A NOTE ON THE GEOLOGY OF THE REGION BETWEEN TAVŞANLI AND DAĞARDI, AND ON THE AGE OF THE SERPENTINES AND LIMESTONES

Adnan KALAFATÇIOĞLU

Mineral Research and Exploration Institute of Turkey

ABSTRACT. — The oldest rocks in this region, which has suffered the Hercynian and the alpine orogenies, are the crystalline schists. Gneisses appear at the lowest part of the metamorphic series, and are overlain by less metamorphosed schists, which have a general strike of NE-SW. This complex has been formed by the regional metamorphism (epi-, mezo- and a little katazonal) of the sediments of probably Devonian age.

In the immediate north of our region, Permian formations unconformably overlie these metamorphic rocks, which have suffered the first Variscan orogeny. The region was again uplifted above the sea-level during the younger Variscan orogeny, at the end of Permian. The acid intrusives belong to this period.

In the region of study, the Mesozoic is represented by the Upper Cretaceous formations. During the deposition of the limestone-and-flysch sedimentary (mixed series) facies of the Upper Cretaceous (Maestrichtian), intrusions and extrusions of members of the ophiolitic series were also taking place. Diabase, volcanic breccia, radiolarites and serpentine, all of which belong to the ophiolitic series, are found in the flysch sediments. After the Maestrichtian, the sea has left the region, never to return again (the Laramian orogenic phase).

The Neogene rests on the older formations unconformably; its thick basal conglomerate, consisting of large pebbles or even sometimes large blocks, passes upwards into sand, clay, marl, limestone, marly limestone, siliceous limestone and intercalated tuffs. In the lower parts of the Neogene there are lignite coal seams. We are not aware of the existence of the Helvetic and Savic phases, but between the Miocene and Pliocene, the Attic phase is present. The volcanic activity began at the end of the Miocene and gained impetus during the Pliocene.

I. INTRODUCTION

The region which has been studied is situated between Tavşanlı and Dağardı, within the Province of Kütahya, West Anatolia, and consists of some 1000 km^2. My grateful thanks are due to Dr. P. de Wijkerslooth and Dr. Klaus Markus, who conducted the petrographic determinations, and to M. Baran and Dr. S. Erk, who carried out the paleontological investigations.

II. PHYSICAL GEOGRAPHY

The average height of the region varies between 1000-1500 meters above the sea level. Appearing generally mourftainous, the region has its highest points located in the SW, around Katranlı (1750 m.), Budağan Dağ (1613 m.) and Okluk Dag (1343 m.).

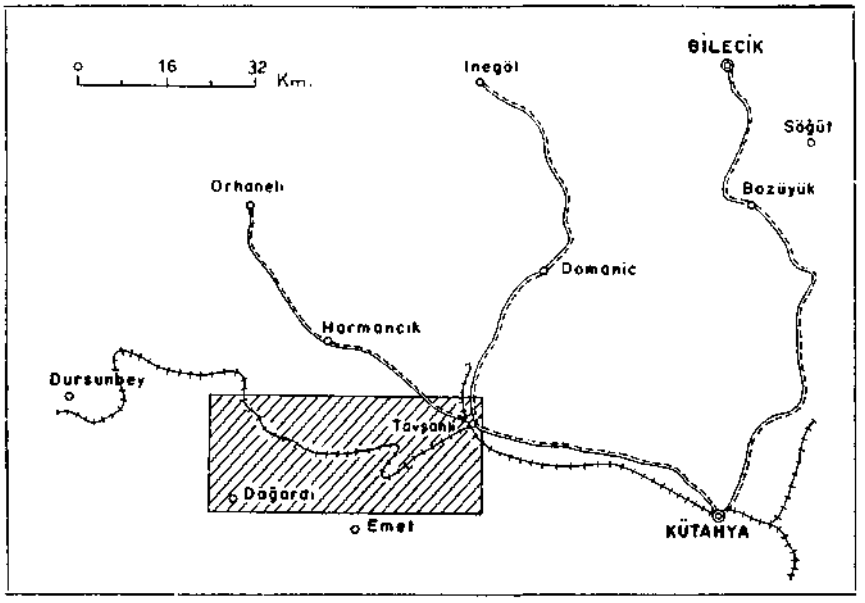

Fig. 1 - Geographic location of the district under study

The important branches of the drainage system are Değirmisaz Çayı and Tavşanlı Çayı (which joins Orhaneli Çayı in the north). In the east of the region, Tavşanlı Çayı runs in a S-N direction, collecting the waters of this part. On the other hand, Değirmisaz Çayı runs in an E-W direction, joining the Simav Çayı outside the region. Numerous small streams, running from north and south, contribute their water to Değirmisaz Çayı. A great part of the region is covered by patchy forests. Tavşanlı-Emet and Tavşanlı-Harmancık roads pass through this region (Fig. 1).

III. PREVIOUS INVESTIGATIONS

Holzer (1953) has studied the geology of this and the surrounding region. He claims a probable age of Upper Mesozoic for the serpentines and granites.

G. v. d. Kaaden, having studied the area to the north of the region, has given a Hercynian age for the granite, and a Lower Paleozoic age for the serpentines.

Wide investigations have been carried out on the lignites of Tavşanlı and Değirmisaz by Nebil Ezgü (1937), P. Ami (1942) and K. Nebert (1952).

IV. STRATIGRAPHY

In the region studied, there are metamorphic rocks of Paleozoic age, Mesozoic limestones and flysch sediments, Tertiary lake deposits, acid intrusions, rocks belonging to the ophiolitic series and lavas and tuffs (Fig. 2, 3, 4).

A. Paleozoic

The metamorphic series. — Gneisses appear at the lowest part of the metamorphic series, and are overlain by schists which occasionally contain lenses

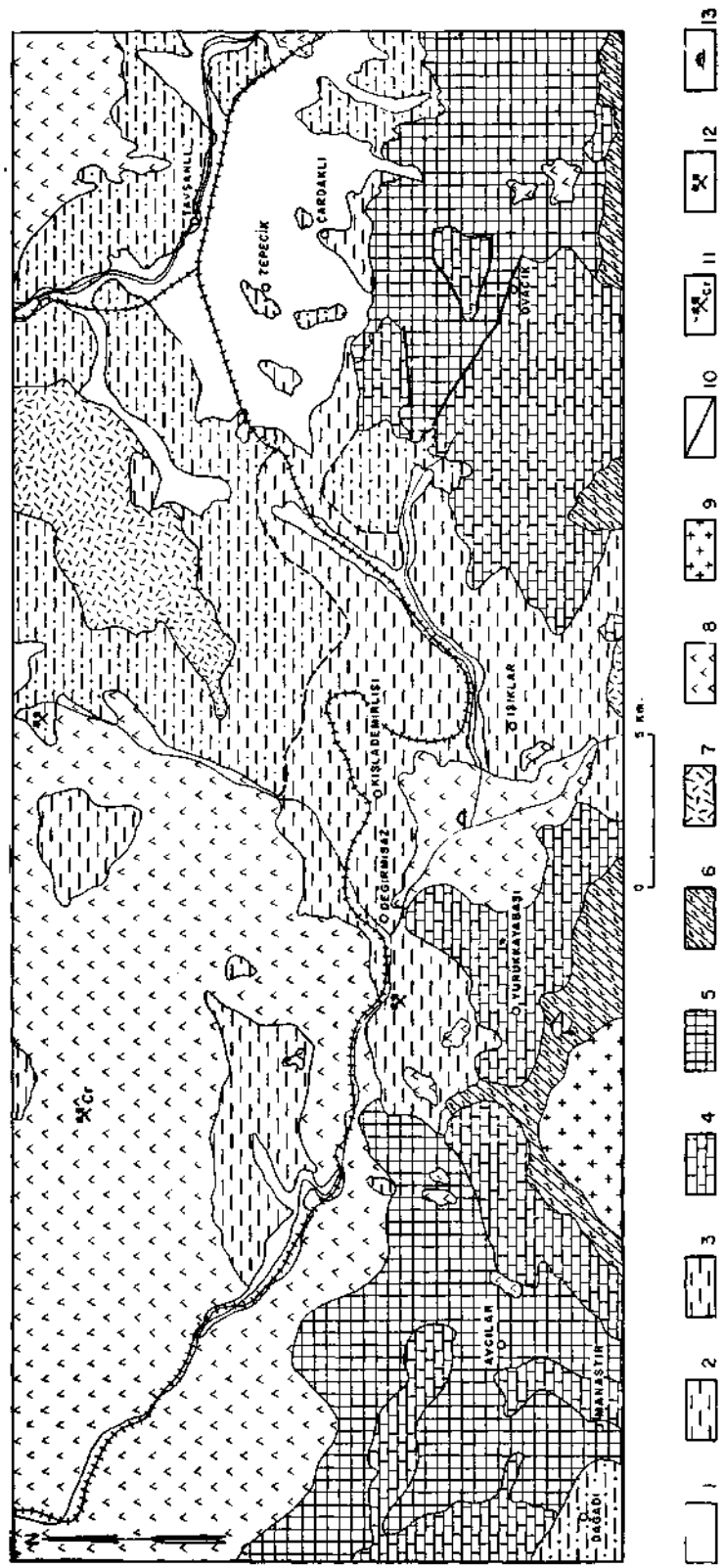

Fig. 2 - Geologic Map of the Tavşanlı - Dağardı Region

1 - Alluvium; 2 - Neogene, volcanic; 3 - Neogene, continental: conglomerate, clay, marl, limestone, ciliceous limestone, lignite; 4 - Upper Cretaceous: limestone; 5 - Upper Cretaceous flysch (mixed series): flysch, schist, radiolarite, diabase, volcanic breccia; 6 - Metamorphic series; 7 - Andesite, dacite, tuff, agglomerate; 8 - Serpentine; 9 - Granite; 10 - Fault; 11 - Chrome; 12 - Lignite; 13 - Hot spring

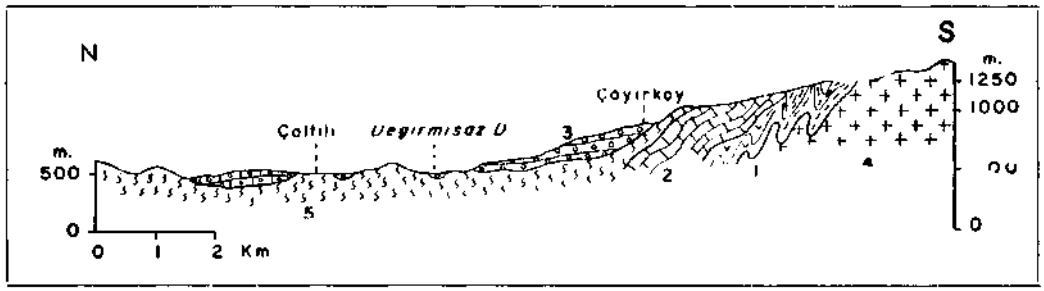

Fig. 3 - Geologic section showing area south of Madenler, southeast of Katranlı

1 - Metamorphic series; 2 - Upper Cretaceous limestone; 3 - Neogene; 4 - Granite; 5 - Serpentine

and layers of marble. In the southwest of the region, around Katranlı, sericite-albite gneisses, which show foliation planes striking N 30°E and dipping at 50° towards NW, gradually pass upwards into less metamorphosed schists. As far as the mineralogical composition is concerned, these schists conform with the conditions of epi-mesozonal fades. The dominant structural strike has been formed at the end of the Hercynian orogeny, because the Alpine orogeny has produced cratonic effects on the metamorphic series. To summarize our conclusions we can state : that the rocks of the metamorphic series are the oldest formations in the region; that they have suffered the Hercynian orogeny; that they have been formed by the regional metamorphism of the geosynclinal sediments, which used to cover the whole of the Aegean region; that they have also suffered contact metamorphism by the granitic intrusions.

The general strike of the schists is NE-SW, though locally it may diverge from this direction. The dips are mostly towards NW.

B. Mesozoic

Upper Cretaceous. — Within the region studied, the Upper Cretaceous rocks appear in two fades: a thick limestone series below, and an overlying flysch series. (The flysch is mixed with members of the ophiolitic series, such as serpentines, volcanic breccias, diabase, and some schists.) In the latter fades, flysch is the dominant type of lithology, while, in our opinion, schists have been brought up in blocks from below, by the ophiolitic magma. Only the upper part of the limestone fades yielded fossils of Maestrichtian age, the lower parts of the lime-

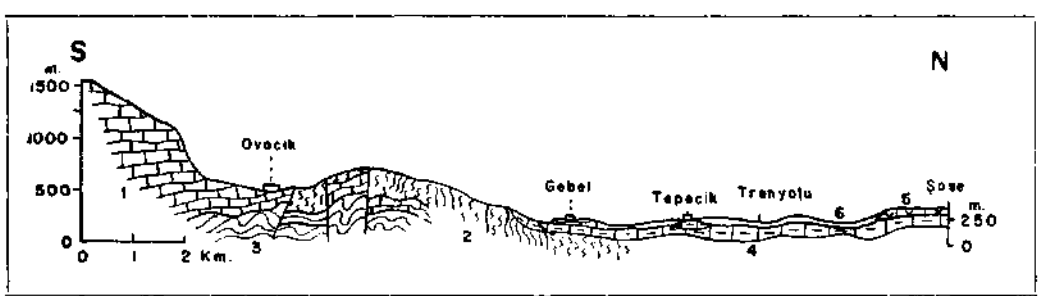

Fig. 4 - Section showing limestone and flysch (mixed series) in the neighborhood of Ovacık

1 - Upper Cretaceous (Maestrichtian) limestone; 2 - Upper Cretaceous (Maestrichtian) flysch (mixed series); 3 - Metamorphic series; 4 - Neogene, continental; 5 - Neogene, volcanic; 6 - Alluvium

stone possibly belong to the Jurassic or Lower Cretaceous. Lower part of this thick limestone series is massive, while the-upper part shows very good bedding. Overlying the limestone series, there comes a «mixed series» of flysch (variegated, sandy, clayey, brown limestones, graywackes, shales, hornstones, and a little amount of bluish metamorphic rocks), rocks belonging to the ophiolitic series, and radiolarites. This «mixed series» has been folded intensively.

The Upper Cretaceous limestones are found in the south of the region, extending in an E-W direction. South of Tavşanlı, between Hamam and Ovacık, southward dipping «mixed series» are seen to be technically overlain by gray-white limestones, striking E-W and dipping at 50° towards south. The paleontological investigations carried out on these limestones by Mualla Serdaroğlu and Suat Erk have yielded :

Orbitoides media (d'Archiac)
Siderolites calcitrapoides Lamarck

which give a Maestrichtian age. These fossils are abundantly present in the limestones and also in the thin limestone lenses enclosed within the «mixed series», and they belong to the large-sized species of Orbitoides and Siderolites, found in Turkey.

The limestones, seen to the north of Dağardı, in the SW part of the region, are also of Upper Cretaceous age, and have been brought into contact with the serpentines, tectonically.

C. Neogene

Neogene (Miocene + Plioccne) sediments are widespread in our region. They can be considered in three parts :

1. Clastic facies,
2. Fresh-water facies,
3. Volcanic facies.

Because of the presence of lignite seams near Tunçbilek and Değirmisaz, the Neogene formations of our region have previously been investigated by a great many geologists. Our studies contribute only a number of small observations.

Miocene starts with a thick conglomerate, consisting of very large pebbles. West of Dağardı, between Musalar and Güğü, this basal conglomerate is seen to be 50 meters thick and resting on rocks of the metamorphic series. Upwards, the conglomerate passes into sands, clays and marls. Above the clays, lignite carrying formations are found. The thick marls, which overlie the lignites, contain clay, limestone and conglomerate horizons, and have been frequently faulted. In many localities this clayey marl formation is followed upwards by limestones, which in turn are overlain by sandstones and sands. Tuffaceous and siliceous horizons are also found in many places throughout the Miocene sediments. K. Nebert has stated that, near the village of Ömerler, to the north of the region, Pliocene formations rest unconformably on the Miocene. The siliceous limestones and conglomerates, attributed by Nebert to the Pliocene, can also be seen in our region of study.

Alluvial deposits

Important alluvial deposits are confined to river channels and downwarped basins. Thus, large alluvial deposits can be seen in the subsided marshy area of Tavşanlı and along the rivers Tavşanlı Çayı and Değirmisaz Çayı.

V. IGNEOUS ROCKS

Acid intrusions

To the south of Katranlı a small granite outcrop—which is the extension of the Eğrigöz granite-granodiorite batholith—can be observed. Eğrigöz granite is mainly a biotitic granite. According to Holzer, the outer part of the intrusive massive consists of light-colored granite with both micas present, whereas the central part consists, mainly, of dark-colored granodiorites. The granite exposures to the south of Katranlı appear to be fresh, with no traces of splitting, breaking and cataclasticism, nor are there any signs of schistosity.

On the basis of some thermal metamorphism, caused by the granite intrusion in the Mesozoic limestones along the granite-limestone junction (north of Dağardı, NW corner of our region of study), Holzer maintains an Upper Cretaceous, or post-Cretaceous pre-Tertiary age for the intrusion. It is surprising, however, that the granite-limestone junction described by Holzer to be north of Dağardı does not appear to exist; indeed areas shown as granite on his map are, in fact, Neogene sediments. Thus—as opposed to Holzer, Ronner and Colin, who give a Mesozoic age to the intrusion—on the basis of our studies in the north of the region, we regard the age of the granite to be somewhere between post-Permian and pre-Trias. This is supported by the fact that, in many parts of the Aegean region, the basal conglomerates of Triassic and Jurassic systems contain pebbles of these granites. Thus, the granite is of young Variscan age.

Ophiolitic series

The basic extrusive and intrusive rocks cover a large area in our region of study. These rocks, which are generally the products of basaltic magmas and their fractions by differentiation, have been given the general name of ophiolites. The initial basaltic magma rises along deep-reaching tension faults in geosynclines. As well as syn-sedimentary rocks, such as diabase, melaphyre, pillow lavas, spilires, etc., intrusions also take place.

Rocks of the widespread ophiolitic series in the region are, generally, found to be serpentinized. The reason for the serpentinization is thought to be closely connected with the tectonics. Without going into the details of this process, we shall find it sufficient to state that, in our region of study, serpentinization covers a very large area.

In the peridotites and serpentines which cover a large area in the NW part of the region, chiomite ores, as well as gabbros and diorites, are found. The gangue gabbros are about 5-10 metets in length, and about one meter in thickness. The serpentines are generally fresh in appearance and locally include some calcedony veins. Sometimes they are porous, altered, or limonitized; rarely

calcification may be observed. To the south of the region, extrusive ophiolites are found within the flysch series.

Ages of rocks of the ophiolitic series

In the carlier literature, the age of the serpentines (which are the most widespread among the ophiolitic rocks) was considered to be Paleozoic by some geologists, and Mesozoic by some others. Holzer, who has worked particularly in our region, considers them to be of Jurassic-Lower Cretaceous age. On the other hand, G.v.d. Kaaden and P. de Wijkerslooth, who have worked to the north of this region, regard the serpentines as of Paleozoic age. In aur opinion, the age of the serpentines (and therefore ophiolites) around Tavşanlı, is Maestrichtian.

South of Tavşanlı, at the village of Ovacık, within the Maestrichtian flysch formation overlying the Upper Cretaceous limestones, rocks such as diabase, volcanic breccia, serpentine, radiolarite are found mixed with, and even occasionally superjacent to, the flysch series. This indicates the Maestrichtian age of the ophiolites.

Holzer has also described, at the same place, the junction of Mesozoic limestones and serpentines. According to him, this tectonic junction contains diopside-tremolite-quarlzfels and metamorphic micro-breccia (indicating contact metamorphism). Now that the age of the limestones is known to be Maestrichtian, it follows that the serpentines must be of the same age.

This conclusion should not be extended to cover all the ophiolites in Western Anatolia. From our studies in Western Anatolia we are convinced that there are two ophiolitic series, of Paleozoic and Mesozoic ages, respectively. Because of the complex tectonic activities which have taken place during both times, it is not always possible to determine the age of the ophiolitic rocks.

VI. VOLCANISM

The young extrusive rocks of our region of study consist of andesites, dacites, tuffs and agglomerates. These belong to a post-tectonic phase and are of Tertiary age. The Neogene sediments and these volcanics are found to be interfingering. The volcanic activity has started at the end of the Miocene, and reached its peak during the Pliocene. The presence of siliceous beds and siliceous concretions above Neogene sediments indicates siliceous flows in a post-volcanic phase.

The important volcanic outcrops of the region can be found to the east of Okluk Dağı, which extends between Ayvalı and Köprücük, in a NE-SW direction. Here, andesites, dacites and a small amount of basalt flows are found to be mixed with tuffs and agglomerates.

VII. TECTONICS AND PALEOGEOGRAPHY

The oldest rocks in this region, which has suffered the Hercynian and Alpine orogenies, are the crystalline schists. These complex rocks, which extend far beyond the boundaries of our region, have been formed by the regional meta-

morphism (epi-,mezo- and a little katazonal) of some geosynclinal sediments, which were probably of Devonian age. The main strike of the metamorphic rocks is NE-SW. They may have suffered the early Variscan orogeny. Within the metamorphic series locally, marble beds are found. Their apparent conformity cannot be considered as unreal. It is probable that the variety in the clastic sediment types in the geosynclinal deposits gave rise to a variety of metamorphic-rocks.

After the early Variscan orogeny, the region was once again covered by the sea, during the Permian period. Permian formations, to the north of our region, unconformably overlie the metamorphic series. At the end of Permian, with a younger Variscan orogeny, the region was uplifted above the sea-level. The acid intrusives belong to this period.

In the Aegean region, Triassic and, at some places, Jurassic rocks unconformably overlie the Permian formations. Within the region studied, the lower part of the thick limestone scries belongs probably to the Jurassic. It is definitely known that the Upper Cretaceous rests unconformably on the older rocks. Thus, it is evident that there is an unconformity between the Lower and Upper Cretaceous formations. In our region of study, the Upper Cretaceous (Maestrichtian) consists of limestones and flysch (mixed series) sediments. The ophiolitic intrusions and extrusions have also taken place during the Upper Cretaceous. The sea has left the region after the Maestrichtian, never to return again (Laramian phase). Further to the west of our region, marine Eocene is found to be folded by the Pyrenean phase.

We do not know yet about the existence of the Helvetic and Savic phases, either in our region *of* study, or in the larger Aegean region.

Fresh-water conditions were prevalent during the Neogene. The important types of sediments are conglomerates, sands, clays, marls, limestones, siliceous limestones and lignites. Though generally horizontal, near dislocation zones the Neogene beds can show considerable inclinations.

The lower part (Miocene) of Neogene has suffered more dislocations than the upper part (Pliocene). The Attic phase exists between the Miocene and the Pliocene. The volcanic activity, which began during the Miocene, increased during the Pliocene. Many volcanic zones can be seen to be interbedded with the Neogene sediments.

Manuscript received March 21, 1962

BIBLIOGRAPHY

ARNI, P. (19121 : Materialien zur altersfrage der Ophiolithe Anatoliens. *M.T.A. Mecm.,* No. 3, Ankara.

ERENTÖZ, C. & TOPKAYA, M. (1950) : Eskişehir su baskını üzerinde tetkikler. *M.T.A. Rep.,* No. 1841, Ankara (unpublished).

EZGÜ, N. (1941) : Kütahya vilayeti dahilinde Kunduren mevkiindeki refrakter kil, Karaholduruk opal ve Sulucudere magnezit zuhuratı hakkında rapor. *M.T.A. Rep.,* No. 1296, Ankara (unpublished).

HOLZER, H. (1954) : Rapport über Geologische kartierungen auf den Karlenblattern Beyce 54/4 und Simav 71/2. *M.T.A. Rep.,* No. 2366, Ankara (unpublished).

KAADEN, V.d. (1958) : Report on W-Zn-Cu prospection in the area between the villages Saadet-Mesruriye, Sefa-Durabey-Domaniç-Tiraz-Saadet; Report on tungsten prospection around the Uludağ range around Orhaneli and south of Mustafakemalpaşa and Report on the geological setting and evolution of the region. *M.T.A. Rep.,* No. 2645, Ankara (unpublished).

KOVENKO, V. (1941) : Note sur la visite de la mine de chrome de Değirmisaz. *M.T.A. Rep.,* No. 1301, Ankara (unpublished).

KUPFAHL, H. G. (1954) : Rapport über die geologischen Untersuchungen zur Kartierung der Blatter 55/2, 55/4 (Eskişehir), 56 1, 56 3 (Sivrihisar). *M.T.A. Rep.,* No. 2247, Ankara (unpublished) .

NEBERT, K. (1960) : Vergleichende Stratigraphie und Tektonik der lignitführenden Neogengebiete westlich und nordlich von Tavşanlı. *M.T.A. Bull.,* No. 54, Ankara.

ÖNEN, N. (1940) : Bilecik vilayetinin İnönü mıntakasında yapılan arama ve jeolojik tetkikat. *M.T.A. Rep.,* No. 1143, Ankara (unpublished).

OKAY, A. C. (1948) : Orhaneli bölgesine ait rapor. *M.T.A. Rep.,* No. 2215, Ankara (unpublished).

ROMBERG, H. (1937) : Bericht über die Kaolinlagerstatten bei Kütahya. *M.T.A. Rep.,* No. 572, Ankara (unpublished).

STCHEPINSKY, V. (1941) : Rapport sur la geologie generale de la region de Kocaeli-Bolu-Bilecik-Bursa-Eskisehir. *M.T.A. Rep.,* No. 1316, Ankara (unpublished).

WIJKERSLOOTH P. de (1940) : Eine Prospektionsreise im Gebiete von Bilecik und Geyve (Mangan-Nickel-und Eisenerz sowie Chrom-und Asbestlagerstatten). *M.T.A. Rep.,* No. 1665, Ankara (unpublished).

———(1946) : Die Kalk- (Marmor-) Vorkommen in der Umgebung von Tavşanlı und Tunçbilek. *M.T.A. Rep.,* No. 1665, Ankara (unpublished).