

GEOLOGY OF THE BEYPAZARI - NALLIHAN - SEBEN REGION

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ABSTRACT. — The oldest rocks in the area are the Paleozoic schist formations. Gneisses occupy the lowermost part of the metamorphic series. These are overlain by little metamorphosed schists of gray, green and brown color. Marble beds are here and there encountered in the gneiss and schist formations.

Jurassic sediments unconformably overlie this series which was subjected to Hercynian orogeny. Upper Jurassic strata, here represented by limestones and marls, -conformably underlie Lower Cretaceous limestones. This region emerged from under the sea during the Austriac orogenic phase. Upper Cretaceous is represented with flysch, marl, sandstone and limestone layers and unconformably overlies Lower Cretaceous formations.

Detritic red series of the continental Paleocene filled the depression areas, which were formed following the last Montian limy sedimentation (Laramian orogenic phase). Volcanic materials are found intercalated in this series comprising conglomerates, sandstones and clays.

Eocene sea covered these red formations. Eocene formations, represented by the Lutetian sediments, include conglomeratic sandstone, clay and limestone beds. Following the Eocene epoch the sea withdrew from the area. Miocene sediments settled down in the lakes which were formed after the close of the Pyrenean orogenic phase and this was followed by volcanism. Miocene here is represented mainly by conglomerates, sandstones, clays, marls, limestones, intercalated tuffs and obsidians. Lignite beds are occasionally encountered.

Following the Attic phase, Pliocenic conglomerates, loose sandstones, marls and thick gypsiferous beds were deposited. Numerous faults occurred in the area, due to regional subsiding.

After deposition of the gypsiferous beds came the tectonic movements (Wallachian phase), which caused the well-known Beypazarı - Çayırhan flexure.

I. INTRODUCTION

The area under study lies within the Ankara and Bolu Vilayets, between Beypazarı, Nallıhan and Seben (northern part), covering approximately 2400 km². Petrographic determination of rock specimens was done by Dr. G. Elgin and Dr. K. Markus, while M. Serdaroğlu, N. Karacabey, M. Türkünel, Z. Dağ, C. Öztömür, E. Sirel and Dr. T. F.J. Dessauvage were in charge of paleontological studies and determinations.

Our thanks are due to all these persons for their assistance and cooperation and particularly to Dr. C. Erentöz, Head of the Geology Department, for his advice and guidance during the preparation of this work.

II. GEOGRAPHY

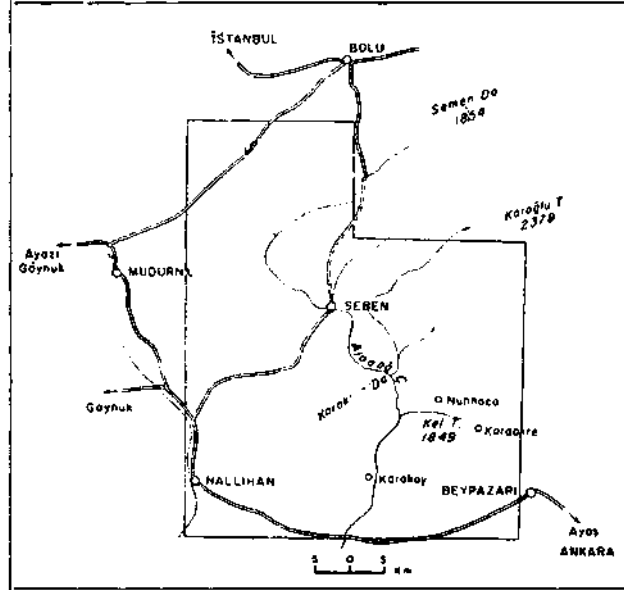
Mean altitude of the region may be taken as 1000 m, with altitudes ranging from 500 m in the south to as high as 1850 m in the north.

Highest peaks in the area include Keltepe (1849 m) and Karakiriş Mountain (1425 m) in the eastern section, and Tergat Tepe (1500 m) and Akkaya Mountain (1692 m) in the northern section.

Drainage system consists of numerous small streams feeding mainly Aladağ and Sorgun Rivers, all of which joining the Sakarya River in the south.

Pine forests cover the northern part of the area.

Ankara-Bey pazarı-Nallihan, Nallihan-Seben-Bolu and Nallihan-Mudurnu highways are the main ones in the region. Apart from these there are roads to villages where a jeep ride may be taken in summer.



Map showing location of mapped area.

III. PREVIOUS STUDY

The area was first visited by V. Stchepinsky whose report in 1941 supplied some information on stratigraphy and tectonics.

In 1956 J. Rondot studied in detail Cretaceous formation in an area that included ours and reported a great many faults, most of which did not exist.

In 1960 S. Türkünal surveyed an area between Nallihan, Mudurnu and Seben, to the west of our area of study, and in 1963 reported his findings in the Bulletin of the Geological Society of Turkey.

IV. STRATIGRAPHY

Main rocks in the area are Paleozoic schists and marbles; Jurassic - Lower Cretaceous marls with intercalated limestone series; Upper Cretaceous, flysch, marl, sandstone and limestone beds; Paleocene marine and continental series; Eocene conglomerates, sandstones and limestones; Miocene lake deposits; and finally Pliocene strata consisting mostly of gypsiferous series, plus basalts, andesites, obsidians, tuffs and agglomerates.

Paleozoic

Crystalline schist series, seen south of Nallihan and also between Karaköy and Sekli, probably belong to the Lower Paleozoic. A gneiss band (containing hornblende and biotite) lying to the north of Karaköy constitutes the lowermost part of the series. Occasional marble layers and lenses are encountered in these gneiss beds. Their southern contacts with andesites are faulted, while in the north they are overlain by Jurassic limestones and andesites.

The brown, green, gray and often little metamorphosed crystalline schists (sericite-schists, mica-schists, graphite-schists, chlorite-albiteschists, quartz-albite-chloriteschists) strike NE-SW.

Marbles are predominant in crystalline schists lying to the south of Nallihan. They are of dark brown and gray color and covered by Paleocene layers.

Mesozoic

Jurassic- — Lower layers of the thick limestone series, stretching from Nallihan in the south through to Keltepe in the east, are of Jurassic age. Because of tectonic disturbances, it is difficult to separate Jurassic from the Lower Cretaceous. However, yellow limestone beds containing thin green layers of marl with Ammonites definitely belong to the Jurassic.

Jurassic limestone strata mostly strike E-W and dip 30°-50° north. In the marls and limestones, which contain yellow sands, such fossils as Perisphinctidae — Dogger - Malm, *Neocomites* sp. (probably *Neocomites benecke* (Jac.)) — Tithonian, *Berriasella* sp. gr. *aizyensis*? Mazenot — Upper Tithonian, are located.

J. Rondot found Jurassic Ammonites on the skirts of Keltepe as well as :

- Ataxioceras and Lamellapycus — Upper Jurassic
- Lithacoceras* gr. *ardescicus* Fontannes
- Lithacoceras* gr. *ernesti* de Loriol
- Lithacoceras* sp. — Lower Kimmeridgian
- Biplices* sp. (approaching *B. tiziani* Opper)
- Planites* sp. (resembling *P. ernesti*) — probably Sequanian

in limestones containing yellow sands and green marls, in the valley to the north of Nallihan.

Lower Cretaceous. — Separation of the Lower Cretaceous from the overlying Jurassic is difficult. In a number of places, however, white and compact limestones of the Lower Cretaceous help separating the series from the Jurassic.

Lower Cretaceous usually comprises well-stratified sandy limestones, white and yellow in color, intercalated with marly beds. This series, which sometimes appears in the form of thin pink or yellow layers, is in conformity with the overlying Jurassic.

Lower Cretaceous limestones, outcropping in the north and south of the Karakiriş Mountain, are easily recognized because of their white color and their protruding appearance in the flysch. They are overlain by the thick conglomerates of the Upper Cretaceous. These limestones contain :

- Berriasella
- Macroscaphites yvani* d'Orbigny
- Desmoceras difficile* d'Orbigny — Barremian

In the neighborhood of Aladağ Stream, north of Dudaş village, a thick limestone massif is visible. Beds here mostly strike E-W and dip 40°-50° north. In this limestone series, approximately 1500 m thick, V. Stchepinsky found :

- Macroscaphites yvani* d'Orbigny — Barremian

White crystalline limestones and yellow marly limestones on the Akkaya Mountain, situated in the northwest of our area, likewise belong to the Lower Cretaceous.

The same limestones are found in the north, between Çirkinler and Kösem, and west of Çirkinler they underlie the basal conglomerates of the Upper Cretaceous flysch.

A thick limestone series outcrops in the north between Kızılgölcük and Ekincik, and also white compact Lower Cretaceous limestones outcrop between Hatipler and Ardıçdağ.

Upper Cretaceous. — The Upper Cretaceous formations, which occur extensively in our area of study, begin at the bottom with a coarse-grained conglomerate roughly 100 meters thick. This conglomerate is visible overlying Lower Cretaceous limestones to the south and north of Karakiriş Mountain, north of Halakayası. Sandstone strata come on top of the coarse-grained conglomerate. Green and gray-colored marl layers are lodged in the sandstone series, showing a variable thickness. This series, as a whole generally called a conglomeratic flysch, underlies a flysch series of intercalated limestone, marl and sandstone sediments. A marly series, which can be separately shown on the map, overlies this series and in turn is overlain by a Maestrichtian sandstone series.

In addition to these, part of the white sandstones encountered in the northern section of the area of study is regarded as Upper Cretaceous.

Thickness of the flysch which constitutes the basal part of marl and sandstone series changes from place to place. It is thicker where the overlying marl and sandstone layers are thin, and thinner where these latter are thick.

a. Flysch series

In many places in the area, such as north and south of Karakiriş Mt., south of the village of Çiğ, and north of Nallıhan, a thick conglomerate series, which also contains Jurassic and Lower Cretaceous limestone pebbles, overlies the Lower Cretaceous limestone formations. The age of this flysch series may reach as far up as Campanian.

Within the valley where Köşözü hot spring is located, J. Rondot found in flysch containing sandstones, marls and limestones :

Inoceramus balticus Bohm
Inoceramus siccensis Perquinviere — Santonian

Marls conformably overlie this series, which has a general NE-SW strike and dips south.

In the western part of our area of study, some 2 km to the north of the village Kabaca, flysch containing sandstones plunges 30°-35° toward southeast, underneath marl beds. Fossils collected from this locality are :

Globotruncana cf. *area* Cushman
Globigerina sp. — Turonian - Senonian

Quite a few Gryphaea fragments were found in flysch, west of Yeni Bozyaka village.

Robulus munsteri Roemer
Robulus rotulata Lamarck — Senonian

were located in flysch overlying Lower Cretaceous strata, south of Çiğköy.

b. Marl series (Campanian)

This series, widespread in the area, usually shows little variation and contains few fossils.

The series, stretching up to the north of Nallıhan and to Seben, displays numerous outcrops within the area defined by Hoçaş, Sarıkaya, Bozyaka, Çomaklar, Seben and Tepeköy.

These marls of gray and blue color, which outcrop over a wide area in the north, between Odabaşı and Tepeören, unconformably overlie flysch series underneath.

Wide marl series in the plain of Seben show no variation and contain no fossils.

Marls overlying the flysch at Çiğköy contain the fossils given below:

Nodosaria raphanistra Linne

Robulus munsteri Roemer

Planularia sp.

Ammodiscus incertus (d'Orb.)

Anomalina sp.

Cibicides sp. — Campanian - Maestrichtian

J. Rondot found :

Hemiaster madagascariensis Cottreau — Upper Campanian

in blue marls overlying flysch with sandstones, south of Emincik village.

c. Sajidstone series (Maestrichtian)

The sandstone series which overlies the marl series can be followed along a SW-NE stretch from Bozyaka to the north of Seben. Sandstones striking NE-SW dip 20°-25° SE. These series are not very thick and contain thin marl layers.

Sandstone series stretching in the south from Soyran to Dudaş once more outcrops in the northern section of the area, near Hacıhasan village. This series is rich in fossils throughout its extent.

Gryphaea (pyncnodonta) vesicularis Lamarck was found in sandstone strata that overlie marls, west of Bozyaka.

From the richly fossiliferous sandstones overlying marls, west of Kızılöz, came the following:

Pecten (Neithea) indet.

cf. *Pholadomya (Liopistha)*

Gryphaea (Pyncnodonta) vesicularis Lamarck

Gryphaea (Pyncnodonta) nov. sp. — Maestrichtian

and as microfossils :

Orbitoides media (d'Archiac)

Siderolites — Campanian - Maestrichtian

Upper Cretaceous limestone series.— In the northern parts white, gray and pink limestone layers of considerable thickness are found within and sometimes overlying marl series.

A part of these limestones with ages varying from Senomanian to Maestrichtian was previously thought to be of early Cretaceous, while another part was viewed with the flysch.

The fossils below were located in light tan-colored limestones immediately north of our area of study, between Bakırlı and Çiftçiköy :

Globotruncana fornicata Plummer
Globotruncana calcarata Cush.
Globotruncana lapparenti lapparenti Bolli
Globotruncana lapparenti tricarinata (Quer.)
Gumbelina globulosa Ehren.

— Santonian - Campanian

These limestones are strongly dislocated and a fault line separates them from serpentines in the north.

Globotruncana fornicata Plummer

— Santonian - Campanian

is also found in limestone strata, pink on the outside and gray on the inside, lying close to the upper layers of flysch which on the south of Çiftçiköy strike N 60°E and dip 30°SE.

In the limestones of light tan and gray color, which lie in the Upper Cretaceous marls, north of Pelitcik situated on the Bolu - Mudurnu highway, are found :

Globotruncana fornicata Plummer
Globotruncana lapparenti tricarinata (Quer.)

— Santonian - Campanian

Likewise, yellowish beige limestones, south of Hasanlar, are seen to overlie marls and these limestones are found to contain :

Siderolites sp.
Lepidorbitoides sp.
Nodosaria sp.
Textularia sp.

— Maestrichtian

Paleocene

To the north of our area of study, between Kırık and Akkaya Tepe and, coming a little southward, between Mandır and Müşir, well - stratified limestones are seen to overlie Maestrichtian sandstones. Although this marine Paleocene series is generally represented by limestones, marl and sandy clay beds are present in the lower sections.

The following fossils were reported from the limestones, south of Mandır :

Laffiteina bibensis Marie
Triloculina
Quinqueloculina
Sigmoidina

— Montian

Continental Paleocene formations

The continental series represented with red and green rocks, which were previously thought by V. Stchepinsky and J. Rondot to be of the Oligocene age, are now, in the light of recent investigations, believed to belong to the Paleocene.

Intercalated volcanic material is found in thin series, which covers a strip of land roughly 15 km long and 10 km wide stretching eastward from Nallihan in the area of study. These red sediments are also found at several places within the Bozyaka-Mandır syncline, wherever they escaped erosion. They mainly consist of conglomerates, sandstones, clays and marls. The red clays at the bottom of the series' contain gypsum and also lignite. In the east of Nallihan, the thickness of these strata reaches and surpasses 2000 meters. Here volcanic rocks are abundant.

Ş. Abdüsselamoğlu, who carried out geological work just west of our area, reported the presence of fossiliferous Eocene strata overlying red - colored detritic series between the villages of Ahiler and Akçakavak, in a locality situated in the north of Sefilköy, 13 km to the southwest of Taraklı. In addition, S. Ürgün found Upper Paleocene fossils in limestones forming the upper parts of the red series in the Pırlar village syncline, south of Taraklı.

As no Paleocene - Eocene relation is observed in our area of study, we have based our age determination of the red detritic series, which we take to belong to the Paleocene, upon characteristics reflected by such a relation observed just west of our area.

Microscopic study of sections made from sandy marl specimens brought in from the series in the vicinity of Bekleme, lying southeast of Nallihan, revealed such fossils as:

Chara (mostly sections of Oogonium)

Ostracod shell sections

Although these fossils do not help in determining age, they, however, indicate that the series in question was deposited either in fresh or only slightly salty water.

Eocene

In our area Eocene shows small outcrops in the north of Çiğköy and west of Akkaya Tepe. In the north of Çiğköy, Eocene formations lie on top of Maestrichtian sandstones forming an angular discordance with these latter. Here they include red clays on the bottom and layers of sandstone as we come upward. This series is overlain by white and yellowish limestones and contains :

Nummulites perforates Denys de Montfort

Nummulites millecaput Boubée

Nummulites globulus Leymerie

Assilina exponens Sowerby

— Lutetian

To the north of this Eocene series a second one outcrops, composed of only red clays and conglomeratic sandstones.

Limestones are predominant in the Eocene strata, west of Akkaya Tepe. Here they are about 100 meters thick and beneath them lie sandy clays. This series unconformably overlies the Upper Cretaceous.

Neogene

In our area of study Neogene is represented by Miocene and Pliocene formations. Miocene; a) limy series (conglomerate, marl, sandstone);

- b) argillaceous marly series containing sandstone;
- c) volcanic Miocene (obsidian, pitchstone, tuff and conglomerate intercalations).

- Pliocene : a) series containing gypsum (conglomerate, sand, loosely cemented sandstone, marl);
- b) yellow series with sandstone.

Miocene

Miocene unconformably overlies older formations. With layers striking E-W and dipping 10°-15° north in the vicinity of Hırka and Köriş villages, west of Beypazarı, bottom part of the Miocene here is a conglomerate. Overlying yellow sand and sandstone layers bear lignite seams. This series continues eastward in the marl and limestone facies. The upper layers end up with sediments intercalated with volcanic materials. Tuffs of various colors, agglomerates and andesites are encountered among the Miocene sandstone, marl and limestone formations between Nuhhoca and Bahçeköy, to the north of Keltepe in the west, north and west of Davutoğlan; the series is formed of alternating layers of pink and brown clay, marl and sandstone. Miocene Gastropods are present everywhere in this series.

Pliocene

To the east of Davutoğlan, Miocene marls and limestones are unconformably overlain by sand and loose sandstone beds. Thick gypsum layers form the upper part of the series which here and there contain marl deposits.

Coarse-grained Pliocene basal conglomerates with material including volcanic rock pebbles form a brown layer, about 20 meters thick, and overlie Miocene marls and limestones south of Beypazarı, right at the southeast corner of our area of study. Covering the conglomerate is a layer of very loosely cemented sandstone about 1 meter thick, followed by thick gypsum strata.

According to P. de Tchihatcheff, this series contained *Melanopsis costata*.

A second Pliocene series is a yellow-colored sandstone formation lying between Soyran and Kızılöz villages, east of Nallıhan and also around the Kürdümeni Mountain. These unconformably overlie older formations.

Alluvium

Alluvial deposits are located in the Başağaç valley, west of Beypazarı, along the southern portion of the Aladağ Stream, west of Davutoğlan and along the course of the river called Nallidere running through Nallıhan and also in the vicinity of Seben.

VOLCANIC ACTIVITIES

Volcanic rocks belonging to the Tertiary nearly cover the entire northeastern portion of our area of study. These volcanic rocks, represented by tuffs, agglomerates, andesites, basalts and obsidians, are intercrossed and well-mingled with Neogene sediments forming several zones.

In addition, andesites and dacitic tuffs covered with Miocene layers overlie Paleozoic schists at Karaköy, in the south of the area under study. Dacites and an-

desites are seen under the Miocene at Karaköy and have a contact zone with Jurassic further up north. Although strong alteration due to weathering, plus burial under loose materials which cover underlying formations, make any reliable direct examination impracticable, we are inclined to believe that Karaköy series date from a period earlier than Miocene, probably late Mesozoic. That submarine eruptions coupled with basalt flows occurred during the late Cretaceous over a wide area including the one we study, is a fact long since known.

Paleocene volcanic series

During the Paleocene time volcanic activities were comparatively more intensive, as deduced from the considerable thickness of agglomerates, basalts and andesites. Basalt flows appear to have come out of a fault zone between Jurassic and Paleocene formations, north of Nallıhan, whereas in the south and southeast of Nallıhan andesites are found located in more than one horizon within continental Paleocene layers. More to the east basalts are observed.

Neogene volcanic series

The fact that andesite, agglomerate, tuff and basalt series, widespread over a large northeastern portion of our area, are found intercalated with lava flows and tuffs in the Neogene sediments is indicative of these former belonging to the Neogene.

First basalt flows were not very thick. Over these came thick layers of andesitic tuffs, agglomerate and lava flows followed by obsidian, pitchstone and final basalt flows, thus closing the volcanic phase in the district.

Tuff and agglomerate series reaching considerable thicknesses overlie Upper Cretaceous, northeast of Seben. Here white-colored tuffs and agglomerates are in an intercalated position. Tuff, gray-colored coarse-grained cinerite and disintegrated basalt layers follow one another. Tuffs here and there show good stratification. This series is overlain by a thick bed of andesite.

In Beypazari pebbles and gravels are found dispersed in white and red tuffs. Thick lava series between Köroğlu Mountain and Kartalkaya are seen to have reached the surface along a crack stretching NW-SE (J. Rondot).

Main components of the thick andesite massif are andesites, basalts, andesitic basalts and basaltic andesites.

TECTONICS AND PALEOGEOGRAPHY

The oldest rocks in the area of study are perhaps those of a metamorphic series belonging to the Lower Paleozoic. It is not possible to set a definite age for metamorphic rocks resulted from the local metamorphosis undergone at the beginning by sedimentary rocks in the Paleozoic geosyncline, which comprise sandstones, marls, limestones, clays and conglomerates. This series probably was folded during the early part of the Variscan orogeny. Alpine orogeny brought kratogenic changes on the metamorphic series.

According to V. Stchepinsky, the area stayed above sea until the Oxfordian epoch. During the late Jurassic, the sea invaded this region and for a long period, including the early Cretaceous, the area remained submerged, when a thick layer of

limestone was formed. The region which emerged from the sea in the course of the Austic orogenic phase of the late Cretaceous was subsequently invaded by this former, causing intermittent flysch deposition followed by sublittoral marl and sandstone sedimentation. Montian marls and limestones are also a product of this time. Formation during the Upper Cretaceous period of different horizons of conglomerates, sandstones, marls, limestones and lavas shows that the sea level kept fluctuating up and down, coupled with submarine eruptions.

After the last limestone deposition during the Montian, began the Laramian orogeny and the entire region once more came above the sea. In lakes, which filled the low-lying areas, formed subsequent to Laramian orogeny, lake deposits started to accumulate with increasing speed, resulting in a thick red detritic formation. This red formation, which we accept to date from the Paleocene, is encountered particularly in depression areas between Bozyaka and Mandır and also between Nallıhan and Sekli. In the meantime faulting occurred along the edges of these depression areas or basins and volcanic material, which escaped through, penetrated the formation in question.

Later Eocene sea once again flooded these red formations. Eocene sediments in our area of study are more abundant in the northern and western parts. They are represented by the Lutetian formations and form an angular discordance overlying the Upper Cretaceous in the north of Çiğköy. After the Lutetian the sea was drained away from the area (Pyrenean orogenic phase).

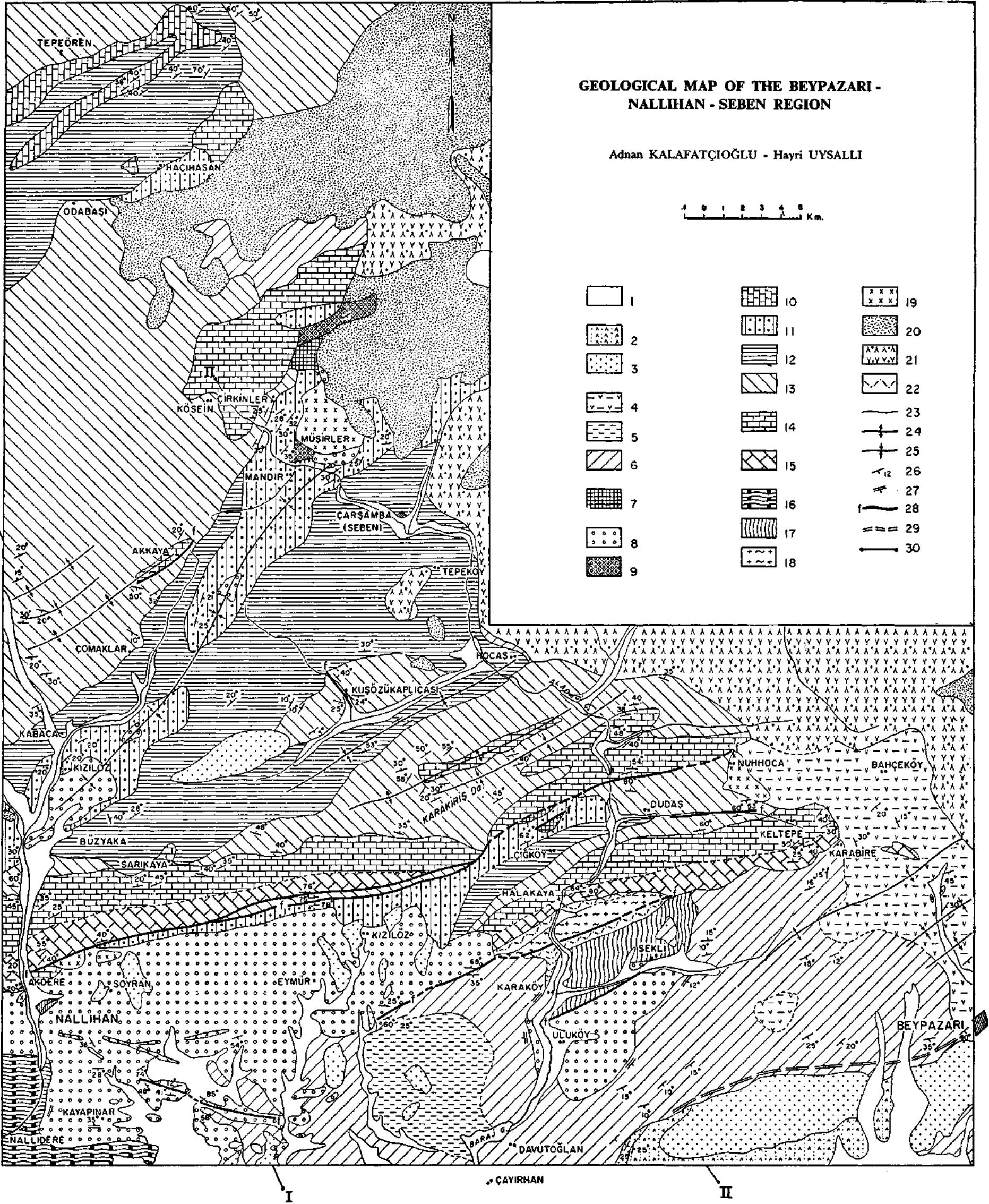
This orogenic phase was followed by erosion, Miocene deposition in the lakes, slackening period, and volcanism. After the close of the Attic phase, Pliocene conglomerates, loose sandstones, marls and thick layers of gypsum were deposited. Well-known Beypazarı-Çayırhan flexure occurred during tectonic movements which took place subsequently (Wallachian phase). This flexure was caused under thrusting forces directed from the north and northwest.

Faults

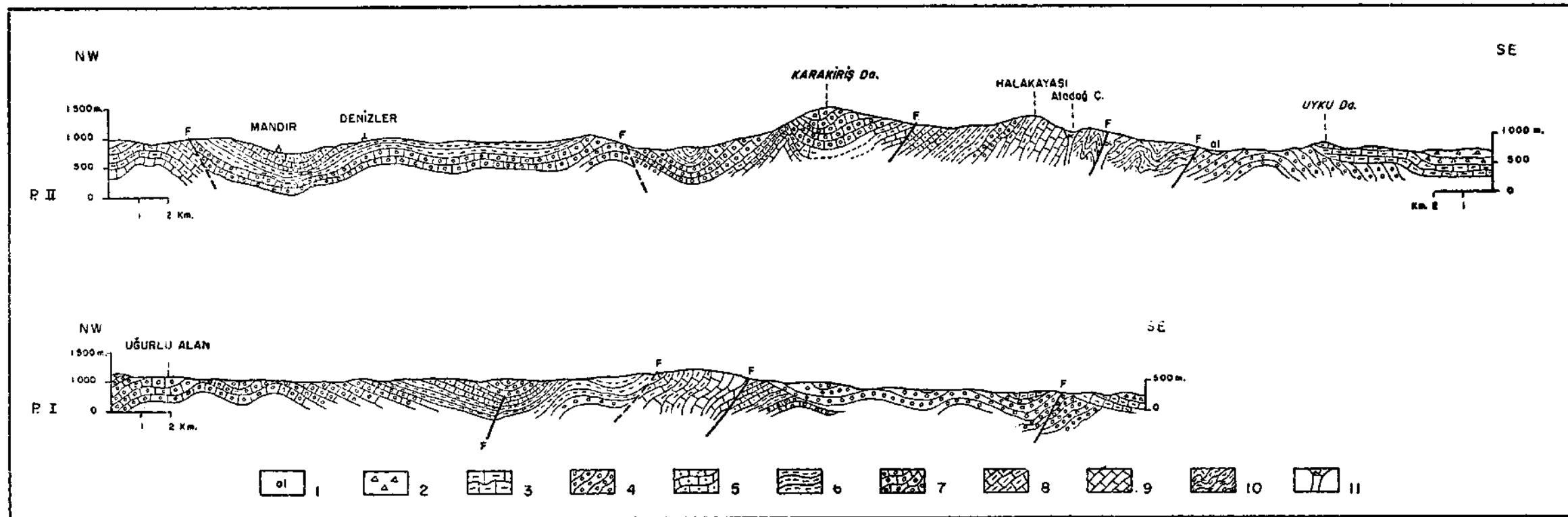
Fault line through Akkaya Mt. — Here Lower Cretaceous limestones display a normal contact with Upper Cretaceous flysch. Direction of the fault is SW-NE.

Nallıhan-Nuhhoca fault. — This fault is the major one in our area of study. It originates just north of Nallıhan; runs through Eymür and Emincik up to Nuhhoca and disappears under the andesites. From the fault cracks between the Jurassic and Paleocene and between the Lower Cretaceous and Jurassic, north of Nallıhan, basalt flows are found to have reached the surface. In the north of Soyran, Jurassic limestones dipping 40° NW overlie Upper Cretaceous sandstone beds. There we have a reversed fault. Reversed faulting is also observed at the contact of Jurassic and Upper Cretaceous flysch in the north and at the contact of Maestrichtian and flysch in the south. Further to the east, toward Nuhhoca, Lower Cretaceous limestones and Upper Cretaceous flysch likewise come in contact which should be termed abnormal.

Displacement at Köşözü hot springs. — This fault running NW-SE does not show a big throw. Vertical displacement measures 100-150 meters, while the horizontal one is only about 20 meters. Mylonite is found in the valley. Angles of dip of flysch formations on the two sides of the valley differ widely.



1 - Alluvium 2 - Gypsiferous series (upper series) - Pliocene; 3 - Conglomerate, sand, marl, loosely cemented sandstone (lower series) - Pliocene; 4 - Volcanic series (marl, limestone, clay, agglomerate, tuff, obsidian) - Miocene; 5 - Marl, sandstone (marl predominant) - Miocene; 6 - Limestone, marl, conglomerate, clay, sandstone, lignite - Miocene; 7 - Red-colored conglomerate, clay, sandstone, yellowish limestone containing Nummulites - Eocene (Lutetian); 8 - Conglomerate, sandstone, marl, clay (continental series with red and green volcanic intercalations) - Paleocene; 9 - Limestone with intercalations of thin marl and sandstone layers - Paleocene; 10 - Limestone - Upper Cretaceous (Campanian-Maestrichtian); 11 - Sandstone - Upper Cretaceous (Campanian-Maestrichtian); 12 - Marl - Upper Cretaceous (Campanian-Maestrichtian); 13 - Flysch (conglomerate, sandstone, marl, limestone and sandy limestone) - Upper Cretaceous (Campanian-Maestrichtian); 14 - Limestone (with thin marl layers) - Lower Cretaceous; 15 - Limestone and sandy limestone (with fine green-colored marl and sandy marl intercalations) - Jurassic; 16 - Schist-marble - Paleozoic; 17 - Mica-schist, slightly metamorphosed schists - Paleozoic; 18 - Gneiss, marble - Paleozoic; 19 - Basalt; 20 - Andesite; 21 - Tuff and agglomerate; 22 - Andesite and agglomerate (Karaköy series); 23 - Formation border; 24 - Anticline axis; 25 - Syncline axis; 26 - Strike and dip; 27 - Lignite outcrop; 28 - Fault; 29 - Flexure; 30 - Geologic profile.



GEOLOGICAL SECTIONS FROM THE BEYPAZARI - NALLIHAN - SEBEN REGION

- 1 - Alluvium; 2 - Pliocene: sandstone, marl, gypsum; 3 - Miocene: conglomerate, marl, sandstone, limestone; 4 - Paleocene: continental series (conglomerate, clay, sandstone, marl);
 5 - Upper Cretaceous: sandstone series; 6 - Upper Cretaceous: marl series; 7 - Upper Cretaceous: flysch series; 8 - Lower Cretaceous (limestone);
 9 - Jurassic: marl - limestone; 10 - Paleozoic: schist; 11 - Andesite.

Fault lying to the south of Akçe- — It runs in the general direction of SW-NE. This normal depression fault seen in the west, between Paleocene and Miocene, continues in the east between Karaköy andesites and gneisses.

Fault lying south of Bekleme. — Running NW-SE, this fault stays within Paleocene formations.

Beypazari flexure. — It runs WSW-ENE. It is the result of a thrust coming from north and northeast on the Miocene limestones, marls and Pliocene gypsum beds, which turned almost vertical under the effect of this thrust.

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