(21): Sub-graywacke.
Photomicrograph showing curved lamination with abundant orhanic matters. x 50: P.P.L.

Fig.(22): Fibrous authigenic gypsum (anhydrite):
Photomicrograph showing a rose-like shape of elongated rectangular gypsum. x100: C.N.

Petrographic Study :

Detailed petrographic study of the various rock types of the investigated sections revealed the following varieties :

(i) Sands and sandstones, feldspatic sandstones and ferrugious sandstones.

(ii) Shales, claystones and siltstone, commonly with gypsum (anhydrite) and rich in organic matters.

i- Sands and Sandstones :

Sands and sandstones occur mainly as non-fossiliferous and devoid of any calcareous matter. The sandstones are white to yellowish white, fine, medium and coarse-grained and have displayed many primary structures cross-bedding, fine-lamination and ripple marks. Commonly, the investigated sections have ended towards the top by a ferruginous sandstone layer of reddish brown and medium to coarse grained.

Petrographically, sands and sandstones are composed of fine to medium quartz arenites. Quartz grains are angular to subangular and occasionally subrounded (Fig. 7), the medium grains appear with normal extinction while the coarse grains are of wavy extinction. These quartz grains consitute about 90% of the main mineralogical composition. Few aggregates of microcrystalline silica are also encountered. Quartz grains are ill-sorted and composite grains are commonly recorded (Fg. 8). some primary and secondary inclusions represented by rutile needles, tourmaline.. etc, and replacement by clay minerals (Fig. 9) are also present. The quartz grains are cemented with secondary silica overgrowths (Fig. 10), or by iron oxides (fig. 11) as well as caly matrix (Fig. 12).

The recorded wackes (Pettijohn et al., 1973) are pale white in colur, grains angular to subangular, poorly sorted and admixed with sand-silt and clay materials (Fig. 13).

Laterally, a relative eastward increase in grain size form Bir Heimer towards Bir Abu Darag , Wadi Qiseib and Bir Abu Sandug may suggest a change in the flow regime concept (Selley, 1976). Also, vertical variation in grain size in repeated manner especially in Wadi Qiseib and Bir Abu Sandug sections could suggest cyclic or rhythmic deposition by slow current velocity through intervals and fluctuation in current intensity in the ancient alluvial deposits (Allen, 1964; VanHouten, 1964, and Selley, 1976). It should be

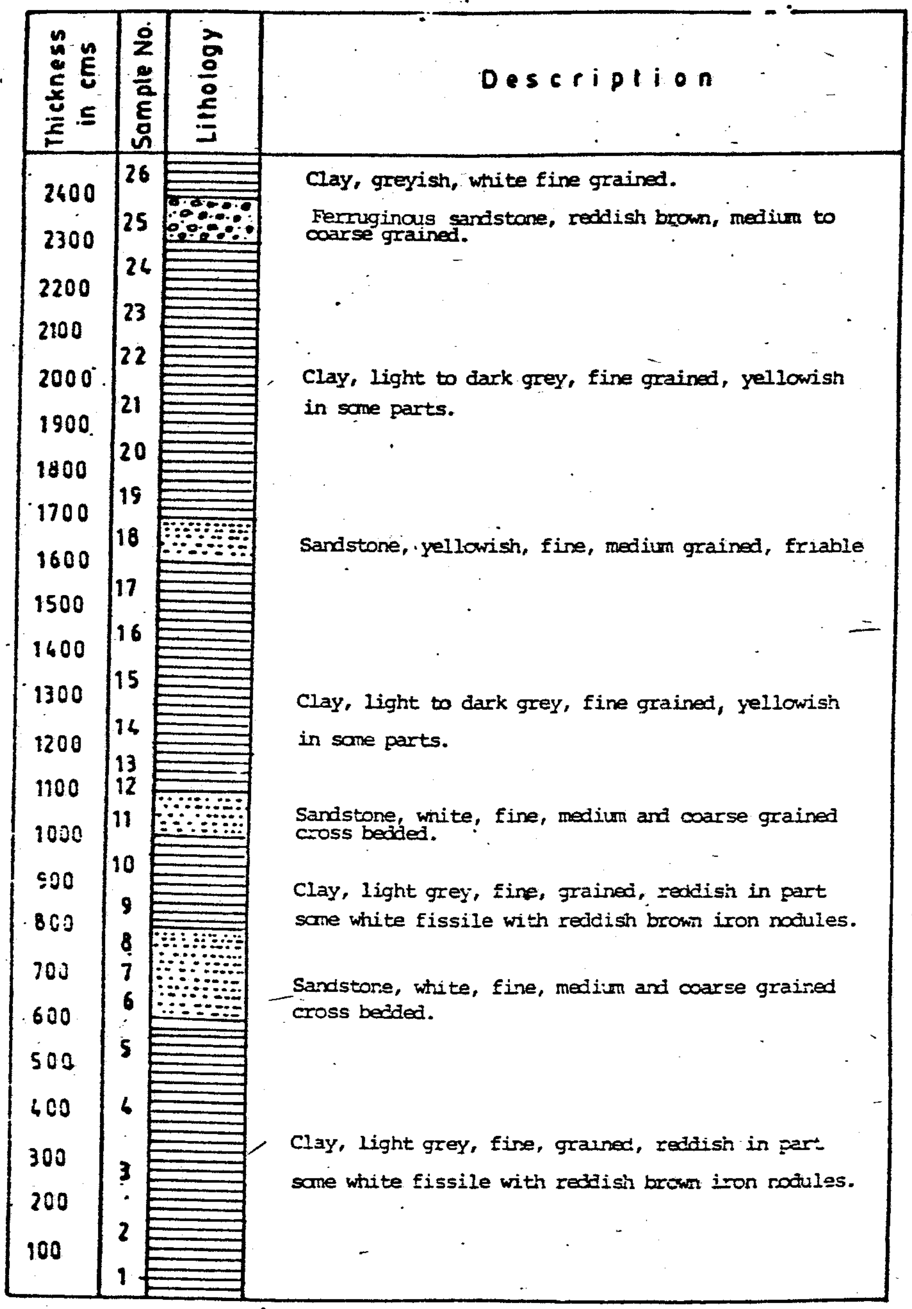

Fig. (5) - Columnar section showing the lithology of Wadi Qiseib.

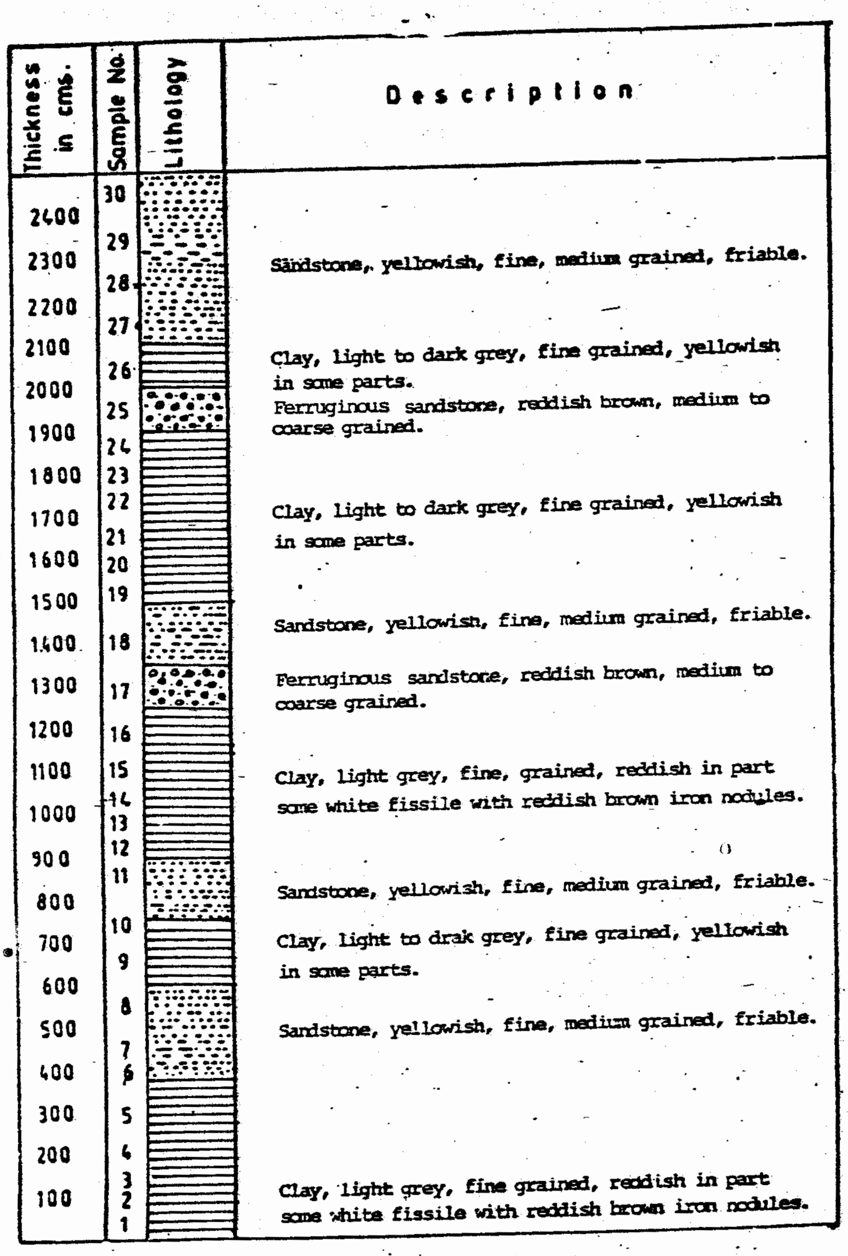

Fig. (6). - Columnar section showing the lithology of Bir Abu Sandug.

taken into consideration that variation of current velocity is possibly the reason for such vertical change in grain size. On the other hand, these sandstones are of medium, fine-grained and mixed with some rock fragments (Fig. 14), of angular quartz and feldspars. Most probably, these sandstones were deposited not far enough from the Pre-cambrian basement source supply, while the silt size grade may represent the deposition in a flood plain of alluvial cycles (Mackin, 1937; Allen, 1964; Visher, 1965). This is confirmed by the higher content of composite and semi-composite grains in all the studied sections.

The studied area was highly affected by tectonism, hence comparing different sampled localities on both sides of the Gulf show different lithological characters (Abdallah and El-Adindani, 1963). Commonly, feldspars and iron-oxides Co-exist with the quartz grains, this can be discussed as follows :

a- **Feldspathic Sandstone :**

Feldspars which are recorded in sandstones are represented in the investigated samples by albite and microcline. They are commonly angular and medium to fine-grained. Both fresh and altered varieties are recorded (Fig. 15). No authigenic feldspars are recorded but they are partially to completely clouded with alteration products (sericitization) due to weathering. Effect of transporation is low as angular feldspars are common, being not far from the source area (Fig. 16).

b- Ferruginous Sandstone :

A reddish brown, medium to coarse-grained and an iron-oxide rich sandstone layer is commonly recorded near the top of the examined sections. Microscopically, iron-oxides are represented by hematititc cement filling the inter-grain spaces and as disseminated patches of varying dimensions and shapes (Fig. 17). Most probably the iron was liberated through the alteration of biotite and hornblende or other iron-bearning silicate minerals and deposited in alkaline medium during advanced stage of diagnesis (Dapples, 1967; Van Houten and Karasekm, 1981).

diagenetic Processes :

Diagenetic phenomena recorded in sands and sandstones are :

1. <u>Silica overgrowths and silica cementation</u>: The secondary authigenic silica rim are believed to be derived from silica supersaturated pore water (Zaghloul et al., 1984). However, pressure-solution can't be excluded as another source for silica supply (Fig. 18). On the other hand, deficiency of silica overgrowths and phenomena of pressure solution in sandstone wackes can be attributed to the effect of clay matrix which acted as an envelope to the detrital quartz grains prohibiting the release of silica and reduce the effect of pressure solution on the quartz grains (funchtbauer, 1967; Zaghloul et al., 1984).

2. <u>Cementation by iron-oxides</u> : It is suggested that the origin of the iron-oxide is from the alteration of iron-rich minerals (Van Houten, 1968). Isomorphous substitution of alumina by iron-oxide in suitable physicochemical conditions can resulted in cementation by iron oxides (Van Houten and Bhattacharyya, 1982). The resulted sediment is highly indurated and is poorly porous.

3. <u>Secondary inclusions</u> : Some quartz grains are bitted and have a spotty appearance,due to the presence of secondary inclusions on the surface of the quartz

Fig. (7)

Fig. (8)

Fig. (9)

Fig. (10)

Fig.(7) : Quartz arenite
Photomicrograph showing angular to subangular quartz grains. Notice few grains are subrounded with overgrowths. some grains show rutile inclusions x 50: C.N.

Fig.(8) : Quartz arenite
Photomicrograph showing semi-composite quartz grain in poorly sorted components x 50: C.N.

Fig.(9) : Quartz arenite
Photomicrograph showing replacement by secondary inclusions on the surface of quartz grains. x 50: C.N.

Fig. (10): Quartz arenite
Photomicrograph showing cementation by silica; silica over-growths and iron-oxides. x 50: C.N.

Fig.(11): Quartz arenite
Photomicrograph showing cementation by iron-oxides in poorly porous sandstone. x 50: P.P.L.

Fig.(12): Sub-wackes
Photomicrograph showing clay matrix filling the inter-pore-space groundmass betweenquartz grains. x 50: P.P.L.

Fig.(13): Wackestone
Photomicrograph showing fine to very fine silty-size grade a clay materials. Notice that the abundant organic matters a admixed with clay groundmass. x 50: P.P.L.

Fig.(14): Siltstone.
Photomicrograph showing fine to medium quartz grains admixed with rock fragments. X 50: P.P.L.

Fig. (11)

Fig. (12)

Fig. (13)

Fig. (14)

grains (Fig. 19). These were formed in the later stage of diagenesis.

ii- Shales and Claystones :

The clayey layers are represented by a thick laminated red-coloured seauence in all the investigated sections. The red colour most probably resulted from weathering of iron silicate-bearing minerals under oxidizing condition (Van Houten, 1961). The mineralogy of the clays in the investigated sections were studied by El-Rahmany et al. (in print). Microscopically, their texture depends greatly on the grain-size and the co-existing organic matter (Pettijohn, 1957). The predominance of clay beds in Bir Heimer and Bir Abu Sandug most probably suggest decrease in current energy in the former three sections then the last one (Selley, 1976). On the other hand, the upward decrease in silt and clay (as revealed petrographically), and increase in sand size grade i.e. coarsening upwards most probably represent a fluctuation from low energy condition below to high energy condition above (Selley, 1976; Van Houten and Karasekm, 1981). Fine-laminations (Fig. 20), and alternations of coarse and fine silt and clay seem to be the result of differential settling rates of the components in the basin of deposition and of common occurrence ins hallow-water delta (Pettijohn, 1957). Also, the recorded curved lamination with organic matter (Fig. 21) might be attributed to the effect of accidental storms and floods (Selley, 1976). Authigenic gypsum and organic matter present in the clays and claystones are interpreted as follows :

(a) Authigenic Gypsum (Anhydrite) :

fibrous gypsum (anhydrite) of rose-like shapes with its typical optical characteristics are commonly recorded admixed with clays in the investigated sections (Fig. 22). The stacked nature of the fibers is characterized by stain-spar type of gypsum and is formed by the hydration of anhydrite. On the other hand, fluctuation in the amount of sodium chloride in the vadoze zone, above the groundwater level may cause periodic gypsum crystallization beneath the surface of evaporation zone with the peripheral dissolution of some gypsum crystal. The recorded gypsum (anhydrite) is therefore of authigenic secondary origin (Mason, 1955; Antia, 1979).

(b) Organic Matters :

Organic matters are commonly recorded associated with clays and siltstone. Their frequency is higher in Bir Hemier and Bir Abu Darag sections compared with other investigated sections. The recorded vascular plant materials may reflect deposition from surface water

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Fig. (16)

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Dapples, E.c. (1967) : "The diagenesis in sandstones". In: G. Larsen, and G.V. Chilingar. (eds). Diagenesis in sandstones. Elsevier, Amsterdam, pp. 91-125.

El-Kholy, D.M.M. (1987) : "Geology and radioactivity of the rocks of Wadi Abu Darag area, Eastern Desert A.R.E.".

El-Rahmany; Kolkila, A.; El-Mansey, I. and Madani, M.: Mineralogical and geochemical studies of Lower Cretaceous sedimients of Abu Darag area, Galf of Suez, Egypt. Ain Shams, Fac. Ed. (in print).

Folk, R.L., (1968) : "Petrology of sedimentary rocks". Hemphill, Austin, Texas, p. 170.

Fuchtbauer, H. (1978) : "Zur Herkunft des quartz sements aoschistzung der quartz Auflosung in silt and sandsteinen". Geol. Rundschaus, Vol. 67, pp. 99-108.

Gibling, M.R.; Tantisukrit, C.; Uttamo, W.; Thanasu-Thipitak and Haraluck, M.(1985), : "Oil shale sedimentology and geochemistry in Cenozoic Mo'e Basin Thailand". AAPG Bulletin, Vol. 69, pp. 767-780.

Kolkila, A.; El-Rahmany, M.; El-Mansey, I. and Madani, I.: Lithostratigraphy and sedimentology of the Lower Gretaceous sediments of Abu Darag area of Gulf of Suez, Egypt. (this volume).

Mackin, J.H., (1937) : "Erosional history of the big horn basin, Wyoming". BUll. Geol. Soc. Amer., Vol. 48, pp. 813-814.

Mason, P.H. (1955) : "An occurrence of gypsum in Southwest Texas", In : F, T. Pettijohn (ed.). Sedimentary rocks, Harper and Brothers, New York, pp. 648-

Millot, G. (1970) : "Geology of Clays". New York, Springer Verlag, p. 429.

Pettijohn, F.J. (1957) : "Sedimentary rocks". 2nd edition,Harper and Bros. Pub. Co., New York, p. 718.

Pettijohn, F.J.; Potter, P.F. and Siever, R. (1973) : "Sand and Sandstones". Springer-Verlag, New York, Heilderberg, Berlin, p. 618.

Said, R. (1962) : "The geology of Egypt". Elsevier Pub. Co., Amesterdam, 1New York, p. 377.

Selley, R.C. (1976) : "Ancient sedimentary environments". Chapman and Hall, London, p. 337.

Van Houten, F.B.(1961) : "Climatic significance of red beds", Descriptive Paleo-climatology, Vol. 7, wiley-interscience, pp. 89-139.

__________________, (1964) : "Cyclic Lacustrine Sedimentation Upper Triassic Lockatong Formation Central New Jersey and adjacent Pennsylvanian : In Symposium on cyclic sedimentation (D.F. Merriamed, ed). Geol. Surv. Kansas, Bull., Vol. pp. 497-532.

__________________, (1968) : "Iron oxides in red beds". Geol. soc. America. Bull. Vol. 79, pp. 399.

__________________, and Karasekm, R.M. (1981) :"Sedimentologic framework of Late Devonian, Oolitic iron formation Shatti Valley, West Central Libya". Jour. Sed. Petrol., Vol. 51, pp. 0415-0427.

__________________, and Bhattacharyya, D.P. (1982) : "Phanerozoic Oolitic Ironstones-Geologic record and facies Model". Ann. Rev. Earth Planet. Sci., vol. 10, pp. 441-457.

Visher, G.S. (1965) :"Fluvial processes as interpreted from ancient and recent fluviatile deposits". Soc. Econ. Pal. Min., Special Pub., Vol. 12, pp. 116-132.

Wentworth, C.K. (1922) :"A scale of grade and class terms for clastic sediments. J.Geol. Vol. 30, pp. 377-392.

Zaghloul, Z.M.; Samuel, M.D.; Yanni, N.N., and Guirgues, N.R. (1984) :"Petrography and mineralogy of Lower Cretaceous clastics near abu Darag, Gulf of suez., Egypt., .Geol., Vol. 128, 1p. 209-220.

Shimron, A.E., 1980. Proterozoic island arc volcanism and sedimentation in Sinai. Precamb. Res., 12, 437-458.

Simpson, E.S.W., 1954. On the graphical representation of differentiation trend in igneous rocks. Geol. Mag., XCI, 3, 238-244.

Stern, R.J., Gottfried, D.G., & Hedge, C.E., 1984. Late Precambrian rifting and crustal evolution in the North Eastern Desert of Egypt: Geology, 12, 168-172.

Stren, R.J. & Hedge, C.E., 1985. Geochronologic and isotopic constraints on Late Precambrian crustal evolution in the Eastern Desert of Egypt. Am. J. Sci., 285, 97-127.

Tuttle, O.F., & Bowen, N.L., 1958. Origin of granite in the light of experimental studies in the system $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2-H_2O. Geol. Soc. Amer. Mem. 74, 1-153.

Washington, H.S., 1917. Chemical analyses of igneous rocks, U.S. Geol. Surv. Prof., Paper 99.

Wright, J., 1969. A simple alkalinity ratio and its application to questions of non-orogenic granites gneisses. Geol. Mag. 106, 370-384.