OIL POSSIBILITIES IN THE SEDIMENTARY BASINS OF TURKEY*

Cahit ERENTÖZ and Zati TERNEK

Mineral Research and Exploration Institute of Turkey

ABSTRACT.— Studies of the sedimentary basins of Turkey with special reference to their oil possibilities have been carried out for many years.

South of the Bitlis Massif and the Anti-Taurus Mountain Range, as well as in the Arabian Block located southeast of the Anatolian region, but slightly deformed synclines and anticlines trend approximately SE-NW and SW-NE. Oil is presently produced from the Raman and Garzan structures. Oil here occurs in the reefy and dolomitic limestones of Jurassic-Cretaceous age.

A thick and more or less continuous sedimentary series is also found in the subsidence basin of Adana. Oil seepages at the surface suggest that oil is present in the reefy limestones of the Lower Miocene and part of the Middle Miocene.

Drilling at Hatay (İskenderun) has revealed the presence of some oil and much natural gas.

A thick sedimentary sequence (Eocene, Oligocene, and Miocene) is found in Thrace south of the Istranca Massif and in the Ergene basin. Closed, regular structures at these localities suggest possible accumulation of oil. Drilling S-SE of this region, at Şarköy and Mürefte (Tekirdağ), has uncovered a continuous and plentiful flow of natural gas.

Among less promising terranes in which sediments are moderately thick and structures more or less regular, the Van-Muş-Hınıs-Malazgirt region and the structures of the Malatya region ought to be mentioned.

Important oil promising structures also, occur in the northwestern part of the Tuz Gölü area and the western part of the Ankara region.

At the northern margin of the Pontides near the Black Sea, in the Rize region, and in the Boyabat - Kastamonu - İzmit region long narrow bands of a facies of flysch and limestone spread out. Oil is to be expected in the Upper Cretaceous and Eocene formations of this facies.

Mention ought to be made also of the salt domes found in the gypsum series of the Sivas-Çorum-Çankırı region.

Apart from the terranes just mentioned, transgressive basins containing sedimentary deposits of different thicknesses, but generally thin, are found in the metamorphic Anatolian Block, the principal basement of Turkey. Recent work in this area has failed to uncover promising oil terranes.

RESUME.—Les bassins sedimentaires de la Turquie, et plus specialement leurs possibilites petrolieres, ont depuis lohgtemps fait l'objet d'etudes tres poussees.

Au Sud du massif de Bitlis et de la chaine de l'Anti-Taurus, ainsi que dans le domaine du Bloc Arabe situe au Sud-Est de la region anatolienne, des synclinaux et des anticlinaux peu deformes suivent des directions approximatives SE-NO et SO-NE. On a deja commence a extraire du petrole des structures de Raman et de Garzan. Ce petrole provient des calcaires recifaux et dolomitiques d'age jura-cretace.

On trouve egalement une serie epaisse et plus ou moins continue de sediments dans le bassin d'affaissement d'Adana. Des suintements de petrole a la surface nous permettent de croire a la presence de ce liquide dans les calcaires recifaux du Miocene inferieur et d'une partie du Miocene moyen.

Des sondages effectues a Hatay (İskenderun) ont mis a jour une petite quantite de petrole et du gaz naturel en abondance.

Une epaisse serie de sediments (d'age eocene, oligocene et miocene) s'etend en Thrace, au Sud du massif d'Istranca, et dans le bassin d'Ergene. Les structures fermees et regulieres de ces localites laissent prevoir la presence de petrole. Des sondages effectues au S-SE de cette region, a Şarköy et Mürefte (Tekirdağ) ont mis a jour un debit de gaz naturel continu et abondant.

Parmi les terrains moins prometteurs ou la sedimentation est assez epaisse et la structure plus ou moins reguliere, il faut surtout mentionner la region de Van-Muş-Hınıs-Malazgirt et les structures de la region de Malatya.

On remarque d'importantes structures petroliferes dans la partie Nord-Ouest de la region de Tuz Gölü et dans la partie Quest de la region d'Ankara.

A la bordure Nord des Pontides, pres de la mer Noire, et dans la region de Rize, ainsi que dans la region de Boyabat-Kastamonu-İzmit, on peut observer un facies de flysch et de calcaire s'etendant en longues bandes etroites. La presence de patrols est tres probable dans les formations d'age cretace superieur et Eocene de ce facies.

Il faut aussi signaler les domes de sel dans les series de gypse de la region de Sivas-Çorum-Çankırı.

En plus des terrains mentionnes ci-dessus, on trouve dans le bloc metamorphique anatolien formant le soubassement principal de la Turquie des bassins transgressifs contenant des depots sedimentaires d'epaisseurs differentes, quoique generalement minces. Les travaux regents que l'on y a faits indiquent que ces terrains sont peu propices a la retention du petrole.

INTRODUCTION

Oil possibilities in Turkey will be considered in this report in the order of importance of sedimentary deposits in various basins.

This paper is based on the data of the geological map recently completed on the scale of 1/100,000 and on the geological surveys so far carried out. The opinions presented are our own only.

The first oil exploration surveys in Turkey began at the close of the nineteenth century, and since 1926 the Turkish Government has had some reconnaissance drilling conducted in Thrace, Adana, İskenderun, Gaziantep and Mardin.

The Mineral Research and Exploration Institute of Turkey has handled the oil explorations and surveys under a program, and has found exploitable oil horizons in the Raman and Garzan structures; in line with these activities, the Institute has executed general and detailed geological and geophysical surveys in certain areas.

Under the Petroleum Law promulgated in 1954, licenses have been so far granted to 21 Turkish and foreign oil companies to search for oil in Turkey. These companies have availed themselves of the surveys and reports of the Mineral Research and Exploration Institute of Turkey and proceeded with oil exploration. The Institute in question is prospecting for oil and is conducting geological and geophysical surveys with its own geologists in such areas as Sivas-Malatya-Muş-Van, which are held closed in accordance with the provisions of the Petroleum Law. The sedimentary basins covered by this paper and which lie outside the areas of metamorphic rocks and some intrusive and extrusive rocks extending 95,660 km^2, will be studied under 3 groups:

I - The Most Promising Areas

There are oil seepages and structures favorable for the existence of oil in these areas and the sedimentary conditions are important. Producing areas come under this heading and cover some 121,688 km^2.

II - Promising Areas

Areas whose sedimentary conditions are favorable for the existence of oil appear in these areas, where there are also oil seepages, and which cover approximately 164,565 km^2.

III - The Less Promising Areas

These areas are very folded, have had heavy tectonic activity, or may have had sedimentary conditions unfavorable for the existence of oil. These cover some 388,950 km^2.

Asia Minor consists of mountain ranges extending lengthwise along the Black Sea and the Mediterranean coastal regions, along the Anatolian plateaus surrounded by these ranges, and generally displays geological evidences of the Alpine system, each tectonic unit bearing the features of a major orogeny.

This Anatolian plateau, which is important in the pre-Paleozoic, Paleozoic, the Mesozoic, and Tertiary formations insofar as the underground mineral wealth and particularly oilfields are concerned, includes various basins whose sedimentary conditions are different. The sedimentary sequence of a part of these basins which constitutes the tectonic units or the orogenic complexes has been disturbed by recent movements and kratogenic phenomena responsible for the present-day morphology. Highland areas of importance are Ağrı Dağı (Mt. Ağrı, 5165 m); Süphan Dağı (Mt. Süphan, 4460 m); and Erciyaş Dağı (Mt. Erciyas, 3916 m). In Eastern Anatolia lie the Anatolian plateaus (1000-2000 m), whereas in the Central Anatolia the plateau is at 750-1000 m.

In the Thrace region lies the Ergene basin; with very thick deposits, squeezed between mountain ranges forming the eastern and northern boundaries of this region and the Rodop substratum in the west. The northern heights reach some 1030 meters and in the south about 360 meters; the depression of the Ergene basin varies between 50 to 100 meters. In this basin there are deposits whose thickness reaches some 6000-10,000 meters including the Neogene and the Quaternary terrestrial covering strata.

GENERAL GEOLOGY

Paleozoic Rocks

The oldest formation in Turkey whose age has been determined by fossils is the *Lower* and the *Middle Cambrian,* located in Southern Turkey, at Derik, Mardin. This formation is unconformably underlain by the Algonkian, and contains volcanic materials.

Metamorphic rocks covering a rather large area and forming the substratum consist, generally, of such rocks as gneiss, mica-schist, quartzite, amphibolite, chloritic and andesitic schists phyllite, marble, and chalco-schists. These areas are often cut by acidic and basic intrusive rocks, and as a whole form the substratum for the other non-metamorphic rocks. These old metamorphic rocks are generally found in the following places :

In Thrace : at Çatalca - Istranca, Ergene-Rodop.

In Western Anatolia: Uludağ, Kapıdağ, the isles of Marmara, Kazdağı, Büyük and Küçük Menderes, Balıkesir, Kütahya-Bolu.

In Central Anatolia: Kırşehir, Niğde, Akdağ, Yıldızeli.

In Southern Anatolia: In the Taurus belt in the form of windows.

In Eastern Anatolia: At the Bitlis Massif.

In Northern Anatolia: Particularlyin Tokat, Tortum, Kaşkar.

We presume that the age of these mountain ranges is Hercynian or older and that the upper levels are younger.

Besides the Cambrian, fossiliferous Paleozoic, systems such as the Silurian, Devonian and the Permo-Carboniferous are also found in Turkey as follows:

The *Silurian* is rather widespread in Istanbul as conglomerates, limestones, sandstones, arkose, quartzite and schists. Marly schists bearing Graptolites, phyllites, dark-red sandstones further east at Ereğli, dark - grey schists bearing Graptolites, phyllites in Southern Anatolia in the Taurus belt, and particularly north of Adana between Kozan and Saimbeyli, are found unconformable under the Devonian or the Permo-Carboniferous. These rocks outcrop locally in the Amanos Mountains and probably further east.

The *Devonian* sea surrounded the older mountain ranges as monadnocks, covering large areas in Turkey, thus formingrather thick, variable or regular deposits. The facies are indicative of the Lower, Middle, and the Upper Devonian. Quartzite, arkose, graywacke, siliceous and clayey schists, nodular dolomitic and reef limestones blue and grey in color, sandstones, and conglomerates make up the main lithology of the Devonian. The Devonian extends in Istanbul, and in the east, to Şile, Adapazarı, Ereğli (on the Black Sea coast), to Bartın, Kastamonu, and further east partly with similar facies. The Devonian is found in Western Anatolia at Karaburun (İzmir); at Muğla-Reşadiye; in the western Taurus belt; and at Alanya. Of the Paleozoic formations in the Taurus, two thirds are Devonian particularly Upper Devonian. While Devonian outcrops are seen in the Anti-Taurus Mountains, the Lower and the Middle Devonian are found only in the southeastern oil basin of Turkey, particularly in the Hacertum Dağı, section north of Diyarbakır. The bituminous sandstones in the central parts of these series are known as the only horizons bearing hydrocarbons in the lower parts of the Paleozoic of southeastern Anatolia. They constitute promising key horizons in deep oil well drilling.

The *Lower Carboniferous* is marine and extensive; the *Upper Carboniferous* is terrestrial, -limited to certain areas, and bears coal. Among the marine formations on which exhaustive studies have been made the Zonguldak coal basin ranks first. The main facies of this basin are dark - grey dolomitic and reef limestones, pink and red sandstones, arkose, and quartzite, all of which are widespread in Elmadağ, Ankara, further east in the Ilgaz Mountains, at Gemlik in Bursa, at Balya, at Karaburun in Izmir in the west, and at Hakkari in eastern Anatolia. Non-marine Carboniferous appears in Zonguldak, in the south Taurus Ranges (probably at Akseki), and at Hazro; generally as an alternation of clayey and sandstone schists, sandstones, clay and conglomerates. The Permian is often seen as limestone and schist facies in places where the Carboniferous series are found.

The *Permo - Carboniferous* rocks are difficult to subdivide and are mainly thick deposits of limestone, marly limestone, and crystallized limestone. This sequence is poorly developed in the northern and southern Anatolian belts and often displays a thickness of more than 1500 meters. The Permo-Carboniferous of the Taurus Mountains underlies the comprehensive series of the Mesozoic, which are dark-blue - black limestones, and in which are found thin sandstone and schist-like rocks sometimes as bituminous horizons. At Hakkari, in Eastern

Anatolia, the Permo - Carboniferous, known as the Tanin formation, is an alternation of thin marls and limestones, often light-yellow in color.

Mesozoic Rocks

The *Mesozoic,* constituting the base of a comprehensive rock series in the Taurus Range, is generally transgressive on the Paleozoic, its deposits being rather widespread. These rocks are made up of Triassic dolomitic or light-red limestones in the lower levels and massive, plaquetted, or semi - marmarized limestones in the upper portion. The radiolaritic silicified horizons of these series form the key horizons. The semi-marmarized limestones, void of fossils, and the greenstone complex covering a wide area in Anatolia are assigned to the Mesozoic in general. This greenstone complex consists sometimes of acidic or basic intrusive rocks, phyllites, diabase, serpentinized periddtites and radiolaries, clayey schists and sometimes of lensing Rosalina limestones.

The *Triassic* outcrops in varipus places of Anatolia. It is transgressive over the Silurian and the Devonian at Kocaeli, east of Istanbul, over the Permo-Carboniferous at Balya (Balıkesir), and over the crystalline schists and the Paleozoic in the Kazdağ district. At the bottom below the basal conglomerates Triassic is formed of red sandstones, dense, nodular, and plaquetted limestones, blue, black, and grey in color and, at the top, black clayey schists. It consists of sandstone, micaceous marls, conglomerates, and limestones between Bursa and Gemlik, of dark-blue dolomitic limestones in Western Anatolia at Fethiye and Bodrum, and at Antalya and in the lake district west of it. It is composed of flysch-like limestones in northern Anatolia and of brown and grey sandstones, and yellowish marly limestones near the top in southeastern Anatolia. The Triassic at Hakkari is known as the Goyan Formation in oil work. The Triassic occurs at Hacertum Dağı in Diyarbakır in marly limestone and clayey strata. The green-red shales, sandstones, and thin-bedded limestones found below massive limestones during deep well drilling operations at Raman are Triassic in age.

The *Jurassic* formations occur as follows: These formations are composed generally of massive and plaquetted limestones and flysch extending from Ankara, south of Eskişehir, Bolu, and west of it to İznik; at Gölpazarı, Bilecik and southern areas; also at Bodrum and Marmaris in Western Anatolia as alternations of limestone and black schists containing bitumen with thin limestone lenses. The upper levels of these formations are represented by thin-bedded limestones and flysch-like facies. In Southern Anatolia, particularly near Bayburt, development varies but deposits are often thick. Here the Liassic is of black sandy, and oolithic limestones, about 2000 meters thick, over which limestones, basal conglomerates, and pink massive calcareous marls are transgressive. At Hacertum Dağı, in southeastern Anatolia, red, blue, coarse sandy limestones are Jurassic and extend to the Turonian. These strata extend to Cilo Dağları in the Hakkari district, undergoing a partial facies change.

The *Cretaceous* formations contain deposits covering wide areas in the north and south, and in the Anatolian plateau below the Tertiary and often -show, after study of rock characteristics in basins whose facies differ, extensive similar and sometimes heterogeneous features.

The *Cretaceous* formations appear in general to be of thick and «deep»

marine facies in the northern Anatolian regions, in southeastern Anatolia, and in comprehensive rock series in the Taurus Mountains in particular. These formations extend in rather regular deposits from. İstanbul to the Eastern Anatolia covering the Pontids. Generally they lie unconformably on the Paleozoic and sometimes on the Triassic. The *Lower and Upper Cretaceous* are differentiated in general by a disconformity between them. In this mountain belt, the Lower Cretaceous strata show a thickness up to 3000 meters in certain places. These strata are developed considerably in Zonguldak, and at Bayburt and Yusufeli in Eastern Turkey. The Lower Cretaceous is made up generally of such formations as conglomerates, plaquetted and massive limestones, sandstones, marls, and flysch. The Upper Cretaceous which sometimes shows a thickness of 2500-3000 m contains particularly, as in the Turonian, such sedimentary strata as sandstones, marls, flysch and limestones intercalated with andesites and dacites, lava, tuffs and agglomerates. The extrusive rocks which have developed considerably in Giresun and part of it in particular, partly decrease towards the south, extending to the Eocene and even to the Upper Miocene.

The greenstone complex, about the age of which long discussions have been made, begins in the Jurassic at Ankara and east of it, and continues in the Kızılırmak sector, radiolarites being predominant. Further east, in the Tunceli district, the submarine intrusions which appear in the Lower Cretaceous are generally of Upper Cretaceous age.

The *Cretaceous* formations, which continue in western, southern and even in eastern Anatolia as changing facies, are represented by Upper Cretaceous rocks showing massive, thick bank and zoogenous limestone and flysch strata. However, in the Taurus Range they appear as a comprehensive series. The upper parts of the partly reefy, dolomitic and massive limestone series which form the oil horizons in the southeastern oil basin of Turkey are Cretaceous in age and are overlain by a grey and greenish clayey sandstone and thick shale series known as the Kermav Formation. This series goes up as far as the Upper Maestrichtian-Paleocene. Determination of the boundary of this Kermav series depends more on fossils than on lithology.

Tertiary Strata

The *Tertiary* in Turkey covers larger areas than any older formations. The Eocene represented is widespread and its facies is represented by marls, sandstones, flysch, detritic or reef limestones, and conglomerates. In the Eocene formations which extend generally with the flysch and limestone formations in the northern Anatolian mountains and in the areas south of them are found such volcanic materials as acidic and basic intrusions, lava, agglomerates, and tuffs, particularly as intercalations in the flysch series. In certain areas, the flysch facies in the uppermost levels comprise the *Oligocene.* These deposits differ considerably from one another and are detritic, reefy, and pelagic, showing shallow-sea characteristics in some places and deep-sea affinities in other places; the thicknesses of these formations, like the facies, differ, reaching approximately 2000 meters.

With the exception of the marine formations in some districts such as the Thrace, Burdur-Acıgöl, Köyceğiz (Fethiye) and Gaziantep, and of certain flysch facies which are likely to be Eocene-Oligocene in Anatolia, the Oligocene in Turkey displays in general gypseous and brackish, and in some

places partly lagoonal facies. The post-Eocene regressive series have appeared also at the beginning of the Oligocene and due to the Alpine paroxysmal phases, brackish and lagoonal series have been formed in the highly broken subsidence and upheaved basins. Particularly in the Central Anatolian region some levels in these very thick deposits, where gypseous, brackish calcareous red sandstones, sands, clays and conglomerates alternate, contain local bitumen. This terrestrial regimen became predominant once again following the invasion of the Lower and the Middle Miocene sea; hence, the same brackish and lagoonal Upper Miocene deposits in many areas. Since it is difficult to determine the age of these facies, as they resemble one another, we shall consider this gypsiferous and brachisk series to be Oligocene-Miocene of age.

The marine Neogene* covered Anatolia during the Aquitanian and the Burdigalian only as gulfs and narrow strips in the coastal regions, continuing till the end of the Vindobonian. The western branch originating from the Mediterranean in the south, extends from Antalya partly to Denizli. The second branch extends from a rather wide gulf between Anamur, the Amanos, and the Paleozoic high massif of Malatya; also from Adana and Mersin up *to* Karaman in the north covering same. This branch has extended itself through the Ceyhan River and the Malatya track to Sivas and Koyulhisar in the north and further west, joining another marine Neogene branch coming directly from Van, invaded in part the Erzurum district. The Anti-Taurus Mountains and the Bitlis Massif became an island and the vast marine Neogene invasion coming from Syria in the south has formed an extensive deposition area in the region situated in southeastern Turkey from east of Antakya (Antioch), Gaziantep, north of Diyarbakır, between the Tigris and the Euphrates rivers.

However, the marine Neogene of Thrace has reached only to the Vindobonian and is restricted to certain areas. Near the end of stage the Sarmatian sea coming from the north invaded vast areas in Istanbul and in Thrace, and by Pontian time all the subsidence basins and plateaus in Turkey had been covered here and there with a rather thick terrestrial cover of Upper Miocene and Pliocene; in many places older formations have been hidden under these somewhat thick formations.

The last invasion of the sea in Turkey occurred in the Pliocene, but at a very limited scale, being restricted particularly to north of Antakya, in Southern Turkey, and to the Kozeir districts. The marine Quaternary has invaded very limited areas, such as Çanakkale, İzmir and Süveydiye (Antakya), leaving rather thick deposits in some districts along the Black Sea coast, and at Sinop in particular, where the thickness exceeds 200 meters, and where these deposits form hillocks on the coast reaching some 100 meters in height.

The young basalt towers, terminating at fault lines formed through tectonic movements taking place at the end of the Miocene and lasting even till the beginning of the Quaternary, cover very large areas in the Erzurum-Kars-Van region in the Eastern Anatolia, in Diyarbakır, and in Kayseri, and at the same time have extended in strips paralleling the strike of certain grabens.

The lithology of the marine Neogene shows a completely heterogeneous facies. The Aquitanian and the Burdi-

galian always begin with a basal conglomerate. Following the sandstone series towards the top are motley, glauconitic, detrital or reef limestones rich in micro- and macro-fossils, the upper levels being intercalated with marls, sandstones and marly sandstones. The Vindobonian consists of a conglomeratic, marly sandstone, and limestone series. Particularly in Adana and in Antakya the yellow sandy limestones bearing Helvetian microorganisms in abundance represent the characteristic feature of this region. The Pliocene occurs in the form of conglomerates and gypseous, thick, marly and sandy series; the Sarmatian is seen with intercalations of limestones, sandstones, marls and gravel. However, the Pontian is a series of thin marls, lumachelle limestones, and gravel between sand beds, usually thick. Finally, the marine Quaternary is made up of sandy, marly, clayey and sometimes of lumachelle limestones.

OIL POSSIBILITIES

We shall discuss in this report, the most promising, the promising and the least promising geologic formations existing in Turkey in various regions with reference to their sedimentary characteristics.

The Most Promising Areas

Structures favorable for the accumulation of oil are found in these areas. Oil seepages in geologic formations of various horizons are also found here. The thickness of the deposits and the facies are favorable, too. The areas are as follows:

1. The Southeastern Anatolia district.
2. The Antakya-İskenderun district.
3. The Adana-Mersin-Mut district.
4. The Thrace district.

The Southeastern Anatolia District.— This district is located between the metamorphic Bitlis Massif in the north, the Anti-Taurus Mountains in the northwest, the south bend interlinking the Anti-Taurus fountains in the -west, and the Arabian Block. In this district lie the oil-producing Raman and Garzan oil fields.

The Cilo, Giri, Tanin and Cudi heights, forming the Hakkari Mountains and extending as a strip east of the basin following the orogenic zone south of the Bitlis Massif, are of paramount importance as they furnish data on the deeper Formations of this area. In this district the dolomitic limestone horizons, partly massive and with hydrocarbon zones above the Permo-Carboniferous (Tanin formation, 2000 m. thick), also contain bituminous limestone-shales occasionally in the Devonian and the Triassic (Goyan formation). These correspond to the massive limestones which constitute the oil horizon in the Raman oil wells. There are impregnations of hydrocarbons in the sandstone beds of the Devonian rocks which are the oldest in the Hacertum Dağı heights, north of Diyarbakır. This is the only hydrocarbon-bearing zone in the lower part of the Paleozoic. Above the Carboniferous, Permian, and Triassic massive limestones, Jurassic-Maestrichtian age, with bitumen accumulations, have always shown lithologic differences due to lateral and vertical facies changes in various parts of the district. These limestones vary in thickness, to wit, the thickness is about 900 meters as shown by the Raman drilling operations, 1000 m in the Kentalan drilling, and 600 m at Gercüş. On the other hand, their thickness varies between 400-1000 meters among outcrops and reaches some 2000 meters in the Cudi heights at Hakkari. These massive limestones which may serve as reservoir rock are overlain by the Kermav formation of Upper Maestrichtian-

Lower Paleocene age, which generally contains shale. The thickness of these formations varies between 300 and 800 to 900 meters. The coarse, clastic, and reddish shale sequence having the features of a regressive facies and overlying the latter series is the Gercüş formation, Ypresian in age.

In the Adıyaman-Kahta-Urfa-Gaziantep districts, each of which lies in this basin, there has been thick and continuous sedimentation ranging from Paleozoic to Miocene as observed in eastern Anatolia. However, facies changes can be seen in certain beds. The Miocene formations above the Lutetian Midyat limestones show another characteristic aspect in this district. In the drilling operations conducted at Kahta, some oil seepages were observed, particularly in the massive limestones where there is a petroliferous horizon 600 meters thick. Again, during drilling at 1300 m at Gaziantep, an asphalt horizon of 25 meters was crossed in massive limestones 400 meters in thickness.

Despite the fact that important oil fields have been found in the Asmari limestones (these correspond to the Midyat limestones) which lie outside the southern boundaries of Turkey, no oil could be seen in the Midyat limestones in Turkey as they are void of good caprock. In southeastern Anatolia as well as İskenderun oil fields are likely to be found in the marine Miocene layers. This is also especially true for the Miocene or Eocerie formations situated under basalt and thick Plio-Quaternary levels widespread in the neighborhood of Diyarbakır. Again this may hold for the Miocene and particularly the Eocene in the Cizre plain, as there exists a rather thick capping layer. Finally, favorable conditions might exist in this district in the Lower Mesozoic, and for the Paleozoic. In the eastern portions of the basin, near fault zones north of Cizre, oil may be found provided that there are traps for petroliferous accumulations.

Owing to the existence of various petroliferous horizons and of the series of favorable source clays and marls in the basin whose depths reach some 6000-7000 m, oil may be expected to be found in these districts in Devonian to Miocene rocks.

The Antakya-İskenderun District.— The end of the southern bend of the Anti-Taurus Mountains constitutes the Amanos Mountains which extend to the island of Cyprus. The Amanos Mountains resemble a horst between two low flatlands. This mountain range is locally broken, dislocated, or cut by stepped faults due to strong tectonic movements. The main Paleozoic nucleus is located in the north, whereas the Mesozoic is widespread in this district. The Paleozoic and the Mesozoic are separated by an unconformity. The greenstone complex plays an important part at Kızıldağ, over which the Maestrichtian transgresses. The greenstones are generally massive and plaquetted limestones. In the reef portions of the underlying dark-grey, blackish, limestone series and in the thin plaquetted limestone series overlying the greenstone series, hydrocarbon seepages have been observed. The thickness of these limestones is about 1500 meters. These limestones lie under serpentines, 1000-3000 meters thick. Among the white Eocene limestones, only one asphalt impregnation has been seen. During an oil drilling operation carried out at Arsuz, İskenderun, the drilling reached a depth of 726 meters and crude oil was found in the Helvetian sandstones and limestones, 50-60 meters thick, and containling micro-organisms in abundance. This thickness varies from place to place. In

some oil drilling done at İskenderun, hydrocarbon gas was observed. Among these Helvetian sandstones and limestones, a marl series, Tortonian and Pliocene in age, was 1320 meters thick.

In another oil well drilled at İskenderun, the drilling reached 1000 meters and was discontinued in serpentine. However, it would not be useless to test the sedimentary strata under the serpentine, which is older than the Senonian. The İskenderun basin deepens to the north and towards the sea in the west. In these lower parts, oil structures can also be expected in the sea.

The Adana-Mersin-Mut District.— The neighborhood of Adana and Mersin, south of the Taurus Mountains, bears the characteristics of a deep subsidence basin covered by Miocene strata. The characteristic features of sedimentary rocks together with oil seepages make this district particularly important.

The substratum of the district is found in the Taurus Mountains, in the south, in the Misis Mountains, and in certain windows. All the old geological formations surround this district; while the Mesozoic with the Cretaceous and the Lower Tertiary strata are spread over limited areas, the Miocene strata cover the basin. These strata are very characteristic regarding petroleum and sedimentary deposits. The reef, biohermal, sandy, and marly limostones overlying the basal conglomerates and the Middle Miocene sandstone sequence show the lateral and vertical facies changes in the basin. These increase in number from north to south. The Burdigalian formations, seen as limestone at the basin edges, vary to sandstones and shales centrally, their thickness being 500-1000 meters. Both the Lower and Middle Miocene beds show the considerable thickness of 3000-5000 meters.

With the exception of the oil seepages seen in the Paleozoic and in the serpentines in this district, the oil seepages in the Lower and in the Middle Miocene are encouraging because of the fact that there are continuous Tertiary deposits with thicknesses and quality favorable for petroleum in the basin; also there are structures, buried hills, stratigraphic and structural traps for oil. Hence this district is one of the most promising areas to find oil.

The Thrace District.— This district which is surrounded by the substratum of the old massifs has long been a theater of oil exploration operations because of its favorable and continuous, sedimentary deposits, oil seepages, and structures. Rocks ranging from the Upper Cretaceous to the Upper Neogene are found in this district. The Eocene, Oligocene, and Miocene are important for oil. Following the marl sequence, 1000 meters thick are detritic sandstones, 50m thick, and Lutetian reef limestones with a thickness of 200-500 meters. The Eocene-Oligocene flysch on top displays a thickness of 2500-3000 meters. Sediments with the enormous thickness of 10,000 meters having been deposited in a narrow basin indicate that the district bears the characteristic of a subsidence. East of the basin, between the Çekmece lakes, the Eocene lies NNW-SSE. At Tekirdağ-Şarköy, the Eocene - Oligocene - Miocene, striking NW-SE (the same lying NE-SW to the west and in the Ergene basin), has E-W oriented anticlines and synclines, forming as a whole a virgation.

In the Thrace district, bitumen and oil have been found only in the Middle Miocene and the Sarmatian beds. Apart from it, Miocene oil and gas have been observed in drillings made at Şarköy, Mürefte.

The Promising Areas

The districts whose sedimentary deposits are satisfactory for the accumulation of oil are covered under this heading. In some parts of this district little reconnaissance or exploratory drilling has been conducted.

These districts are as follows :

1. Van-Muş-Hınıs-Malazgirt
2. Sivas-Erzincan-Erzurum
3. Rize
4. Malatya
5. Çorum-Çankırı
6. Ankara-Tuzgölü-Ereğli (Konya)
7. Antalya
8. Niksar - Boyabat - Kastamonu - İzmit strip.

The Van-Muş-Hınıs-Malazgirt District.— This district is situated in a large basin between the Bitlis and Paleozoic Massifs in the north. In particular the eastern and southern parts of this district have been covered by lava, mainly due to the recent kratogenic movements The lava is somewhat faulted.

That the sedimentary deposits are satisfactory for the accumulation of oil, that the seepages are numerous and that there exist in certain places structures, rank this district as the first of the promising areas as regards oil. Geologists of the M.T.A. Institute are conducting facies studies in this district."

The acidic and basic intrusive rocks, the Paleozoic marbles and the greenstones form the northern border of this district whose southern border is the metamorphic, rocky, Bitlis Massif. Here is a somewhat important thick sedimentation. With the exception of the faulted, broken, basic intrusive series, the Cretaceous displays continuous sedimentation and consists of a flysch-like *se*quence with marl alternations over blackish, dark-grey limestones. The unbroken Paleozoic series, 1000-1500 m thick, is as important as the other Tertiary formations. The Paleocene is a motley shale-conglomerate sequence from the bottom up. The thickness of the flysch-like Eocene is 2500-2700 m. The same facies continues till near the end of the Oligocene. The Lower Miocene is 1500 meters thick, with a white, sandy limestone-marl alternation at the bottom, and containing detrital and reef facies rich in micro-organisms. The Middle Miocene with sandstones and thick marls above serve as very favorable covering layers. All these rocks thin considerably in the Van district, being reduced to 1500-2000 meters. The terrestrial deposits of the Upper Miocene are in alternation with sandstones, conglomerates and thick marls. The basalt and andesito-basaltic eruptions of different phases and sometimes in alternation with the Pliocene facies above are very widespread in the eastern district like the Upper Neogene beds, and seem to hide the tectonic and lithological characteristics of these sequences and of the older formations under them. These basalt towers become more common and important in the Şerafettin and Bingöl Mountains region.

This characteristic of the eastern districts is of primary importance since the basalt towers give a characteristic aspect to oil explorations. Indeed, the Hamurpet Mountains in which the basalt series are found (west of the Bitlis Massif and Murat suyu) extend for some 50 km, striking E-W, and together with their regional faults and fractures parallel the Bitlis Massif and the Paleozoic series in the northern highlands. The structure of these mountains is hidden entirely by the Lower, Middle and Upper Miocene marine series. The Upper Miocene and Pliocene contain also basaltic ledges at different horizons. These basalt flows have come from far away and

have spread over a large area, thus covering the deposits and structures likely to contain oil.

Oil seepages are observed in the Upper Cretaceous, in the Eocene (Paleocene inclusive), in the Oligocene flysch facies, and particularly in the Lower Miocene in this extensive district.

Sivas - Erzincan - Erzurum District.—The important prospective rocks of this district, so far as the sedimentary deposits are concerned, lie west of Erzincan-Erzurum. The Mesozoic in its entirety lies unconformably over the Paleozoic and shows a thickness of 6000-7000 meters.

The Triassic alternates with motley sandstones, quartzite, and limestones. The black dolomitic limestones, sandstones, and the thick massive limestones and conglomerates are Jurassic. There is a regressive series between the Lower and the Upper Cretaceous. From the bottom upwards come the marly limestone, sandstone and conglomeratic series, and then the greenstone complex which covers large areas in the district. Over these is the Maestrichtian as reef limestones. The topmost levels contain a flysch sequence. The Eocene has flysch beds at the bottom, continuing upward as limestones rich in fossils. The Eocene displays a thickness of about 1000 meters.

Gypseous and brackish beds, Oligo-Miocene in age, containing lagoonal and brackish facies, overlie this series. These gypseous and brackish series are developed in Central Anatolia, particularly in the Sivas area. These beds extend in strips towards Erzincan and Erzurum, especially in the Miocene. In the red sandstones, limestones, and marls of these strips are found in places hydrocarbon occurrences such as bitumen, asphalt and gas. The marine Miocene, bearing the features of a shallow sea in this District, contains limestones, sandstones and marls, and in its eastern extension joins the eastern branch of a narrow strip of the sea coming from the south. Some oil seepages have been observed in the Miocene beds. The existence of oil seepages and of thick and continuous sedimentary deposits in this district are valuable evidences.

The Rize District. — Evidences of hydrocarbons originating from three different places in the eastern Black Sea, Rize and Çayeli districts make the Rize district important for oil explorations.

The marine Eocene or the Miocene having grey and red sandstones 500-600 meters thick overlies the Cretaceous, in turn made up of andesitic and dacitic tuffs, limestones with agglomerate intercalations, and marls and sandstones whose thickness varies between 700 and 850 meters and is very important for the district. The Pliocene is 800-900 meters thick, with fluviatile gravels and conglomerates.

The existence of oil seepages and of structures in the marine formations makes it necessary to include this district among the promising ones.

The Malatya District. — The stratigraphic order of this district is as follows : Over the metamorphic Paleozoic series and the conglomeratic, regressive, Permo-Carboniferous lie the Upper Cretaceous flysch, greenstones, and reef limestones. The greenstone complex produces oil seepages. The Eocene has a calcareous character at the bottom, and is flysch-like at the top. There are bituminous levels also in the Eocene and these levels are quite thick. The Lower Miocene is in the thick sandstone and limestone facies, the Upper Miocene being an alternation of marls and sandstones. The Pliocene

consists of thin limestones. At the top are found the basalt covers of the Quaternary. The strike of the structures here is generally NNE-SSW. It is presumed that other structures could be found under the Malatya plain.

Owing to the existence of suitable structures and sedimentary deposits of the proper kinds, and of evidence of seepages, as well as consideration of the fact that the Eocene, particularly the Upper Cretaceous and partly the Miocene limestones have reef characters, we may consider oil possibilities good. Finally, the existence of marly beds or of rocks where marls and sandstones alternate and are sufficiently thick to cap possible oil reservoirs also should make this district important for oil exploration.

The Çorum - Çankırı District. — This is a district characteristic for its brackish and gypseous formations. The substratum is of Paleozoic metamorphic and crystalline limestones. The Jurassic consists of crystalline limestones, 100 -150 m thick: the Upper Cretaceous strata, having thickly plaquetted red and green limestones are 400-500 meters thick. The Lower Eocene with brecchoid limestones, dark-red in color, and the flysch-like Upper Eocene with an alternation of sandstones and marls total 700-900 meters thickness. Over these lies an Oligocene sequence 700-900 m thick, made up of variegated marls with lenses of gypsum and salt beds. The gypseous sandstones and the variegated marls are 600-700 m thick. On the Lower Miocene He the loosely cemented sandstones of the Pliocene, also containing sand, marls, and gravel 100-150 meters in thickness. The Quaternary deposits complete the sedimentary deposits of this district.

The parts of the Cretaceous remote from the basaltic eruptions, the Middle Eocene formations, and part of the Oligocene have necessary characteristics for the accumulation of oil. The marls and flysches in this district form capping beds. In certain locations structures have been seen. In view of the fact that hydrocarbons (gas) and asphalt were seen in this district, and that salt springs, making the existence of salt domes at depth seem possible, this district may be considered important.

The Ankara Tuzgölü-Ereğli District. — This district is a large basin surrounded by the Elmadağ Paleozoic series in the north; by the Kırşehir metamorphic series in the east; by the Taurus belt in the south; and by the Sultan and Emir mountains in the west. The sedimentary deposits lying among the Paleozoic massifs are rather important but are partly broken and faulted. These locations, as well as the metamorphic rocks, plus also the Paleozoic, Mesozoic, Tertiary, and particularly the Upper Miocene and younger sedimentation have resulted in extensive and thick deposits. Crystalline limestones are widespread in this district. A basal conglomerate, a marly limestone bed, and the flysch-like Jurassic overlie the Paleozoic. Above the basal plaquetted limestones the Cretaceous is generally of greenstones. The lower levels of this complex go down as far as the Jurassic. In the fissures of the uppermost limestone series there is an accumulation of hydrocarbons. The Paleocene is in the form of volcanic breccia limestone and as clastic flysch. The Eocene overlying it is more calcareous. The upper part of the Eocene, contains a flysch series. These flysches which cover the Oligocene together with the andesites show a total thickness of 900-1500 meters. Over them are found, as is the case in Central Anatolia, Oligo-Miocene limestone beds and flysches. Above them is probably an alternation of terrestrial Neogene lime-

stones, marls, sandstones and conglomerates, and fluviatile Quaternary deposits. Also is found the Upper Neogene containing travertines 200 meters thick, Quaternary strata, and above these are eruptive rocks covering rather extensive areas particularly between the north of the district and the south of Tuzgölü, and east of it.

The marble-like limestones, Paleozoic in age, sometimes smell of bitumen. The Eocene-Oligocene flysch may serve as a reservoir rock. The thickness of the possible caprock in this district sometimes suggests favorable oil accumulation conditions. It has been observed that this thickness increases from the east towards the west and from south to north in the basin. Therefore, oil possibilities in north of the Taurus Mountains are more likely to exist near Tuzgölü than the periphery of the basin; in other words, in this basin, which is limited on the north and east by NW-SE trending faults, the sedimentary deposits increase in the central parts.

We presume that the structures, which seem to narrow near the borders of the basin and widen towards the central parts, would get still wider in areas hidden by the thick Neogene covers. Furthermore, it may be that a salt dome lies under the Tuzgölü.

The north western part of Ankara is as important as Tuzgölü. In this vicinity oil seepages have been observed in the Cretaceous limestones. There are some asphalt occurrences in the Paleocene, in the Eocene conglomerates in the vicinity of Polatlı, and in some Eocene limestones northwest of Ankara. The Upper Cretaceous and the Paleocene in this district serve also as a bedrock with oil possibilities, It is likely that stratigraphic traps and favorable caprocks exist in this district.

Although there are favorable structures and oil seeps in this basin, the structures are generally somewhat faulted and broken, and since aquifers exist in certain areas, these districts could be included only among the promising areas.

The Antalya District. — The Antalya district has sedimentary deposits starting from the Devonian and ending with Tertiary or Quaternary. In the plains sector travertines often form the topmost layers.

The Cretaceous is represented here by limestones and locally by marls; the upper levels often have massive and reef limestones. Above the Cretaceous lie the massive Eocene limestones. The Miocene consists of reef limestones, marl-sandstones, sandy limestones, and conglomerates. These formations all have possible oil-bearing horizons.

South of Antalya, at the contact of greenstones with the Cretaceous limestones, and in the Mesozoic limestones, there are oil seepages and some favorable structures in the district which render it promising for oil.

The Niksar - Boyabat - Kastamonu-İzmit Belt District. — This belt parallels the Black Sea coastal line and in the south extends east and west as a Tertiary corridor. The important area in this belt is the Boyabat- Ekinviran sector. The Cretaceous lies unconformably over the Paleozoic here and is a rather thick-bedded unit. The Lower Cretaceous consists of crystalline limestones and the Upper Cretaceous is a flysch, 2000-3000 meters thick. The Lower and the Middle Eocene in this district is a marl series containing thin limestone banks. The Upper Eocene consists of sandstones, conglomerates, and marly and sandy limestones. The thickness of the entire Eocene is about 2000 m; it is

B L A C K S E A

U. S. S. R.

BULGARISTAN
BULGARIA

YUNANISTAN
GREECE

İSTANBUL

MARMARA

SİNOP

ORDU

SAMSUN

RİZE

ÇANKIRI

SİVAS

VAN

HAKKÂRİ

İRAN

IRAK
IRAQ

SURİYE
SYRIA

İZMİR

AEGEAN SEA

MEDİTERRANEAN SEA

OIL MAP OF TURKEY

Cahit ERENTÖZ - Zati TERNEK

25 0 50 100 Km.

- *Crystalline and intrusive rocks*
- *Favorable areas*
- *Most favorable areas*
- *Less favorable areas*
- *Structures*
- *Seepages*

overlain by the Oligocene in the form of marls and conglomerates.

There are locally some oil seeps in this belt unit. In the Upper Cretaceous flysch are found hydrocarbon seepages as gases and liquids. The lower levels of the Eocene and the Oligocene beds over this flysch serve as a good oil reservoir. There are also some structures in this district. The Cretaceous - Oligocene deposits are favorable for oil, from the point of view of thickness of the deposits.

The Less Promising Areas

These districts include sedimentary basins where the thickness of the deposits is small and whose rocks have been disturbed, as is the case with the Pontids and the Taurids which contain semi-metamorphic massifs or are highly disturbed by volcanism.

In these areas are found generally metamorphic rocks, semi - metamorphic rocks, probably of the Paleozoic age, the greenstone complex, the Mesozoic, and part of the Tertiary formations. Due to the effects of magmatism, the conformity of the Neogene overlying them has been disturbed over wide areas.

It is obvious that the areas constituting the backbone of the Pontids, and particularly the Taurids, that were subjected to complex tectonic effects are only slightly prospective. Hovewer, oil seepages have been observed in the orogenic belt complex which has undergone strong tectonic movements as well as in certain grabens.

Among such areas some, which have been considered favorable for oil possibilities as regards sedimentary facies and structural features and which have been subject to weak tectonic movements, might later be included in the promising areas after future detailed studies have been conducted. Much cannot be expected from the areas whose petroliferous characters have been partly disturbed by volcanism either during the depositions of the sediments or thereafter. Furthermore, districts where the marine facies have been intermixed with the lagoonal and terrestrial facies have reduced oil prospects.

Also, partly tranquil areas with predominant terrestrial strata or with thin sediments are naturally of little importance regarding accumulation of oil.

In summary, areas where there are metamorphosed formations, thin formations with complex tectonics, formations highly disturbed by volcanism and whose marine facies have been much intermixed with lagoonal and terrestrial facies, or whose terrestrial characteristics are predominant, rank among the less promising areas.

BIBLIOGRAPHY

ALTINLI, E. (1944), : Etude stratigraphique de la region d'Antalya. *İst. Üniv. F. Fak. Mecm.,* Se. B, C. 9. No. 3, p. 228, Istanbul.

———(1954) : The Geology of Southeastern Siirt. *İst. Üniv. F. Fak. Mecm.,* Sc. B, C. 19, No. 1, p. 1, İstanbul.

———(1954) : The Geology of Southern Hakkari. *İst. Üniv. F. Fak. Mecm.,* Se. B, G. 19, No. 1, p. 33, İstanbul.

ALTINLI, E. (1956) : Geology of the sheet of Van to 1/500,000 scale.

———(1958) : Geology of the sheet of Cizre to a scale of 1/500,000.

ARNI, P. (1937) : L'importance des recherches geologiques pour l'etude et l'exploitation des ressources minerales de la Turquie. *M.T.A, Mecm.,* No. 2, p. 17, Ankara.

———(1939) : Contribution to the Geology of the Siirt Region with some Conclusions in Regard to Possible Oil Reserves. *M. T. A, Derleme,* Rap. No. 1284, Ankara.

———(1939) : Relations entre la structure regionale et les gisements mineraux et petroliferes de l'Anatolie. *M. T. A. Mecm.,* No. 2, p. 29, Ankara.

BAYRAMGİL, O. (1953) : Ueber die Petrographie der Bohrproben gengen Nr. III (S.E. Türkei) *M. T. A. Mecm.,* No. 44/45, p. 125, Ankara.

BLUMENTHAL, M. (1944) : Quelques considerations sur la tectonique de la region de Harbol et son importance pour la recherche du Petrole. *M.T.A. Derleme,* Rap. No. 1683, Ankara.

BURGER, J. J. (1946) : Etude geologique du bassin miocene de Mürefte - Şarköy. *M.T.A. Derleme,* Rap. No. 1738, Ankara.

EGERAN, N. (1945) : Contribution apportee aux connaissances sur la tectonique effectuees recemment en Turquie. *M. T. A. Mecm.,* No. 34, p. 327, Ankara.

———(1948) : Geology of the Raman Dağ. M. *T. A. Mecm.,* No. 38, S. 66, Ankara.

———(1949) : Raman petrolü. *M. T. A. Mecm.,* No. 39, p. 7, Ankara.

———(1949) : Geological Characteristics and Oil Possibilities of the Adana basin. M. *T. A. Mecm.,* No 39, p. 23, Ankara.

———(1949/50) : Observations nouvelles faites au champ petrolifere de Raman. *Türk. Jeol. Kur. Bült.,* C. 2, No. 1, p. 110, Ankara.

———(1951) : On the Oil Fields Located in South-Eastern Turkey. M. T. *A. Mecm.,* No. 41, p 59, Ankara.

———(1952) : Relations between Tectonic Units and Oil Fields in Turkey. M. *T, A. Mecm.,* No. 42/43, p. 115, Ankara.

———(1953) : Relations entre les unites tectoniques et les gisements petroliferes de Turquie. *Congres Geol. Inter. Alger,* 1952, Fasc. XVI, p. 125, Alger.

ERENTÖZ, C. (1953) : Etudes geologiques dans la region de Çatalca (İstanbul). *M. T. A. Neşriyati,* Ankara.

———(1954) : Geologie du bassin de l'Aras. *Türk. Jeol. Kur. Bült.,* C. V, No. 1/2, Ankara.

———& TOLUN, N. (1954) : Le Charriage d'İskenderun. *Türk. Jeol. Kur. Bült., C.* 5, No. 1, p. 215, Ankara,

ERENTÖZ, C. (1954/55) : Geologie detailtee de la structure petrolifere de Kışlaköy (İskenderun-Hatay). *M.T.A. Mecm.,* No. 46/47, p. 1, Ankara.

———(1956) : A General Review of the Geology of Turkey. *M. T. A. Mecm.,* Foreign Edition, No. 48, p. 37, Ankara.

ERENTÖZ, L. (1956) : La sedimentation actuelle dans la Mer Noire. These, *M. T. A. Neşriyatı,* Ankara.

———(1956) : Stratigraphie des bassins neogenes de Turquie, plus specialement d'Anatolie Meridionale et comparaisons avec le domaine Mediterranean dans son ensemble. These, *M. T. A. Neşriyatı,* Ankara.

———(1958) : Mollusques du Neogene des Bassins de Karaman, Adana et Hatay (Turquie). These, *M. T. A. Neşriyatı,* Ankara.

ERICSON, D. B. (1939) : Report on the Northwest Van Region. *M. T. A. Derleme,* Rap. No. 851, Ankara.

FOLEY, E. J. (1937) : Geology of Kermav-Hermis. *M. T. A. Derleme,* Rap. No. 672, Ankara.

FOLEY, E. J. (1937) : Geology of Raman Dağ. *M. T. A. Derleme,* Rap. No. 249, Ankara.

———(1938) : Geology of the Asphaltic deposit at Harbol. *M. T. A. Derleme,* Rap. No. 1351, Ankara.

———(1938) : Geology of the Van Area. *M. T. A. Derleme,* Rap. No. 719, Ankara.

İZGİ (TAŞMAN), M. & TROMP, S. W. (1942) : The microfaunae of the basal-Eocene and Upper Cretaceous section of Raman Dag well No. 2 (S. E. Turkey). *M. T.A. Mecm.,* No. 26, p. 113, Ankara.

KERR, R. G. & NIGRA, J. O. (1952) : Petroleum Developments in Middle East and adjacent countries in 1951. *Bull. Amer. Assoc. Petrol. Geol.,* Tulsa, v. 36, pp. 1427-1444.

KIRK, H. M. (1937) : Summary report on Mürefte. *M. T. A. Derleme,* Rap. No. 240, Ankara.

LÖCZY, L. (1938) : Vorlaeufiger Bericht über die Erdolmoglichkeiten Thrakiens. *M. T. A. Derleme,* Rap. No. 727, Ankara.

MAXSON, J. H. (1937) : Oil possibilities on the District around Lake Van. *M. T. A. Derleme,* Rap. No. 243, Ankara.

———(1937) : Reconnaissance Geology, Oil possibilities and Mineral Resources of Southeastern Turkey. *M. T. A. Derleme,* Rap. No. 680, Ankara.

MERCIER, J. (1953) : Contribution a la connaissance des gisements petroliferes du Moyen-Orient. Congres *Geol. Inter. Alger,* 1952, Fasc. XVI, p. 135, Alger.

MOSES, H. F. (1934) .: Reconnaissance Report on the Oil possibilities of the Mürefte Area Turkey. *M. T. A. Derleme,* Rap. No. 185, Ankara.

ORTYNSKJ, I. & TROMP, S. W. (1942) : Geological notes on the area between Boyabat and Ekinveren Vilayet Sinop (Northern Turkey;. *M. T. A. Mecm.,* No. 28, p. 412, Ankara.

ORTYNSKI, I. (1947) : Geological Report on Mürefte Area. *M. T. A. Derleme,* Rap. No. 1740, Ankara.

PAIGE, S. (1934) : A Geologic Reconnaissance of the Mürefte Region. *M. T. A. Derleme,* Rap. No. 229, Ankara.

PAMİR, H. N. & BAYKAL, F. (1947/48) : Le Massif de Stranca. *Türk. Jeol. Kur. Bült., C.* 1, No. 1, p. 26, Ankara.

PAREJAS, Ed, (1940) : La tectonique transversale de la Turquie. *İst. Üniv. F. Fak. Mecm.,* Se. B, C. V, No. 3-4, p. 133, Istanbul.

ROOTHAAN, J. Ph. (1939) : Provisional Abstract of Geological Investigation in the Vilayets of Erzincan and Erzurum with Special Reference to its Oil Possibilities. *M. T. A. Derleme,* Rap. No. 1116, Ankara.

SANDERS, B. & HANSGIRG, W. (1923) : Die Bitumenmergel von İzmit in Kleinasien. Petroleum, Wien.

TAŞMAN, C. E. (1930) : Prospective Oil Territory in Turkey. *Bull. Amer. Assoc. Petrol. Geol.,* Tulsa, t. 14, pp. 1088-1089.

———(1930) : Report on the Petroleum Possibilities of Northern and Eastern Vilayets. *M. T. A. Derleme,* Rap. No. 201, Ankara.

———(1930) : Report on the Geology and the Oil possibilities of the Mürefte-Şarköy region. ***M. T. A.*** *Derleme,* Rap. No. 187, Ankara.

———(1931) : Petroleum possibilities of Turkey. *Bull, of Amer. Assoc. of Petrol. Geol.,* Vol. 15,

———(1936) : Oil at Korzot near Lake Van. *M. T, A. Mecm.,* No 5, p. 43, Ankara.

———(1936) : Search for Oil in Mürefte. *M. T.A. Mecm.,* No. 3, p. 17, Ankara.

———(1937) : Salt Domes of Central Anatolia. *M. T. A. Mecm.,* No. 4, p. 45, Ankara.

———(1937) : Turkey and Petroleum. *M. T. A. Mecm.,* No. 3, p. 9, Ankara.

———(1938) : A Geologic Synopsis and Status of Oil Exploration in Thrace. *M. T. A. Mecm.,* No. 3, p. 18, Ankara.

———(1939) : Oil possibilities in Southern Turkey. ***M. T. A.*** *Mecm.,* No. 15, p. 17, Ankara.

TAŞMAN, C. E. (1945) : Thrace and Oil. *M. T. A. Mecm.,* No. 34, p. 336, Ankara.

———(1945) Tuzlarımız. *M. T. A. Mecm.,* No. 33, p. 105, Ankara.

———(1946) The Oil Seepage at Mapavri (Çayeli). *M. T. A. Derleme,* Rap. No. 1802, Ankara.

———(1946) Harbolite a Carbonaceous Hydrogarbon. *M. T. A. Mecm.,* No. 35, p. 51, Ankara.

(1949) Petrolün Türkiye'de Tarihçesi. *M. T. A. Mecm.,* No. 39, p. 14, Ankara.

———(1950) Türkiye'de Bitümlü Tezahürlerin. Stratigrafik Yayımı. *M. T. A. Mecm.,* No. 40, p. 41, Ankara.

———(1950) Preliminary Observations of Raman Dag Field Based on Subsurface Data. *M. T. A. Mecm.,* No. 40, S. 50, Ankara.

———(1953) Petrol Aramalarında Stratigrafinin Önemi. *Türk. Jeol. Kur. Bült.,* C. 4, No. 1, p. 140, Ankara.

TEN DAM, A. (1951/52) : Sedimentation, Facies and Stratigraphy in the Southern part of the Neogene Basin of İskenderun. *Türk. Jeol. Kur. Bült., C.* 2, p. 49, Ankara.

TERNEK, Z. (1949) : Geological Study of the region of Keşan-Korudağ, İstanbul.

———, & TOLUN, N. (1951/52) : Notes Gdologiques sur la Region de Mardin. *Türk. Jeol. Kur. Bült., C.* 3, No. 2, p. 1, Ankara.

TERNEK, Z. (1953) : Mersin-Tarsus Bölgesinin Jeolojisi. *M. T. A. Mecm.,* No. 44/45, p. 18, Ankara.

———(1953) : Geological Study Southeastern Region of Lake Van. *Turk. Jeol. Kur. Bült.,* Vol. IV, No. 2, Ankara.

———(1953) : Regional Geology North of Mersin-Tarsus. *M. T. A. Mecm.,* No. 44/45, Ankara.

———(1957) : The Lower Miocene (Burdigalian) formations of the Adana Basin, their relations with other formations, and Oil possibilities. *M. T. A. Mecm.,* No. 49, Ankara.

———(1958) : Geological Study and Oil Possibilities of the Bucu-Kılbaş (Adana) Region. *Turk. Jeol. Kur. Bült.,* Vol. VI, No. 2, pp. 37-66, Ankara.

TOLUN, N. (1948) : Observation sur le pli bordier du Taurus Oriental et les possibility de l'existence en hydrocarbures. *M. T. A. Derleme,* Rap. No. 1804, Ankara.

———(1951) : Etude geologique du bassin Nord-Est de Diyarbakır. *M. T. A. Mecm.,* No. 41, p. 65, Ankara.

———(1953) : Contributions a l'etude geologique des environs du S et SW du Lac de Van. *M. T. A. Mecm.,* No. 44/45, p. 77, Ankara.

———(1955) : Notice Explicative de la Feuille Diyarbakır 1/500,000. *M. T. A. Derleme,* Rap. No. 2281, Ankara.

TROMP, S. W. (1940) : Preliminary report on the Oil possibilities of SE Turkey. *M. T. A. Derleme,* Rap. No. 1216, Ankara.

———(1941) : Preliminary Compilation of the Stratigraphy and Structural features and Oil possibilities of South-Eastern Turkey and comparison with neighbouring areas. *M. T. A. Mecm.,* (A), No. 4, pp. 1-34, 5, Ankara.

———(1943) : Micro-Fauna of the Upper Cretaceous and Tertiary Sections (Arabian Facies) in the Urfa and Gaziantep Regions. *M. T. A. Mecm.,* No. 29, p. 134, Ankara.

YÜNGÜL, S. (1951/52) : Çukurova'da Petrol Aramalarında Kullanılan Gravimetrik ve Sismik Usullerin Korelasyonu ve Bunların Bazı Jeolojik Enterpretasyonu. *Türk. Jeol. Kur. Bült., C.* 3, No. 2, p. 27, Ankara.

ZIEGLER, K. G. J. (1941) : Bitumen-Schiefer in Westanatolien. *M. T. A. Mecm.,* No. 25, p. 521, Ankara.