GEOLOGY OF TUNCELİ - BİNGÖL REGION OF EASTERN TURKEY

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ABSTRACT. — This region is located in the Taurus orogenic belt of the highland district of Eastern Turkey. Lower Permian metasediments and Upper Permian suberystalline limestone are the oldest exposed formations of this region. Lower Cretaceous flysch overlies partly eroded Upper Permian limestone discordantly. The enormous thickness of flysch, tuffs, basaltic - andesitic flows, and limestones constitute deposits of Lower Cretaceous, Upper Cretaceous, and Lower Eocene; the deposits of each of these periods are separated from the others by an unconformity. Middle Eocene limestone is overlain discordantly by Lower Miocene marine limestone which grades upward into lignite-bearing marls of Middle Miocene and red beds of Upper Miocene. After Upper Miocene time, this region has been subjected to erosion and widespread extrusive igneous activities.

During Permian this region was part of Tethys geosyncline; in Triassic-Jurassic times it was subjected to orogenesis, uplift and erosion, and from Lower Cretaceous until Middle Eocene it was part of an eugeosyncline. It was affected by Variscan, pre-Gosauan, Laramide, Pyrenean, and Attian orogenies.

The entire sedimentary section above the basement complex is intensely folded, faulted, subjected to igneous intrusion, and during five orogenic episodes has been exposed and eroded.

INTRODUCTION

In the August of 1964 the Mineral Research and Exploration Institute of Turkey assigned the writer to undertake geologic study of the region which is the subject of discussion in this report. This region is located in the highland district of Eastern Turkey, extending from Karasu River in the north to Murat River in the south. It comprises the districts of Pülümür, Tunceli, Hozat, Mazgirt, Bingöl, and Kiği (Fig. 1). With the exception of the area to the south of Mazgirt, this region has very rugged topography with numerous high peaks and deep valleys (Photo 1). The highest peak of this region, located 18 km east of Pülümür, is Bağırbaba Dağı with an elevation of 3287 m above sea level, and the lowest point is located south of Göktepe village in Mazgirt district, where Munzur River leaves the region at an elevation of 900 m above sea level. In most of this region, except Bingöl area, the beds are dipping at high angle and differential erosion has produced prominent escarpments. Bingöl area is a basaltic plateau with enormous thickness of almost horizontal flows of extrusive rocks. Numerous streams of the area have cut deep and narrow valleys in this plateau (Plate I).

STRATIGRAPHY

PALEOZOIC

Permian

The oldest exposed rocks in this region consist of a series of sericitic schist interbedded with thin beds of quartzite. These metasediments of clastic origin grade upward into Upper Permian subcrystalline limestone of enormous thickness. One of

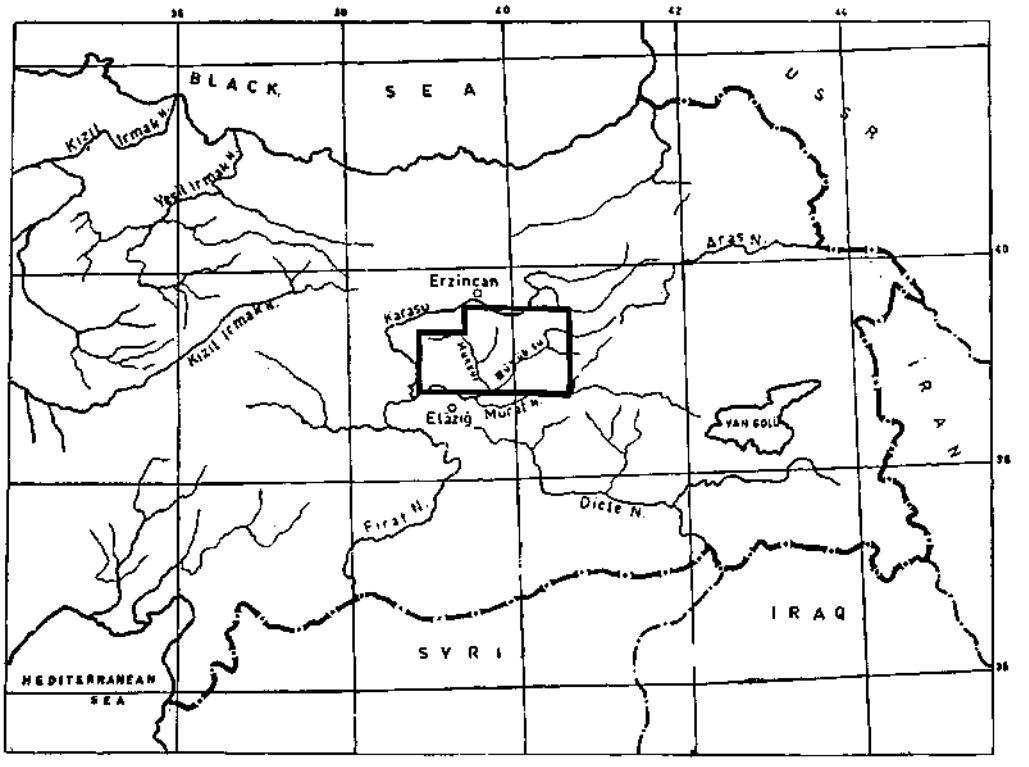

Fig. 1 - Index map showing area of the report.

the localities where this schist-quartzite series is exposed is situated 20 km northwest of Tunceli. Here a section of 15 m thickness, consisting of 50 cm to 2 m of gray-colored schist alternating with thin beds of quartzite, is exposed on the south bank of Munzur River. Another area where the schists with quartzite beds are exposed is located within the immediate vicinity of Dolan village, about 7 km west of Karakoçan. They are exposed also in a small area about one kilometer west of Hoyer village and 2 km south of Dolan. Base of this schist and quartzite series is not exposed in any part of this region and there is no break in sedimentation between them and overlying subcrystalline Upper Permian limestone. From their lithology and stratigraphic position they are probably correlative of upper Lower Permian Grödner Sandstein of Karnic Alps which belong to Kungurian stage.

The schist beds are overlain concordantly by a very thick subcrystalline limestone which contains *Neoschwagerina carticulifera* in its upper part. This fossil is typical of Upper Permian of Tethys geosynclinal area. Lower part of this limestone formation consists of thin beds of limestone of 5 to 8 m thick, interbedded with thin beds of schist. Toward the upper part of the section intercalations of terrigenous sediments disappear and it becomes a massive limestone. The limestone has typically dark-brown color with considerable amount of organic matter disseminated in it. High organic content has given it the dark color and when the rock is subjected to friction it gives off hydrocarbon odor. Due to tectonic disturbances it is intricately folded (Photo 2), extensively fractured and the fractures are filled with numerous calcite veins. In some places it is subjected to granitic intrusion (Plate II, a). It is metamorphosed to a sub-crystalline limestone, however, the degree of metamorphism varies from place to place,

in general, stratigraphically lower parts of the formation and areas of granitic intrusion show higher degree of metamorphism.

The distribution of Upper Permian limestone in the regions occupied by Tethys geosyncline during Upper Paleozoic is widespread. This limestone is known as Bellerophon Limestone in the Alps, Zechstein in Germany, Sosio Limestone in Sicily and it occurs in Djulfa district of Azerbaijan and in Zagros Mountains of Iran. In this region, it is exposed rather extensively in two localities, and there are several small outcrops scattered through. The largest area of exposure starts from about 2 km north of town of Tunceli and extends for a distance of 34 km toward north, and in NE-SW direction it is exposed for a distance of 45 km. This area of exposure is crossed on the east by Harçik River and on the west by Munzur River. Removal of post-Paleozoic formations in this area is partly due to erosional action of these two rivers and mainly due to orogenic uplift.

About 20 km northeast of Tunceli on Erzincan highway, Harçik River has cut a narrow gorge of about 200 m of depth in a localicy 2 km west of Harik village. From here to the vicinity of Hodik village, a distance of about 40 km along Harçik River, the outcrops consist entirely of this suberystalline limestone. Due to intricate folding, this formation shows enormous thickness in this locality. About 30 km northeast of Tunceli, in the vicinity of Zel Dağı it attains a thickness of about 1250m measured from the banks of Harçik River; whereas, an unknown thickness of it lies below the river bed. This enormous thickness is due to complex folding and the actual thickness of the formation is considerably less than this amount, being approximately 800 m thick. The northern limit of this Permian limestone is defined by a major fault beyond which Mesozoic and Cenozoic formations are exposed. In this locality of Permian limestone exposure, there are several isolated patches of Eocene flysch resting directly on the limestone without any Mesozoic rocks in between, indicating that at the end of Mesozoic this fault block was uplifted and subjected to erosion, as a result of which Mesozoic rocks on it were removed before deposition of Eocene flysch. In Munzur valley, at a distance of about 9 km northwest of Tunceli, this limestone is intruded by granite.

Another area where this crystalline limestone is extensively exposed is located about 19 km north of county seat Çemişkezek. Here, its width in NW-SE direction is about 14 km and its length in NE-SW direction is more than 30 km, extending to Euphrates River in Kemaliye district. Here, measured from bottom of Tagar Deresi to the top of Yılan Dağı it shows an apparent thickness of about 1700 m. In this locality its degree of metamorphism is less than in Tunceli district and *Neoschwagerina carticulifera* fossils are found in the outcrops near Euphrates River. The actual thickness of this formation is about 800 m.

Several small and isolated outcrops of this Permian crystalline limestone occur in the immediate vicinity of Kılcan village and adjacent areas about 20 km southeast of Pülümür. They crop out from underneath Eocene flysch. About 26 km east of county seat Mazgirt, on the banks of Büyüksu River in the environs of Bağın village, several small outcrops of the crystalline limestone occur. Here a hot spring comes out of a fracture in this limestone. In the Bingöl area, about 7 km west of Karakoçan, in the vicinity of Dolan and Hoyer villages small outcrops of highly metamorphosed facies of this limestone are exposed.

On the eroded surface of this Permian, formation in some places Mesozoic beds and in other places Cenozoic beds are lying discordantly.

MESOZOIC

The Mesozoic formations in this region are typical of eugeosynclinal mobile belt. They consist of enormous thickness of flysch deposits intercalated with pyroclastics, andesitic-basaltic flows and marine limestones of Lower and Upper Cretaceous period. These are deposited on the intensely folded and eroded surface of Permian suberystalline limestone.

In this region I could not find any beds of Triassic or Jurassic period; it is probable that in the early Mesozoic times this area was emergent above sea level, during which folding and extensive erosion of Permian deposits were accomplished. During Lower Cretaceous this area was undergoing intense crustal disturbance and the sediments were deposited in deep geosynclinal trough accompanied by paroxysmal volcanic eruption and igneous extrusion.

The Permian formation in this area as a result of intense folding has assumed enormous thickness, and is a regional uplift in the form of a tectonic axis trending in NW-SE direction. To the north of this axis Mesozoic and Cenozoic formations are subjected to intense folding and faulting, due to pressures origiriating farther north. As a result of these severe orogenic movements, they are uplifted and subjected to erosion in such a way that most of the Cenozoic deposits are removed and great majority of outcrops consist of Mesozoic rocks. Whereas to the south of this tectonic axis post-Permian formations are less disturbed, Cretaceous formations are not exposed and the outcrops consist of Cenozoic rocks.

Lower Cretaceous

Oldest Mesozoic formations in this area consist of enormous thickness of gray and brown flysch, gray and pink limestone, green and gray radiolites, and serpentines of Lower Cretaceous age. Base of Lower Cretaceous section is conglomeratic grading upward into thick section of flysch, and they are separated from underlying Permian limestone by a major unconformity. Southwestern part of Munzur range and north of upstream Munzur River consist of buff-colored Lower Cretaceous limestone forming orographic heights like Eğripınar and Büyükgölbaşı mountains. On the eastern part of Munzur range, about 35 kilometers southwest of Pülümür county seat, gray to buff-colored Lower Cretaceous limestone having *Exogyra, Requienia* and *Ostrea* is exposed in a large area. A large area starting from three kilometers northeast of Pülümür and extending for a distance of more than 50 kilometers in northeasterly direction consists of Lower Cretaceous radolarite-serpentine complex. Further east, a large area located in the northern part of Kiği quadrangle (Pafta 64-1) consists of Lower Cretaceous buff and gray-colored limestones interbedded with gray-colored flysch.

Upper Cretaceous

The enormous thickness of Upper Cretaceous formations consisting predominantly of flysch and limestones overlie Lower Cretaceous beds discordantly. The base of this section is conglomeratic grading upward into gray-colored flysch. Limestones of pink and gray color, most of which are slightly argillaceous, occur interbedded with flysch.

The Upper Cretaceous beds are widespread in the northern part of the area of this report. An area starting about 5 km south of Pülümür and extending south for about 16 km consists of Upper Cretaceous flysch an limestones. The southern boundary of these outcrops are defined by a major fault contact with Permian limestone. In this locality these beds extend from 18 km west of Harçik River for a distance of over 90 km toward east and most of their southern boundary is defined by a major E-W fault. One of the best exposed sections of Upper Cretaceous flysch-limestone series is located in the vicinity of Hakiston village, Kiği district, along the upstrearns of Büyüksu. Here enormous thickness of flysch with some limestone beds are exposed striking E-W, having an average dip of about 60°N.

CENOZOIC

Paleocene

I could not find any beds of Paleocene age, it is probable that Paleocene was a period of erosion in this region.

Eocene

The Cenozoic formations overlie Mesozoic rocks discordantly in this region. Oldest Cenozoic beds are of Eocene age, lower part of the section consists of series of flysch with some thin beds of limestone interbedded with andesitic flows and stratified pyroclastics of tuff and agglomerate type. A short distance from the Tunceli-Erzincan road junction of Nazimiye road, toward Nazimiye, stratified tuff and andesitic agglomerate of Lower Eocene are exposed. Here these beds are transgressive over eroded Permian suberystalline limestone, which is exposed in a few small outcrops along the road. On both sides of the road until Nazimiye Eocene beds are extensively exposed. From Nazimiye to Hodik village, located about 6 km to southeast along a narrow valley, over 800 m of buff flysch, gray-colored tuff interbedded with pink andesitic flows of about 20 m thick and some gray argillaceous beds are exposed, A gray limestone bed of 4 m thick, interbedded in flysch, consisting mostly of Eocene Pelecypodae (Lamellibranches) fragments, is exposed at the bottom of the valley 200 m south of Hodik village. From here to village Dal, Kavanik, Yukarı Ponus the entire area consists of Eocene flysch series. Here- and there folded and truncated Eocene beds are overlain by Miocene limestone and Pliocene basalt.

About 12 km northeast of Tunceli, near Nuran village on both sides of Harçik River, the Lower Eocene flysch interbedded with stratified pyroclastics, andesitic flows and some carbonate beds are exposed. Toward the upper part of section, carbonate beds become predominant so that the upper part in this locality consists of dense pink limestone of about 40 m thick, forming high cliffs on the east bank of the river (Photo 3). The county seat Pah is situated on this dense limestone formation. This limestone formation of Middle Eocene age is very widespread, extending from Pah toward southeast for a distance of 15 km as far as villages Avnik and Keştun in Mazgirt district. From Pah it extends to the town of Tunceli, forming high escarpments immediately north of the town (Photo 4)".

South of Tunceli, between Munzur River and Dinar tributary, stream erosion has removed this 'Middle Eocene limestone and Lower Eocene flysch is exposed. But

to the southwest of Dinar valley again this limestone formation outcrops are widespread, forming prominent topographic features near Cilasur and Kayındul, covering extensive areas and extending to the west and southwest as far as villages Teştek, Cet, Kinik and Erkan in Hozat district.

-In Hozat district Lower Eocene flysch with similar lithologic character as in Tunceli - Nazimiye district is extensively exposed. Here a section identical to the one exposed in Pah area is exposed about 4 km south of town of Hozat in the Hozat valley. In this locality again green, gray stratified tuff and agglomerate beds with intercalations of carbonate beds grade upward into dense Middle Eocene limestone of about 30 m thickness.

This Middle Eocene limestone formation, which occurs very extensively in this region and is typically developed in Pertek district, could be given the stratigraphic name of «Pertek formation» The town of Pertek is situated on this formation and 11 km north of the town in the vicinity of Mercimek köy type section is located which has rich and abundant Middle Eocene Nummulites and other microfossils. In the type locality it has more than 200 m thickness, lower part of section is sandy and argillaceous, toward top it grades into pure limestone, and it has characteristically buff color. Erosion has removed its areal continuity at the present time, but in isolated patches it extends in E-W direction for a distance of more than 100 km. In N-S direction it extends from the vicinity of Nazimiye toward south to Tunceli, Hozat, Pertek and farther south.

From samples of the type the locality the following microfossils are identified by Y. Pekmen :

Nummulites intermedius d'Archiac
Nummulites vascus Joly & Leymerie
Nummulites incrassatus de la Harpe
Nummulites lucasi d'Archiac
Nummulites irregularis Deshayes
Nummulites subirregularis de la Harpe
Nummulites cf. *murchisoni* Brunner
Nummulites atacicus Leymerie
Nummulites subatacicus H. Douville
Nummulites globus Leymerie
Nummulites guettardi d'Archiac
Nummulites distans Deshayes
Nummulites planulatus Lamarck
Nummulites granifera H. Douville
Assilina granulosa d'Archiac
Operculina
Amphistegina
Nodosaria
Textularia
Bryozoa

Everywhere in this area the upper part of this Middle Eocene limestone formation has been subjected to erosion.

Oligocene

There is a small area of Oligocene outcrops extending from the vicinity of Pülümür to Karasu River and a short distance north of it. They consist of fine to coarse clastic deposits, of brown and gray colors, subjected to severe folding and extensive erosion. On the highway between Pülümür and Karasu bridge these beds are intruded by diabase and the intrusive igneous rocks are exposed in two localities. This intrusion has produced considerable alteration in these beds. About 10 km south of Pülümür, on the highway near Pardi village, there are several very small patches of gypsiferous clastic deposits; these also may be of Oligocene age.

Miocene

Between Eocene and Miocene beds there is an unconformity everywhere in this region. Lower part of Miocene section consists of dense gray-colored sandy and in some places slightly conglomeratic limestone. Toward the upper part of the section thin limestone beds alternate with gray and cream-colored marls and in some places thin lignite beds of generally 30 cm thickness are interbedded in the marls. The dense sandy limestone of Lower Miocene age has abundant molluscan fauna characteristic of shallow marine ecologic conditions. About 4 km southeast of county seat Kiği, continental facies of Upper Miocene consisting of dark-red and maroon-colored shale and sandstone beds of about 600 m thickness are exposed.

In Tunceli district Miocene limestones appear on the east side of Munzur valley near Hopik village above Eocene limestone and below basaltic flows of Pliocene age. These outcrops continue south along Munzur valley as far as Kanoğlu village for a distance of about 18 km. From there they extend to the east and west over wide areas where overlying basaltic flows are removed by erosion. From Kanoğlu, exposures of these Miocene limestones with some interruptions of basaltic cover extend to Hozat district. From there they continue to Çemişkezek town, covering a large area extending about 15 km to the north and south of the town and reaching as far west as Euphrates River.

From Kanoğlu, Miocene limestones extend east to Mazgirt-Muhundu district. This district is located between Munzur and Büyüksu Rivers at their confluence, where the erosional action of tributaries of these two rivers have removed all but a few small patches of basaltic cover and Miocene limestones are exposed over greater part of this district. One of the well-exposed sections in this district is located 8 km due east of Mazgirt in a partly eroded anticline between Kuşhane and Kaban villages. Lower part of the section extends from Aquitanian to Helvetian and has a thickness of about 200 m; and the upper part of the section which consists of alternating yellow and gray marl beds of Upper Miocene age is about 90 m- thick. The upper part of Miocene section is eroded throughout this entire district and Pliocene basalt flows in some places are resting on the lower member of the section and in other places on the eroded surface of upper marly member. -Another locality where considerable part of Miocene section, especially lower part of it, is exposed, is in the vicinity of Muhundu county seat. On the eastern outskirts of the town, in a small valley dense, partly sandy, fossiliferous limestone is exposed in the eastern flank of a small anticlinal fold. Lower member of the Miocene limestone contains *Flabellipecten burdigalensis*, *Chlamys rotunda, Miogypsina* and other Lower Miocene fossils. To the east of Muhundu both sides of Büyüksu consist of Miocene limestone outcrops.

Northeast of Muhundu, upstream along the banks of Büyüksu in several places below thick agglomerate and tuff deposits, Miocene limestone is exposed. One of these places is located between Çamrik (Çamlık) and Pas villages where 35 m of light-colored dense fossiliferous limestone of Lower Miocene is exposed on both banks of the river. Northwest of here and north of Kalman Deresi in the area of Hemuk, İresi, and Yerinduk villages, Upper Miocene marls are exposed. From Pas toward northeast along Büyüksu the Miocene limestone is covered again by agglomerates, but a short distance upstream and two kilometers before reaching İlbeki village the limestones are exposed on both sides of the river. From here a narrow strip of these outcrops extends eastward for a distance of 20 km to the area of Akpınar and Kavman villages of Karakoçan district. In Çan district Middle and Upper Miocene beds are exposed over a large area. About 6 km south of county seat Çan, near Keklik village, interbedded in Upper Miocene marls about 25 cm of lignite is exposed.

In Holhol and Kanigevrik area Middle Miocene limestone exposures are widespread and from here they extend eastward along the banks of Büyüksu as far as town of Kiği for a distance of about 50 km. One kilometer southwest of Gaje village more than 60 m of Miocene limestone is exposed in a small anticlinal fold on south bank of Büyüksu River. At a distance of 10 km south of Kiği, on the left bank of Büyüksu River and 150 m east of Hacı Halil Köprüsü bridge, a section of Miocene formation is exposed, the upper part of which shows considerable facies change compared with other areas which are located farther west; here Upper Miocene beds are partly continental red beds. Base of Lower Miocene starts with a dense slightly conglomeratic sandstone of about 2 m thick, followed by thin-bedded calcareous sandstones and sandy limestones, altogether 25 m thick. These dominantly clastic beds are overlain by 15 m of massive dense buff fossiliferous limestone. The upper part of the section consists of about 600 m of Upper Miocene red beds, consisting mainly of red shale interbedded with sandstone beds of generally one meter thickness. The upper part of red beds is eroded and overlain by basaltic flows. Appearance of Miocene red beds in the eastern part of this region is of considerable significance in that it shows a resemblance to the Upper Miocene section of Iran.

Pliocene

During Pliocene times this region was uplifted and subjected to erosion and extensive igneous extrusive activity (Photo 5).

QUATERNARY

Pleistocene

In the area where town of Pülümür is situated, there is a conglomerate deposit of about 400 m thick extending, from Meydanlar to the vicinity of Karasular, for a distance of 5 km. These beds are younger than basaltic extrusive rocks of Pliocene age, are tilted with a dip of about 35°, therefore, they must be of Pleistocene age. There is considerable amount of travertine deposits in Tunceli and Bingöl areas. These are deposited under atmospheric conditions from spring waters having high calcium carbonate content.

In Tunceli area these deposits extend in a narrow strip from 2 km south of town of Tunceli, along the west bank of Munzur River to Pulançayır village for a

distance of 12km. Northeast of Tunceli they occur on the west bank of Harçik River, between villages Marcik and Pakak, over a distance of 5 km. In the vicinity of Taht village, 4 km northwest of Tunceli on the left bank of Munzur River, they occur around a small spring which is depositing travertine at the present time.

About 3 km northeast of Bağın village, in the environs of villages Deştiaşan and Dalik, travertine occurs over a large area. In the same general area, about 50 km west of town of Bingöl, in the vicinity of Kızılca village, these deposits occur in several localities.

The other Quaternary deposits of geologic interest consist of alluvial terrace deposits along the major streams. One of the striking examples of stream terrace is located along Karasu River, about 3 km south of Zarik village.

TECTONICS

An axial uplift located about the middle of this region, trending in NE-SW direction and plunging toward northeast under Mesozoic and Cenozoic formations, constitutes one of the major tectonic elements. In this uplift, subcrystalline limestone formation of Upper Permian age is exposed. Tectonically, this region is situated in the eastern part of Taurus orogenic belt, and the nature of deposits indicates that from Lower Cretaceous until Middle Eocene times it was occupied by an eugeosynclinal trough. Although there is discordance between Lower Cretaceous and Upper Cretaceous formations, and between the latter and Eocene formations, eugeosynclinal conditions prevailed during this long span of time and these interruptions are considered unusual events in this type of geosyncline, which is characterized by mobility and tectonic unrest. Enormous accumulation of flysch and other terrigenous sediments, interbedded with flows of spilites, ophiolites, andesites and pyroclastic deposits, indicates an unstable crust undergoing rapid sinking in the basin of sedimentation and the marginal land experiencing rapid uplift. This mobility of crust gave rise to widespread igneous activity, both of effusive flows and volcanic eruptions, producing large quantities of pyroclastic deposits of tuff and agglomerate type.

In this region the enormous deposits of Cretaceous and Eocene are subjected to intense folding due to pressures originating from the north. In additon to intense folding this region was affected by several major faults, some of them extending for a distance of more than one hundred km in E-W direction. Indeed major reverse faulting has been a dominant tectonic element both during Cretaceous-Eocene geosynclinal period and afterwards. During crustal instability of geosynclinal period rising fault blocks furnished enormous flysch type-clastics to the rapidly sinking trough and along the fault lines effusive igneous flows poured out and in some places on the fault lines volcanic eruptions were located.

At the present time a major fault has brought Upper Cretaceous formations in sharp contact with Permian rocks in a locality 16 km south of Pülümür (Pl. I). Here the fault surface is dipping at an angle of. 75° to the north. This fault extends from the vicinity of Kavak and Şilmek village, in the western part of quadrangle (Pafta 63-2) toward east, for a distance of more than 100 km beyond Süleymanbey village in the eastern part of Kiği quadrangle (Pafta 64-1). There are some offshoots of

this major fault along the line and two of these subsidiary faults are located 6 km southeast of town of Kiği in the environs of Seyitpendan village.

Another regional fault extends from northern side of Bağırbaba Dağı, west of Kiği quadrangle (Pafta 64-1), where Lower Cretaceous serpentines have been lifted in sharp contact with Eocene rocks (PL I). This regional fault extends from the northern side of Bağırbaba Dağı, for a distance of 50 km toward east of Dikan village and beyond it. There is another E-W fault north of Karasu in the area of Darebik and Pülümür villages. These are reverse faults, unlike thrust faults which appear south of Elazığ.

These faults are confined to the area north of axial uplift of Paleozoic formations, and they are of post-Miocene age as they have affected Upper Miocene beds. To the south of the axial uplift, structure is not complex like that of northern part. The southern part, that is the area extending from Hozat to Mazgirt and Bingöl, is a single fault block, the northern limit being axial uplift of Permian formations and southern limit is the valley of Murat River. The southern end of this block is dropped down where Upper Miocene marls and Pliocene basalt - andesitic flows south of Bingöl have come in contact with the older rocks along Murat River, and the northern end of this fault block is tilted up where Permian is in sharp contact with Upper Cretaceous and Cenozoic rocks. Due to this downdrop of southern part of this block, there is a regular regional dip of the formations to the south, where from the axial uplift toward south the outcrops are progressively younger until Murat valley (PL II, b). It is due to this tectonic condition that in the southern part of this region no Cretaceous rocks are exposed and in the Bingöl area downdrop is of such a magnitude, that although the basaltic plateau has been incised by streams to the depths of 900 m, still underlying Upper Miocene beds are not exposed.

GEOLOGIC HISTORY

Of the Paleozoic formations only Permian is exposed in this region and it consists of a clastic series at the base grading upward into a dark-colored limestone formation carrying *Neoschwagerina carticulifera,* typical of Upper Permian of Tethys geosyncline. The lower clastic member may well be correlative of Grödner Sandstein of Central Europe which belongs to Kungurian age, and the limestone formation correlating with Zeckstein and Bellerophon Limestone of the Alps. There is no break in sedimentation between the clastic and carbonate formations and the lower part of the limestone is intercalated with clastic deposits. Due to intense tectonic activities since the deposition of these formations the clastic deposits are metamorphosed to quartzites and sericitic schist and the limestone is transformed to a subcrystalline carbonate rock.

During upper part of Lower Permian this region was occupied by shallow marine waters and situated close to the land mass which furnished clastic sediments that were sorted and deposited under subaqueous conditions. From the beginning of Upper Permian widespread marine transgression started, and together with subsidence of the crust pelagic marine waters completely submerged the former land mass which used to be the source of clastic sediments, and marine limestone was the only deposit accumulating in this region. This marine transgression continued until the end of Upper Permian.

Lack of Triassic and Jurassic formations, intense folding, uplift and erosion of Upper Permian formation before deposition of Lower Cretaceous formations indicates that during early part of Mesozoic times this region was involved in extensive orogenic movements.

With the start of Mesozoic, the orogenic processes were in action and the Permian formations were subjected to severe folding, granitic intrusion, and uplift. As a result of these orogenic events marine waters withdrew from this region and a period of erosion started, which lasted until the end of Jurassic. After this post-Permian mountain building and erosion a period of crustal disturbance started, as a result of which eugeosynclinal conditions with rapidly subsiding trough and fast rising marginal land mass prevailed in this region from Lower Cretaceous until Middle Eocene times. Into rapidly sinking trough enormous quantities of dominantly flysch, intercalated with tuff and effusive igneous flows were deposited. The volcanic events were intimately related to these tectonic movements. In the process of sinking of trough and rising of border lands, this region was periodically a scene of extensive volcanic outbursts which furnished stratified tuffs of andesitic type and the basic flows of ophiolites and spilites, which are mostly serpentinized. Ophiolites, which mark the early phase of eugeosynclinal development interbedded with tuff and flysch, were deposited in the early part of Lower Cretaceous time. During the upper part of Lower Cretaceous times the orogenic activities were subsided to a large extent and conditions became favorable to the deposition of limestone.

At the end of Lower Cretaceous time orogenic movements, related to Pre-Gosauan folding, started in this region and the Lower Cretaceous formations were folded, uplifted and subjected to a short period of erosion. After pre-Gosauan orogeny, this region started subsidence and the conditions of sedimentation similar to those of Lower Cretaceous times developed again.

The Upper Cretaceous deposits, which are marked by conglomerate at the base, overlie Lower Cretaceous discordantly. The conglomerate is followed by great thickness of flysch interbedded with tuff and extrusive flows. Toward the upper part of the section limestone deposits are predominant.

After deposition of Upper Cretaceous beds, Laramide folding affected this region, as it is indicated by the fact that Eocene beds overlie folded Upper Cretaceous beds discordantly It is probable that folding and erosion of the Upper Cretaceous beds took place during Paleocene time. During Eocene this region was transformed to a deep trough of sedimentation into which great thickness of flysch derived from the rising marginal land was deposited. But this was the last phase of geosynclinal subsidence. The rapid sinking of the trough and accompanying uplift of land mass gradually diminished until during Middle Eocene time relatively shallow marine waters inundated the entire region. As a result of this widespread inundation, we find Nummulitic limestone of Lutetian age transgressive over all of the previous formations.

After deposition of Middle Eocene limestone epeirogenic warping affected Eocene beds. Oligocene was a period of restricted, seas and semiarid conditions. After Oligocene, this region was subjected to widespread erosion, because over most of this region Miocene beds overlie directly on the eroded surface of Eocene beds without any Oligocene in between; the region was affected by Pyrenean folding.

During Lower Miocene widespread marine inundation prevailed in this region and in Burdigalian - Helvetian times extensive marine limestones were deposited. With the approach of Upper Miocene epeirogenic uplift caused gradual withdrawal of marine waters. During this gradual uplift marl and shale beds with deposits of lignite were deposited. During late Upper Miocene continental red beds were deposited.

Upper Miocene was followed by a period of intense orogenic movemets. This disturbance of the crust, which had its start at the time of Attian folding of Europe, lasted throughout Pliocene period.

Pliocene was a period of uplift, extensive erosion and widespread extrusive igneous activity. During Upper Pliocene perhaps extending into Lower Pleistocene enormous quantities of andesitic and basaltic flows with occasional bursts of tuff spread over entire region (Photo 5). These igneous flows are found lying over folded and eroded surface of Upper Miocene and the older formations of this region. The magnitude of this igneous extrusion is evident in Bingöl district, where nearly flat-lying basaltic flows occasionally interbedded with tuff, show a thickness of about 900 m in the vicinity of Koruca Mountain.

The process of uplift which started at the end of Miocene has been continuing to the present time.

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Photo 4 - Eocene limestone escarpment immediately north of town of Tunceli.

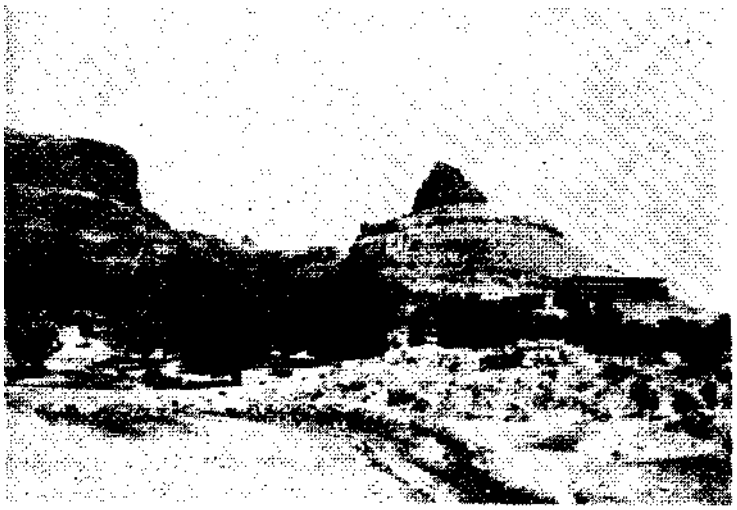


Photo 5 - Basaltic flows north of town of Mazgirt.

Photo 1 - View near Sırtıkân village, 15 km north of Hozat, on the road to Ovacık.

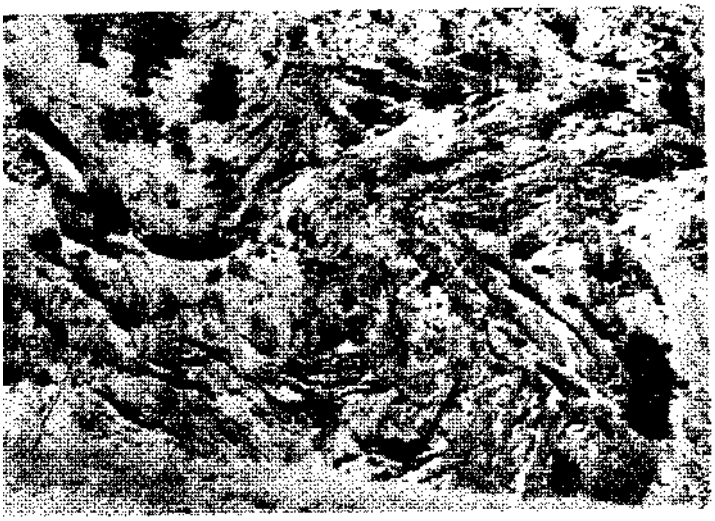


Photo 2 - Lower part of Upper Permian subcrystalline limestone interbedded with sericitic schist and intricately folded, located 2 km south of Tunaş village on western bank of Harçik River.

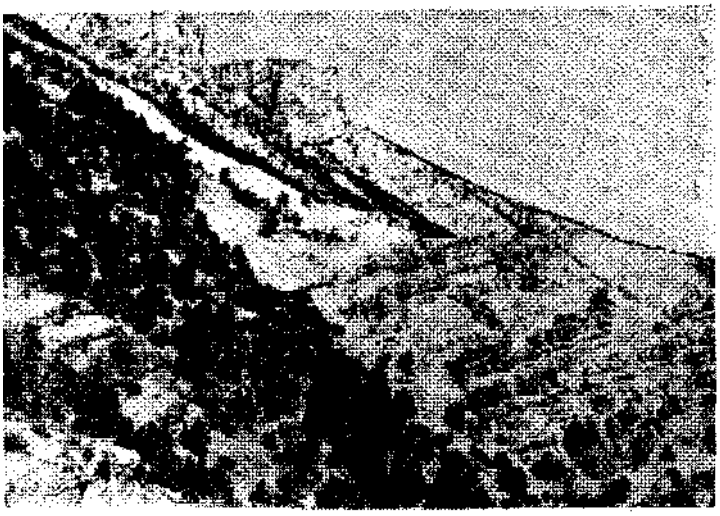
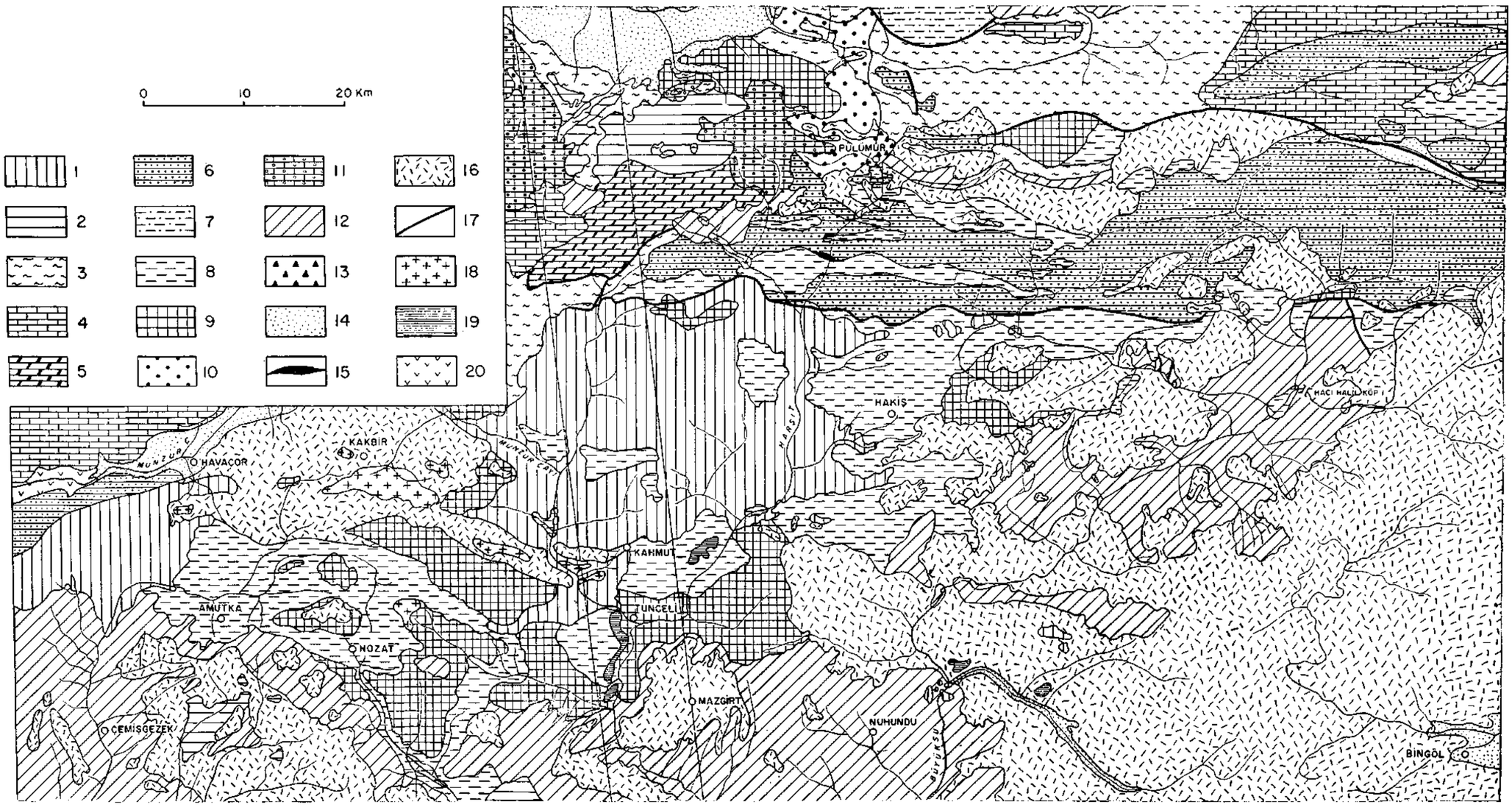


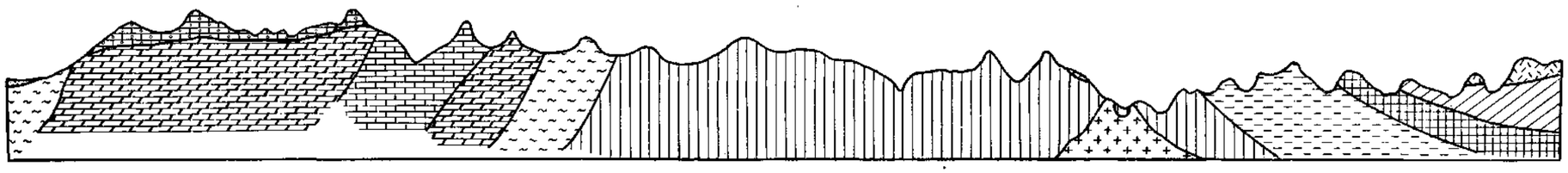
Photo 3 - Eocene limestone above flysch, 12 km NE of Tunceli and 1 km east of Nuran village.



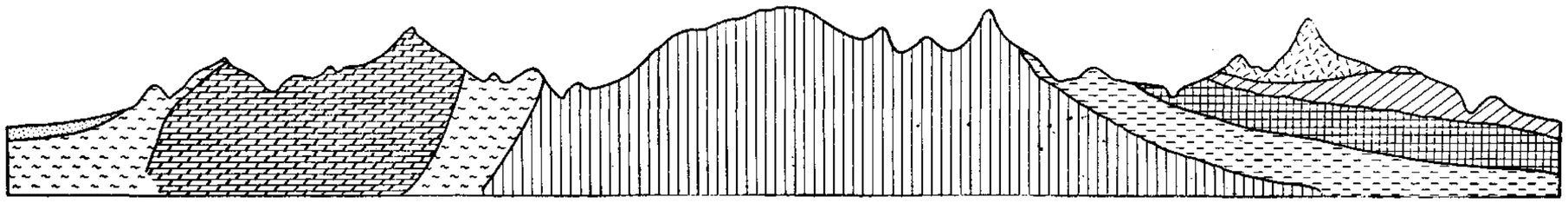
GEOLOGIC MAP OF TUNCELİ - BİNGÖL REGION

1 - Permian; 2 - Mesozoic; 3 - Lower Cretaceous: serpentine, radiolarite, diabase; *4 - Lower Cretaceous:* limestone; *5 - Cretaceous; 6 - Upper Cretaceous:* limestone; *7 - Upper Cretaceous:* flysch; *8 - Eocene:* flysch; *9 - Eocene:* limestone; *10 - Oligocene; 11 - Lower Miocene; 12 - Miocene; 13 - Pleistocene; 14* - Alluvium; *15* - Gypsum; *16* - Andesite, basalt; *17* - Fault; *18* - Granite; *19 - Quaternary:* travertine; *20* - Gabbro.

a



b



GEOLOGIC CROSS-SECTIONS OF TUNCELİ-BİNGÖL DISTRICT

(For legend see Plate I)