Mısır ve bilhassa Kızıldenizin jeolojik tarihçesi

S. W. TROMP [1])

Özet: Mısırdaki strüktürel durumun kompleks olması, teressüplerin başka başka havzalara ait bulunması muhtelif jeolojik katlardaki sahraların litolojik karakterlerini hülâsaten vermesi güç yapmaktadır. Mısır'da 1897 denberi Mısır Jeoloji Enstitüsü tarafından bir çok işler görülmüş olmakla beraber Mesozoik ve daha genç sahaların dakik hartaları petrol kumpanyaları tarafından yapılan faaliyetle başlar. Bu hususda bilhassa son on sene zarfında büyük terakkiler kaydedilmişse de maalesef bu malûmatın çoğu kumpanyaların arşivlerinde mahfuz bulunmaktadır. Bu konuşmada verilen bilgi 1937-1940-1947 ve 1949 senelerinde yapılan şahsi incelemelerle Mısır'da çalışan bir çok jeologlarla yaptığım şahsî temaslara istinad etmektedir.

Mısır'da arazinin büyük bir kısmı yaşları Karboniferden eski olan sahalarla örtülüdür. Sina yar1madasının cenubu, Süveyş Körfezinin batısı, yaşları kesin olarak bilinmeyen gnays, metamorfik şist ve granit entrüziyonları 2000 metreye kadar yükselen dağları kaplarlar. Granit ve şistlerin üzerinde diskordansla kalın bir Karbonifer seksiyonu bulunmaktadır. Cenup batı Libya'da Graptolit ihtiva eden ve Silüre izafe edilen şeyl ve sleyt tabakaları bulunmuştur. Karbonifer en iyi Süveyş Körfezinin batısında ve doğusunda inkişaf etmiş bulunmaktadır. Nubia Formasiyonu fosil ihtiva etmeyen kalın ve az sertleşmiş beyaz, pembe renkte bir gre serisi olup Karboniferden eski sahaları örter. Bu kumtaşlarının yaşı Karboniferden Kampaniyene kadar değişmektedir,

Mısır Jeoloji Enstitüsü tarafından 1945 de Sina doğusunda Ortatriasa ait sahalar bulunduğu gibi daha evvelce gene Sina'da iyice inkişaf etmiş bir Jurasik Seksiyonu bulunmuştur. Kretase umumiyetle Altkretase olarak boz veya kırmızı renkte demirli, bazen glaukonitli, ve kil ara tabakaları ihtiva eden 300 metre veya daha kalın bir kumtaşı serisiyle başlar, Senomanien, Turonien ve Senonien daha ziyade kalker fasiyesinde zuhur etmektedir. Bununla beraber Ras Garib'de kumlu, killi, jipsli Senomanien bulunduğu

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1) Mısır I nci Fuat Üniversitesi sabık jeoloji Profesörü. Tebliğ Nisan 1950 de verilmiş olup makalenin alınış tarihi 20/5/1950 dir.

gibi Nilin sağ cenahında Asuan' ın kuzeyinde Senonien, Nubia kumtaşları olarak görülmekte ve oolitik kısımlarında demir cevheri ihtiva etmektedir.

Kretaseden Eosene geçiş, yakın doğu memleketlerinde umumiyetle olduğu gibi tranzisyon iledir. Üstsenonien ile Alteosene ait sahralar taktirde petrol göstermeleri dolayısile hususi bir ehemmiyeti haizdir. Alteosenle Lütesiyen arasında bölgenin en mühim diskordansı bulunmaktadır. Bu diskordans bazen büyük Nümmülitler ihtiva eden konglomera ile kendini göstermekte ve bu konglomera ise Süveyşin doğusunda bulunan petrol sahalarında olduğu gibi petrol hazne taşlarını teşkil etmektedir. Mevzii bazı şakulî arz hareketleri neticesi olarak bazı bölgeler devamlı erozyona tabi olmuş ve ancak Üstmiosende su seviyesinin altında kalabilmiştir. Oligosen Süveyş Kanalının doğusunda ve Süveyş-Kahire arasında kumtaşı, konglomera, kuvarsit, breş olarak ve Süveyş'in batı sahilinden Cebel Zeit'te deniz teressübü olarak bulunmaktadır. Oligosen, Eosen üstünde bir diskordansla bulunmaktadır.

Neojene girildiği vakit Miosen denizinin müteaddit kollarla ayrılmış olması ve ayrı ayrı müstakil havzalar teşkil etmesi dolayısile sahralar arasında mukayese güçleşir. Böylece Miosen stratigrafisi (a) Batı çölü Mioseni, (b) Kahire-Süveyş bölgesi Mioseni, (e) Süveyş körfezi doğu sahili Mioseni olarak üç grupta mütâlea edilmiştir.

Pliosen umumiyetle daha yaşlı tabakalar üzerinde bir diskordansla bulunmaktadır. Pliosen teressüpleri (a) Süveyş bölgesi, (b) Batı çölü Plioseni, ve (c) Nil vadisi Plioseni olarak üç bölümde ele alınmıştır.

Pleistosen alttaki tabakaları diskordansla örter. Pleistosen sedimentasyonu: (a) Süveyş Körfezi çevresi, (b) Akdeniz sahili Pleistoseni, (c) Nil vadisi Pleistoseni, (d) Fayın çöküntüsü Pleistoseni, (e) Sina Çölü Pleistoseni, (f) Karga ve Kurkur vadileri Pleistoseni, olarak altı muhtelif bölgedeki tekevvünü gösterilerek izah edilmiştir.

Kızıl Deniz çöküntüsü hakkında son elli sene zarfında bir çok neşriyat yapılmıştır. Süveyş Körfezi çöküntüsü Alteosende başlamış olmakla beraber Kızıl Denizin pek eski zamanlardan beri bir kırıklık zonu olarak mevcut olması muhtemeldir. Süveyş bölgesinin 25° arz dairesinden Akdenize kadar Mesozoik ve Alteosen, devirlerinde su altında olduğu ve transgresyonun Akdenizden başlayarak Cenuba doğru ilerlediği bilinmektedir. Senoniende deniz 25 inci arz dairesine kadar ilerlemiş bulunuyordu. Alteosen sonlarında Süveyş çevresinde yükselmeler ve bu hareketlerle birlikte şakulî faylanmalar husule geldi, Bu hâdisenin neticesi olarak vukua gelen aşınma yüzünden Ortaeosen tortulları eski sahralar üzerine diskordanslı bir temasla teressüp etti.

Ortaeoseni müteakip tekrar ve muhtemelen daha mühim iltivalanma ve yükselme vukua geldi. Üsteosen denizi bu iltivalı satıh üzerine teressüplerini bıraktı. Bazı bloklar deniz seviyesinin üstünde kaldılar. Böylece erozyon bütün Tersiyeri aşındırdığı gibi bazen bu aşınma granitlere kadar nüfuz etti. Oligosen içindeki alçalmalar kalın Miosen teressüplerinin bazı yerlerde doğrudan doğruya granitler üzerinde olmasına imkân verdi. Öte yandan Kızıl Denizin çökmesi kısa fasılalarla Miosen, Pliosen ve Pleistosein'de devam etti. Kahire-Süveyş bölgesinde 40 metre kadar kalın olan karasal Oligosen üstünde bulunan bazalt akıntılarının kat'î surette Altmiosen olarak tesbit edilen sahraların altında bir diskordansla uzandıkları görülmektedir.

Süveyş Körfezinin teşekkülünden evvel bölgede bir umumî yükselme vaki olduğu ve bunun neticesi olarak derinlerde birleşen tansiyon fayları husule geldiği ve bu hareketlerin en çok Sina yarımadasında faal olduğu ve tansiyon faylariyle yırtma faylarının müştereken Süveyş Körfezi çöküntüsünü meydana getirdikleri kabul edilebilir.

The Geological History of Egypt and of The Red sea in particular

S. W. TROMP [1]

1) *Introduction:*

The geological history of Egypt is a very complex but most fascinating story which starts at least 1000 million years ago in the Pre-Cambrian. In order to give the complete history it would be necessary to discuss both the macro-stratigraphical and the micro-paleontological conditions in Egypt. However, in view of the limited time available, I shall have to restrict myself to the macrostratigraphy only and in particular to the lithological aspects of Egyptian stratigraphy.

Due to the complicated tectonic structure of Egypt and the sedimentation in different, often separated basins, it is extremely difficult, if not impossible, to give a brief summary of the lithological characteristics of the different geological periods in Egypt. Since 1897 considerable reconnaissance work has been done by the Geological Survey in Egypt (1. 2, 3, 4, 8), but verv accurate detail surface mapping in Mesozoic and younger beds started much later, in combination with extensive drilling for oil by the Standard Oil Co. of Egypt, Anglo-Egyptian Oil- fields (Royal Dutch Shell) and the Socony Vacuum Oil Co. Their studles increased our knowledge about the post-Paleozoic rocks tremendously, in particular during the last 10 years. But unfortunately most of these latter data are kept secret by the different oil companies. The summary given here represents therefore only a compilation of facts known from published data, personal observations during 1937-1940 and 1947-1949 and finally verbal informations received from a great number of oil geologists of the Socony Vacuum Oil Co., Anglo Egyptian Oilfields (Shell) and the Standard Oil Of Egypt. Still this compilation gives far from a complete picture of the present geological knowledge of Egypt.

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2) Stratigraphy of the Pre-Carboniferous:

In Egypt an extensive area is covered by old rocks of unknown age, of which we know only that they are pre-Carboniferous in age. For this reason it seems preferable to indicate this area as Pre-Carboniferous only. Little is known of the stratigraphy of these Pre-Carboniferous beds (8, 10). They are outcropping in the southern part of the Sinai Peninsula (south of latitude 29°) east of Abu Zenima and along the western border of the Gulf of Suez (south of latitude 28° 45). This section is composed of gneisses, schists and extensive granite intrusions of unknown age. The latter group is found for example on the west coast of the Gulf of Suez as mostly reddish coloured quartz-felspar granite ranges, representing a 50-70 km. wide batholithic Pre-Cambrian intrusion, forming high mountains many over 2000 m. Apart from granites, also dioritic intrusions have been found in the lower hills of the same area. The granites sometimes contain enclaves of older sediments.

Both the granites and schists are unconformably overlain by a thick carboniferous section. These relations can be studied for example between Abu Zenima (E. coast of the Gulf of Suez) and the more eastwards situated manganese mines of Umm Bogma. The schists in this region are intruded by enormous granite batholiths which are covered by Carboniferous sandstones, the most remarkable feature being the contact plane between sandstones and granites, which is completely flat surface, not covered by a basal conglomerate of granite boulders as we would expect.

Also different types of volcanic rocks occur in the Pre-Carboniferous section, such as the rhyolitic lavas and tuffs, dolerites in the Dokhan and EshRange, including the famous imperial porphyry used for Egyptian statues, and still found in some of the historic monuments of İstanbul, etc.

The exact age of these different Pre-Carboniferous lithologic units is difficult to determine. HUME and his collaborators pointed out that all the above mentioned rocks probably are pre-Silurian, as beds with clearly marked Silurian fossils were found in the Ahagger regions of the Central Sahara and present no such metamorphosed characters. However, the pre-Cambrian age of the crystalline series in Egypt is particularly suggested by the stratigraphy of other neighbouring countries.

1) During the last war a publication appeared from BEHREND who compiled different geological observations in Lybia made by DESİO and other Italian geologists. West of the Egyptian border a series of schists and gneisses occur which are intruded by granites containing gneisses and sandstone enclaves. Their age is uncertain. In 1933 DESIO discovered in a younger sandstone series lower and middle Devonian limestone intercalations, containing Chonetes, Spirifer, etc. In SW Lybia a narrow zone of shales and slates occurs with upper Silurian Graptolites, but also sandstones with lower Silurian fossils have been reported. For these reasons at least part of the schists is considered to be pre-Silurian, the more so as near Tschad, further south, the schists seem to be covered by pre-Cambrian sediments.

2) BLANKENHORN discovered in 1910 near the SE corner of the Dead Sea large masses of granites, quartz porphyries and diorites resembling those of Sinai, which near wadi Sarmuj are overlain unconformably by red sandstones, covered by 14 m. of red and green marls, followed by 51 m. of dolomites and limestones containing at nearby localities middle Cambrian Trilobites and Hijalithe. Later studles by WYLLIE, CAMPBELL and LEES indicated similar middle Cambrian beds in Jordan.

3) The lithologic similarity between the pre-Cambrian (or basal Cambrian) volcanic series of Telbesmi in S. E. Turkey, west of Mardin, the volcanic series of the Dead Sea, Tanganyika, etc. and the Hammamat-Dokhan series of Egypt suggests a similar age for these Egyptian formations.

4) BARTHOUX discovered in 1922 microscopic organisms in the green breccias of the Hammamat schists, which he described as Holothurian fragments. The organisms are half a millimeter long, 0. 1 mm wide and are in the shape of a cornucopia, the interior being spongy. EVANS found similar organisms in the pre-Cambrian Nama beds of south Africa, which are common in the Cambrian of N. America, Siberia, Australia, etc. but seem to occur also in the pre-Cambrian of Canada.

Although the greatest part of the Egyptian schists series seems to be pre-Cambrian in age, we should keep in mind that part of the pre-Carboniferous section in Egypt (e. g. the Gattarian intrusions) may be Cambrian or youger in age.

HUME compiled a great number of data on the relative age of the igneous and metamorphic pre-Carboniferous rocks of Egypt, Sinai and the N. Sudan which, except for a few alterations as a result of recent studies by ANDREW and SCHURMANN, are still accepted by most geologists who have studied the region. The stratigraphy of the pre-Cambrian of Egypt could be classified as follows.

I a) Ereier schist and gneisscomplex: The oldest series of Egypt exposed in Wadi Ereier and composed of intensely crushed schists, micagneiss and igneous rocks.

b) Sikait Magnesium series of Hume or Baramia series of Schurmann: They comprise Beryll-mica schists, Talc-, Graphite- and Chlorite schists and dolomites. The schists partly derived from sandstones, partly from argillaceous sediments.

c) Haimur or lower paraschist series: The most typical occurrence being near Wadi Haimur. It consists of green epidotic calcareous schists, alternating with white marble bands. Both the Sikait and Haimur schists are intruded by Serpentines, e. g. at Baramia, which in places are rich in Chromium ores.

II a) Shait series: Plutonic intrusions of hornblende granites and diorites (partly changed into gneiss). Many of the Auriferous quartzveins in Egypt seem to be connected with these intrusions.

b) Shadli or middle parasehist series: particularly developed near Bir Shadli. They are composed of purple schists alternating with dolerite flows and a system of fine grained diorite sills.

III a) Dokhan or Feram series: a volcanic series exposed in the Dokhan and Esh range, being contemporaneous or older than the Hammamat series. It consists of porphyrite, diabase quartzporphyrite and quartzporphyry flows and tuff beds.

SCHURMANN considers the Shadli and Dokhan series as one unit, both underlying the Hammamat series (see below), the main difference between Shadli and Hammamat series being the abundance of dolerites in the Shadli series, which seem to be absent in the Dokhan and Hammamat series.

The famous <<Imperial Prophyry>>, in Pharaonic times quarried at Mons Prophyritus. belongs also to this Dokhan series. It is found in most antiquity sites along the Mediterranean, also in İstanbul for example.

b) Hammamat series or upper paraschists: they occur e. g. near Wadi Hammamat and are composed of reddish brown (sometimes greenish) conglomeratic greywacke, felspathic quartzites and black to greygreen, brecciated schists (also known as breccia verde d'Egitto) intercalated with acidic and slightly basic tuff beds and andesitic lava flows. The conglomerates contain acc. to ANDREW and SCHURMANN pebbles of the Dokhan and older series, which should indicate a post Dokhan age.

The <<breccia verde>> was used in Pharaonic times for sarcop- hagi and Egyptian statues and can be found in many antiquity sites along the Mediterranean. Both the Dokhan and Hammamat series are probably the Main periods of copper ore deposition in Egypt. At the end of the Hammamat period probably a new period of strong volcanic activity started with quartz porphyry and quartz porphyrite flows, known as post Hammamat volcanic series of Hume. This whole section resembles the Cambrian volcanic series of Telbesmi in S. E. Turkey and the Cambrian volcanic section near the Dead Sea.

IV) Gattarian intrusions: Probably pre-Carboniferous crystalline series; probably the following succession of extrusions and intrusions took place:

a) Ultrabasic rocks (gabbros, peridotites, serpentines, etc.) as fringe around a batholithic diorite nucleus (oldest Gattarian intrusions).

b) Diorite intrusions (Second Cataract type).

c) Biotite-and Hornblende granites and granodiorites (Aswan type), the latter being responsible for some of the Auriferous veins in Egypt.

d) Red granite intrusions and pegmatites (Central range type): Period of tin, molybdenum and tungsten ore deposit in quartz veins.

e) Dykes of felsite and prophyry.

f) Dykes of dolerite (youngest Gattarian extrusions).

The classifications given above is based on a great number of short fieldtrips in very large areas and it should be kept in mind therefore that this classification is still rather hypothetical. Unless a detailed map of the whole pre-Carboniferous area of Egypt is prepared by a great, number of experienced petrologists, we shall not be able to establish a detailed stratigraphy of this pre-Carboniferous section, the more so as it is of no interest to the oil companles who up till now did most of the detailed mapping in Egypt.

3) Stratigraphy of the Carboniferous

Carboniferous rocks can be studied best in the Wadi Araba area (W. coast of the Gulf of Suez) and E. of Abu Zenima (E. coast of the Gulf of Suez) in the Umm Bogma area near the manganese mines. Interesting sections have been found also in the sub-surface sections of the Ras Gharib oilfields (W. coast of the Gulf of Suez).

1) Wadi Araba section: in Wadi Araba and along the east slope of the northern Çalala Plateau carboniferous beds were discovered in 1883 by SCHWEtNFURTH. They were studied more in detail by Prof. J. WALTHER in 1887. From top to bottom the section consists of the following beds:

abt. 400 m: middle Eocene limestones; at base large erosional unconformity.

240 m: upper Senonian (Maestrichtian and Campanian) chalky marls

abt. 90 m: marly limestone and marl with sandstone intercalations and L. Senonian Ammonites

115-150 m: Turonian limestone

155-190 m: Cenomanian marls and limestones

250 m: non fossiliferous reddish Nubian sandstone (probably Carboniferous in age)

2 m: bed with siliceous trees (Araucarioxylon)

60 m: sandstones and marls

1 m: hard blue-grey Carboniferous limestone with many Crinoid stems. Zaphrentis, Spirifera, Rhynchonella, Productida, Bellerophon, Fenestella, etc.

40 m: marl and sandstone

The term Nubian sandstone is given to a thick monotonous nonfossiliferous sandstone series, either white or brownish in colour, usually loosely cemented and easily weathering into loose sand, consisting mainly of quartz and a few other minerals, which is overlying the Pre-Carboniferous granites and schists. Their age varies between Carboniferous and Campanian, but as a rule further north towards the Mediterranean the Cretaceous sandstones change gradually into marine argillaceous-, chalky- or limestone deposits.

2) Umm Bogma section: a very interesting section is out- cropping along the road in Wadi Baba leading up to the Umm Bogma manganese mines, which can be summarized as follows from top to bottom:

abt. 150 m: white or brownish sandstones with clay intercalations and prints of Lepidodendrons.

abt. 40 m: hard dolomites or soft grey limestones with Corals, Crinoids, Brachiopods and Fish-teeth. They are overlying the deeper beds with a slight unconformity;

40 cm.-few m: black or reddish shales, locally with green copper and ferrous salts. The thickness varies from place to place; the thinner the shale, the thicker the overlying limestones;

1,2 — 6m: Manganese ore, probably originating sedimentary by discolution of manganese salts of contemporaneous or older basic intrusions (the thicker the covering shale, the thinner the ore deposits);

10 m: white solid sandstone;

105 m: alternation of white Nubian sandstones, green shales and red micaceous sandstones, the number of shales is increasing upwards. The basal sandstones overly with an arkose or Nubian sandstone (but without a basal conglomerate) a completely flat fossil peneplain, the top of a Pre-Carboniferous granitic batholith. This suggests a nonfluviatile and non-marine deposition probably of aeolic, origin.

About 8 cm. SSE of Umm Bogma, at Gebel Maghara, almost at the same stratigraphic level as the manganese ores of Umm Bogma, Turquoise deposits occur. The detail section consists from top to bottom of the following beds;

60 m.: sandstones

Two horizontal ferrugineous seams, abt 2 1/2 m. apart; turquoise occurring at this level as joint-filling or as concretionary nodules;

Lower sandstone series of Umm Bogma.

3) SubSurface section at Ras Gharib: under the Miocene evaporite series (see later) a carboniferous section occurs which can be summarized as follows (from top to bottom):

abt. 80 m.: black clay-slates with small Brachiopods and Conodonts (discussed in article on "The microstratigraphy of Egyptû;

80 m.: alternation of white Nubian sandstones and black clay-slates, the number of clay-slates intercalations increasing upwards;

at least 100 m.: white Nubian sandstones with clay intercalations and prints of Lepidodendrons, which are

lmportant reservoir horizons in the Ras Gharip oilfield.

4) Stratigraphy of the Triassic :

Up till now nowhere in Egypt Permian beds have been found with certainty. But M. Triassic beds were discovered in 1945 by the Geological Survey of Egypt (in particular by Dr. GALLAL HAFEZ AWED) at Gebel Araifel-Naga in N.E. Sinai. They were described later in detail by Mr. EICHER from the Standard Oil Co. of Egypt. It seems that a few years earlier this locality was discovered by the oil geologists of the Shell Oil Co., but no data were published on it. The section of Araif- el-Naga consists from top to bottom of the following beds:

Thick section of L. Cretaceous Nubian sandstone, overlain by marine U. Cretaceous and Eocene beds, and directly underlain by the following Triassic beds:

80 m.: Grey to brown limestone with greenish and multi- coloured shale intercalations;

6,5m.: Shaly marl with Progonoceratites, Myophoria laevi gata, Avicula sp., Ostrea montis, Pseudoplacunoides, etc.;

abt. 70 m.: Grey to brown limestones with one 4 m. thick sandstone intercalation and a few shaly intercalations. Also in these beds Myophoriat Ceratites and other Triassic macro-fossils were found.

This Triassic section is also interesting because some of the shales contain Conodonts micro-fossils up till now mainly known from Palaeozoic beds.

5) Stratigraphy of the Jurassic:

One of the best exposed (more than 1200m. thick) Jurassic sections was found in N. Sinai in Gebel Moghara and was described by MOON, SADEK and others round 1920. The author measured a standard section in 1937 (17) for the Socony Vacuum Oil Co., which can be summarized as follows from top to bottom:

a) *Upper Jurassic:* About 300 m.

120 m.: Light grey limestones with flint and chert beds and ferruginous Corals;

60 m.: Light grey chalky limestones;

100 m.: Grey limestones, in lower part with yellow-brown marl intercalations.

b) Middle Jurassic : About 550 m.

200 m.: Alternation of grey limestones and yellow-brown

marls and marly limestones;

80 m.: Dark brown ferruginous calcareous sandstones;

140 m.: Alternation of grey limestones and brown marls with Rhynehonellas, Terebratulas, Echinoids and Algae nodules;

140 m.: Alternation of grey limestones, brown marls and brown calcareous sandstones; at base a 5 -10 m. thick clay bed.

c) Lower Jurassic: 400 m.

200 m.: Brown ferruginous calcareous sandstones

with a few marl and limestone intercalations, with Rhynehonellas, Plant-fragments and Algae nodules; at base a thin clay horizon;

More than 120m.: Grey limestones with a single marl intercalation.

This marine facies of the Jurassic is only known near the Mediterranean, probably north of latitude 29°. Further south the Jurassic is developed in a Nubian sandstone facies.

6) Stratigraphy of the Cretaceous:

a) Lower Cretaceous: It is usually developed as brown, reddish or purple strongly ferruginous, sometimes glauconitic sandstones with clay intercalations. The thickness varles considerably but is mostly more than 300 m.

b) Cenomanian (U. Cretaceous): A section of abt. 150 m. thickness consisting of an alternation of limestones or dolomites, multicoloured ferruginous, sandstones (often greenish glauconitic) and marls (often brownish); in lower section many gypsiferous clay intercalations occur. In certain areas (e. g. W. of Ras Gharib) the clay and sandstone content may dominate, in other areas (e. g. near Sudr) the limestone facies. In south Egypt (S. of 27° 15' lat.) the Cenomanian is developed in a Nubian sandstone facies, often calcareous in its upper zones. In N. Sinai often two facies are found in the same structure: On the flanks the dolomitic facies, in the centre an alternation of limestone, sandstone and marls, which indicate sedimentation during folding.

Common fossils of the Cenomanian are: Orbitolina, Rudistae (Preradiolites, Hippurites), Oysters (O. olisiponensis, O. flabellata, etc.), Neolobites, etc.

c) Turonian: in the N. Part of Egypt (N. of Gebel Zeit) it is usually developed as a cliff-forming section. In the S. part of the Red Sea district (e.g. in Wadi Melaha) it is developed in a Nubian sandstone facies, which changes further north, near Ras Gharib, into 80 m. of light grey marly limestones with few clay intercalations; on the E. side of the Gulf of Suez near Ras Matarma a 200 m. section of limestones with few marly limestone intercalations is developed. Further north in Sinai it consists of 160 m. chalky limestones or even dolomites (flank facies), in upper part alternating with marly limestones. Rudistae and Echinoids (Hemiasters) are common.

North of Cairo in the Abu Roash structure a Turonian section is developed which consists of a number of well deve-loped units which from top to bottom can be described as follows:

45 m. Flint series: white chalky marly limestones with many flint intercalations;

20 m. Nerinea beds: 160 m.: limestone either composed of a Biradiolite reef (on N. flank of structure) or a Nerinea-Acteonella bed (in the centre); in places thick Coral masses;

4 m. ; very gypsiferous clay

130 m. Chalky limestone series: white chalky limestones.

Several phenomena in the Abu Roach and N. Sinai structures, such as facies changes with respect to the present day structural axis, indicate local structural movements in Egypt at the end of the Turonian.

d) Senonian: in N. Egypt 100-200 m. of light grey, dark grey or brownish marly limestones occur; in S. Egypt (S. of Ras Gliarib) the uppermost Senonian (Maestriehtian) is composed of 40 m. of white chalky marls, underlain by 20-40 m. of brownish grey marls and clays with several thin Phosphate beds (Campanian) which cover a Cretaceous Nubian sandstone series (composed of sandstones with few sliale intercalations), usually calacareus near the top. These phosphate horizons, which sometimes are rich in Reptile bones [2]) (so-called, Bone Beds,) and Fish-teeth, may reach considerable thicknesses and are exploited by the phosphate compames in Safaga and Quseir on the W side of the Gulf of Suez.

In the L. Senonian (Santonian) Echinobrissus, Ostrea costei and Plicatula often are abundant, in th Campanian Exogyra Overwegi, Pecten farafrensis and Gryphoea vesicularis are common, also a few Cephalopods have been found.

An interesting, about 90 m. thick, Senonian Nubian sandstone section occurs E. of the Nile, 4 km. north of Aswan (N. of Wadi Abu Agag). It consits from top to bottom of the following section:

2) It is interesting to note that, in accordance with other countries, the first mammalian bones were found in Egypt in Eocene (U. Eocene) times.

15 m.: sandstone, grits, quartzites, etc.;

10 m.: clay

8 m.: sandstone:

0.1 m.: oolitic Iron ore, further east developed into two bands, each abt. 2 M. thick, separated by ferrugiuous sandstone;

6 m.: refractory (fire) clay;

2 m.: sandstone ripple marks;

5 m.: two bands of oolitic iron ore, abt. 1 m. each alternating with ferruginous sandstone:

10 m.: sandstone with ferrnginous concretions;

10 m.: laminated clay;

20 m.: sandstone, kaolinised at base; covering irregular erosional surface;

Granites and schists.

These oolitic ores may be used in the future for a steel industry in Egypte, the electricity for the electric furnaces being supplied by a new hydro-electric plant which at present is constructed near the Aswan dam.

The Senonian age of the Nubian sandstone is indicated by the presence of the following fossils: Inoceramus balli, İ. cripsi, fresh water shells of the genera Unio, Mutella and Spatha and plant-remains. These fossils, together with the great lateral variation of the beds and their cross-bedding, suggest very shallow water conditons during their formation. Also the oolitic structure of the iron ore indicates shallow coastal conditions, the wave action allowing the gradual growth of the oolites floating in colloidal solutions rich in iron oxide.

7) Stratigraphy of the Eocene:

a) Lower Eocene: (In Egyptian literature often indicated as Ypresian, Suessonian or Lybyan): The transition of Oretaceous and Eosene in Egypt and in the Near East in general is a gradual one and the exact boundary can not be established on a lithological or heavy mineral basis. Only a micro-faunal analysis (and perliaps also a drilling-speed analysis) enables us to establish this boundary within a meter (17, 18, 23). This transition zone of marls and marly limestones in Egypt is known as Rsna Shales or Danian in the older Egyptian literature, a stratigraphic name which has proved to be superfluous in the Near East (23).

In S Egypt the marly basal Eocene section is only a few meters thick and is covered by at least 200 m. of creamish-white limestones, very rich in large flint nodules. Further north (near Ras Gharib) the whole Lower Eocene section is becoming more argillaceous and chalky (particularly in N E Sinai).

The L. Eocene is rather unfossiliferous: small Nummulites have been found (N. variolarius, N. curvispira); Operculina libyca, small Gastropodos (Turritella aegyptica), Conoclypeus, etc.

Hundreds of dry distillation tests of filed samples have revealed that oil drops were obtained after dry distillation only from L. Eocene and U. Senonian chalky beds (see also later U. Eocene). The Miocene, with a single exception, always gave a negative test. This suggests that the main source rocks of Egyptian oil are found in the Senonian and L. Eocene (see also U. Eocene).

b) Middle Eocene: (In Egyptian literature often indicated as Lower Moqattam, Parisian or Lutetian): At the top of the LEocene usually a big unconformity occurs which is probably the most important hiatus of the Near East, from Turkey up to Egypt and which is caused by regional uplifts which at the end of the L. Eocene created the initial faults of the Red Sea and Dead Sea graben zones. Due to this regional uplift in Egypt higlier blooks were deeply eroded during the end of the L. Eocene and basal M. Eocene and were covered unconformably by the nummulitic limestones (e. g. Nummulites gizehensis) of the M. Eocene. In some fold blocks the erosion went as far as the Cretaceous (e. g. in Abu Roash) and as a result M. Eocene limestones covered directly Senonian or older beds. In certain places (e. g. near Hammam Faraun orWadi Dara) the hiatus probably is absent or very small. They were the deeper basins of the L. Eocene sea which remained below sealevel during this period of regional uplift. In those areas also the thickest M. Ecene deposits seam to occur. At those places where a big unconformity is developed often a thick basal conglomerate with large Nummulites can be found which can act as an oil reservoir horizon (e. g. on the E. side of the Gulf of Suez).

Due to local block movements in the Red Sea graben during the M. Eocene (and later) certain areas were continu ously eroded and were covered for the first time in U Miocene time only. However in the deeper basins between these blocks marine sedimentation continued through the M. and U. Eocene and Oligocene.

Thick M. Eocene sections have been described from the Fayum area, the Moqattam Hills near Cairo and the Nile

Valley which seem to indicate a deeper water facies in N Egypt (limestones and chalks) than in S Egypt (many argillaceous intercalations in a limestone section).

In the FAYUM AREA, 80 km. S W of Cairo, a well-developed section is outcropping which was classified by BEADNELL (from top to bottom) into 3 units: Birket el Qarun series, Ravine beds and Wadi Rayan series of which the Birket el Qarun- and the upper part of the Ravine beds proved to be upper Eocene during the most recent surveys of the oil companies.

1) Lower ravine beds: abt. 30—40 m. thick also known as Gaharinam beds.

Top 10 m: hard light yellow limestone partly marly and sandy in places with Nummulites gizehensis;

9 m: ochreous yellow and grey clays and marls with gypsum,

3 m: hard yellow very gypsiferous shaly marl;

10 m: yellow marly clays, brown clays, sandy glauconitic yellow and black clays with much gypsum and Seuglodon remains.

2) Wadi Rayan series: abt 130 m. of siliceous limestones, marls and some clay intercalations; fossils: Nummulites gizehensis, Fasciolites, Carolia placunoides, small Seaurchins (Porocidaris, Rhabdocidaris), etc.

c) Upper Eocene (In Egyptian literature often indicated as Upper Moqattam, Priabonian or Bartonian): this section can be studied best on the E. coast of the Gulf of Suez near Hammam Faraun, in Wadi Tayiba, near Cairo (E. of Maadi) and in the Fayum area.

Wadi Tnyiba-Hammam Faraun section:

40 m.: Tanka beds : white marly limestones, near top often reddish below a coveriwg dolerite flow (so-called Lower Red Beds);

105 m.: Gypsiferous marls: 'in upper part dark brown saliferous marls, lower section grey or greenish gypsiferous marls;

20 m.: Green bees: brownish and greenish sandy marls, marly limestones and limestones;

65 m.: Cardita series: whitish weathering. Light brown chalky marls and marly limestones with many chert intercala-tions;

160 m.: Chalky limestone series: white weathering light brown chalky marly, limestone chalky marls, in lower part often pinkish; at base a thin conglomerate.

This lowest unit often gives after dry distillation small oil drops which indicate that also the U. Eocene may be a potential source rock for oil particularly on the E. side of the Gulf of Suez.

Wadi Dara section:

A thick Eocene section (the age of which being established by the lack of Globigerinoides and Orbulina and presence of small Gümbelinas in an extremely richly developed marly section, flooded with Globigerinidae; see also my article on ûThe microstratigraphy of Egypt,, was encountered on the W. side of the Gulf of Suez, N. of Gebol Zeit in the Wadi Dara (Socony Vacuum) well. It consists of more than 400 m. of grey marls with several thick clay intercalations.

Maadi Section:

South of Cairo (E. of Maadi) a 70-80 m. thick U. Eocene section occurs which is considerably broken up by faults. The section is overlying M. Eocene Nummulitic limestones of the Moqattam Hills. U. Eocen consists of the following beds:

Top max. 7 m.: thick-bedded (50 cm or more) sandy limestone with a 40 cm thick white sand intercalation; the limestone is for the greatest part non-fossiliferous but in places rich in small Echinoids and large Oysters

(Upper Echinoid zone);

15 m.: light grey and greenish-grey, often yellow- brown weathered, gypsiferous sandy clay, partly clayey sandstone, with limonite concretions; abt. 3 m. from top of this unit a 1 m. zone full of large Oysters (Upper Carolia Bed);

1 m.: brownish weathering creamish-white limestone full of shell fragments;

10 m.: very sandy, very gypsiferous clay, yellow-brown weathering, in upper part full of Oysters (0. fraasi);

1m.: white limestone full of Echnoids and Oyster

fragments (Lower Echinoid zone);

4 m.: Yellow-brown slightly sandy marl;

1m. : hard limestone with Carolia (Lower Carolia

Bed);

1,5 m.: yellow-brown sandy marl;

8-10m.: dark brown gypsiferous shale with small Oys- ters;

Bottom 26 m.: brownish weathering light grey and creamish- white gypsiferous marly limestone and argillaceous limestone.

It is rather certain that a hiatus exists in th Cairo area at the base of the U. Eocene, although it is usually more a disconformity than a real uncoriformity.

The following fossils are most common in the Maadi section; large Oysters (Carolia p]acunoides), smaller Oysters (Ostrea fraasi), Echinolampas, Plicatula polymorpha, Nummulites beaumonti: it is interesting to note that the Nummulites are practically missing above the base of the U. Eocene section.

Fayum section:

BEADNELL deseribed a 175 m. thick U. Eocene section from the Fayum area as Qasr el Sagha or Carolia series, which consists of an alternation of very fossiliferous limestones and purple or grey clays, with ferruginous sandstones particularly in the upper beds. Locally lignite horizons occur, near the base gypsiferous clays are common. The section is rich in Oysters (see Maadi section) and Turritellas and contains a famous Vertebrate fauna which was discovered round 1879 by SCHWElNFURTH. The following U. Eocene Mammalia and Reptiles were found: Zeuglodon, Pterosphenus, Eosiren, Moeritherium, Stereogenys, Tomistoma, etc., which were described by ANDREWS a. o. The occurrence of land-animal skeletons together with Crocodile and Turtle remains and the abundance of plant-impressions and even lignites, indicate very shallow water conditions near an old shore-line.

We mentioned above that recent studles by the oil companies have revealed that also deeper beds in the Fayum area belong to the upper Eocene. They were described by BEADNELL as Birket el Qarun series and Upper Ravine beds, which are difficult to differentiate from the higher Qasr el Sagha series.

Birket el Qarun series: abt 50 m. ochrous coloured sandstones and clays with sandy limestones overlying the Upper Ravine beds; few concretionary sandstones weathering into large globular masses. Fossils: Nummulites fraasi, N. beaumonti, Operculina discoidea, Plicatula polymorpha, Turritella pharaonica, Zeuglodon, Cardita- and Cardium, sp etc.

Upper Ravine beds: abt.40m. yellow sandstones alternating with yellow brown and greyish gypsiferous clays, marls and marly limestones, containing small Nummulites and Oysters.

The whole upper Eocene unit on the Fayum area is indicated at present as Qarun sagha series. In a section 22 km W. of Qaret Gahannem this Qarun-sagha series is abt. 2l0 m. thick. It is composed of two units:

1) a lower unit of abt. 112 m. composed of calcareous sand-stones, in the upper part with few sandy clay intercalations and at the top a thick white sandy limestone; the section is rich in Nummulites contortus-striatus, Carolia, Ostrea kerunia and Turritella;

2) upper unit abt. 100 m. Of brownish ferruginous sandstones with few clay intercalations containing Ostrea kerunia, Turitella and Carolia but no Nummulites; at the top Zeugledon remains occur.

The varying thickness of the Qarun-Sagha series and other similar phenomena (which are omitted for lack of space) indicate structural movements during sedimentation which started probably at the end of the M. Eocene.

8) Stratigraphy of the Oligocene

On the E. border of the Gulf of Suez a 50 m. thick section occurs known as Upper red beds. It consists of a basal conglo-merate, overlying the upper Eocene Tanka beds, which is covered by abt. 40 m. reddish sandy marls, calcareous sandstones and sandy limestones which in their turn usually are covered by a conglomerate which is overlain by a thick (up to 40 m.) dolerite bed. This dolerite bed usually is covered again by a conglomerate, which in its turn is covered by Miocene (probably lower) beds.

On the W. border of the Gulf of Suez a 100 m. thick marine section, composed of grey clays and marls, was encountered in the Wadi Dara (Socony Vacuum) well, N. of Gebel Zeit.

Oligocene is outcropping also in large areas between Cairo and Suez. It is characterized by at least 40 m. thick ochrous, brown, reddish or black silicified sandstones or quartzites, loosely cemented white or yellow brown weathering sandstones (resembling ordinary Nubian sandstones), hard breccias, congl- omerates, etc. The sandstones often show pronounced cross-beddings and in many places they are rich in silicified wood. Trunks of up to 16 m. length have been found, belonging to the genera Araucaxioxylon, Palmyloxylon, Nicolia Laurinoxlon, Acacioxylon, etc. The trees probably are not in plaee because the bark seems always to be absent, tliere are no branches or roots and they are always in horizontal position. They were probably drifted into an estuary together with the sandy deposits which are partly aeolic or fluviatile in origin. As these beds are overlain by thick (up to 18 m. basalt flows, which are unconformably covered by Lower Miocene beds and as the Oligocene sands are covering unconformably the upper Eocene beds, this usually non-fossiliferous sandy section is definitely Oligocene in age.

Near these U. Oligocene basal flows often very hard siliceous sandstones, chalcedony and extremely hard-cemented conglomerates occur. These phenomena and the reddish and ochrous colouring of the Oligocene id probably due to the hydrothermal action which followed the late Oligocene volcanic activity. It is very likely that part of the silicification of the fossil trees is due to these solution which may explain their greater abundance and better preservation near these volcanic centres. It was found that the volcanic activity was completed before the L. Miocene beds were deposited. The silicified sandstones and conglomerates gave rise in recent times to denuded necks and isolated hills such as Gebel Alimar near Cairo and ûRennebaum's volcanoû on the top of Gebel Moqattam, etc. The Oligocene is unconformably covered by the Miocene which we shall discuss later on.

The sands of the Oligocene and the many flint pebbles probably derived from the Eocene limestone ridges, which after being folded and faulted, came above sealevel in pre-oligocene times and were denuded in places as far down as the Pre-Cretaceous Nubian sandstones.

Further eastwards the gritty sections change into a limestone facies: e. g. near Gebel Genefe, S. of Bitter Lake, abt. 100 m. of m. Miocene limestones are developed rich in Heterostegina and Lithothamnium the limestones in places being gritty and intercalated with marls. This section is underlain by abt. 19 m. of sandy limestones, gypsiferous clays and marls which belong probably to the L. Miocene.

Miocene of the Gulf of Suez area:

The Miocene transgression did not start in all parts of the Gulf of Suez at the same time. High blocks such as Gebel Zeit, Shadwan Island, oil structures such as Giftun Kebir, Sherm el Arab, Dishet el Daba, Ras Gharib, etc., were only covered completely in U. Miocene times. In other structures this took place in M. or L. Miocene times. The U. Miocene is therefore a rather uniform unit with thicknesses fluctuating usually between 90 and 120 m. only, whereas the M. and L. Miocene, due to these overlap conditions, vary considerably in thickness. This is even more so as also between the L. and M. Eocene local block movements seem to have taken place creating small erosional hiatuses.

The pre-Miocene erosional hiatus usually is consiclerable and may reach even the basement, in other words in the most extreme case granite blocks are covered directly by U. Miocene beds. Up to the basal U. Miocene open sea conditions prevailed and as a result, during the M, Miocene, marls were deposited often flooded with a planktonic Globigerina fauna (see later). Only in the deepest basins of the Gulf of Suez, e. g. in the Jemsah and Towila area, the influx of fresh water was insufficient to compensate the evaporation and as a result in lower and middle Miocene times thick saliferous deposite were formed also known in Egyptian geolgy as Lagoonal series or Evaponte series.

At the beginning of the U. Miocene the whole Red Sea basin was probably closed off and everywhere, except in the area N. of Suez, a solid saliferous section was deposited of abt. 100 to 120 m. thickness. In the Gharib and Sherm el Arab—Hurghada area this section is abruptly covered by sandstones and grits which suggests a sudden increased erosion of the granite mountains bordering the Gulf of Suez. This, together with the sudden absence of evaporite deposits in the higher beds (except in the deeper parts of the basins, e. g. near Abu Shaar, Jemsah, Wadi Dara, etc.), suggests a reopening of the Red Sea basin as a result of new tectonic movements.

An interesting Oligocene section occurs S. Of Cairo in the Fayum area and was described by BEADNELL as Fluvio-Marine series or Gebel el Qatrani beds. It consists of abt. 280 m. of variegated (red and yellow) sands, sandstones and grits alterna-ting with clay or marl; the limestones practically disappear in contrast with the Çasr el Sagha series. In the upper part a probably contemporaneous horizontal sheet of basalt was formed. Few fossil beds occur with Melania, Potamides, Lucina, etc. indieating as estuarine or fluvio-marine origin. Also enormous quantities of large silicified trees (without branches or roots) to-gether with numerous remains of land-animals, crocodiles, tortoises and turtles have been found, indicating depostis of large rivers in a very shallow sea near a coastline comparable with large swampy delta regions in present day tropical countries. The most important Vertebrata discovered in this section are: Arsinoitherium, Palaeomastodon, Moeritherium, Megalohgrax, Saghatherium, Pterodon, etc.

It is interesting that this fluvio-marine facles continues in the Miocene and Pliocene of the Western desert, only the facies boundary moved gradually northward; in the Fayum this facies appears in the U. Eocene, abt. 70 km. N. a similar facies appears in the L. Miocene, near Wadi Natrun in the Pliocene. In other words the Large Delta area of N. Egypt was gradually filled up after the M. Eocene.

In 1938 ANDREW and CUVİLLİER discovered marine Oligocene limestone near Borg el Arab, W. of Lake Mariut, which contains Nummulites intermedius and Lepidocyclina dilatata.

The Oligocene usually covers the Eocene with a pronounced unconformity or disconformity, except in the Fayum area where a gradual transition seems to have taken place. In the Cairo- Suez area a considerable erosional hiatus exists but the whole U. Eocene has not been completely removed in this area.

9) Stratigraphy of the Miocene:

As soon as we enter into the Neogene it becomes extremely difficult to correlate beds of different areas as the Miocene sea was split up in a great number of smaller basins with different facies conditions. It is therefore almost impossible to characterize the Miocene development in a few pages, the more so as the correlations are not yet definitely established and even amongst the different oil geologists of Egyptconsiderable difference of opinion exists concerning the Miocene classification. We shall try to give a brief summary of the many facies developments of the Miocene, our classification being based on personal observations in the field, on our regional lithological subsurface correlations of a great number of wells drilled in Egypt by the different oil companles and on micro-faunal studies of these sub-surface sections and of different surface sections (see my article on "The microstratigraphy of Egypt,, and 17, 20, 21)

Miocene of the Western Desert:

From Cairo westwarde a rapidly broadening Miocene zone occurs which covers unconformably the pre-Miocene beds. This

zone which can be followed through the Lybian desert and further on into Cyrenaica forms a plateau rising southwards up to 200 m. and more. The Miocene consists af abt. 400 m. of marine deposits composed of sandstones, limestones and clays. The lowest beds are fluvio-marine or continental as remains of Mastodons and other extinct land-animals have been found. The Miocene contains also the following marine fauna: Scutella Zitteli, Ostrea Virleti, Clypeaster sp. Echinolampas, etc.

Miocene of the Cairo-Suez Area:

The Miocene is overlapping with a pronounced unconformity the Oligocene sandy series, which is often covered by a thick Oligocene basalt flow, in its turn being covered by conglomerates and grits. This large erosional hiatus is also indicated by the above mentioned silicified Oligocene plugs, which are surrounded irregularly by Miocene beds. Due to these overlap conditions the different Miocene sections are difficult to correlate in detail. BARRON has given the following general Miocene section f'or the western part of the Cairo-Suez basin, which consists of abt. 79 m. of the following beds.

Top abt. 14 m.: hard white or yellow, often gritty limestones, rich in Peeten sp., Echinolampasy Ostrea virleti, etc., with a thin marl intercalation near the base;

10 m.: calcareous grits changing northward into Lithothamnium limestones;

1 m.: Lithothamnium limestone;

M.Miocene 11 m.: cross-bedded calcareous sandstone;

5,5 m.: marly sandstone with Pecten, Turritella sp., etc.

L. Miocene 1,5 m.: hard fossiliferous ferruginous grit.

10 m.: fossiliferous sandy marl and marly sands.

5 m.: alternation of gypsiferous marls and hard, often ferruginous, limestone.

West coast of the Gulf of Suez:

Lower Miocene: Max. 350-400 m. thick either composed of grey marls intercalated with thick clay and anliydrite (or gypsum) deposits (e. g. near Wadi Dara) which may increase to such an extent that a completely saliferous section is developed (e. g. at Towila Island), or an alternation of dark grey carbonaceous shaly clays and sandstones (or sands) is developed, in the upper part rich in marls (e. g. Hurghada and further south). In this latter facies, being the oil-producing horizon in Hurghada, near the top often a so-called flint conqlomerate occurs, overlying purple coloured marls; both facts, together with the varying thickness of the covering Globigerina marl series, indicate a small erosional period at the end of the L. Miocene as a result of local block movements. The L. Miocene usually directly covers the pre-Carboniferous granite ridges.

Middle Miocene: Max. 400 m. thick greenish grey Globigerina marl series, near the base often with limestone or dolomite intercalations particularly if the marls are directly overlapping basement rocks. The limestones are important oil reservoir horizons, e. g. in Jemsa, but particularly in the new oilfields 0n the E. side of the Gulf of Suez, the source rocks overthere being probabty U. Eocene (see above). In surface sections Aturia aturi and Carcharodon are common fossils. In the deeper basins often anhydrite (or gypsum) intercalations occur which may increase to such an extent that a completely saliferous section is developed either composed of anhydrite or rocksalt or an alternation of both (e. g. near Wadi Dara and at Towila). In certain shallow areas (e. g. Habashi) clays are replacing the marls. At the top of the M. Miocene (in Abu Shaar and Dishet el Daba) a thick (up to 40 m.) conglomerate occurs mainly composed of enormous granite boulders.

Upper Miocene: abt. 100-120 m. of solid anhydrite, gypsum or rocksalt (in the deepest parts of the basins), sometimes with few thin clay or marl intercalations. In the southern part of the Gulf of Suez, near the W. border of the graben faults, the basal section is sandy developed (e. g. Dishet el Daba); N. of Suez (at Habashi) slightly calcareous clays with few gypsun hodules occur, indicating the northern end of the saliferous basin. In the above mentioned structures (Giftum Kebir, Sherm el Arab, etc.) the upper part of the U. Miocene solid anhydrite series is directly overlying the granite ridges with a relatively thin basal reef limestone or dolomite.

East coast of the Gulf of Suez:

Lower Miocene: thickness varies in places at least 250 m. thick. Either developed as grey or blueish green shaly clays with thin grit intercalations (usually in surface sections) or as gypsiferous Globigerina marls with limestone intercalations (usually in subsurface sections) overlying M. Eocene or Cretaceous (marine or Nubian sandstone facies) often with basal conglomerate composed of limestone-, flint-, and dolerite pebbles. This unconformity represents an important oil reseruoir horizon on the E. coast of the Gulf of Suez (e. g. in the pre-Miocene beds and the basal L. Miocene beds act as important oil reservoir horizons on the E. coast of the Gulf of Suez. The source rocks probably being upper Eocene m age.

Middle Miocene: more than 300 m. thick, either composed of Globigerina marls with gypsum intercalations (in deep subsurface sections(or developed as a gritmarl series (usually in surface marl intercalations (containing Aturia aturi, Carcharodon) and and upper shaly marl section (dark green and black). A general tendency seems to prevail (similar to the M. Miocene of the W. coast of the Gulf of Suez) that the thicker the Globigerina marl series is developed, in other words the deeper the local block sturctures, the Less limestone intercalations (usually beach- or detrital limestones) occur in the M. Miocene. The greatest development of limestone can be expected if the marls are directly overlying the pre-Miocene beds, an important observation in connection with the accumalation of oil. In the Ras Matarma oilfield and near the old faultscarps in the Sudr oilfiild, the basal M. Miocene (or top L. Miocene) is composed of abt. 170 m. of oil sands, conglomerates, gritty algae limestones shales, etc.,

which probably can be compared in age with the "Flint conglomerate" (at the top of the L. Miocene) of the W. coast of the Gulf of Suez. Near Wadi Feiran, in sub-surface sections, the M. Miocene Globigerina marls seem to cover directly the granite basement, which is outcropping further south in the Abu Durba Mountains. The transition between marls and granite is formed by abt. 20 m. of fine oilproducing sand underlain by 18 m. of shale.

Upper Miocene: abt. 120 m. of solid anhydrite or gypsum, known by the oilgeologists as First gypsum bed or Loner lagoonal or Lower evaporite series. It is remarkable that thick rocksalt sections, such as occur on the W. side of the Gulf of Suez, have not been encountered yet.

All three sections (U., M. and L. Miocene) seem to change laterallv into gritty sandstones, conglomerates and clays towards the E. border of the faults.

10) Stratigraphy of the Pliocene:

Tlie Pliocene usually is unconformably covering the lower beds. Different Pliocene areas are known in Egypt, the most important ones being the foollowing:

Gulf of Suez area:

E. Coast of Gulf of Suez: the previously mentioned lower lagoonal series is covered by the so-called Upper lagoonal or

evaporite series (abt. 570 m.) which is subdivided by different geologists in a number of units which locally aan be recognised relatively easily in sub-surface sections, but which are extremely difficult to map in surface sections. Those units are from bottom to top:

a) Lower intergypseous marls with second gypsum beds (abt. 120 m.): Composed of yellowish foraminiferal marls rich in Globigerinidae often with a gypsum intercalation, near the top often changing to greenish gypsiferous clays.

b) 3rd gypsum bed (abt. 170 m.): gypsum.

c) Upper intergypseous marls (abt. 60 m.): composed of white marls and yellow or greenish gypsiferous clays.

d) 4th gypsum bed (abt. 75 m.): alternation of gypsum and marls.

e) Marl bed (abt. 60 m.): Yellowish marls sometimes with sandstone at the base.

f) Nullipora rock (abt. 75 m.): White limestone with abundance of Lithothamnium.

g) 5th gypsum bed (abt. 10 m.): Gypsum alternating with creamish marls.

This upper lagoonal series may change into reef limestones and grit near the E. border of the Red Sea graben. But also for other reasons given above this classification has only local significance. A great number of oil geologists still consider this section as Miocene, but for different reasons there seems to be little doubt that the Upper Lagoonal series is a Pliocene section.

W. coast of the Gulf of Suez: Three different facies are known:

a) Sandstone facies: It is particularly developed S. of Hurghada and in the Ras Gharib area and consists of more than 400 m. of usually calcarous sandstones and grits with marl and clay intercalations and a few limestone beds; Laganum depressum is the most common fossil in the upper part of this section. The section always is unconformably covered by Pleistocene beds, which explains the great variety in thickness of these sections.

b) Argillaceous facies: In certain areas near the border of the Red Sea graben and above the deep subsurface structures (e. g. Giftün Kebir, Ras Gharib well no. 2) a thick argillaceous section occurs mainly composed of clays, marls and gypsum intercalations, in the upper part usually sandy developed. The thickness may vary between 400 and more than 800 in. depending on the erosional hiatus at the base of the Pleistocene.

c) Evaporite facies: In the deeper parts of the Pliocene basin the U. Miocene saliferous deposition continued through- out the Pliocene. As a result an up to 700 m. thick section was deposited either composed of gypsum with clay intercalations, rock-salt or a combination of both. Usually rock-salt is developed only in the L, Pliocene. In certain places e. g. Hurghada, Jemsa, Abu Shaar etc., diatomaceous earth was encountered. Usually the erosional hiatus at the base of the Pleistocene is very small or even missing.

At the base of these three different facles usually a thin marl section occurs, known as the intergypseous marls, which is extremely rich in Globigerinidae, the ratios between the different genera being different from the M. Miocene Globige- rina marl series.

In the Gulf of Suez area at the base of the Pliocene grit series probably no erosional hiatus exists, which is indicated e. g. by the equal thickness of the underlying solid anhydrite unit. The grits and argillaceous deposits were probably washed into a shallow sea from the neiglibouring Red Sea Mountains, the sudden increased erosion during the L. Pliocene probably being due to the structural movements.

Pliocene of the western desert:

L. Pliocene sands and gypsiferous clays were found at the Wadi Natrun depression, containing bones of Hippopotamus, Elephants, Giraffes, Antilopes, Crocodiles, Fishes, etc. At Deir el Rizo on the Bir Hammam - Moghara road quartzites have been found with Pliocene Cardium, Cytherea and Lucina sp.; S. of Siwa Oasis fresh water limestones occur of probably Pliocene age.

Pliocene of the Nile valley:

At the base of the Moqattan Hills near the Nile and S. of the Gizeli pyramids on the Saqara road, sands and loosely cemented sandstones occur with Pliocene Oysters (Ostrea cucullata), Pectens, Clypeasters, etc.

In the present Nile valley from Beni Suef southwards Pliocene conglomerates and sands occur, but north of Beni Suef limestones, sands and clays have been found containing corals, marine shells and seaurchins, indicating a sea arm which extended during Pliocene time up the Nile valley. The depth to which Pliocene can be found in the Nile valley of abt. 60-70 m. above sealevel. The presence of marine Pliocene in the present-day Nile valley and the above mentioned origin of the U. Eocene and Oligocene deposits in the Fayum area indicate that the Nile valley was developed in its initial stages in pre-Pliocene times, probably at the end of the Oligocene during the general rise of S-Egypt.

11) Stratigraphy of the Pleistocene.

The Pleistocene usually overlies the deeper beds with a considerable erosional hiatus and is differently developed in the different paits of Egypt

Pleistocene of the Gulf of Suez area:

In surface sections along the Red Sea and the Gulf of Suez a number of raised eoral reefs and sea beaches can be observe often at great heights above sealevel. Between Safaga and Quseir reefs have been found at 25 m, 72 m, 90 m, 114 m, 156 m, 168 in, and 238 m above sea-level, the lowest ones occurring close to the sea, the higher ones standing back 4-7 km BALL pointed out that these reefs may date back to Miocene time; only thosenearthe present sea-shore are proba-bly formed in Pleistocene times (probably U. Pleistocene) and it is due to these most recent regional uplifts that the Isthmus of Suez was finally uncovered,

In sub-surface sections the L. Pleistocene is either developed as a section of at least 200 m of pebbly sandstones alternating with clays (or marls) or as an evaporite series of at least 350 m thickness composed of gypsum with clay intercalations. The latter facles is restricted to the areas with a saliferous development of the Pliocene. The U. Pleistocene is developed as gritty or pebbly, often calcareous sandstones with clay (or niarl) intercalations or as coral reef limestones (e. g. at Giftun Kebir). These sub-surface sections combined with the surface observations indicate a further deepening of the Red Sea graben in Pleistocene times in a regionally rising continent.

Pleistocene of the mediterranean coast:

W. of Alexandria a ridge occurs, abt. 20 m above sea-level composed of very calcareous sandstones and oolithic limestones. The base of this section (at least- in a well 3 km S.-E. of Mersa Matruh) lies 43 m below sea-level. A few km inland an other ridge occurs, the area between both ridges being occupied by salt-lagoons and marshes with loamy ground. These ridges are fossil dunes which must have been formed as a result either of a subsiding coastline or of a gradually rising Mediterranean sea-level. BALL has given an excellent summary of the youngest history of the Mediterranean coast. For different reasons (1 p. 56-67) he came to the conclusion that the following processes must have taken place:

a) From the M. Pliocene till U. Pleistocene (abt. 20,000 years B. C., so-called Middle Palaeolithic or Mousterian cultural period of Sandford) the coastal area was gradually rising above sea-level due to continenal uplift, creating a number of continental uplift, creating a number of Nile terraces, the highest being at a level of 180 m (the coastline in the M. Pliocene being only 33 km N of Cairo), the lowest at 18 above present Mediterranean level.

b) During the early Recent (abt. 10,000 B. C., so-called late-Palaeolithic or Sebilian cultural period) the variations in sealevel seem to be caused by actual subsidence of the level of E. Mediterranean itself during periods of temporary severance of its connection with the ocean.

c) During the Middle-Recent (Neolithic period slow continental subsidence took place in the Nile Delta area with a rate of 14 cm per century, which seems to continue at the present day. This explains the submerged Pleistocene fossil dunes of Alexandria, the submerged ancient building in the sea near Alexandria and presence of rock-cut catacombs in Alexandria (dating from 150 A. D.) below present subsoil waterlevel.

Pleistocene of the Nile valley.

As stated above, in the Nile valley a number of gravel and sandterraces occur which were created by a rising continent and continuous deepening of the Nile channel in the marine Pliocene deposits. Similar gravel deposits were deposited as a delta in the Pleistocene sea, at the time only 30-50 m North of Cairo. They were covered in recent times by Nile mud deposits, usually abt. 9 m in thickness, the gravel series being' known as sub deltaic deposits

Pleistocene of the Fayum Depression:

This enormous depression with a surface of abt. 12,000 sq, km lies abt. 80 km South of Cairo. At its lowest place a Lake occurs (Birket el Qarum) the bottom of which lies 45 m below sea-level. This depression was probably formed by wind-erosion in late Pliocene or early Pleistocene times because no Pliocene has been found in the centre of the depression. The origin of the depression in a over 700 m thick 2-3° N. dipping Eocene section was possible:

1) because of a dome-shaped structure in the S. part of the Fayum which originated probably at the end of the M. Eocene;

2) because of the presence of thick beds of soft arenaceous and argillaeeous strata in hard Eocene limestones (see above);

3) because very likely faults are present in the Nile valley E. of Fayum which may be partly responsible for the W. part of the Nile being lower than the E. side.

In U. Pleistocene times the barrier between the Nile valley and the Fayum depression was broken up and the depression was filled up with a large lake (Lake Moeris). Thick lacustrine deposits, rich in fresh-water shells, fish-bones, remains of hippopotamus, crocodiles, turtles, etc., composed of gravels and sands, were formed in this lake. They are covering at present extensive peripheral parts of the Fayum depression as a series of terraces with pre-historic dwelling places, the highest being 44 m above sea-level. The level of Lake Moeris, being in free communication with the Nile, fluctuated considerably in U. Pleistocene times, gradually the connecting channel was filled up and the lake-level was lowered gradually by evaporation. In the 12 dynasty King Amenemhat I re-establislied the free connection with the Nile; the lake acted as a result as a flood regulator. However, in the time of Ptolemy II the connection was not existing any more. A well drilled at Madinet el Fayum in 1898 passed through 5 m of Nile mud, 1,5 m mixed mud and sand, and 12 m of sand and gravel and finally the Eocene. The presence of an abundance of tamarisk stumps in the youngest lake terraces indicates a difference in climate in pre-historic times.

Pleistocene wadi deposits of Sinai, Eastern- and Western desert:

In the deserts E. of the Nile and in Sinai deep erosional gullies were formed in Pleistocene times, in the W. desert however, very few distinct drainage channels occur, indicating arid conditions in that area at least during the last 20,000 years. The study of pre-historic implements in a wadi gravel terraces indicate, according to Dr. SANDFORD, that the large wadis in the E. desert were flowing streams prior to the close of the U. Pleistocene (Mousterian or M. Palaeolithic).

Pleistocene of the Kharga and Kurkur oasis:

Calcareous tufa are covering the escarpment of Kharga Oasis. In one place they cover M. Pleistocene (Palaeolithic) implements which indicate an U. Pleistocene or Recent origin. These fresh water tufa, precipitated from Ca CO3 solutions and the presence of tree-remnants in them indicate a more humid climate than at present (see above Fayum depression). Also at Kurkur Oasis similar deposits occur which are deposited after the formation of the depression.

XI — Recent:

During the discussion of the Pleistocene we mentioned several times the Recent deposits, the most interesting ones being the up to 30 m high, hundreds of km long, dune-ridges of the W. desert, which in the central part of the Libyan Desert are moving southwards, the northern ends being supplied with disintegrated sandstone material of the northern scarp of the Qattara and other depressions, which similar to the other great depressions of the Western desert were formed in Pleis-tocene times by wind erosion of pre-existing tectonic structures.

XII — The age and origin of the Red Sea Graben:

During the last 50 years a great number of publications appeared on the tectonic origin of the Red Sea Graben zone and its continuation towards East Africa and Turkey (9). A careful study of these publications indicates however that only very few were based on actual field observations and many of these observations were only made during short reconnaissance trips. If all geopliysical and geological surface and subsurface data known at present to the main oil exploration companies of Egypt (Royal Dutch Shell, Standard Oil Co. of Egypt and Socony Vacuum Oil Co.) could be published, no doubt a very accurate tectonic history of the greatest part of the Gulf of Suez could be written; Still the facts already on hand enable us to give a rather aceurate analysis of this regional faulted zone.

Age of the Graben Zone:

We mentioned already that the Gulf of Suez Graben was formed initially at the end of the L. Eocene, but the fault movements continued at least till Pleistocene times. Some of the arguments favouring this statement are the following:

1) The Gulf of Suez, with a NW—SE direction euts almost perpendicularly the NE—SW folding trends of N. Sinai. The difference in facies between flank and centre of some of these Sinai structures (e. g. Geliel Naghara) in the Cenomanian and Turonian beds indicate that these folding lines probably existed already in Cretaceous times. The Wadi Araba structure on the W. coast of the Gulf of Suez indicates that the direction of the Gulf of Suez is the youngest one and has cut the Cretaceous direction.

2) Up to the basal M. Eocene there is little difference in facies bet,ween both sides of the Gulf of Suez,

3) The important regional unconformity at the base of the M. Eocene most areas between Egypt and Turkey, causing the direct deposition of M. Eocene limestones on basal Eocene or even Cretaceous beds indicates major tectonic movements in this part of the world at the closure of the L. Eocene.

4) There is a large erosional hiatus at the base of the Miocene in the Gulf of Suez indicating strong tectonical movement followed by a long period of erosion in pre-Miocene time.

All these different facts indicate that the Red Sea Graben originated in pre-Miocene and most probably in basal M. Eocene time. This graben did not subside however as one block during the Neogene, but differential block-movement took place.

5) In Wadi Dara (W. side of Gulf of Suez), in a deep oil well drilled by the Socony Vacuum Oil Co., a continuous section was encountered containing Pliocene, the whole Miocene, Oligocene and U. Eocene,

(well was abandoned at this stratigraphic level). Both Oligocene and U. Eocene were developed in a marine facies, their ages being established by microfaunal analysis. The presence of marine Oligocene and U. Eocene in the deeper parts of the Gulf of Suez Graben, whereas this sec-tion is missing in the regions directly west of the Graben fault (Eocene being present in those areas) indicates that this depression was formed in pre-U. Eocene and probably in M. Eocene times. Also the presence of basal Eocene in subsurface sections (e. g. W. of Ras Gharib) both in the graben itself and outside of it and of M. Eocene (unconformably overlying Cretaceous beds at the edge of the Graben fault) indicates a basal M. Eocene age for the first large structural movements in this area.

During the Miocene transgression the deepest parts of the graben were covered first but some of the higher eroded peaks of the graben blocks were covered for the first time only in U. Miocene times. These overlap conditions, which can be seen on the surface (e. g. in Gebel Zeit) and in subsurface sections of the different oil structures in the Gulf of Suez area, are anotlier clear indication that the graben structures existed in pre-Miocene times.

Although the first definite subsidence and block-faulting in the Gulf of Suez must have taken place in the basal M. Eocene, it seems probable that the Red Sea Graben zone may have existed as a zone of weakness in inuch older periods. Facies researches on hand suggest that facies boundaries in the Cretaceous deviate considerably from the E-W direction which may be due to a pre-existing topography. Also the regional extention of these different graben zones in this part of the world suggests an older age. It should be kept in mind however that no positive evidence is available for this assumption, at least not in Egyptian territory.

Structural history of the Graben zone

The actual tectonic history of the Gulf of Suez area is less simple

than may appear from the above mentioned facts. We mentioned previously that from 25° N. latitude till the Mediterranean the whole of Egypt subsided during the Mesozoic and L. Eocene. The subsidence started in the North and took place with greater speed than in the South. As a result, during the Jurassic, continental deposits (Nubian sandstones) were formed in S-Egypt, whereas at the same time marine sediments were deposited further north. In the U. Senonian practically the whole of Egypt, at least as far south as 25° latitude, was covered by the sea.
At the and of the L. Eocene reversed movements took place. A regional updoming occured accompanied by considerable block-folding along old (probably pre-Cretaceous) fault-zones with, at least partly, NE-SW direction. These block- movements created large dome-shaped structures, such as G. Maghara and G. Yelleg in N.E. Sinai, Abu Roash (W. of Gairo) et.c (22).Erosion removed the L. Eocene and uppermost Cretaceous in the high uplifted parts, and as a result durmg the following period of regional subsidence M. Eocene limestones were deposited on older beds with a considerable hiatus. In the deeper, less upfolded, parts of Egypt sedimentation continued and as a result no hiatus exists or only a very small one. The M. Eocene transgression was followed by a second period of regional updoming (probably more important even than the previous one) which was accompanied by local cross undulations. From this period onwards great parts of S. Egypt, stayed more or less permanently above sea -level. Only north of the 28° latitude subsidence continued during the U. Eocene, the sediments being deposited on a tectonically undulated surface. In the Gulf of Suez graben faults brought the M. Eocene far below sea-level again, this is indicated for example in tlie subsurface-sections of the oil structure near Ras Matarma (E. side of the Gulf of Suez), where a thick Miocene section is overlapping M. Eocene limestones which form the crest of the eroded pre-Miocene blocks.

Several of the blocks, that subsided in the Gulf of Suez depression remained above sea-level or moved temporarily up-wards as a result of local anti-thetic block movements. Erosion removed the Tertiary and older beds from the crest of those blocks, often as far down as the pre-Cambrian granites. Further subsidence during Oligocene times enabled Miocene beds to cover directly these granite peaks. Whereas in the Red Sea graben zone subsidence continued throughout the Miocene, Pliocene and Pleistocene, only temporarily interrupted by local uplifts as a result of tilted block - movements in the graben, Egypt as a whole was rising continuously, this is indicated by different facts;

1) The fluvio-marine facies of the U. Eocene was gradually moving northwards during the Miocene and younger periods (I) in other words the continental conditions, prevailing in U. Eocene times south of latitude 28° N, gradually appeared further north and large rivers from the south filled up the large basin north of Fayum.

2) Thick marine Pleistocene beds were encountered in Sub- surface sections along the Gulf of Suez, whereas at the edge of the Graben Pleistocene and older uplifted terraces can be found.

3) The sudden change in facies of the Pliocene (sandstones, grits, boulder deposits, etc.) after the deposition of abt. 120 m of solid anhydrite, gypsum or rock-salt during the U. Miocene, as a result of the closure of the Gulf of Suez and Red Sea both in the north and south, indicates a reopening of this basin, probably accompanied by vertical uplifts of the bordering areas followed by a sudden increased erosional activity.

Mechanism of the Red Sea Graben faults

Three outstanding phenomena must be taken into consideration in any theory on the origin of the Red Sea Graben zone:

1) Sinai, N. Eygpt and the Gulf of Suez formed one large updoming area, the movements of which stated at the end of the L.Eocene, but becoming very large st the end of the M.Eocene. Since this period the rising movements continued more or less regularly throughout the whole Tertiary.

2) Since the M.Eocene a NW-SE zone crosses this updoming area, this so-called Red Sea Graben zone, which subsided more or less continuously during the whole Tertiary and Pleistocene.

3)Large basalt extrusions took place at different localitles in Egypt, the age of which in several cases could be established to be definitely U. Oligocene and pre-L. Miocene.

a) In the Cairo-Suez area a more than 40 m thick fluvio- marine Oligocene section is outcropping, this covers unconformably a definitely U. Eocene section. A the top of the Oligocene sandstones, etc., a (up to 18 m) thick basalt flow occurs. These basalt flows are unconformbly covered by definitely L. Miocene marine deposits. No traces of volcanic activity are found in the L. Miocene. In otlier words these basalt flows represent a relatively short, well-marked period of volcanic activity.

b) The same conditons can be found N. and NW of Fayum indicating a similar U. Oligocene age.

c) Also the basalt extrusions N. of the North Qalala Plateau, abt. 45 km W. of Bir Odeib, indicate the same field relations as in the Cairo-Suez area.

d) Near Hammam Faraun (E. side of the Gulf of Suez) and furher south near Abu Zenima an interesting surface section is exposed near the edge of the graben faults. The upper Eocene Tanka beds are covered unconformably by a basal cong- lomerate which is overlain by 40 m of reddish sandy marls, calcareous sandstones and sandy limestones, which in their turn are covered by a conglomerate which is overlain by a thick (up to 40 m) dolerite bed. This dolerite bed is usually covered again by a conglomerate which is overlain by sandy Lower Miocene marine deposits. In other words a condition similar to the Cairo-Suez region. Near Hammam Faraun in the neighbourhood of the edge faults of the graben a hot water spring occurs.

e) In Ras Lagia, north of Hammam Faraun, the Socony Vacuum Oil Co. encountered in an oil-exploration well between 2300 and 2500 feet the same dolerite sill which further south is outcropping on top of the U. Eocene.

There is no reason to assume that the other basalt outcrops in Egypt are different in age. Some are definitely post-Upper Eocene, others post-M. Eocene, but lack of marine Miocene deposits prevent us of dating them more accurately.

If we consider these different facts, there seems to be little doubt that the formation of the Gulf of Suez was preceded by a regional updoming. This regional fold was due either to a regional buckling phenomenon as a result of two opposing, mainly N-S directed geotectonic forces in the African continent or to the HELMHOLTZ mechanism (12,13), in other words to a frictional undulation fold created by the movements of the sial crust with respect to the sima. In both cases the movements or forces may be related to the upfolding of the Tethysbelt in the Mediterranean zone, which at least as far as Turkey, has on the whole an EW trend. This is supported by the fact that also in Turkey the main period of upfolding started at the end of the M. Eocene.

We have demonsrated in 1941 that due to the upfolding of the Alps by NS forces in the more rigid regions north of Switzerland two shearing-fault systems can be expected: a SE-NW system, known as the Hercynian - Thuringian or Saxonian fault system anda SW-NE system, known as Variscian-Erzgebirge fault system. These fault systems can be created artificially also in tectonic experiments (13,16).

It seems probable that a similar fault pattern was developed also in the more rigid areas south of the Balkans and of the Anatolian orogenic belt after the upfolding started in the basal M. Eocene. Updoming itself creates a system of stretch-faults converging downwards. As the up-doming in Egypt seems to have been strongest in Sinai and the areas E of the present Nile Valley, we could expect the greatest stretch-faults in these areas. A combination of both phenomena, sliearing-fault patterns and stretch-faulting may have been the main cause of the formation of the Gulf of Suez depression.

The extensive basalt extrusions in the Oligocene of Egypt and also during later periods on the W coast of Arabia, along the graben-faults of Ethiopia, along the Dead Sea graben zone (e. g. W and N of Lake Tiberias and in Syria) indicate that these originally superficial Eocene fault-systems in the M. East must have reached the sima layer during the Oligocene and later periods as a result of further updoming during the U. Eoeene. The updoming created a further relief in pressure and enabled the sima to become an active fluid which could extrude. Where two major opposing fault-systems were present very likely the mechanism of St. TABER (Il) became important because the sial blocks were floating in a liquefied sima layer. Blocks bordered by faults which were converging downwards became graben zones, those bordered by diverging faults became horsts. As the fault-systems were not completely symmetrical, in reality tilted block movements must have taken place and as a result parts of the horst nearest to the graben became the topographically highest points. As a result of later erosion the pre-Cambrian basement was exposed on these highest edges, whereas further away from the graben faults younger forma- tions can be found.

Further updoming and stretching created a fault pattern as was clearly shown by CLOOS in a series of most elucidating experiments (5,6,7). As a result of these stretch-phenomena both Synthetic graben faults (i.e. faults having the same ten- dency as the main edge-faults and increasing the general downthrow in the graben) and Antithetic faults (i.e. faults counteracting the movements along the main faults) are formed.

Particularly in the region near Hammam Faraun and also further south splendid examples of these f'ault-patterns can be seen.

We fully realize that this synthesis of the origin af the Red Sea graben is not complete. Many facts could not be given as they are company secrets and several problems have not been solved yet. We have tried to compile only the main facts which may give a clue to the origin of the Red Sea graben a zone which probably was not formed either by compression or stretch, but by a complicated interaction of different fold and fault mechanisms.

This bring us to the end of the summary of "The Geological History of Egypt. I have tried to give a very brief summary of the vast literature concerning the geology of Egypt and of the different oyinions of the oil-geologists in Egypt and I have naturally stressed those opinions which I consider to be the most probable ones. A complete discussion of the Stratigraphy of Egypt would require a great, number of Papers in order to give all the arguments which support our brief statements. Those interested in this evidence are referred to my article on "The Micro-Stratigrapliy of Egypt" to be published in the near future in the U. S. A.

We should keep in mind, however, that many of the stratigraphic problems discussed, still await further field studles before a definite solution can be given. Still we are inclined to believe that the picture given above is approximately correct and does not require fundamental changes in the near future.

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