URANIUM AND THORIUM POSSIBILITIES IN TURKEY *

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ABSTRACT. — This paper deals with the formations and districts which are likely to bear Uranium and Thorium in Turkey.

In view of the great demand for Uranium during the last years, intensive and comprehensive surveys have been conducted in the world, whereby it has been proven that certain formations show more favourable conditions and hence are more promising in so far as Uranium and Thorium are concerned.

Based on various publications, on the visits we have made in the largest Uranium mines both in the U. S. A. and France, and in the light of the data obtained from surveys conducted during the last years, particularly by the Mineral Research and Exploration Institute of Turkey (M.T.A.), it has been possible to make a comparative study and after going meticulously over the data compiled, the districts in Turkey promising in Uranium and Thorium have been established.

This paper has been drawn up hoping that it will be of some use in bringing to light the Uranium and Thorium deposits in Turkey.

1. INTRODUCTION

In view of the great demand for raw materials of atomic energy during the last years of World War II and the post-war years, Uranium prospecting became very simple following the exploration of guides, varying in origin, as a result of large-scale studies, conducted particularly in the U.S.A., Canada and France, and thus the unsure groping applied at the onset of explorations has hence practically come to an end. Although it cannot be asserted that the last word has been said yet in this field and though it may be expected any day that new facts are brought to light, it may, however, be emphatically pointed out that very valuable data have been obtained until now in Uranium prospection.

The best answer to the question, «Where to look for minerals and particularly for Uranium?» is «Uranium is where you find it». In our interpretation, these words express the following :

1 - Uranium is found in formations which are favourable for its existence;

2 - Despite the existence of favourable conditions Uranium may not be found there;

3 - Uranium may be found in areas which are unfavourable or considered as such.

Accordingly, in mineral prospecting one might come across with many surprises; however, the most scientific and efficient way of prospecting is to proceed with the prospection by taking as bases the geological data and conclusions reached by comparing the ones already obtained abroad and to plan reconnaissance and thereafter radiomet-

ric work as detailed as to conform to these works.

By means of the studies conducted during the last years and the statistical conclusions derived therefrom, various types of igneous, metamorphic and sedimentary rock formations could be subjected to a classification so far as their Uranium content is concerned and useful ideas could be brought forward as to which kinds of rocks could bear which types of Uranium minerals under what probabilities and under which types of deposits. According to these ideas, certain formations or certain parts thereof have more favourable lithological, mineralogical, structural and chemical features than the other formations as regards Uranium deposits.

With a view to making savings in time and in expenses for the time being and to directing the studies and surveys to a scientific aim, we are convinced that to check whether the natural conditions prevailing in the countries where Uranium is found exist also in this country, is the most important task to perform from the viewpoint of efficiency and to obtain definite results when same are possible. After comparing systematically the conclusions reached from visits we have paid to some major Uranium mines both in the U.S.A. and France, and the conclusions we derived from the rich and various literature Of the world on Uranium, and also the results obtained in the recent studies carried out on the geological structure of Turkey, and finally, as it will be observed from our paper and the map annexed to it, written in the hope that it may serve as a scientific basis for surveys and prospecting for Uranium proper — with the exception of surprises which may eventually come up by sheer luck — it may be said that there are some major areas with favourable conditions, in the widest sense of the word, for the deposition of Uranium. These areas, varying in origin and value, are scattered from east to west and from north to south in districts covering a minimum of 250,000 square kilometers in Turkey. An important point to exist in line with the favourable conditions, in that sense of the word, is that the districts or at least part of them in Turkey must have been originally a metallogenic province for Uranium. Although favourable conditions and media can be considered as very advantageous signs; yet, the existence of the last point is essential.

Nevertheless, the fact that certain secondary and primary Uranium minerals have been already proven to exist in several places, may be considered as promising in this respect.

2. FEATURES TAKEN INTO CONSIDERATION IN SELECTING MAJOR AREAS

The districts likely to bear Uranium in Turkey have been established by taking into account, among other, the following particulars[1] :

Old rocks related to acidic intrusions in particular, outcropping or located near the surface, and to volcanisms, rich

in K and Na; that is to say various metamorphic rocks, may contain vein-type U minerals (high-grade but limited in quantity). The veins bearing much hornblende, biotite or garnet are interesting.

Uranium originates especially from acidic magmas. Therefore, the acidic intrusive rocks—and, among these, granites with two micas—are likely to bear more Uranium than any other formation; basic intrusive rocks are likely to bear less and the ultrabasic igneous rocks the least Uranium among the formations. The intrusive rocks and the pegmatites, crossing subsequently the old intrusions, and intrusives rich in fluorite may be of some importance.

Amongst the volcanic rocks, basalts are considered unfavourable. Intrusive rocks rich in K or Ga-Na may be taken into account. As for the sedimentary rocks, those of terrestrial origin particularly are important in so far as Uranium is concerned. Despite the fact that their grade is generally low, these rocks can display large reserves; however, high-grade ores may be expected. Placer deposits originating from granitic massives and from highly metamorphic rocks, organic sediments (black shales) formed on the continental shelf and phosphate formations of the same medium are important in certain parts.

Such formations as marine limestones, sandstones, conglomerates, marls and clay are not, actually, deemed as important.

In permeable and porous sedimentary formations, Uranium can migrate far away to a great distance from the igneous mass from which it originated. The presence of younger granites next to the old ones is considered as a more promising feature.

Terrestrial sedimentary formations such as conglomerates, coarse- and fine-grained sandstones, clays, shales, etc., of fluviatile, lacustrine, eolian, subaerial origin, or formed under semi-arid, arid and even in desertic climates, are the most favourable formations for Uranium. The formations with alternations where the quantity of clay is equal to that of sand; with mica and arkose, with plant remains and even with coal, cross-bedding, quick lateral transitions and those eroded by old streams are most interesting. Faulty and highly folded structures, bearing -porous strata, oil. bituminous shales and natural gas, ferrous and manganiferous layers are amongst the most favourable ones.

As associated minerals Co, Ni, Ag; Pb, Zn; Cu; Bi, Mo, Ti, V, etc. and as a gang siliceous concretions, smoky quartz, dark fluorite are considered favourable for Uranium.

Volcanic tuffs are factors which have helped the deposition of Uranium in sedimentary formations.

Pyritization and hematitization, fluoritization, kaolinization, alunitization, dolomitization, and silicification are also favourable conditions for Uranium.

Formations with such features in Turkey

1 - Igneous rocks - acidic intrusives. — These rocks differ in age. The oldest ones have been formed probably by intrusions which have taken place in the pre-Paleozoic and the youngest ones formed probably by early Tertiary intrusions. Batholiths form stocks or smaller intrusions and, according to their age, mineralizations may be found in the contact haloes of more or less metamorphic sedimentary or other igneous and volcanic contact haloes or in the uneroded upper parts of the plutonic body. Those of granitic and syenitic origin, rich in light-coloured or black elements, may be found either separately

or together with diorites, which are more basic on account of the magmatic differentiation. There are also monzonitic intrusions. These might have various mineralizations in the periphery or in the upper parts.

2 - *Volcanic rocks.* — There are volcanic rocks, which are Paleozoic and probably older as well as Mesozoic, Tertiary and even Quaternary. They may be andesitic, dacitic, basaltic and rhyolitic, trachytic; among these may be cited old greenstones like diabase and various volcanites, spilitic in structure.

Volcanic rocks of the Upper Cretaceous and the early Tertiary have caused mineralizations varying in composition and importance (Cu, Pb, Zn, Fe, sulphides, etc.).

The volcanic rocks cross the older strata and are in turn cut by acidic intrusives.

Lavas, particularly basaltic ones, which lie beyond the mineralized volcanic rocks and which cover large areas, are not considered favourable for Uranium.

3 - Metamorphic formations. — These formations vary in age, composition and in the degree of metamorphism. When studying each district separately, some important types of these formations will be mentioned.

The metamorphic formations are, in places, found either together with intrusive rocks or surrounding them, or are observed intermixed as to form a complex. Various apophyses of the magmas cut these formations at places.

The age of the metamorphic formations is pre-Paleozoic, Paleozoic and partly Mesozoic.

Once the importance of these metamorphic formations, outcropping on the surface of the earth is known, it should be tried to locate such formations buried under younger overburden.

4 - Terrestrial sedimentary formations. — Among these formations may be cited those of lacustrine, fluviatile origin, particularly of the Tertiary, which cover large areas in Turkey.

Paralic and/or lacustrine productive Carboniferous (arkose sandstones, conglomerates, black shales), terrestrial Liassic at Çakraz, certain Paleocene and Oligocene formations and terrestrial sedimentary deposits of the Neogene are formations worthy of note. In the Tertiary, lignite has been formed almost in every stratigraphic level depending on the locality. Formations of volcanic tuffs are frequently found, especially in the Neogene terrestrial deposits.

5 - Shallow - sea organic formations- — The presence of phosphate deposits has not, so far, been known in Turkey. However, glauconitic sandstones of the Lower Albian (Gault facies) in the Zonguldak region reveal under the microscope the existence of phosphate minerals.

As some phosphate formations are known to exist in Syria, south of Hatay, similar deposits may be expected in the unconformities in the thick Cretaceous series of the Amanos Mountains and of the Taurus Mountains. Incidentally, attention must be drawn to the study of the districts in Turkey where oil has accumulated, as regards Uranium.

3. AREAS IN TURKEY WHERE THE EXISTENCE OF URANIUM IS PROBABLE

These areas have been described with reference to the particulars concerning Uranium.

1 - The Thrace area

This area may be studied under two sectors :

1 - The Istranca and Çatalca massives sector.— This sector extends from the Bulgarian border as far as a point

to the west of the Büyük Çekmece Lake. A basement, consisting of very old and younger gneisses accompanied by mica-schists, and phyllites and of marbles on the top, is cut by granitic apophyses, pegmatitic and aplitic dykes and quartz veins, probably of Caledonian or younger age.

In the marble - granite contacts in these districts garnets and other contact-metamorphism minerals are found. Uranium minerals may be expected as veins or accumulations filling the cracks in the pegmatites or other intrusive and metamorphic formations in this sector, which are structurally very much folded and fractured and in which lead, antimony, blende, tungsten and copper occurrences are found.

In the northwest of Çatalca, lenticular graphitic deposits are also found in crystalline schists.

Although related to the andesites, it will not be without interest to conduct a radiometric survey of the Sarıyer mine district on account of the existence of pyrite, copper and of kaolinization.

At the upper levels of the Neogene sand deposits, there are old and new dunes of the Quaternary age and sand beaches along the coast. Study of these is deemed useful as regards Thorium and Ilmenite.

2 - The Ergene Basin. — This basin, situated in the south of the Istranca range, which is an outcropping old basement, consists mainly of terrestrial formations, which overlie the Eocene limestones, the marine and brackish Miocene formations in the neighbourhood of İstanbul, the marine Eocene, Oligocene and Miocene formations at the Gelibolu-Saros region, and vary probably between Pontian and Upper Pliocene in age. The following cross-section may be made as a composite over the Mactra - limestones of the Sarmatian :

> Rather thick, series of layers or lewises of greenish and greyish marl and clay at the bottom, including sands, sandstones and lignite beds in certain places; rather thick, loose sands in the roof and finally gravel scatterings of fluviatile origin of the Quaternary age.

Cross-beddings and quick lateral transitions in various elements of the series are frequently seen. The formations are of lacustrine and fluviatile origin. The thickness of this terrestrial series is estimated to be 200-300 m. and even more.

The loose conglomerates are made up of sand, clay and marls and contain red and variegated thin sand layers in the upper parts of the so-called «Belgrade Forest gravels», which can be considered in a way as being in this series.

The Ergene basin series, which have been formed of the denudation materials of the basement, are generally horizontal or tilted. On the edges, near the older formations, the dip may increase.

Lignite deposits belonging to different horizons occur in many places and also natural gas and oil may possibly exist in this area.

The lignite deposits at Keşan, Malkara, Uzunköprü and in the east of the Terkos Lake may be related to this subject.

2 - The Kocaeli area.

This area starts in the west from the Bosphorus, extending to Akçakoca in the east, to Samanlı Mountains in the south up to their eastern extension (north of Geyve).

In this area, apart from marine formations, are found, in the north of Geyve, crystalline schists consisting, at the bottom, of partly migmatitized gneisses and mica-schists overlain by quartzites,

phyllites, etc. and, on the top, of marbles and some acidic rocks (granite, pegmatite, aplite, quartz) which cut the Devonian and whose youngest formation is probably Hercynic in age (Kayışdağı, north of Geyve, west of Samanlıdağ).

The Mesozoic sediments are marine in origin, but lignite deposits may be found locally in the Triassic formations.

The terrestrial formations of the Tertiary cover comparatively small areas. The places where the Neogene is best developed are the northern skirts of the Samanlı Mountains and the southwest of Şile up to Kılıçlı. This Neogene, which is interstratified with bituminous shales in the south of Gölcük, shows the following sequence : At the bottom, clayey shales (with bituminous intercalations) surrounded by andesites in the floor and roof, marls, calcareous and clayey horizons, and above them sandstone horizons. Plant imprints, lignite veins and volcanic tuffs are found here and there in these series (150-250 m.).

The Black Sea Neogene in the north is practically the same as that in the north of the Istranca Mountains. This Neogene consists of cross - bedded, loose formations with tuff, white marls, white-grey clayey and sometimes reddish sandy gravel, lacustrine and fluviatile in origin. On the coast- in the estuaries, dunes and sand beaches are observed.

The basement has been roughly folded in the direction of N-S or E-W and the young Tertiary dips to the north or the south.

The main fractures are of E-W direction, the secondary ones crossing them. Sulphidic copper and lead ore deposits are locally found in this district.

3 - The Çanakkale-Bursa-Bilecik area

The following sectors can be distinguished in this area :

1. The Kapıdağ peninsula sector.— This sector covers the area restricted between the Kapıdağ Peninsula, the isles of Marmara, Lapseki in the west, Mudanya in the east, and Manyas-Kemalpaşa in the south.

The metamorphic basement outcrops between the Kapıdağ Peninsula, the isles of Marmara, Lapseki and Karabiga, and consists of gneiss, hornblende, epidote, garnet - bearing mica-schists and phyllites. At the top of these marbles are also found. Plutons, Hercynian in age, are granodioritic. Granites, aplytic-pegmatitic apophyses and quartz veins cross locally the crystalline schists. At places, the black elements increase in number in the granodioritic pluton; garnet is also found among other minerals in the contact zones.

The Tertiary terrestrial formations are Neogene in age. The conglomerates containing the materials of the older formations consist of grey-greenish sandstones, marls, marly limestones and in some places of volcanic tuffs; these may reach at places a thickness of 200-250 meters. Gross-bedding, lateral transitions and lenticular formations and a few lignite and plant remains - bearing layers are observed in places. Outside the fractured areas, the Neogene is generally less folded. Here some sulphide ore occurrences exist.

2. The Kazdağ massive sector. — This sector covers the districts of Çan, Çanakkale, Ezine, Ayvacık, Edremit, Balya and Yenice.

The basement is represented by the Kazdağ metamorphic complex and by its western extension. Here next to an old rock system consisting of biotitic

gneiss with or without hornblende; pegmatitic-gneisses, amphibolites and mica-schists, some old Paleozoic phyllitic and graphitic schists, volcanic greenstones, scarns, biotite schists and, furthermore, more or less crystallized limestones at the top are observed. Here are granitic and granodioritic intrusive rocks, Hercynian or probably older in age; these rocks and their apophyses cut the complex at places (Alpine and lamprophyric dykes). Pegmatites are comparatively rare and less developed.

The Tertiary terrestrial formations are Upper Miocene in age, consisting of lacustrine and fluviatile conglomerates with lignite seams or plant and fish remains, volcanic tuffs, clay and gypsum, of medium to fine - grained sandstones, and of clay and marls. The thickness of this series reaches sometimes 500 meters. It is possible to find cross-bedding and lenticular formations.

Volcanic rocks: The greenstones of the Paleozoic may be in contact with granites; spilites of the early Mesozoic and andesites of the early Tertiary are found, according to their age, under, in or above the Upper Miocene. Agglomerates and tuffs are abundant.

The direction of the substratum is generally N-S, whereas the Neogene is, generally speaking, in the direction of the grabens which it fills.

With reference to the granodioritic intrusions of the early Paleozoic, there are found in the intrusive bodies and in the contact zones such minerals as magnetite, hematite, pyrite, chalcopyrite, pyrrhotite, molybdenite, scheelite, galena and cobalt ore. Despite the fact that nothing can be said about their quantity, it is most probable that radioactive minerals exist in this complex. Related to the volcanisms in the Tertiary, lead, zinc, bismuth, copper and gold mineralizations have taken place (Balya).

In the Neogene of the neighbourhood. Balıkesir and Burhaniye, bituminous shale occurrences have been observed in clay and fine-grained sandstone layers.

3. The Bursa - Eğrigöz massives sector, — This sector covers Bursa, Kemalpaşa in the north; Balıkesir, Gediz, Simav in the south and Kütahya in the east. The Paleozoic metamorphic series south of Bursa, south and west of Kütahya, and in Dursunbey, are cropping out under the early Tertiary formations and forming rather high mountains. Among these are found gneisses, mica-schists, amphibolites, phyllites, marbles, etc. and diabasic old green tuffs and also granitic and other intrusives. In Uludağ and in the Eğrigöz massive, which is the southern extension of the former, the Hercynian granites and their differentiation elements are in contact for instance with marbles, gneisses and amphibolites. Particularly in contact with the marbles, there are widespread scarn zones and scheelite occurrences. Pegmatite, spilite and quartz dykes cut at places the plutons, as well as the metamorphics in the neighbourhood.

The terrestrial formations, which are very widespread in this sector, are mainly Neogene and are stratified over the basement and younger formations. In contrast with the Neogene series of the other sectors, these Neogene series are interstratified with very thick andesitic, dacitic and rhyolitic lavas and tuffs. In these series are found greyish-white, grey and greenish marls, sandstones, conglomerates, marly limestones and, in the upper levels, porous white and cream, marly lacustrine limestone banks. In the marly and sandstone horizons, low- and high-quality lignite deposits are found. The conglomerates contain intrusive and metamorphic rock

materials belonging to the basement, the quantity of these materials varying according to the location. These formations, of the Upper Miocene and Pontian age, are of lacustrine and fluviatile origin, their thickness reaching sometimes 400-500 meters. Here are also cross-bedding and quick lateral transitions.

The old basement strikes generally N-S and the Neogene conforms to the old structures. However, the depressions are of E-W direction and display locally different dips. Outside these depressions broad domes, almost with horizontal tops, are predominant. Fractures abound particularly in the depression basins. In this district, alunite is found besides such minerals as lignite, bituminous shales, copper, zinc, molybdenum, boron, tungsten.

Furthermore, asphaltic and bituminous occurrences are found in sandstones, sands and marls in the Neogene formations at various places in the Bursa - İnegöl area.

4. THE İZMİR - MANİSA - UŞAK - DENİZLİ - AYDIN AREA

This sector is surrounded by Uşak, Demirci, Gördes, Ayvalık in the north; Manisa, İzmir, Aydın, Muğla in the south and Denizli in the east.

The basement, which is probably Hercynian in age and best known as the «Menderes massive», outcrops under the Neogene or older formations. Paragneisses and orthogneisses, black mica-gneisses, granite-like muscovite gneisses, mica-schists, amphibolites, phyllites, quartzites and marbles, etc. make up the metamorphic complex. At places, -granites and pegmatitic, spilitic and quartz veins cross the entire complex. The granitic body outcrops in a few areas (vicinity of Saray, Nazilli, Buldan) The metamorphic haloes, where the gneisses appear, may cover areas sometimes extending hundreds of sq. km. Here in mica-schists and phyllites, contact minerals such as garnet can be observed. In the neighbourhood of Gördes, beryl crystals and probably traces of spodumene are found in mica-schists and gneisses.

As regards terrestrial series, these series are Neogene and widespread, particularly in the north and south of Uşak, in the neighbourhood of Bergama, and have formed important deposits in depression basins, such as the Gediz and Menderes basins.

The floor and roof of these young series, lacustrine and fluviatile in origin, are in general surrounded by thick conglomerates. In these series there is an alternation of limestone, marly limestone, sandstone, sandstones and conglomerates and, as is the case in the vicinity of Bergama, very thick intercalations of volcanic tuffs, in the west in particular, characterize this series, whereas these tuffs diminish in the east. Their thickness varies according to the locations, reaching 800-1000 meters and even 1500 meters. The predominant colours are white, grey, cream, pink, wine - red, red, yellow, brown.

Important lignite deposits, low-grade lignite and plant remains are found in these series. Lateral transitions, cross-bedding and lenticular formations are worthy of note.

The old formations are much folded and fractured, while the younger formations generally dip very slightly or are almost horizontal. However, in the depression basins and fault zones the slopes are more significant.

In this district are found lignite, asphalt (Alaşehir, Eşme), bitumen (Uşak, Bozdoğan), and copper, zinc and other minerals.

5. THE KÜTAHYA - UŞAK - BURDUR AREA

This sector is demarcated by Kütahya in the north; by the eastern part of the Uşak-Denizli line in the west; by Acıpayam, and the northern part of Fethiye, Burdur in the south; and by the line extending between the Isparta-Kütahya regions in the east. The basement is the Menderes massive, probably Hercynian or older, emerging under the Neogene as inliers in the Çivril district.

In this district, where there are generally mica-schists, gneisses, phyllites, quartzites and marbles, the marbles are predominant. This complex has been in places cut by granites and aplite and quartz veins.

As for the terrestrial series, their age is Oligoccne and Neogene. The Oligocene is found in the NNW of Burdur-Isparta, and consists of a series intercalated with sandstones, sand and conglomerates, where marls are particularly predominant, and containing gypsum lenses, red, white and variegated in colour.

The Neogene bears conglomerate series in the south of U§ak, displaying a considerable thickness, probably reaching some 1000-2000 meters in the south of Çal and especially in the south of Acıpayam. These formations, which have taken place in the grabens, are lacustrine and towards the upper levels mainly fluviatile in origin. The floor and roof are generally limited with conglomerates. There are fossiliferous thick marl series and, furthermore, intercalations of marly limestones, white limestones, sandstones and conglomerates in small quantities. Volcanic materials are less frequent in the south as compared to the north. The predominant colours are white, cream and grey.

Lignite deposits are found in these series. Lateral transitions, lenticular formations, cross-bedding may also exist. Furthermore, bituminous shales are found as thin layers in the Neogene in the neighbourhood of Acıpayam.

The old formations, are very fractured and folded and with the exception of the Oligocene, the Neogene shows a horizontal or nearly horizontal dip. On the other hand, the terrestrial Neogene of Acıpayam-Fethiye is isoclinal and folded in certain places.

In this district are found lignite, bituminous and copper ore deposits of secondary importance.

6. THE ESKİŞEHİR-SİVRİHİSAR AREA

This area lies between Eskişehir-Bozüyük in the south; Bilecik, Söğüt, Göynük in the north; Sivrihisar, Beypazarı districts in the east and can be studied in two sectors.

1 - The Eskişehir-Söğüt sector

Here epidote and glaucophane-schists, mica-schists, quartzites, grey and blue phyllites are found in the basement. Over this complex, slightly metamorphosed yellowish and brown clayey schists, and upwards sandstones greywackes, volcanic tuffs, arkosic sandstones, graphitic schists and between them marble lenses occur at places.

The greenstones are predominant, particularly in the north of Eskişehir (peridotite). The acidic intrusions in the form of granite cover large areas in the Sakarya basin. Along with the granites are younger diorites. The granites cross-cut the old complex elements, and hence the marbles; however, no contact has been observed or proven yet with the overlying Liassic limestones. In the north, at Bilecik and Söğüt there are pegmatite, aplite and quartz veins, kaolinized in places.

Particularly in the north of Sakarya, in the Gölpazarı district, there exists a terrestrial formation of the Paleocene which has developed conformably over the Cretaceous and Paleocene flysch. This formation starting with an alternation of marls, sandstones and sands, green, grey and yellowish in colour at the bottom, contains, towards the top, horizons with looser sands, gravels and sandstones which are reddish and yellowish.

Over these horizons, at Nallıhan, lies the terrestrial Oligocene, loose in structure, with an alternation of sandstones, conglomerates and marly limestones mostly reddish and yellowish.

Carbonized plant remains and lignite streaks may rarely occur in the terrestrial Paleocene, although lignite is found as seams in the terrestrial Oligocene.

The terrestrial Neogene covers a limited area and is made up of an alternation of white fine-grained limestone and clay, and finally bears gravels and sands on the top. In between there are bituminous layers and tuffitic beds. The predominant colours in this variegated formation are red and yellow.

In the upper levels the grey and white colours are important. There are lateral transitions and cross-bedding in this Paleocene, Oligocene and Neogene of lacustrine and fluviatile origin.

Bituminous shales, varying in importance, are fourid in marls, clays and limestones in terrestrial formations, such as the Paleocene at the Gölpazarı and Göynük districts. At Nallıhan and Beypazarı, bituminous deposits are also found in the gypsum-bearing series of the Oligocene and the Neogene.

The direction of the formations, which make up the main structure of this district, is E-W in the north of Eskişehir. In these formations elongated anticlines and synclines have developed and these foldings have been broken by means of tear-faults, striking N-S.

Copper ore occurrences are seldom found.

2 - The Sivrihisar sector. — The old basement, corresponding to the eastern extension of the Sakarya complex and consisting of mica-schists, phyllites, marbles, etc., outcrops in a comparatively limited area in this sector.

The Sivrihisar and Karakaya intrusives are mainly made up of a granite, Hercynian in age. However, this granite with black elements has been cut by diorites, and gabbros and even by peridotites, formed due to differentiation. Moreover, siliceous veins also have been observed in the granite.

The volcanic formations in this sector are found as andesitic lavas, agglomerates and tuffs in the Neogene; the basalts forming the upper levels.

The Tertiary terrestrial formations have variegated red marl, sandstone, marly limestone, conglomerate layers at the bottom, and grey, white conglomerate, sandstone, limestone, marl, gypseous marl, gravel beds at the top. At the uppermost layers are horizontal grey-white lacustrine limestones forming cuestas. Within these series, quick vertical and lateral lithological transitions are observed.

This folded series, red at the bottom, which is considered to belong also to the Oligocene, corresponds in fact to the lower part of the upper levels of the Neogene; hence the age of the three series mentioned is Neogene.

The basement shows a resemblance to the Sakarya complex in so far as tectonics is concerned. The granites are divided into blocks limited by faults, forming horsts (Sivrihisar, Karakaya). The Tertiary is generally horizontal

(Sivrihisar); however, at the contact points with the andesites (east and west of Ayaş) and in the fault zones of Beypazarı - Nallıhan, vertical folds, monoclines with dips more than 80° and even overturnings are observed.

There are some sulphide occurrences and lignite deposits in the Neogene of this area.

7. THE ANKARA - AFYON- KONYA AREA

The metamorphic base in this area occurs as the Elmadağ series, which consists of marbles, west of Ilgın (Konya) and of schists, greywackes, sandstones and limestones in the south of Ankara.

The terrestrial formations are of the Neogene age and are very widespread in this area.

The following sequence is seen at the Afyon district:

Clay with intercalations of kaolin a few centimeters thick, rich in carbonaceous plant remains and light-grey, dark-grey, white in colour, lying unconformably over the Paleozoic, and over them layers of conglomerates and opal, clayey sandstones with limonitic cement, marly limestones, volcanic glass, conglomerates, partly oolithic marly limestones. Over all these series lie light-grey or white marls with tuff intercalations, and limestones. The tuff series at the topmost layers has a thickness of about 300 meters.

The terrestrial lacustrine Neogene in the Konya area differs from that of Afyon in that it contains tuff materials in lesser quantities and is in contact with the marine Neogene situated in the south, in the neighbourhood of Karaman. In this boundary zone, the floor of the lacustrine Neogene, Upper Miocene in age, and parts of the roof (the Pliocene inclusive) show outcrops in the north of Konya.

In general, the bottom series overlie the marine Neogene at Karaman; the Mesozoic limestones in the vicinity of Yalaklı dağ; the Kırşehir massive in the west; and the Paleocene, Eocene formations in the north. They contain, from the bottom to the top, conglomerates, sandstones, marls and lacustrine limestones and at the roof, in the Konya plain, more loosely cemented fluviatile materials. The thickness of these series varies between 150-300 meters.

As regards the Neogene in the Ankara district, it resembles the Nallıhan-Beypazarı and the Ayaş Neogene. Compared to the south the tuffs are more abundant in the north.

The lacustrine and fluviatile formations display in many places lateral transitions and cross-bedding. The upper parts of the series are covered by Plio-Quaternary gravel, sands and boulders.

The old, tectonically complex, formations in the vicinity of Ankara extend in the NE-SW direction, with the Neogene following practically the same trend.

In this district, west of Afyon, in the neighbourhood of Ankara, in the west of Konya (Beyşehir-Yalvaç), several lignite occurrences were encountered; there are evidences of asphalt and bitumen in the vicinity of Polatlı - Haymana and Eğridir Lake, whereas copper occurrences are found in the north and south of this district.

8. THE ÇANKIRI-YOZGAT-KIRŞEHİR-KAYSERİ - NİĞDE AREA

This area can be studied in three different sectors as regards its size:

1 - The Kızılırmak - bend sector

This sector, which is very large, covers Alaca, Sungurlu, Çankırı in the north; Kalecik, Kırıkkale, Bala and

Tuzgölü (Salt Lake) in the west; Aksaray, Kayseri in the south and Akdağmadeni areas in the east.

The visible floor of this district forms the schist complex of the Central Anatolia block. Paleozoic gneisses, mica-schists, quartzites, phyllites and marbles represent the main elements of this complex and are cut by acidic and basic intrusives. The younger marbles at the top are sometimes very widespread (Akdağmadeni).

There are younger diorites, other than granites and syenites, which are post-Upper Cretaceous-pre-Tertiary and which outcrop over wide areas.

In the Upper Cretaceous and at the end of it, acidic lavas and tuffs, Lutetian basic lavas and tuffs have been formed. As a result of the extensive volcanic activities which took place during the Oligocene, the Neogene and even Quaternary, lavas and tuffs have been spread over wide areas. As for the terrestrial formations, they are red, variegated, grey, greyish- white in coulor, of lacustrine and fluviatile origin, Oligocene in age. These formations begin usually with conglomerates, and continue with an alternation of conglomerates, sandstones, clay, marls and marly limestones. The thickness sometimes exceeds 250-300 meters.

Gypsum lenses are found, at places, in this series (especially in the south of Çankırı, Kalecik, Bala). The Neogene is also of lacustrine and fluviatile origin. In the upper levels of the Oligocene there is sometimes an imperceptible transition to the Neogene. The Neogene consists of sand, gravel, clay, marls, lacustrine limestones and volcanic tuff layers. In the Kayseri, and particularly in the Ürgüp, Göreme districts this Neogene (Pontian) develops as a very important and thick volcanic tuff series. To the north of this thick tuffaceous area and in the vicinity of the acidic intrusive rocks, the thickness of the Neogene diminishes and the tuffs lose their importance. The younger acidic intrusives have cut and deformed the substratum. The younger Tertiary formations are generally horizontal or slightly folded. On the other hand, the Oligocene appears to be rather folded. There exist lignite deposits of various importance in the vicinity of Bala, Kalecik, south of Çankırı, Yerköy, Yozgat, Şarkışla and Gemerek. Occurrences of bituminous shales are also observed in the sand, gravel and marls in the neighbourhood of Yerköy.

In the syenitic parts of this district, purple fluorite, and lead, molybdenum, zinc, copper, tungsten mineralizations related to the acidic intrusions draw one's attention. The areas comprising Denek dağı, the eastern extensions of Çiçek dağı, Karasınır dağları, Akdağmadeni and the Yıldızeli complex are of particular interest.

2 - The Niğde sector

This sector, which comprises also the Niğde complex, extends from Ereğli (Konya) in the NE direction, as far as the Çamardı, Niğde and Bor districts.

The substratum consists of schists, such as phyllites, amphibolite - schists, quartzites, intercalated with the Paleozoic gneisses, mica-schists and marbles. These series are covered by thick marbles.

In this sector, next to the hornblende- and biotite- granitic plutons, are found diorites, gabbros and serpentines. Aplite, pegmatite and quartz veins cut in places the granite massive and the schists.

The terrestrial, lacustrine and fluviatile formations of the Oligocene are red and variegated in colour and consist of an alternation of marl, clay,

sandstone, conglomerate, marly limestone and, at places, of gypsum lenses, reaching 300 meters in thickness.

The Neogene is also terrestrial and tuffaceous in character. It contains fine sand, sandy clay, loose sandstone, conglomerate, marly lacustrine limestone and tuffite, which reach a thickness of 200 meters. Lateral facies variations are observed in the Neogene.

The old massive, rising in the middle of the younger cover, is folded and fractured. The Oligocene and the Neogene correspond to a fractured structure, striking N-S and NE-SW. The Oligocene is folded, whereas the Neogene is rather horizontal and less folded.

There are lignite deposits in the Oligocene. At Çamardı thin asphalt layers are seen in the Oligocene formation and lead occurrences in the crystalline complex are observed.

3 - The Bolkardağ sector

The Bolkar Mountains, extending to the southwest of the Çiftalan - Pozantı railway and representing the highest places of this district, are covered particularly by Paleozoic marbles. Amphibolites, phyllites and dolornitic limestones are less abundant.

The igneous rocks are found more to the northern extension of the mountain range and particularly in the vicinity of the Bolkardağ mine. They consist of quartz-porphyry, granite, syenite, etc.

In the Bolkardağ sector at the quartz-porphyry and limestones contact and in the fault and breccia zones in limestones, there is an important and complex lead, zinc, gold, silver mineralization of hydrothermal origin and, furthermore, secondary stratification is observed in the caves. The ore may be of sulfidic, oxydic and carbonaceous composition. Jarosite, pyrite, limonite, rarely copper, arsenic minerals, silica and alunite are also fourid.

With these characteristics the Bolkardağ sector seems to be interesting as regards radioactive minerals.

In the Aladağ massive, which is considered as the vicinity of Bolkardağ, the existence of the same kind of mineralizations may be expected.

9. THE BOLU - ZONGULDAK - KASTAMONU AREA

This district can be studied under three sectors :

1. The Bolu massive sector

In this sector, situated in the southwest and northeast, of Bolu, the substratum contains various amphibolites, phyllites and gneisses, which are overlain by a variety of Paleozoic schists (chloritic schists, calc - schists, sericite - schists, graphite-schists), quartzites and limestones.

Various granite - plutons, probably of Paleozoic age, are found in this sector: the pegmatitic and aplitic veins are sometimes very dense. The granite has hornblende in it, which increases in quantity, at places. The granites may be syenitic or monzonitic. The diorites and pyroxenites are found to have formed a complex with the formations making part of the substratum.

The volcanic formations in this sector are Upper Cretaceous or Eocene in age and occur as a variety of andesites, liparites, trachytes, basalts and tuffs.

The terrestrial formations of the Neogene contain yellowish, yellow, clayey siliceous, loose sandstones and sands and in certain places white lacustrine limestones, soft thick conglomeratesi

The tuffs are relatively more abundant in the east. The clay may contain peat and plant remains.

The basement is represented by a highly metamorphosed complex whose general strike is NE-SW. The faults conform to the axis of folding or cut it; and surround the older formations. The old Tertiary is folded, the young Tertiary is generally horizontal.

In the Tertiary formations of the district there are lignite deposits; bituminous schists in the neighbourhood of Türkbeşli and copper and lead occurrences in the vicinity of Bolu were also observed.

2 - The Kastamonu sector

This sector comprises Daday, Kastamonu, Taşköprü, Devrekani, Elekdağ and the northern surroundings.

The basement, which is more metamorphosed than the Bolu sector, consists of schisteous gneisses, phyllites, mica-schists and greenstones, with local granite outcrops.

In the Ilgaz massive of this district, various less metamorphosed phyllites, chlorito-schists, graphitic schists, quartz-schists, ophiolites, greywackes and clayey schists may be seen in the basement complex.

The Oligocene consists of red conglomerates and sandstones, and the Neogene is a lacustrine and fluviatile formation having tuffs in small quantity.

In the northeast of the sector, there are some copper and pyrite occurrences.

3 - The Northern Anatolia coal basin sector

This sector forms a wide belt -along the coast, starting from Karadeniz Ereğlisi to the surroundings of İnebolu.

The formations taken into consideration here are particularly the productive (Namurian - Westphalian) deposits of the Carboniferous.

At the bottom are found the Namurian layers (the Alacaağzı formation) consisting mainly of sandstones, arkosic sandstones, mica-sandstones and shales; over it lie Westphalian A, particularly with conglomerates in it (the Kozlu formation) and the Westphalian B + C + D+E (the Karadon formation) coal formations with, again, conglomerates, arkosic sandstones, black shales. In this system, which corresponds to a very thick series, the presence of some old fluviatile deposits has also been observed. The coal seams are abundant. Black clayey shales are found in certain formations.

These formations have been folded and fractured in a very complicated manner in the east, while in the west the folding and fracturing has been comparatively more quiet. At Çakraz, east of Amasra, terrestrial Liassic is found.

Carboniferous formations outcrop, starting from the west, at Çamlı, Kandilli, Armutçuk, Alacaağzı, Tefenni, Kirenlik, Kireçlik, Ilıksu, Çataldere, west of Kozlu, Kozlu, Üzülmez, Zonguldak, Gelik, Kilimli, Göbü; in the east of the Filyos River, in the area situated between Tarlaağzı and Amasra, Çakraz, Değirmenağzı deresi, Pelitovası, Söğütözü, Kozcaviran, Azdavay, Suğla yaylasi, Karafasıl and in the other smaller areas. The red, grey, variegated, non-fossiliferous sandstones and conglomerates, which are found overlying the Carboniferous formations and around them, deserve additional studies.

The Upper Cretaceous andesites, dacites, trachyandesites, and basalts, covering larger surfaces, are more important than the same formations of older or younger age.

Furthermore, the Carboniferous also emerges at places in the Taurus belt in the productive facies (the Akseki, Güzelsu, Hazru lacustrine Carboniferous and Permian, etc.).

10. THE ÇORUM -SİNOP - AMASYA AREA

The schists in the north of Osmancık and in the south of Amasya represent the eastern extension of the Ilgaz massive, outcropping in inliers.

As regards the terrestrial formations, the Boyabat Oligocene and the slightly red, grey, greenish, gypsum-bearing, marly conglomerates and loose sandstones of the Neogene age, outcropping at places, contain tuffs and various lignite deposits and are generally slightly undulated (Dodurga, Çeltek). Various hydrocarbon occurrences are seen in this district.

11. THE SİVAS - ERZİNCAN AREA

The basement of this sector —which lies between Sivas, Hafik in the west; Koyulhisar, Şebinkarahisar in the north; Erzincan, Tercan in the east; and Kemah, Divriği in the south— outcrops east of Erzincan and between Refahiye and Şebinkarahisar.

The metamorphic basement in the east of Erzincan corresponds to the southern extension of the Bayburt complex, which will be discussed in Part 12/2 of this paper. The granitic intrusives outcrop in very few places in this district. The metamorphic mass located between Refahiye and Şebinkarahisar contains mica - schists, chlorito - schists, phyllites and marbles, and is crossed, at places, by a large number of younger granitic intrusions. In the south of Suşehri, there exists the Kösedağ granitic batholith.

An interesting part of this sector is the vicinity of Divriği. Here the Permian and the Mesozoic limestones, the Cretaceous serpentines, and the younger intrusive rocks are in contact. Although there are various syenites, granites, monzonites, gabbros, granodiorites and. diorites, monzonites are particularly important so far as mineralization is concerned. In the north and south of Demirdağ, Penkürt, in the Efendi creek, north of Göldağ, syenite and diorite massives outcrop in limestones. Various aplitic or more basic dykes, in the syenite-diorite intrusions, cut the serpentine and syenite-diorite mass.

The dolomitic limestones, as well as other limestones, are responsible for the formation of magnetite, scapolite, fluorite, grenatite, pyroxenite, cipolin, pyrite, molybdenite, chalcopyrite, etc. at places where they are in contact with serpentines, syenites, diorites and the dykes (fault and bredcia zones also exist). The Miocene basalts cover the granites in the Dumluca dağ area.

The gypsum-bearing series of the Oligocene, found in the neighbourhood of Divriği, is the eastern extension of the formations which are widespread in Sivas; it consists of the green clay and marls, white limestones, conglomerates, red sandstones and a basal conglomerate of the terrestrial and lacustrine facies. The brackish and gypseous lenses may sometimes be very thick and widespread. In the upper parts of the marine Miocene, it is observed that a lacustrine facies with plant remains, probably Upper Miocene and Pliocene in age, has developed again.

In addition to those already enumerated in this sector, lead, copper, zinc, gold, silver and nickel occurrences are also observed.

In the neighbourhood of Sivas, Hafik, Zara, Erzincan, and Tercan, bitumen and oil seepages are found in the Tertiary formations.

12. THE NORTHEASTERN ANATOLIA AREA

This district will be dealt with in two sectors:

1 - The Gümüşane - Trabzon - Ordu-sector

This sector is surrounded by Mesudiye, Fatsa in the west; by the Black Sea (Ordu, Giresun, Trabzon) in the north; by Trabzon, Gümüşane in the east; and by the Alucra regions in the south.

The characteristic of this sector belonging to the Pontides is that it is covered by liparites, andesites, dacites, olivine- and augite- basalts and tuffs produced by widespread Upper Cretaceous and partly Eocene volcanic activities.

The metamorphic series are very limited here and outcrop only in such places as the southwest of Bayburt and east of Suşehri. These series consist of various mica-schists, micaceous quartzites and marbles, which are cut by granites and granodiorites. In this mass are also found schisteous gneisses with feldspar and gneiss-granites.

Granites — a part of which seems to be older than the Upper Cretaceous and a major part of which has formed early in the Tertiary, together with the granodiorites and diorites — have metamorphosed the schists, the sedimentary and volcanic formations till the Upper Cretaceous and these have resulted in mineralizations. Among the volcanic rocks, the dacites in particular have been mineralized and are furthermore favourable for kaolinization and silicificatiori (Giresun). Lead, zinc, copper, pyrite, hematite and magnetite ore occurrences are known since old times.

The sedimentary formations in this sector are very limited in number.

The terrestrial formations of the Oligocene are known to exist only in the faulted zone of the Kelkit Çayı. These red and variegated formations have sandstones, marls, limestones intercalated with tuffs.

On the Black Sea coast, there are scattered terrestrial formations of the Neogene age. These formations are, from the bottom upwards, coarse-pebbled conglomerates, sandstones, marls, conglomeratic limestones, limestones, loose sandstones and conglomerates. The thickness varies, reaching in some places 60 meters.

2 - The Rize - Bayburt - Çoruh sector

This sector comprises the Sürmene, Çakırgöldağ, Bayburt districts in the west; the Black Sea (Rize, Hopa) district in the north; Borçka, Çoruh, Ardanuç, in the east; and İspir, Bayburt districts in the south.

The basement crops out as large areas in the west and southwest of Bayburt, in the vicinity of Çoruh and Yusufeli and in the north of Oltu and Örtülü. In these series are found mica-schists, biotitic gneisses, quartzites, graphitic schists, chlorito-schists, biotitic schists, feldspar-schists, metamorphic volcanic rocks. Intrusives, such as granites, biotite-granites, granodiorites, which might have a porphyric structure, outcrop in extensive areas. These granites are in contact with metamorphic schists and Paleozoic schists (neighbourhood of Ögene), with the volcanic rocks and basalts (east of Iskılaş, north of Zülfe dağı) and with the Eocene flysch in the south (in the neighbourhood of Toronoz). Apart from the acids, basic veins also cross the stratified formations.

Important quantities of pyrite, copper and some lead and zinc mineralizations exist in this sector (Murgul, Kuvarshan, etc.). As the

Gümüşane, Trabzon, Ordu sectors, this sector also is an interesting, important area.

The terrestrial Neogene consists of lacustrine and fluviatile formations restricted to some unimportant areas in the inner districts and contains partly lignite occurrences.

Formations of the same age existing in certain places, such as Rize, Pazar on the Black Sea coast, are made up, in general, of gravel series, loose in structure, marly limestones at places, and marls with intercalations of coarse-grained pebble conglomerates, sandstones and sands. The thicknesses of these formations vary and may reach in some places 500 m. In the Rize district there are oil seepages in the sea.

13. THE ERZURUM-KARS-VAN AREA

The basement in this area outcrops in very limited areas, as marbles in the north of Hınıs, as gneisses, quartzites, quartzitic schists, phyllites and marbles between Ağrı and Diyadin. In connection with these may be cited such intrusives as granites, granodiorites and gabbros, and some apophyses, aplites, etc. In the greenstone complex, south of Kağızman, there are mainly diorite veins, granite and gabbro apophyses and mineralization zones (arsenic ore, etc.), whereas a granitic body is found under the basalts in the north (Kötek) and under the limestone banks of the Upper Cretaceous.

One of the main characteristics of this district is that andesitic and basaltic lavas are covering it, overlying a very extensive area.

The gypseous terrestrial formations of the Oligo - Miocene age have been formed particularly in the Kağızman and Oltu grabens; they contain an alternation of very thick, loose conglomerates, marls, sandstones and sand at the bottom, and alternating marls sandstones, limestones, salt and gypsum at the top. The predominant colours are red and variegated in the lower scries and white and particularly grey in the upper parts.

The terrestrial Neogene, lacustrine and fluviatile in origin, consists of sands, marls and andesitic tuffs and agglomerates, red, green and yellow in colour. The upper levels, especially at Horasan and in the north of Van, are sandy and very thick. On the other hand, the sands, sandstones, and marls, in the terrestrial formations of the Pliocene, underlying the Quaternary basalts in the Kars region, are small in quantity and the tuffs and the volcanics are predominant.

The Oligo-Miocerie formations are folded and fractured, whereas the terrestrial Neogene is horizontal or nearly horizontal. This horizontality disappears on the graben edges as well as in the fault zones.

Copper, lead, zinc mineralizations rarely occur in this sector. However, lignite deposits, bitumen and oil evidences are observed here.

14. THE ELAZIĞ-BİTLİS AREA

This district will be dealt with under two sectors: one situated in the west and the other one in the east.

1 - The Malatya - Elazığ sector

This sector — which extends from Doğanşehir and an area south of Plümür in the south, as far as the vicinity of Keban, Pertek, Ağacandağ, Elazığ, and Ergani in the north — has undergone important mineralizations, both from the point of view of quantity and quality.

The basement, considered as the western extension of the Bitlis massive,

consists of Lower Paleozoic or older age mica-schists, sericite-schists, graphitic schists, garnet-schists, hematite-schists, calc-schists, phyllites and marbles of varying degrees of metamorphism, and of amphibolites, gneisses and quartzites in smaller quantities, belonging to the deeper zones. The acidic intrusives outcrop extensively at Çavuşlu, south of Akçadağ, in the vicinity of Baskil and in the southeast of Pertek, and only locally in the Keban mine district.

Syenites, granodiorites and granites are found in the Malatya-Elazığ sector; as it is seen in the Keban mine district, these rocks sometimes may have a porphyric texture. The syenite-porphyry, aplite, granite, granodiorite, quartz, andesite and basalt dykes have caused mineralizations at the contact, fault and breccia zones. The granodiorites are post-Jurassic, but pre-Eocene. The scheelite, scarn, garnet, epidote and magnetite, lead, zinc, fluorite and other minerals, and locally vanadium occurrences are found in these rocks.

The other rocks causing mineralization are the ophiolitic series (ferrous manganese) and the andesites and dacites of the pre-Eocene (chalcopyrite, pyrite, goldblende).

The basalts are Miocene and partly younger in age. The young faults formed after strong tectonic- movements, which were responsible for the formation of the main, structure, are considered to have little connection with the mineralization.

Coarse conglomerates with large-size pebbles, sandstones and gypsum, cemented with limestone of the Quaternary, have developed in extensive areas and in large thicknesses, especially in the Malatya plain.

The metamorphic basement has undergone highly strong movements, which resulted in faulting and slicing. The predominant directions are E-W and ENE-WSW.

The Ergani copper mine is particularly interesting because it contains cobalt in pyrites. Occurrences of copper, lead, zinc and lignite depozits are found scattered in this district.

2 - The Bitlis massive sector

This sector extends as far as the south of Bingöl, Muş. south of the Lake Van, Çatak, Pervari, Şirvan, Baykan and Lice; its basement is known as the Bitlis metamorphic massive and consists of quartzites, phyllites, gneissic schists, mica-schists, graphitic schists, garnet-schists, fluorite-schists, amphibolites, calc-schists, marbles and limestones of the Paleozoic age. Syenites occur locally next to gabbros, diabases and lamprophyres. The crystalline mass has been crossed by an abundant quartz and rarely by pegmatites with large mica crystals. No contact of the syenites with the uppermost Permian limestones has been observed.

Andesites, basalts and tuffs have been spread over wide areas in the north of the district. There are old basalt flows covering the old fluviatile terrace alluvium, particularly in the northwestern parts of the Bitlis massive.

15. THE HAKKARİ AREA

In the area southeast of Yüksekova, extending as far as the frontier, and also under the Devonian and the Cretaceous-Paleocene, north of Hakkari, the phyllites and quartzites of the Paleozoic constitute the visible basement of this district. The hornblende-granites of the Paleozoic form wide outcrops in several points in the neighbourhood of Şemdinli and in the southeast of Yüksekova. Basic rocks, such as gabbros cross these granites. Pegmatites are also found.

Andesitic and dacitic lavas and tuffs are found in the Devonian interstratified with shales or slightly disturbing them. In the Cretaceous - Paleocene complex are seen various ophiolites, such as pyroxenites, serpentines, etc., which are rather basic.

The existence of bitumen occurrences has been observed in the flysch sandstones and in certain limestones.

16. THE SOUTHEASTERN ANATOLIA AREA

The terrestrial formations in this region have developed in three areas: between Diyarbakır and Siirt, between the southeast of Cizre and Besni, and between Adıyaman and Kahta. The age is Upper Miocene and Plio-Quaternary.

Between Diyarbakır and Siirt and in the neighbourhood of Cizre, these formations consist in general of sandstones with clay intercalations, fine-grained sandstones, and salt and gypsum lenses bearing clayey sandstones.

In the Besni, Adıyaman and Kahta districts is found a sequence composed of grey sandstones and sandy clay, clayey sandstones at the bottum, and of coarse-grained conglomerates at the top, of lacustrine and fluviatile origin. These upper conglomerates, which may have a thickness of 100 meters, diminish towards the south, where they are substituded by gypseous sandstones and clay.

The dips in the mountainous regions are about 30°, whereas the layers are practically horizontal in the south.

In the southeastern Anatolia district, which is one of the important oil districts of Turkey, there are asphalt, bitumen and oil occurrences in several marine and terrestrial levels and in places oil seepages; hence, this district is interesting as regards our subject matter.

CONCLUSIONS

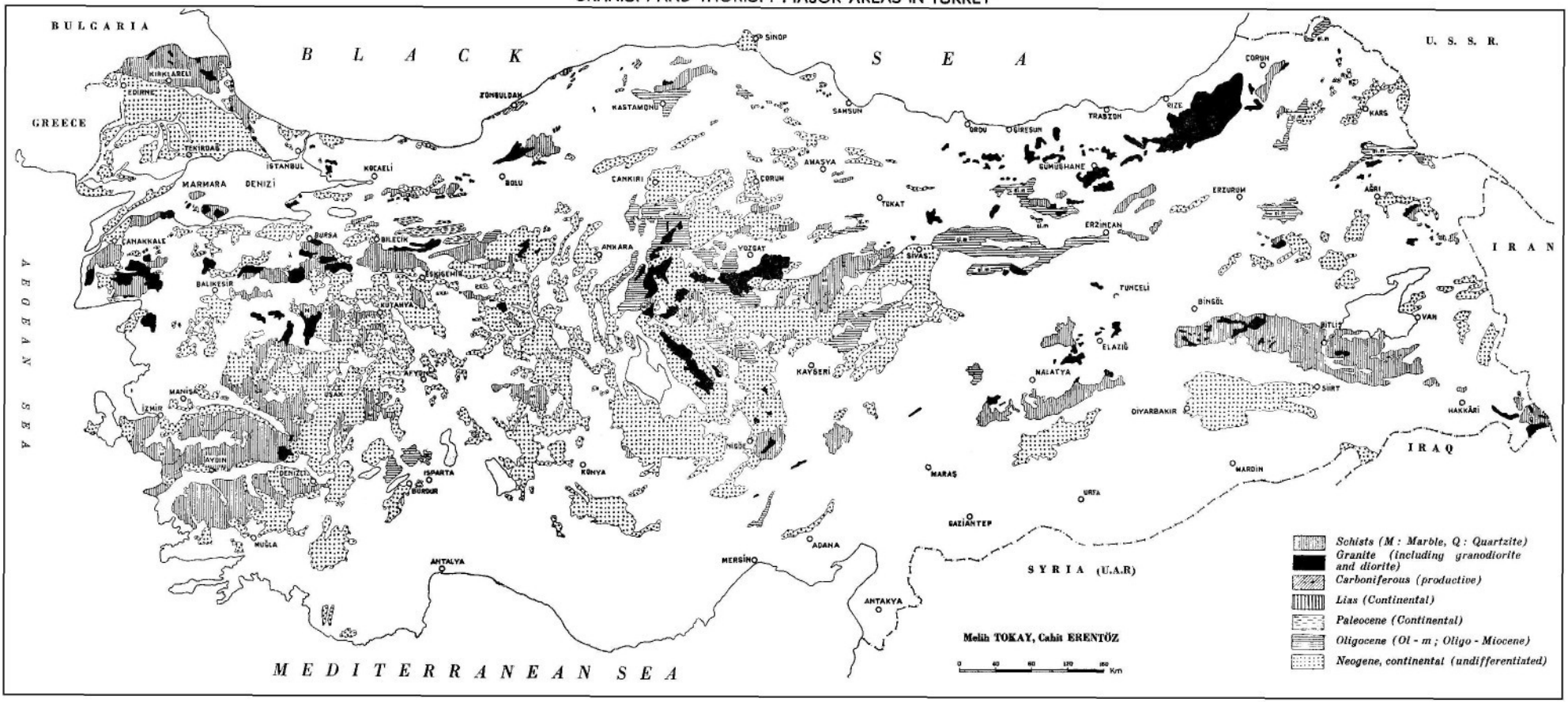
From evidence cited in this paper, it will be observed that there are formations in Turkey which show favourable conditions for the formation or, rather for the deposition, settling, migration and conservation of Uranium and Thorium occurrences.

Nevertheless, the presence of such favourable conditions is not sufficient and another important condition which has to exist is the fact that at least some parts of the country must belong to a Uranium-Thorium metallogenic province. That is to say, in any phase or various phases of the magmatic processes, which have brought mineralizations from the depths upwards, at the initial stage, Uranium and Thorium elements must have existed in one component or another and that it must have been carried upwards along with the other minerals.

However, the formations, which we have determined by comparison with similar formations in different regions of the world, are widespread and cover a number of different areas in Turkey. The general and detail studies to be conducted on these areas will show, in the first place, whether or not there are mineral deposits and then, whenever the existence of such deposits is proven, the necessary data with regard to their location, extent, depth, thickness, type, origin and grade should be obtained and then the work on definite and restricted localities of economic value be started.

In consideration of the importance, extent and urgency of the matter, it appears evident that, for the time being a general reconnaissance survey should be executed on these widespread areas,

URANIUM AND THORIUM MAJOR AREAS IN TURKEY



using the most efficient, speedy, up-to-date methods. The «Aerial survey program», recently sponsored by the M.T.A. Institute with a view to exploring certain metallic and radioactive minerals, will serve this purpose.

Inasmuch as radioactive occurrences might possibly exist also in some places which were not taken into consideration here, in the light of the present geological data and available literature, and which lie beyond the areas discussed by us, it will, naturally, be necessary to make the subsequent reappraisal when more data are available and new ideas are brought forward.