GEOLOGY OF EASTERN AND SOUTHEASTERN ANATOLIA

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INTRODUCTION. — The geological sheets to a scale of 1:100,000, mostly accompanied by professional reports, accomplished since the creation of the Mineral Research and Exploration Institute of Turkey (M.T.A. in short and in Turkish), are at present intended for a Geologic Map of Turkey to a scale of 1:500,000 in 21 sheets. Since 1954 the present author spent two years for each of the Van, Cizre and Erzurum sheets, doing actual field investigation, control, correlation, and compilation. The results now permit a comprehensive short paper for Eastern and Southeastern Anatolia, organized according to the known structural regions, which lays the foundations for detailed stratigraphic and structural future investigations. The writer is most indebted to the authorities of the M.T.A. Institute for assigning to him the study of this highly intricate and little known sector of the country, as well as for permitting him to publish the results in a reorganized form.

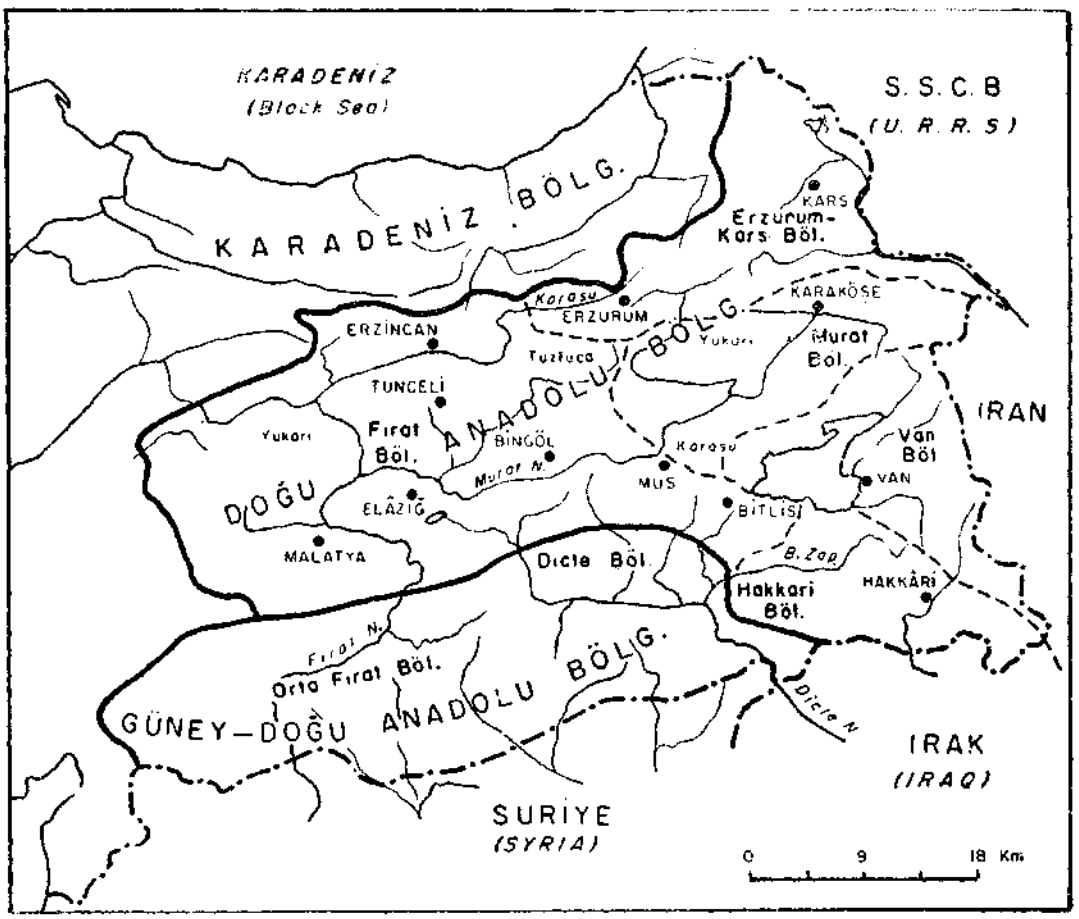
The accompanying black and white geologic and tectonic maps need to be colored for better understanding. A long and irregular strip is missing in the base maps to the NE of Siirt province, and furthermore an offset is involved; these gaps must be taken into consideration in reading the geologic and tectonic maps, where the link is processed by dotted lines.

GEOGRAPHY

General

The accompanying sketch map shows the natural regions and districts; almost the whole of the Eastern Anatolian region together with Upper Fırat (Euphrates) district, Erzurum - Kars district, Upper Murat district, Van district and Hakkari district, and the northern sector of the Southeastern Anatolian region together with Middle Fırat district, Dicle (Tigris) district enter into the area under discussion. The relative boundary lines of these units differ only in detail according to different authors.

Orography: In the main, the area under consideration is made up in the north of the lofty Eastern Taurus, which starts from the eastern bank of Zamanti River, and in the south of a comparatively level plateau and then a plain. As the country is highly rugged and the sceneries are changeable, multiple geological associations are involved in a variety of structural intricacies, and consequently the pattern of the land forms could be deciphered only after the stratigraphic and structural geology had been worked out. The key lies in an alternate pattern of the structural highs and lows, which correspond with the topographic highs and lows, shown respectively as divides and plains («ova» in Turkish). Beginning from north" there are, respectively, the twin arcs of the Internal Eastern Taurus, again the twin arcs of the External Eastern Taurus, and then a few rows making up the Southeastern Taurus. The most northern arc nearly parallels the Black Sea's main divide. The longitudinal mountain chains display salients and recesses. The troughs are divided by axial lows and axial highs into topographic depressions. The axial highs make transverse low divides, hereinafter called thresholds. On



Eastern and Southeastern Anatolian Regions.

the accompanying Orographic and Hydrographic Map to a scale of 1:500,000 the alternate divides and troughs are shown as follows:

— Aşkale Ovası - Erzurum Ovası - Pasinler Ovası.

— Akdağ (2710 m), Mayram (2260 m), Güller (2550 m), Palandöken (2974 m), Taşkom (2700 m), Ziyaret (3000m), Hama (3243 m), Büyük Ağrı (5163m), Küçük Ağrı (3925 m): External Arc of Internal Eastern Taurus.

— Erzincan Ovası - Tercan Ovası - Söylemez Ovası - Ağrı Ovası - Doğubeyazıt Ovası.

— Munzur (3250 m), Bağırbaba (3282 m), Bingöl (3650 m), Katavin, Muratbaşı (3519 m), Tendürek (3542): Internal Arc of Internal Eastern Taurus.

— Ovacık Ovası - Pertek Ovası - Karlıova Ovası - Varto Ovası - Patnos Ovası - Çaldıran Ovası.

— Pokir (2460 m), Sancak (2282 m), Şerafeddin, Süphan (4454 m), İrerini (2250 m), İsabey (3000 m), Çilli (2710m): External Arc of External Eastern Taurus.

— Elazığ Ovası-Bingöl Ovası - Muş Ovası-Van Lake (1720 m), Erçek Lake (1890 m), Özalp Ovası.

— Hazarbaba, Akdağ (2561 m), Supuluz (2200 m), Haçreş (2350 m), Karz, Vaviran (3000m), İspiriz (3587m), Hırabit (3350m), Mirömer (2730 m): Internal Arc of External Eastern Taurus.

— Ergani Ovası - Dicle Ovası - Hani Ovası - Gürpınar Ovası - Başkale Ovası.

— Herakol (2943 m), Körkandil (3831 m), Katumihent (3000 m), Kelamerik (3250 m), Mur (3810 m): Internal Arc of Southeastern Taurus.

— Kasrik Ovası - Hakkari Ovası - Yüksekova Ovası.

— Cudi (2089 m), Tanin (3049 m), Geliaşin (4168 m): Middle Arc of Southeastern Taurus.

— Şemdinli depression.

— Garanda (2250 m), Karadağ (3331 m): External Arc of Southeastern Taurus.

A trip from Elazığ to Diyarbakır is enough to convince one that the structure conforms the morphology and where Hazar Lake gives the impression of a future plain. In the south lies the Diyarbakır-Siirt plateau, which is a part of the Syrian - Arabian platform.

Hydrography: The early drainage, which conformed with the late Tertiary features, evolved intricately to give the present picture and be of integrated type. The process has also modified the trends of the mountain ranges. The rivers in the highlands have steep profiles and are deeply entrenched, swift, tumultuous, clear and foamy. They are mainly fed through melting snow and springs. Their discharge oscillates highly with seasons.

The longitudinal sectors are long, the transversal ones short. Sudden bends at right angles characterize the stream captures. The streams are narrow and not alluviated in the highlands, but are widely alluviated along the lowlands, where they occasionally form wide plains (ova). A few branch streams display braided channels, which are dry arroyos in summer. Behind the narrow gorges are large slant - surfaced terrace flats. The passageways for wind currents influence locally the regime of the rain and temperature. The catchment areas are separated by right - angled thresholds, which also have separated the plains. All the streams are actively degrading the land, as they reached very low base levels. The mountain glaciation did not change the drainage pattern.

There is the upper course of the Aras (Araxes) River in the northeast. West of it is the Murat River, a large tributary of the Fırat River. The brooks joining Dicle and starting from east are Şemdinli, Rübarşin, Zap and Büyük Zap, Habur, Hezil, Botan, Başor, Garzan and Batman. The running waters reaching Van depression make large streams only in the east.

There are altogether 28 large and small lakes on the Van Sheet. Those of noteworthy size are: Van (1720 m), Erçek (1890 m), Balık (2241 m), Nazik (1870 m), Nemrut (2400 m), Haçlı (1500 m), Arın (1725 m). The Erzurum Sheet exhibits Hazar (1155 m), and Hamurpet.

Climate: Over the highlands in the north dominate strong continental and subtropical mountain climate. Local conditions may cause local climates, as for example the depressions which lie behind the gorges through which damp winds from the south are maintained at plateau and high plateau climate. The lowlands in the south have

a subtropical climate, approaching that of the Mediterranean area, which is manifested by a mediterranean precipitation regime. There the minimum precipitation is in winter, and the lower the land, the less snow and rain in the winter. In spite of the local variations the orographic precipitation is conspicuous during the winter time. The winter period embraces October-April, and there are areas with winter of six months' duration. .The annual range of mean temperature is mostly greater than 25°C. The lowlands are subject to lesser extremes. The summer period between June - September is dry under a persistingly blue sky.

Glaciation: The terrane of Eastern Anatolia shows the effects of extensive glaciations. Living glaciers remain where peaks rise above the present level of perpetual snow, and much larger ones existed during the several glacial stages of the Pleistocene period. Ağrı Mountain displays the most spectacular glaciers. Over the Suphan peak the glacier descends to 3400 m, and has a tongue of 1.5 km long. Over Cilo and Sım Mountains tongues descend to 2800 m and have a maximum length of 4 km.

Vegetation: Plant associations change with local climate in an orderly progression from the highest peaks toward the lowlands. So there are successively alpine types and associations; forest and mild climate associations with pine forest at the extreme north; mediterranean plants at Iğdır in north and Diyarbakır-Siirt basin in south; the thicket over the slopes and steppe iff the lows; and eventually large barren stretches.

The natural limit of the forest lies high. It is adapted to meager precipitation and long winters; it is poor in species, and its dependant plant association is destitute. It is preserved far from the population centers. It is usable as fire wood, and the twigs of the oak trees are trimmed in autumn to supplement the ration of the herds.

Settlement and population: The area is mainly mountainous and its population is consequently mountaineers. The rough country and climate make the living hard. Settlements are scattered along the streams. The cities are small. The nomadism in highlands has declined together with its customs. The heat, the need for pasture make the summer residency obligatory, at least at the extreme east and south. The old domestic industries are being replaced by the modern ones. Hakkari province is the most thinly populated area of Turkey, and there are less than five persons per square kilometer. Near the larger population centers of the other provinces the rural density ranges from 30 to 40.

Agriculture: The severe long winters and the hot dry summers result in meager crops, of which 90 % are cereals. The mountaineers in far east and south cultivate millet, but millet is becoming less and less appreciated and so the tendency is toward barley and wheat. Tillable lands may reach 2400 m altitude. The gardening (vegetable and fruit) is concentrated near population centers. The irrigation difficulties are encountered as there are only antiquated waterways. A living strictly dependent on agriculture is possible in the west and over the large plains.

Stock raising: Sheep raising is almost a unique occupation in the far east and southeast, mainly due to a general lack of croplands. Cattle breeding is successful in the north, although there is difficulty in feeding the herds during the winter. The agriculture of the western and southern parts of the region is supplemented by stock raising, in varying proportions.

Means of transportation: Reaching into northeastern and southeastern parts of the region are two railroads and two surfaced roads. The old caravan tracts are either abandoned or modernized for truck transportation. The branch roads arc not abundant, as both their construction and maintainance are expensive. The traffic is lively in the west. Main arteries link the cities.

1. Eastern Anatolian Region

Erzurum-Kars District: This is a land of mountains and high plateaus. It has the most severe and long, but the least humid winter of Anatolia; its share of annual precipitation is 18 %. The spring is the most humid season with 35.4 %. The natural limit of the forest lies at an altitude of 2000 m. There are steppe-like depressions. Plains and plateaus, including croplands, total 5 %. Stock raising is superior to agriculture. Erzurum is a large antique city.

Upper Fırat District: An intricate association of mountains, plateaus and plains gives diversified scenery. The amount and regime of the precipitation differs locally. 22 % of the annual precipitation falls in winter, 40 % of it in springtime. The ground is frozen for a mean 116 days, beginning in October. The mountains are either oak forested or barren. The rural population predominates. Stock raising follows agriculture in importance. Elazığ is a lively city. Tunceli and Erzincan are sparsely settled.

Upper Murat District: This is a plateau land with steppe-like depressions. Although the area is arid, the streams flow abundantly. This is an area of least precipitation in Turkey. The croplands average 4-5 %. Cereals, tobacco and beets are grown in the Muş plain. The city of Muş is extending toward the recent railroad station at the brink of the plain.

d. Van District: The mean altitude averages 2200-2500 m Except for the Büyük Zap River all streams debouch into Van Lake. Important population groups are centered in the low-lying well-drained depressions. The climate is arid and severe, except on the slopes of Van Lake, where it is moderate. The city of Van is being modernized and developed.

Hakkari District: This is the most rugged district in all of Turkey. The precipitation is rather abundant during November and February - March; the dry season starts in June. The natural oak forest is thin and dry. Population density is greatest along the streams. The agricultural methods are yet primitive. There are artificial antique agricultural terraces provided with waterways, which are now abandoned. On the deep, flat - bottomed valleys and plains two different harvests are secured. Sheep raising is superior to the agriculture. There are trails, but no wheeled transportation is possible off the Van - Hakkari - Yüksekova highway.

2. Southeastern Anatolian Region

Dicle District and Middle Fırat District: The mountain chain's front is indented by aligned deep and narrow water gaps. Abundant water and favorable climate permitted a higher standard of living to be realized than in the Diyarbakır - Siirt lowlands. The county seats lie at the foot of the range, where the gardening of mediterranean vegetables and fruit is prospering.

PREVIOUS INVESTIGATIONS

The geology of Eastern and Southeastern Anatolia has been systematically investigated since the creation of the M.T.A. Institute in 1935. The work included reconnaissance mapping to a scale of 1:100,000 and physical prospecting of the underground resources, such as minerals, petroleum and combustibles. The first results were published in a preliminary «Geologic and Tectonic Map of Turkey» to a scale of 1:800,000 in 1941. It was planned in 1952 to build a more accurate Geologic and Tectonic Map of Turkey to a scale of 1:500,000, based upon elaborate field control. A comparative account of the accomplishments and shortcomings of the very many geologists go beyond the scope of this condensed account, intended as an overall picture of Van, Cizre and Erzurum sheets' accomplishments and contributions. There are comprehensive geological reports for Van, Cizre and Erzurum Sheets at the M.T.A. Institute's Archives, available for perusal for further details. The geology of Turkey is still being mapped only by systems rather than by formations that have a type locality, a type section and stratigraphic sections measured by instrumental traverses.

The discrepancies and misfittings in and between adjoining maps have been eliminated by changes made in the field and office during the compilation. The geologists who contributed to the exploration mapping on a scale of 1 : 100,000 have their reports accompanying their sheets or, on rare occasions, only their maps at the MTA's Archives. Titles of papers by the following authors are given in the bibliography, at the end of this account: Altınlı, Baykal, Bobeck, Chaput, Erentöz, Ericson, Erk, Foley, Gattinger, Holzer, Ketin, Kovenko, Lahn, Maxson, Mercier, Ortynski, Pamir, Rosier, Stchepinsky, Ternek, Topkaya, Tolun, Tromp, Türkünal, Wijkerslooth.

STRATIGRAPHIC GEOLOGY

The tectonic control of stratigraphy is striking in Eastern and Southeastern Anatolia. Each of the main and secondary belts had its own stratigraphic sequence, igneous history, metamorphism, orogenic and epirogenic movements and geomorphic evolution. That leads into a presentation of the stratigraphy and structural geology according to the following tectonic units (see the attached Tectonic Map of Eastern and Southeastern Turkey to a scale of 1 : 500,000) :

1. Massifs.
2. Eugeosyncline or Orthotectonic Region or Flysch region which is subdivided from south to north into: (a) Iranid (b) Taurid and (c) Anatolid components.
3. Miogeosyncline or Paratectonic region or Border folds region or Border trough.

1. The metamorphic rocks seen in the massifs of the eugeosynclinal region are not yet correlated with the fossiliferous sediments of the miogeosyncline. As the Permian limestone cover at places grades downward into mica-schists, these latter should not represent remnants of a shield. Correlations between different lithologies of the same age in the two tectonic regions are not wanting, for example interfingering is observable in the field between the Upper Jurassic - Turonian limestone in the miogeosyncline rocks with the flysch beds of Upper Cretaceous-Paleocene in the eugeosyncline region; again the latter is correlated with the Upper Cretaceous-Paleocene (Kermav for-

STRATIGRAPHIC TABLE OF THE EASTERN AND SOUTHEASTERN TURKEY

SYSTEM	FORMATION	THICKNESS (m)	OROGENIC PHASE	VOLCANISM	LITHOLOGY
PLEISTOCENE AND RECENT	Old and young alluvium, talus cone, slope waste, travertine, glaciation cirque, nivation	0-300	Pasadenic	Basalt, welded tuff, cinder cone	
PLIOCENE	Tahtreşa formation in the E	50-500	Wallachian	Basalt	Fluviatile conglomerate: flat pebbly sand, bedded and cross-bedded and poorly cemented predominates; marl and sandstone are subsidiary.
MIO-PLIOCENE	Siirt series in the SW Cizre series in the SE	500-1000 +1000		Andesite, basalt	There are marl, carbonate and fine detritals at the middle of the basin, eventually together with evaporites, but continental flood deposits are encountered at the periphery. The intrusive and exrusive volcanics abound in the highs and over the swells separating the basins.
	Horasan series in the NE	200-1000	Rhodanic: angular unconf. in the N, disconformity in the S		Thin-bedded and cross-bedded, poorly cemented, yellowish sand, alternating with soft marl and marly limestone containing biostromal *Congeria, Dreissensia,* Gastropods, etc.
LACUSTRINE UP. MIOCENE	Zap series in the SE	200			Basal pink-green marl is overlain by alternating fine and coarse detritals with intercalated travertine, travertinous limestone and marly nodular limestone interbeds.
MARINE LOWER-MIDDLE MIOCENE	Limestone: Silvan fm. in the S, Adilcevaz fm. in the NE	500-1000	Young Steiric: ang. unconf. in the N, disc. in the S	Hornblend andesite, pyroclastics, trachyte, rhyolite	Occasionally the thin base is red conglomerate, shale and limestone, overlain by a sequence of white, zoogene limestone.
	Molasse: Dicle fm. and Hazi member in the SE, Micinger fm. in the NE, Beygur series in the SE,	500-1000			Alternating green marl, fine limy sandstone with zoogene limestone interbeds; conglomerate is infrequent, but delta deposits make a member.
	Hozat fm.	1000			Alternating and grading green shale, siltstone, fine-textured limy sandstone with zoogene limestone interbeds, occasionally intertonguing with contemporaneous limestone sequence.
OLIGOCENE	Lagoonal: Tuzluca series	500	Savic: ang. unconf. in the N, disc. in the S	Basalt	Marine fossiliferous limestone or polygenic conglomerate at base; alternating with variegated clay, marl, pebbly limestone, conglomerate and evaporite.
	Marine: Hacisur fm.	50			Nodular and pebbly limestone is overlain by evenly packed limestone strata.
	Doğubeyazıt fm. in the NE	250	Pyrenean: ang. unconf. in the N, disc. in the S		Greenish, lensing, limy marl, siltstone and thin-bedded limestone is ovarlain by evenly packed white limestone strata.
	Bernuvaz fm. in the E	200			Mainly red, flysch-like, coarse detritals with a few limestone interbeds.
	Menkova fm. in the E	100			Detritals with impure or marly limestone interbeds are of shallower facies.
LUTETIAN	Tunceli flysch in the SW	1000		Andesite	Basal red conglomerate and marl; alternating red-green flysch beds with increasing limestone interbeds toward the top.
	Elâzığ fm. in the SW	1000			Alternating shale, marl, siltstone, sandstone include intertonguing or lensing limestones that become more frequent near the top.
	Midyat fm. in the SW	—1000			Occasional limestone or red, coarse detritals at the base; followed by creamy or white limestone. There are some discontinuous chalky horizons.
	Bedevi fm. in the SE	200	Van phase: ang. unconf. in the N, disc. in the S		There are either gray, fossiliferous *(Alveolina)* marl and limestone or alternating gray marl and limestone.
UP. PALEOCENE	Gercüş fm. in the S	—1000			Reds beds consist mainly of bedded conglomerate, but contain also lenticular sandstone, shale, marl, green-pink limestone.
	Beciriman limestone in the S	100			A sequence of pure, fossiliferous, bedded limestone is intertonguing with Kermav.
	Kermav fm. in the S	500			There are, successively, marly limestone; soft, thin-bedded, greenish flysch-like beds, and coarser, reddish transition beds with Gercüş.
UPPER CRETACEOUS-PALEOCENE	Hakkâri complex and Cilo member, Ersincan series, Penek conglomerate, Kırmızıköprü conglomerate, Maden series	2500		Synorogenic acid intrusion, continuous basic intrusion, initial magmatism	An orogenic flysch is complicated through effusion tectonics, turbidity current and gravitational tectonics. Red beds, various limestones and conglomerate predominate at places. Lagoonal facies is persistent for short episodes and over limited extents. The reworked ophiolites, mixed with sediments, constitute a complicated lithology. Cilo series is a complex formation represented by lenticular, white limestone, red radiolarite and greenstone, sedimented in miogeosynclinle and ortho- geosyncline.
			Austric phase: ang. unconf. in the N, disc. in the S		
LOWER CRETACEOUS	Kop fm. in the N	500			There are, successively, white limestone, flysch beds, greenish-purpliah limestone.
	Munzur limestone in the N	1000	Subhercynian: ang. unconf. in the N		Gray-white, thick-bedded, dense, angular-conchoidal fracturing, partly dissolved limestone sequence.
UPPER JURASSIC-TURONIAN	Cudi group (massive limestone to the W of the map area)	500-2500		Some intrusive diabase	At Cudi Mountain a uniform sequence of black, fetid, coarsely textured, sparsely fossiliferous, thickly bedded, dense limestone weathers into brown hues.
MALM		400	Young Cimmeric: ang. unconf. in the N, disc. in the S		At Hazro there are, successively, marly limestone, unfossiliferous fetid limestone; Middle-Upper Jurassic limestone; bedded limestone; zoogene Turonian limestone.
			Dogger: ang. unconf. in the N		Over the Anatolids, thin- to thick-bedded, sandy and pebbly limestone is found together with detritals.
LIAS		2000			Over the Anatolids, the flysch beds contain limestone interbeds.
TRIAS	Goyan fm.	500	Old cimmeric: ang. unconf in the N		Alternating sandstone and limestone at base; then green, gray, red marl alternating with cream-white, smothered surfaced and ripple-marked limestone and yellowish, foliated shale; then gray laminated marl and thin-bedded limestone in gradational transition with the overlying system.
PERMIAN	Arabi fm. in the E	500	Pfalz: ang. Unconf. in the N, disc. in the S		A continuous and uniform, gray thin-to thick-bedded, seldom laminated and cherty limestone cover over the massifs is partly dissolved, crystallized and eroded. There are, at places, gradational beds with the underlying mica-schists made up of closely alternating limestone, quartzite and mica-schists.
PERMO-CARBONIFEROUS	Tanin fm. in the SE	—2000			Gray-black, evenly thin- to thick-bedded, regularly packed limestone; fetid limestone and black bituminous shale.
	Marine beds in the NE	+100	Asturic: disc. in the S and N		The lower section of the Permian limestone is possibly Carboniferous.
CARBONIFEROUS	Lacustrine beds in the S (Hazro)	+100 (500 at Hazro)	Bretonic: disc. in the S and N		A regular sequence is made up of gray-black limestone and clayey slate.
DEVONIAN	Şoke fm. in the SE	200		Rare dacite, spilite and intrusives in NE	Black, weathering slate contains smothered surfaced, limy shale and marly limestone interbeds. Alternating limestone and quartzite are lincreasing at the top and make up the transition beds with Permo-Carboniferous.
	Aras basin in the NE	200			Conformable, black, foliated graywacke with quartzite and limestone interbeds belong possibly to Devonian.
	Hazro in the SE	100			Marl, bituminous sandstone, clay fossiliferous sand limestone.
SILURIAN	Giri fm.	1000	Ardennic: disc. in the N and S	Acid tuff, intrusive diabase	Mainly gray-red-purple, coarsely grained, continuously thick-bedded, regularly packed quartzite; and subsidiary lenses of psammite, marl, limestone.
CAMBRIAN (?)		100	(?) Sardonic: disc. in the S		Black, thin-to thick-bedded, laminated, cataclastic, dissolved and crystallized limestone.
PRE-PERMIAN	Old massifs	several 1000	Caledonian and Variscan movements	Acid and basic intrusives and extrusives	Core of garnet-, amphibolite-, biotite-schists and amphibolite and gneiss; it is overlain by a shell of various slates, phyllites and crystallized lensig limestone.

mation) of the miogeosyncline region. Thus the crystalline schists of the massifs could be equivalent to rocks of the Caledonian and Variscan geosynclines in the Border trough.

2. Within the eugcosyncline region the environmental conditions of deposition vary from place to place during the same geologic period, and so the same sedimentary unit changes lithology from one place to another. Intertonguing and lensing of the bedding and the sequences are usual. Angular unconformities are common. Igneous phases are of moment. Intense stresses made similar-type folds. Rock cleavage and foliation are evolved. Faulting and overthrusting are outstanding. Morphology is of second order, i.e. the eroded mountain chains are rejuvenated through subsequent morphogenic uplift.

3. Within the miogeosyncline region the environmental conditions made lithologies more persistent and therefore bedding and sequence more uniform over large areas. Intertonguing and lensing are less common. Disconformities are the rule. Igneous activity is wanting or very slightly manifested. Gentle folding caused concentric buckling. Faulting is superficial. Morphology is of the first order.

The Block-faulted region is near the southeastern corner of the map area, i.e. to the south of Çermik county.

The systems, the differenciated formations, the thicknesses, the orogenic phases, the igneous activities are offered in the accompanying Stratigraphic Table.

METAMORHIC ROCKS MASSIFS

Bitlis massif is the largest and it stretches over the sheets of Van-Cizre-Erzurum, making the backbone of Eastern Anatolia. Smaller massifs in the Van sheet are Özalp, Sarıgöl, Gölesor, Diyadin, Akdağ; in the Cizre sheet Paysan, Karadağ; and in the Erzurum sheet Pertek, Tunceli. Mayram, Akdağ, Toprakkale, Söylemez and Pütürge. They all lie within the former eugeosyncline. There are anticlines with salients and recesses, with axial highs and lows, with or without overthrusting. An overall Permian limestone cover is largely eroded, so that there are long stretches of crystalline schists. However metamorphism is not an infallible criterion of the rock being part of an old nucleus. Along dislocations, and locally elsewhere, dynamic effects on clayey shale, for example, make it simulate crystalline schist. The outlook of the massifs is similar. Only gneiss is mapped separately, but it is less common than the less metamorphosed types. There are amphibole- and biotite-gneisses. There are various and possibly repeated intrusives, which occasionally altered the existing trends. The zones, the metamorphic facies and the sequences are not yet worked out.

There are para- and orthometamorphics intimately associated. Besides the regional metamorphism there are effects of contact-metamorphism and even scarns. The petrographic determinations show the existence of an epizone and a mesozone and even changes toward granitization.

The bedding is confused, but where determinable it nearly parallels the foliation. Besides, there are rock cleavages, joint sets, shear zones, crushed zones, etc. A scaly weathering is characteristic of the mica-schists. The smooth outcrops may have a crude sheeting parallel to the surface. There are lensing or «en echelon» white quartz veins. Although three zones are mentioned by some workers, a highly metamorphosed core of mesozone underlying a phyllitic epizone is more striking. The former includes

coarse-textured marble, while the latter exhibits finely textured crystalline limestone; both occur ordinarily as lensing bodies. The carbonate lenses together with quartz interbeds become more frequent in higher horizons. There may be gradational lateral and vertical transitions. There are laminated and cross-laminated crystalline limestones. The carbonates are pure or impure, fine-grained or coarse, dissoluted and recrystallized at various degrees, foliated or not, crushed or not, deprived of recognizable organic remains through secondary transformations. The crystalline schists are gray from afar, while the limestones are yellow.

There are a few outcrops over the Kop Mountain chain, which are xenoliths in greenstones. The rock types of the deeper core are: epidote-, graphite-, feldspar-, staurolith-, garnet-, talc-, biotite-schist. Those of the outer zone are: sericite-, chlorite-schist, phyllite, graywacke, radiolarian chert and quartzite. The relationship with the overlying Permian limestone is obscured through repeated strong organic movements. There are a few locally observed angular unconformities, but also gradational vertical transitions, and mostly the contact plane is deeply affected. The overall maximum thickness of the exposed basement complex should amount to several thousand meters.

SEDIMENTARY ROCKS

1. Orthotectonic region or the true geosynclinal area (eugeosyncline)

Besides the pre-Permian massifs there are in the northeastern part of the map area outcrops of the old Paleozoic basement, which is unaffected by metamorphism and highly fossiliferous.

Marine Devonian (?) and Carboniferous (dk). — In the Aras basin, in the northeastern corner of the map area, there are conformable sequences of Paleozoic rocks. The small outcrops help one to deduce a westward-plunging anticlinorium, named «Karaköse massif». This is a Variscan basement hidden by the lofty Ağrı volcanic system.

To the southeast of Küçük Ağrı and at Kozlukışlağı there are exposed along the valley walls reddish-brownish foliated greywacke and also chloritized spilite and andesite, followed stratigraphically upward by limestone and quartzite interbeds, which in turn are overlain by a thick uniform sequence of limestone containing Permian fossils, such as : *Schwagerina, Yangchienia* aff. *tobleri* Thompson, *Corwenia diphylloides* Huang. No index fossil is detected in the fine detritals and carbonates of the lower section, which are nevertheless assigned to the Devonian. Also the early limestone strata are thought to belong to Carboniferous without any proof.

Over the Kalos knoll to the northeast of Doğubeyazıt the sequence is made up of slate and conglomerate with limestone interbeds, overlain by uniformly thick-bedded, gray-black limestone strata containing Permian fossils, such as *Schwagerina, Schubertella, Mizzia,* etc.

A Dinantian fauna is determined through the fossils collected from two low hills nearby Çiftlik village, to the east of Iğdır county, which is made up of bedded limestone, reddish schistose limestone, and yellowish clayey slate : *Caninia cylindrica* Scouler, *Zaphrentis, Syringopora, Athyris, Fenestella.*

Marine permian (pm). — Over the Bitlis massif and also with the smaller massifs there are uneroded remnants of a limestone cover. It is made up of well-bedded,

similarly repeating, partly dissolved and recrystallized, occasionally fossiliferous, cliff-making limestone strata, which are sometimes hard to identify in the field because limestones of various age look alike when poorly fossiliferous. The larger and less affected outcrops lie over the plunge sectors of the anticlinoria and along the axial lows. A typical area to the southeast of the Bitlis massif is called «Arabi formation» after the name of a local mountain. Over the western plunge of Bitlis massif and further west, the limestone cover is highly crystalline, and its assignment to the Permian is hypothetical. The massifs along the Taurid belt more or less preserve their Permian limestone carapace, while those over the Anatolids are deeply enough eroded to expose only the crystalline schist. Farther north in the Anatolid belt, in the Trabzon sheet, the Permian is made up of a lower sequence of sandstone, quartzite, arkose, and sandy slate, and an upper sequence of gray fossiliferous limestone and quartzite. Thus, different environmental conditions of sedimentation existed in Northern Anatolia.

Ordinarily the limestone is black, evenly bedded, regularly packed, hard, brittle, angular fracturing, and locally contains chert nodules. It is thick-to thin-bedded, occasionally even laminated. A white and gray banding may indicate the bedding. Subsidiary crystalline schist and schistose quartzite are intercalated. The limestone is comparatively less affected by regional metamorphism than the fine detritals. There are fine-grained detritals, such as the siltstone interbeds, which are metamorphosed, crumpled and sheared and look like a true mica-schist. The fossils are seldom well preserved: *Schwagerina, Parafusilina, Polydiexodina, Doliolina, Yangchienia* aff. *tobleri* Thompson, *Verbeekina verbeeki* (Geinitz), *Tetraxis,* Algae. The limestone, where least eroded, exceeds 200 m of thickness. As the boundary with the underlying mica - schist is altered by severe orogenic movements, the field observations are seldom clear enough for a definite boundary line. At a few places, thin, red marl may lie between the limestone and the mica - schist.

Trias (t). — To the southwest of Çatak county there is a remanant of Trias similar to Goyan formation of the miogeosyncline, which gives evidence of the southern sea depositing red, purple, green marl, reddish marly limestone, brownish limestone.

Lins (jl)- — Over the area of Erzurum sheet and along the Anatolid belt the crystalline schist is transgressively overlapped by part of a thick sedimentary series in which Sinemurian, Charmouthian, Toarcian and Aalenian were determined through *Ammonites* included in slate, sandstone, marl and limestone, which are accompanied by lavas and tuffs. Dogger is missing (Ketin). The Lias beds are 2000 m thick.

Malm (jm). — which accompanies the Lias beds is 400 m thick and is made up of bedded fossiliferous limestone, thick-bedded limestone, sandy and pebbly detritals. The whole is overlain by Berriasian (Ketin).

Lower Cretaceous (kra). —There are two facies of Lower Cretaceous strata: (a) «Kop formation», named after the mountain chain in the norhtwest, is made up of flysch beds and limestone members; (b) «Munzur limestorie», named after Munzur chain farther southeast, displays a uniform sequence of limestone in Urgonian facies.

a) The Kop formation is in angular unconformity with the basement. There are, successively, white limestone, flysch beds and gray-green-purple limestone. The white limestone member is a thinly bedded, finely textured, white, closely folded, brittle, angular fracturing, barren limestone sustaining stubby talus cones. There are few

limestone lenses near the base. The upper member, which is conformable and in gradational transition, is made up of red-brown, hard angular fracturing, thin to medium-bedded, occasionally contorted, sheared limestone containing a few interbeds of sandstone and gray marl. The limestone exhibits some ripple marks. The system is somewhat different along İspir county highway, where green and dark red flysch beds alternate with limestone strata, each one locally wedging into the other. Here the limestone is green-purple-cream, thinly bedded, occasionally somewhat schistose and traversed by white quartz veins.

b) Munzur limestone is white-cream-light gray, dense, thinly textured, thickly bedded, angular to conchoidal fracturing, and vuggy. It weathers to a karst Topography. It has a dented sierra profile over the divides. In thin section it is a pelsparite, which is due to quiet environment deprived of currents. There are *Ammonites* and *Apthycus* in flysch beds and *Orbitolina* in limestones. The ophiolftic suite rocks and the serpentines, nearly all of which are Upper Cretaceous - Paleocene in age, may include single or clustered, limited or widespread, single or repeated limestones, which occasionally are fossiliferous. A few among them over both the eugeosyncline and the miogeosyncline contain fossils older than the Upper Cretaceous - Paleocene range. A noteworthy finding is an *Orbitolina* limestone to the east of Komikan village, to the north of Çerme township. A similar limestone further east is unfossiliferous. Ketin has generalized his discovery and used it to separate the Lower and Middle Cretaceous, as well as to establish a boundary in between Taurids and Anatolids; but there seems to exist a xenolith similar to a mica-schist over the Kop Mountain chain.

Upper Cretaceous - Paleocene (krep). — The eugeosyncline, with its component orogenic belts of Iranids, Taurids, and Anatolids, is characterized by a comprehensive series of manifold sedimentary and igneuos rocks having intricate relationships. There is essentially an orogenic flysch, the continuity of which is interrupted by varying admixtures of products of initial volcanism as well as by limestones. Besides intertonguing and lensing there are effects of turbidity currents with boulder mud, effusion tectonics, and possibly glide tectonics (wild flysch). There were misconceptions and wrong assignments as the series may simulate all kind of systems, and various names were applied by different authors in different districts, mostly for the appearence, such as Hakkari complex, Ergani-Hakkari series, Maden series, Complex tectonic facies, Compound series, Mixed type, Orogenic flysch, Complex series, Green series, Variegated series, Complex, Hakkari series. Over Cizre sheet and over the Border trough area, in between Hakkari city and Salaran village a conspicuous «Cilo Series» is a huge lensing member within the Upper Cretaceous - Paleocene flysch beds. It is due to an inconspicuous dislocated anticlinal high of the Upper Jurassic - Turonian limestone of the miogeosyncline, and to a southernly advance of the orogenic sediments, hence an interfingering between the contens of the two tectonic regions.

Although the denomination of Hakkari complex is the most representative for the series, none of designations mentioned is a systematic formation name; the series awaits detailing. The lowest strata of the sedimentary cycle are contemporaneous with Upper Jurassic - Turonian, and both are observed in interfingering relationship to the south of Hakkari. Nevertheless, the series near Salaran village starts with fairly well bedded gray-black, marly limestone over the Upper Jurassic - Turonian limestone of the miogeosyncline. The uppermost horizon is observable mostly over the eastern half of the map area, where thick limestone lenses are embedded in less coarse flysch beds. The

«Van limestone» is the most typical example. Similar lensing and interfingering of carbonate and fine detrital sediment are not scarce. Even though the upper horizon is removed over large tracts by erosion, and the entire sedimentary cycle ranges from Upper Cretaceous to Paleocene (included), as learned through microfossils determined in thin section, Paleocene is applied in the sense of Nummulitic, as suggested by Haug. Field practice permits this series to be recognized and established as an entity, the younger flysch beds being less affected by tectonics.

Over the area of Cizre sheet there are Nummulites-bearing limestones embedded in flysch beds, similar to Midyat limestone of the miogeosyncline. These small or large pebbles and blocks should belong to a uniform, thin Lutetian cover, which being brittle was reduced into fragments that plowed into the underlying flysch beds during subsequent overthrusting and imbrication. As they are devoid of definite trends and ot conspicuous dislocational planes, even though they are affected by secondary mechanical features such as polishing and brecciation developed through differential movement and competency, they are not true klippen.

Over the Iranid belt the series is continuously red-brown-green because the percentage of ophiolitic admixture is high, while over the Anatolids there are large green tracts due to an unusual expansion of serpentines and related lithologies. Over the Pontids, north and outside of the map area, a gray-black, uniform flysch sequence is rich in andesite. The Kermav formation of the Border trough, the Pontid facies and the Upper Cretaceous are penecontemporaneous sedimentary cycles.

The opinions differ in regard to the origin: Altınlı's effusion tectonics and turbidity currents, Bailey and McCallien's Anatolian thrust, Blumenthal's precursor tectonic movements, Bobek's brecciated klippen, Chaput's imbrication of the Mesozoic cover during Tertiary, Fairbridge's gravitational tectonics, Maxson's metamorphosis of old deposits, Türkünal's′ lithologies of unlike age and character are to be mentioned.

A gray, uniform flysch deposition together with red, green, variegated Red beds similar to those in the Prealps took place along the troughs, but variegated compound deposits evolved over the ridges, where white limestone, green ophiolite and some flysch detritals and red radiolarian chert are associated. These two sequences are intertonguing. The igneous products eventually predominated or became admixtured with sediments in various proportions, so that hybrid tuffitic lithologic types evolved. As the composition and the appearance of the series is so inconstant as to facies and lithology, or lithologic associations, the description will arbitrarely be divided: (a) basal beds, (b) Red beds, (c) limestones and the Paleocene limestone lenses, (d) flysch, (e) Cilo series, (f) conglomerate, (g) saliferous and gypsiferous and lignite facies, (h) metamorphic facies.

a) Over the Cizre sheet and near Pervari, an uneven Permian limestone country is invaded by Upper Cretaceous-Paleocene deposits; the relationship is an angular unconformity. Further northeast and nearby Hişet the Upper Cretaceous - Paleocene transgressively overlaps Upper Jurassic-Turonian limestone. In the neighbourhood of Şirvan county the basal beds are a pure flysch. The limestone appears higher in the section and in interfingering relationship. To the south of Gürpınar county, the pinkish limestone strata appearing in the basal beds, which cover Permian limestone, are overlain by gray flysch. To the west of the county seat there is a basal conglomerate, the pebbles of which are mainly Permian limestone. Farther south the lowest beds contain reworked

mica-schist pebbles and blocks. To the east of Gevaş county the series starts with a basal conglomerate and continues successively with akernating white limestone, sandy limestone, gray limestone and serpentine. In the domain of Gilo Mountains, the series begins with flysch beds and greenstone that cover a very uneven surface of Upper Jurassic - Turonian strata. Between Çatak county and Narh township and above Upper Jurassic - Turonian limestone, the series starts with pillow lavas.

b) The Red beds are similar to those in the Prealps' «Couches rouges» and they are made up of finely textured, pure or impure limestone containing pelagic remains such as *Globotruncana* and *Globigerina*. It is a valuable guide for recognition of the series in the field. The Red beds are most abundant in the east and southeast of the map area. They are pink, red, gray, green, purple and even variegated, in the same shades, thinly bedded or laminated, but the bedding becomes complicated by compression, so they may even be transected by a coarse and uneven rock cleavage. They commonly interlens or intertongue with other facies; they may be invaded by greenstone and then become xenoliths, which occasionally may be deposited concurrently to give odd breccias. The ophiolite suite caused changes imperceptible to the naked eye.

c) The limestones are always as lensing and intertonguing lithologic units of limited or extended outcrop, usually in repeated horizons, and more increasingly abundant toward the end of the sedimentary cycle. The color, texture, density, pureness, bedding, fossil content, dissolution and recrystallization, dynamometamorphism, etc. are changeable. The age span is secured through spot samples for thin section foraminifera, the megafossils being scarce. The limestones should correspond to shoal phases, developed over the shallow trends. Some are of biohermal nature. Most, and especially the small lenses, are clean-cut bodies affected by polish, brecciation, etc., due to differential movement rather than to deep-seated dislocations; hence these are secondary features imposed upon the primary depositional units. The limestones stand out conspicuously because of differential weathering. The limestone is reddened near contacts with the rocks of the ophiolitic suite.

There are outstandingly thick limestone lenses nearby Tercan, Elazığ, etc. which were considered as projecting from beneath, and hence older than the containing flysch beds; but in reality these are penecontemporaneous limy deposits, and also possibly patch reefs. There is an extraordinarely large lensing gray limestone member full of Nummulites, etc. to the north of Lice. In the neighbourhood of Van the «Van limestone» makes prominent hills. It is cream to white, sharp-conchoidal fracturing, poorly or well-bedded or unbedded because of dissolution, stylolithic, porcellaneous-sublithographic and occurs as single or multiple lenses in flysch beds. Occasionally the limestone lenses display mechanical features due to differential movements. There are similar lenses toward Yüksekova county and to the north of Karaköse. There also are pink, green and cream limestones in comparable stratigraphic positions.

d) The flysch beds are either clayey and sandy or limy in nature. Their sequences trend along the troughs, as seen over the north of the Ağrı plain, and they are intertonguing with the variegated beds deposited over the ridges.

e) The «Cilo series» to the south of Yüksekova county is deposited conformably, as discussed above, over the Cilo anticlinorium, the core of which is made up of Upper Jurassic - Turonian limestone. The member is devoid of flysch beds. Pebbly flysch-looking basal beds, that overlie the black limestone of the Upper Jurassic - Turo-

nian, are overlain by interfingering white limestone, red radiolarian chert, and intrusive greenstone. The thickness amounts to several hundred meters. Over Sümbül Mountain, farther east, the variegated sedimentary cycle oversteps the Upper Jurassic - Turonian limestone.

f) Coarse detrital sediments, mainly conglomeratic, are commonly intercalated in flysch beds. They are lensing or intertonguing. They are due to the peculiarities of the depositional environmets in equilibrium with exunded areas.

Locally the conglomerates thicken and may even make a whole mountain, such as Spirez to the southeast of Yüksekova county. There are in places, prominent red conglomerate lenses that simulate the red Gercüş conglomerate beds of the miogeosyncline; they are made up of prevailingly red-brown round pebbles of various hard limestones, greenstones, etc., weakly cemented with a red sandy and limy matrix. These delta deposits may attain 100 m in thickness. They are called «Penek conglomerate» to the south of Aşkale, and «Kırmızıköprü conglomerate» to the north of Tunceli. There are huge lensing conglomerate strata to the north of Baykan county (Korekem Mountain), and less important ones further west. At Göceharman and Karataş, to the north of the Pasinler plain, are found conglomerates exhibiting large blocks of mica - shist and quartz, pebbles which could denote a shallow depth to the basement complex.

g) A few stretches or localities display lagoonal deposits with salt, gypsum and lignite; some are merely simple showings, others are exploitable. The ridge separating the eugeosyncline from the miogeosyncline is not exposed, but it can be deduced through the presence of a lagoonal trend to the northeast of Siirt. From the Bünyan water gap to Pervari county there are aligned salt springs, saline soil and even salt rock, together with soft, red or variegated marl, sandstone, conglomerate, and greenstone. Several saltworks are among these.

At Tuzluca village near the junction of Varikürt and Meydanıkoli creeks to the west of Beytişebab county, and at Camesuki locality the pinkish-greenish marl and siltstone are salty, and they are overlain by purple and green marly limestone in red bed facies. Further east and west there are salt springs. Dülgel lignite mines are included in the Upper Cretaceous - Paleocene flysch series. The lignites represent swamp forest of that time.

h) The limestone lenses and members resist metamorphism much better than the fine detrital sediments. There are a few localities where the effects of dynamometamorphism are observable. Still larger areas of mica-schists of the massifs grade laterally into rock that looks like the non-metamorphic Upper Cretaceous - Paleocene beds.

The thickness of the Upper Cretaceous - Paleocene should amount to 2500 m. The outstanding fossil determinations are as follows :

Actinosiphon, Alveolina, Alveolinella, Amphistegina, Asterigerina, Asterocyclina, Baculogypsinoides, Bulimus, Calcarina, Calpionella, Discocyclina, Eulepidina, Eponides, Globigerina, Globigerinella aequilateralis (Brady), *G. aspera* (Ehrenberg), *Globorotalia aragonensis* Nuftal, *Globotruncana area* Cushman, *Globorotalia crassata* Cushman, *G. truncanoides* (d'Orb.), *G. velascoensis* (Cushman), *Globotruncana contusa* Cushman, *G. lapparenti* Brotzen, *G. lapparenti lapparenti* Bolli, *G. leupoldi* Brotzen, *G. linnet* var. *calciformis* de Lapp., *G. rugosa* Marie, *G. stuarti* (de Lapp.), G. cf. *lapparenti tricarinata* (Quereau), *Gümbelina, Heterostegina, Laffitteina,* Lagenidae, Lituolidae, *Lockhartia,*

Miscellanea miscella d'Arch., Miliolidae, *Nummulites granifera* H. Douv., *N. lucasi* d'Arch., *N. praelucasi* H.Douv., *N. uroniensis* A. Heim., *Nonion, Orbitoides media* d'Arch., *O. apiculata* Schlumb., *O. gensacicus Leym., Omphalocyclus macroporus* (Lmk.), *Operculina, Orbitoides media* d'Arch., *Ovalveolina, Pararotalia, Pentelina, Praealveqlina dordonica* Reich., *Pseudotextularia elegans* Rzehak, *P. cf.-varians* Rzehak, *Pyrgo, Robulns, Rotalia, Rupertia, Siderolites vidali* Douv., *S. calcitrapoides* Lmk., *Spiroloculina, Valvulammina, Actaenella,* Brachiopods, Bryozoae, Corals. Echinids, *Exogyra* cf. *conica* (Sow.), *Hippurites, Inoceramus balticus* Böhm, I. cf. *regularis* var. *baltica* Bohm, *Alectryonia, Ostrea, diluviana* L., *Spondylus,* Algae (Melobesiae, *Jereminella pfenderae* Lugeon), Ostracods.

Lutetian (el). —- The orogenic Van phase, which followed the Eonummulitic period, was nearly of paroxysmal strength in Eastern and Southeastern Turkey and was the forerunner of the present structural pattern of the country. A widespread sea invaded a very uneven floor, so that the sedimentary cycles differ greatly in different secondary geosynclines. Over the eastern Iranids was deposited a flysch which is called «Bernuvaz flysch» after the village of the same name. Further south the «Menkova formation» is made up of detrital sediments and limestone the latter increasing in abundance toward the top. Over the Taurids the «Elazığ formation» is found in the west and a «Tunceli formation», which is a true flysch, is farther north. Along the Anatolid orogenic belt Lutetian occurs in limited scattered outcrops, but the flysch facies is not general. The Lutetian may exceed 1000 m in thickness.

Bernuvaz flysch: At Bernuvaz village, near the Persian frontier, to the east of Yüksekova county, there are coarse, reddish flysch beds made up of closely alternating red-brown sandstone, pebbly sandstone, conglomerate and marl with subsidiary fossiliferous limestone interbeds. Somewhat similar strata are in the Upper Cretaceous - Paleocene sequence and their natural relations are not obvious; but an angular unconformity is expected. The older series may be diffcrenelated from the younger by the presence of greenstone and whitish limestone lenses. The bedding may be confused. Lensing and intertonguing are common. There are Nummulites up to 6 cm in diameter.

In the direction of the plunge sector of the Bitlis massif and in the neighbourhood of Put village there is a rather thin section of a gray-black, thickly and evenly bedded, regularly packed, hard, brittle limestone; but nearby in the Gevaş county the sedimentary cycle starts with a basal conglomerate and continues with sandy limestone and sandstone.

Menkova formation: To the east of Yüksekova county and near Menkova village the sedimentation took place in a shallow trough, where mostly detritals and later on biohermal limestones were deposited. To the west of the village there are only aligned gray limestone outcrops, which are erosional remnants. The latter may contain small Nummulites and also rounded sandstone and limestone pebbles.

Tunceli formation: A flysch deposition took place to the north of Karhova county, to the north of Tunceli province, to the south of Hınıs county, etc. and especially along the structural lows. There is no greenstone, but andesite is noticeable. There are eventually thick and large lenses of limestone, preferably along with the regular horizons, and they are barren, steeply ending. The limestone may be pure or not, sometimes cataclastic, eventually fossiliferous, ledge - making or not. The bedding of the flysch is even, persisting and regularly repeating. The effects of turbidity currents

and gravitational tectonics are quite subsidiary. The alternating red and green flysch beds lie in angular unconformity over the Permian limestone.

To the south of Hınıs county the flysch contains peculiar red conglomerate strate simulating those of Gercüş formation in the miogeosyncline. These intertonguing or lensing intercalations may repeat. The fossils are scarce in the sediments and even the limestone interbeds became cataclastic and dissolved. Andesitic flows, agglomerate and breccia are present mostly in red shades.

To the east of Ovacık county alternating gray marl, thinly textured sandstone and coarse conglomerate, with some limestone interbeds are abundant toward the top of the series. To the north of Muş plain there is an outcrop of sparsely fossiliferous Lutetian flysch.

Elazığ formation: This stratigraphic unit is not a flysch, but consists of alternating shale, marl, siltstone and sandstone, with limestone interbeds that gain in importance toward the end of the sedimentary cycle. There are horizontal and vertical transitions as well as lensing and intertonguing. To the west of Uluova and along the northern bank of Murat River there are, successively, gray sandstone, siltstone and conglomerate that alternate with marl and limestone. Local unconformities exist. Within the sequence the limestone gains in importance toward the east. It is light in color, medium to thick-bedded, biohermal, and ledge making. The fossil content indicates mainly Lutetian but also Upper Eocene, especially to the southwest of Elazığ. Near 82 nd Highway Department's Maintainance Station were found the following fossils: *Nummulites atiricus* Joly & Leym., *N. rouaulti* d'Arch., *N. gizehensis* Forskal, *N. curvispira* Brug., *N. brongniarti* d'Arch., *N. contortus* Desh., *Discocyclina pratti* Michelin, *Fabiania cubensis* Cush. & Bermudez.

To the south of Elazığ province and near Balaban village, the fauna indicates an Upper Eocene age: *Nummulites atiricus* Joly & Leym., *N. rouaulti* d'Arch., *N. munieri* Fischeur, *N. helveticus* Kaufman., *N. fabiani* Prever, *N. contortus* Desh., *N. striatus* Brug.. *N. incrassatus* de la Harpe, *N. chavannesi* de la Harpe, *N.* cf. *pratti* Michelin, *Discocyclina scalaris* Schlumb., *D.* cf. *scalaris* Schlumb.

On a mountain trail midway between Karlıova and Tekman, and to the east of Maman village, basal conglomerate beds that overlap the Upper Cretaceous - Paleocene basement contain the following Upper Eocene fossils : *Nummulites laevigatus* Brug., *N. lamarcki* d'Arch., *N. brongniarti* d'Arch., *N. rouaulti* d'Arch., *N. uroniensis* A. Heim, *N.* cf. *acutus* Sow., *N. djokdjokartae* Martin, *N. incrassatus* de la Harpe.

Over the Anatolids along the «Transit Highway» to the north of Aşkale, the Lower Cretaceous is overlain unconformably by Lutetian. A red basal conglomerate is made up of uneven and unequilateral pebbles in a reddish limy matrix. Further northwest and to the north of Müşekrek village the Lutetian beds are in transgressive overlap over a highly uneven Upper Cretaceoes - Paleocene basement. The basal beds are sandy, pebbly, regularly bedded, yellowish limestone, nearly 20 m thick, wedging into the unfossiliferous Lutetian flysch beds. The fossils determined are *Nummulites atacicus* Leym., N. *irregulariformis* Flandrin, *Assilina* cf. *granulosa* d'Arch., *Operculina, Amphistegina* (Lutelian).

To the east of Rize village, along the Erzurum - İspir highway, Lutetian limestone with Nummulites seems to be preserved inside a tightly pressed syncline.

To the northeast of the map area, and near Doğubeyazıt, there is an onlapping, epineritic Lutetian, in which alternating greenish marl, siltstone, and thinly bedded limestone are below a regular sequence of evenly bedded, white to cream - colored, dense limestone with small Nummulites. There are only a few limestone lenses in the lower part of the sequence, and of these the lowermost may either be a marl, or lie directly on the Upper Cretaceous - Paleocene basement. The fossils determined are : *Nummulites contortus* Desh., *N. striatus* Brug., *N.* cf. *rutimeyeri* de la Harpe, *N. chavannesi* de la Harpe, *Discocycllna* cf. *pratti* Michelin.

Oligocene (Ol) . — The Oligocene deposits are extremely limited in exposure. Near Tuzluca county Oligocene deposition started with marine limestone, but soon lagoonal deposition took over, and there were interbedded basalt lava flows. At Hamurkesen village there are sandstone, pebbly sandstone, and conglomerate which contain Nummulites. A. Dizer determined Oligocene through *Nummulites intermedius* d'Arch., *N. fichteli* Michelotti, *N. fabiani* Prever passage *fichteli* Mich., *Operculina alpina* Douv., *O.* cf. *complanata* Defr.

These are overlain by bright - colored, variegated marl, clay, conglomerate, pebbly sandstone and sandstone in regular bedding or intertonguing. The higher section may start with polygenie basal conglomerate, which is red and cross-bedded, shows graded bedding, lensing or intertonguing, and grades into sandstone, pebbly sandstone and other rocks. As the series is soft, it is easily eroded and the country is being deeply carved.

To the west of Elazığ, to the northeast of Taşbaşı locality, at Hacısur knoll, unconformably above the crystalline Permian limestone are two tiny limestone outcrops made up of basal nodular and pebbly limestone, followed by cream-colored, slightly marly, thin- to thick-bedded, slightly karstic marine and fossiliferous limestone. A. Dizer determined Oligocene through : *Nummulites intermedius* d'Arch., *N. fichteli* Micht., *Nephrolepidina tournoueri* Lemoine & R. Douv., *Lepidocyclina, Operculina complanata* Defrance, *Spiroclypeus, Archaeolithothamnium.*

This isolated occurrence should be an outlier, preserved from a formerly continuous outcrop; the higher of a continuous sedimentation being preserved over a high relief. So Lutetian, Upper Eocene and Oligocene would make a single and continuous sedimentary cycle. Followins the orogeny which ended the Oligocene period, an erosional episode of comparable strength to the one which followed Upper Cretaceous - Paleocene took place.

Miocene- — As orogenetic deposition ended in the area, a sea advanced over an undulated basement of pre-Lutetian rocks and deposited first along the structural lows either molasse or limestone of Lower-Middle Miocene. The Upper Miocene is lacustrine and continental. The deeper parts of the troughs, that were subjected to continued disturbances, received molasse beds, while biohermal lime deposition took over the axial highs and shoals. Moderately deep, quiet basins accumulated alternating fine detritals, marl and clay. The facies are intertonguing according to the vicissitudes of the environments.

The molasse over the eugeosyncline is in discontinuous outcrops and is less fossiliferous than other lithologic associations. The secondary orogenic belts differ as to their relative proportions of sedimentaries and volcanics. The latter are more abundant over the Taurids, more widespread in the eastern portion of Anatolids, more frequently

intercalated in northeast. The fossil content gives evidence for a range of Lower - Middle Miocene. The marine environment was interrupted by transitory lagoonal phases and environments, which resulted in evaporites and lignite. Although there are large gypsum intercalations, the Miocene sedimentary cycle is not the equivalent of the Gypsiferous series of Central Anatolia, which is Upper Eocene - Lower Oligocene in age.

Marine Lower - Middle Miocene (md)

Molasse.— Molasse is a formation name in a broad sense and even better a group name. This is a facies built up of light gray-greenish marl, shale, limy sandstone, arkosic sandstone and conglomerate. There are thick lenses of conglomerate which represent delta deposits as a Nagelfluh, but only in front of the front range and included in the Miocene. The narrow and shallow troughs retain more evaporites.

There are typical molasse deposits in the eastern portion of the northern foredeep of Bitlis massif, which lies to the southeast of Van Lake and which is traversed by Micinger stream. Limestone intercalations are encountered in the east; they are white, thin-bedded, richly fossiliferous, and thus valuable for distinguishing from flysch beds, but they lack in the west. Upon the Permian limestone slopes lie an alternating succession of gray marl, finely textured greenish marl, sandstone and sandy limestone; then follow the typical molasse deposits. But either limestone or conglomerate or molasse beds may overly the Permian limestone. To the east of Harami pass, along the road from Van to Gevaş, a wedging conlomerate, nearly 100 m thick, separates the fine detritals and limestone from the molasse beds

At Saçlık village of Horasan county, to the northeast of the map area, green molasse beds intertongue irregularly with a thick sequence of alternating fine and coarse red detritals, devoid of limestone. To the south of the county seat, however, an association of variegated marl, siltstone and fine sandstone possess nodular, sandy or pebbly, richly fossiliferous limestone interbeds. Following a tuff and a lava flow there are regularly bedded marl and marly limestone beds. A thick andesitic flow is overlain by an unbedded red marl belonging to the lacustrine Upper Miocene.

Halfway of the mountain road from Cat county to Çerme township there is a molasse at the base, followed by alternating pink marl and fine detritals. There are fossiliferous, white, thin-bedded limestone intercalations in molasse nearby Civ village. There is a basal conglomerate as well as conglomerate intercalation higher up in a molasse sequence to the west of Kemah county. The molasse beds are light gray but sometimes pink, evenly and thinly bedded, regularly packed, lightly fossiliferous, devoid of volcanics. Near the county seat, and north of it, the basal beds are made up of limestone with gray-green marl intercalations.

Limestone- — There are large, conspicuous, white, biohermal limestone sequences deposited along shallow ridges. The Upper Cretaceous - Paleocene olivine melaphyre of Ahlat county is first overlain by red conglomerate, shale, sandstone, and then by limestone. The sedimentary cycle to the west of Erciş starts with a gray tuff that contains pumice pebbles; the tuff encloses a marine limestone lens. Andesite may also enclose such limestone intercalations.

Alternate marl, shale, sandstone and limestone. — This is most common lithologic association, and it is not a true molasse. The various lithologic types alternate

and grade according to the vicissitudes of the environment, and they are interfingering; it is the same with the biohermal limestone over the highs.

There are typical sections nearby Hozat county. There, the greenish marl is well-bedded or not, the sandstone is finely textured, the limestone interbeds are more or less frequent, lensing or intertonguing, richly fossiliferous, and ledge- or cliff-making. There are lava flows and tuffs intercalated. A few lignite seams are exposed. In the neighbourhood of Tercan there are coarse conglomerate lenses, which are delta deposits. Near Eyüboğlu Komu hamlet there is a coarse-textured, pebbly and blocky tuff. To the east of Refahiye county a coarse, ill-cemented detritic sediments with marly limestone intercalations form the base of the molasse. Near Erzincan, gypsum occurs within the fine and coarse detrital sediments and also between limestone beds, which contain Pectens, etc.

At Aşkale, gypsum lenses are conspicuous and they may crop out along isoclinal ridges. South of Tercan and Cat counties is found limestone that forms a particularly continuous and conspicuous biohermal ridge, which intertongues with the fine detritals and marls of Pırnaşıl syncline. Farther east, red marls are followed by fine detritals and marls with limestone intercalations. At some places lignite occurs within marl directly above the Upper Cretaceous - Paleocene, and then detritals with gypsum intercalations Also limestone is encountered as scattered or heaped pebbles in marl and mudstone. To the north of Tekman county the Lower - Middle Miocene is interfingering with andesitic lava flows.

Near Mesçitli there is a beautiful natural section made up of closely alternating, thinly and regularly bedded marl and marly limestone, with a few lignite and gypsum intercalations. Farther south, the troughs exhibit alternating fine detritals and marl, while the highs display a consistent sequence of well-bedded, cream-colored, cliff-making biohermal limestone. The latter may repose directly upon Upper Cretaceous - Paleocene. The whole may include lava lenses or intertongues.

To the north of Karaköse a variegated, ill-bedded, weakly cemented, polygenie basal conglomerate is more than 50 m thick; above follow, successively, red marl about 10 m thick; green or red, brecciated, lensing limestone; and large bodies of whitish biohermal limestone.

At Doğubeyazıt the series starts with green marl, together with limestone lenses, then follows an alternation of marl, fine detritals, gypsum and limestone. Near the Iranian frontier the sedimentary cycle begins with a basal conglomerate over Permian limestone.

At Canik saltworks, to the east of Van Lake, there are greenish gypsiferous and saline clay, marl, siltstone, sandstone, conglomerate and limestone; this sequence is truncated and followed by a basal flow, which is overlain by a sandstone with lava pebbles and blocks.

The sedimentary cycle of Lower - Middle Miocene age amounts to a few hundred meters in thickness. The molasse may be thicker than the other lithologic association. The fossils mentioned by different authors are : *Alveolina elongata* d'Orb., *Amphistegina radiata* (F. & M.), *A. lessonii* d'Orb., *A. hauerina* d'Orb., *Globigerina bulloides* d'Orb., *Heterostegina praecursor* Tan, *H. costata* d'Orb., *Lepidocyclina morgani* Lem. & Douv., *L. (Nephrolepidina) tournoueri* Lem. & Douv., *L. (Eulepidina) dilatata* (Mich)., *L. (Eulepidina) elephantina* (Mun.-Chalm.), *L. (Nephrolepidina) verbeecki* New. & Holl,,

L. sumatrensis (Brady), *Miogypsina mediterranea* Brön., *M.* cf. *irregularis* (Mich.), *M, inflata* Yabe & Hanzawa, *Miogypsinoides complanata* (Sch.), *M.* cf. *dehaarti* (Van der Vlerk), *Neoalveolina melo curdica* Reichel, *Operculina complanata* (Defr.), *O.* aff. *bartschi* Cushman, *Orbitoides gensacica* Leymerie, *Lilhophyllum prelichenoides* Lem., *L. lanqueneri* Lem., *L.* aff. *chaperi* Lem. & Douv., *Mesophyllum laffittei* Lem., *Amussium cristatum* Bronn, *Cerithium, Chlamys northamptoni* Mich., *Clypeaster* aff. *martinianus* Desm., *Echinolampas acuminatus* Abich, *E. (Paleolampas)* aff. *acuminatus* Abich, *E.* aff. *sentiformis* Leske var. *angulatus* Merian, *Eastonia* aff. *crassidus* Lam., *Hypsoclypeus, Isastrea turbinata* Douncan, *Lucina globulosa* Desh., *L.* aff. *multilamella* Desh., *Melongena cornuta* Agas., *Ostrea crassicostata* Sow., *O. (Pycnodonta) squarrosa* (M. de Serre), *Schizaster lovisatoi* Cotteau, *Spatangus eufratensis* Abich, *Pericosmus* ci. *latus* Agas.

Lacustrine Upper Miocene (mü)- — A powerful orogenic phase threw the Lower - Middle marine Miocene into close folds; then an upheaval, followed by erosion made a gently undulatory country over which a large lake, or lakes were bounded by main ridges and high tresholds. The lake level or levels oscillated through a wide range, so that the sediments are overlapping, especially along shoals and narrow troughs, such as those to the south and southeast of Siirt. The lacustrine deposits should be intertonguing with continental deposits. The delta deposits are easily recognized. The deposits over the various organic belts are alike. The sedimentary cycle may end by a thick lacustrine limestone. The faunal associations together with *Dreissensia, Congeria,* etc. are difficult to study, and there is not yet an assured age determination, so it is only probable that the sedimentary cycle might include Pliocene. The overall thickness exceeds 200 m.

There are fine natural sections to the south of Horasan, which are made up of marl, siltstone, sandstone, and limestone. At the south end of the Aras bridge a finely textured, ill - cemented, laminated and coarse laminated, yellowish sandstone exhibits biohermal *Congeria,* Gastropod, etc. Farther south gray - greenish marl is extremely rich in *Dreissensia.* Near Karaköse alternating marl, siltstone, and conglomerate are first overlain by pebbly and blocky tuff and then by andesite lava flows. At Diyadin county there are lignite seams in between limestone beds containing *Planorbis.* There the limestone is unaffected by volcanic flows. There are travertine - looking limestone intercalations, which are due to deposition from carbonate - bearing waters entering into the lake. Travertine is especially common along Zap River, where the series is somewhat different than elsewhere. Over the narrow channels the typical *Planorbis* limestone is wanting while the detritals outweigh. In the neighbourhood of Van there are limited intermontane depressions displaying short distance transitions, and where — especially toward the end of the sedimentary cycle — very coarse detritals may predominate.

To the west of Van Lake, above the marine Miocene limestone, the series starts with red conglomerate, which is overlain by alternating soft gray marl, siltstone, and white limestone, with intercalations of tuff and basalt. The marl contains *Dreissensia, Hydrobia,* etc. At Bulanık county there are, successively, greenish marl with limestone intercalations and basalt-capped limestone. At Solhan county the alternating marl, marly limestone, and conglomerate beds enclose lenses or intertongues of tuff, volcanic breccia, and lava flows. An angular unconformity is conspicuous to the north of Muş, where marl, siltstone, tuff alternate with limestones that contain *Dreissensia, Hydrobia* and other genera.

In the neighbourhood of Erzurum the strata include gray, green and brown marl; soft, laminated and cross-laminated siltstone and sandstone; cream-white, vacuolar, biostromal shellstone, limestone and gypsum. Alluvial roundstone lenses at places may alternate or intertongue with tuff, agglomerate, volcanic breccia and lava. ,To the south of Çobandere township lava flows fill in the topographic irregularities of the lacustrine Miocene. At Tekman county the marine Miocene is overlain mostly by white travertine or chalk-looking limestone, and by less abundant Gastropod-bearing green marl and fine detritals. To the south of Hınıs the lacustrine beds over Cat county's channel may start directly above Upper Cretaceous - Paleocene with pink marl and sandstone, which are overlain by lava sheets. At Aşkale county an angular unconformity between marine and lacustrine Miocene may be strikingly conspicuous, and the degree of folding helps to distinguish between the two sets of similar lithologies. The fossils determined are : *Bythinia, Congeria, Dreissensia, Hydrobia, Paludina, Unio, Valvata, Vivipara,* Diatom *(Melosira),* etc.

Pliocene (pl). — There exists no Pliocene determined through the fossils over the domaine of the eugeosyncline. Restricted areas of coarse detritals of possibly fluiviatile origin, being unlike the usual Miocene deposits or found higher than the stream terraces, are tentatively attributed to this system. The period is mainly degradational, however a few deposits are preserved over the structural lows. Some of the Pliocene deposits are overlain by Quaternary and recent deposits. At the Çarpanak promontory, to the northwest of Van, the thick-bedded and cross-bedded, gray conglomerate is weakly cemented by sand. The pebbles of diverse types are easily loosened and strewn over the slopes. With the conglomerate some green and red marls are encountered.

To the east of Tuzluca county a plateau is capped by conglomerate that is weakly cemented by sand and lime, and the pebbles are set free easily.

Tahtresa formation, to the southeast of Pervari county and south of Narh township, is a noteworthy regular sequence of evenly bedded conglomerate strata in which red marl is subsidiary. This unconformable lithologic unit may reach a thickness of 500 m. At Toranis, a red marl covers the Upper Cretaceous - Paleocene, whereas a variegated marl covers the marine Miocene. To the west of Muş there are thinly bedded, micaceous, friable, occasionally laminated siltstone beds, truncated by a surface that is overlain by a recent talus cone. There are a few coarser deposits at the periphery of large plains, which may belong to Pliocene.

2. Miogeosyncline or paratectonic region or Border trough or Border folds zone

The Old Paleozoic beds are exposed in deeply breached anticlinoria such as the «Middle Büyük Zap uplift» in the southeast and the «Hazro uplift» in the southwest. There and elsewhere are found sections exhibiting younger sedimentary deposits, including nearly the whole of the stratigraphic column.

Cambrian (?) (c). — At Piyre village, along Han stream and the mountain road from Hakkari city to Çukurca county, a thick sequence of uniform limestone conformable with the overlying Silurian quartzite beds crops out over a few square kilometers along an anticlinal trend. The limestone is gray to black, thinly to thickly bedded and occasionally laminated, angular-fracturing, cataclastic, somewhat dissoluted, and seemingly unfossiliferous. The thin sections also were barren. The sequence exceeds

500 m, much thicker than lensing intercalations of similar limestone observed at Semedar Mountain.

Silurian (Giri formation) (s)- — The large, doubly plunging Middle Büyük Zap anticlinorium or Rejgar-Semedar-Gönherçi anticlinorium in the southeast simulates to a certain degree the position of the Bitlis massif over the eugeosyncline, and it is likewise deeply carved by mountain steam. Thick sections of uniform quartzite are finely exposed. There are subsidiary limestone lenses, slate, variegated marl and tuff; also, especially at the top there is a gray-black or reddish, thinly textured thin-bedded, shining micaceous siltstone. The formation name is taken from Giri Mountain, where a good natural section is present. The thickness is nearly 1000 m. The quartzite by itself makes lofty mountains. It is gray, red purple, coarse-grained, thickly and evenly bedded, and regularly packed. It may display ripple marks of different kind, flow casts, coprolites, various tracks, and quartz veins. Only *Cruziana* is determined. The sequence underlies disconformably the fossiliferous Devonian, and overlies conformably or disconformably the presumed Cambrian. The large limestone lenses, being laminated, are of shallow-water origin; they deposited in the absence of turbidity and detritals.

The pre-Devonian in Iraq is made up of quartzite with *Cruziana* and siliceous shales, which likewise are presumably Ordovician in age. There are other large quartzite outcrops in Turkey which through interfingering or interbedding are more or less known to be Silurian.

To the southwest of the map area and near Dandere village, over the eastern bank of Fırat River, a limited outcrop of a black slate with graptolites was found. Adrilling from the exposed Devonian at Hazro county entered after 500 m of Devonian into green siltstone, sandstone and argilite for an intervall of 500 m considered to be Silurian.

Devonian (Şüke formation) (d). —Devonian beds to the southeast of the map area crop out in a narrow and discontinuous strip that wraps around the core of the middle Büyük Zap anticlinorium, or of similar smaller anticlines or appears in the deeply carved central part of Cudi anticlinorium. This disconformable unit of contrasting fossiliferous lithology serves as a key horizon.

The name is given after Şüke village, and there are typical sections to the west of it. The widest outcrop lies at Düle village, where gray-black smothered surfaced shale (slate) and marly limestone that weathers buff are exposed. Dynamometamorphism has transformed the shale into a poorly foliated slate, has deformed the fossils. The limestone ledges and interbeds become more abundant toward the top. The black slate, which weathers scaly, may be laminated and cross-laminated; it is less fossiliferous than limestone. A set of joints is well developed and the mechanical disintegration is in fast progress. The thickness of the Devonian varies between 50 and 150 m.

The system is absent over the southern flank of the Middle Büyük Zap anticlinorium because of upthrusting. Devonian along Hizil stream is also upheaved by faulting. There and elsewhere the lensing limestone alternates with discontinuous quartzite and these make up the transition beds with the overlying Permo-Carboniferous.

In the southwest and over the Hazro uplift there are first marly limestone, sandy limestone, clayey shale, marl and variegated clay and then, cross-bedded fine sandstone, which is impregnated with bitumen, together with clay and varie-

gated marl intercalations. A list of fossils for Lower and Middle Devonian is given: *Thamnopora cervicornis* de Blainville, *Aulopora tubaeformis* Goldfuss, *Dalmanella eifeliensis* de Verneuil, *Uncinulus elongata Ü*nsalaner, *Atrypa reticularis* Linne, *Spirifer? silvaniensis Ü*nsalaner, *S. verneuilli* Murchison, *Cyrtina biplacata Ü*nsalaner, *Athyris concentrica* von Buch, *Nucleospira concinna* Hall.

To the south of Çüngüş a sandstone lies in between fossiliferous Silurian and thin-bedded limestone, possibly of Upper Jurassic - Turonian age.

The deformed and partly dissolved, thin-shelled and brittle fossils from near Şüke are difficult to determine, so from the whole of the collected fossils only the following are given : *Spirifer, Leptaena rhomboidalis* var. *analoga* (Davidson), *Chonetes, Orthis drcularis* Quenst., *Spirifer speciosus* Schloth.

The thin sections made of a few limestones are microscopic-pseudo-oolithic in texture, occasionally sandy, and rather fossiliferous. An earlier study stated an Eifelian age.

Lacustrine Carboniferous (k). — Over the Hazro uplift there are, successively, variegated clay with thin sandstone partings, sandy limestone, variegated marl, and blue marl. The higher horizons retain exploitable lignite seams, which contain megaspores, and the combustible is possibly of Westphalian age. The system is 500 m thick.

Permo-Carboniferous (Tanin formation) (pk). — A second competent lithologic sequence, represented by a shield-like conspicuous positive structure, is made up prevailingly of uniform limestone strata in disconformable relationship with the underlying and overlying formations. Formerly the mountain was erroneously shown as «Tanintanin» on the base map, but the true name is «Tanin», which means «summer residence», so the correct formational name is «Tanin formation». The system is underneath Trias beds and not above them as claimed earlier. The formation is absent over the southern limb of the Middle Büyükzap anticlinorium, possibly through upthrusting. The limestone is not all fossiliferous. In places it becomes clayey or bituminous or contains shale partings. Then its recognition in the field is difficult. A few exposures are due to thrust-faulting. Kahnispi, in the vicinity of Düle village, lies halfway between Beytişebab county and Habur stream and affords a type locality and a typical section. There the black, smothered surfaced Devonian slate is overlain first by a limestone leas, and then by alternating quartzite, fossiliferous shale, greenish limestone, thinly bedded quartzite, and gray limestone. The Permo-Carboniferous starts after these transition beds with limestone that is gray-black, evenly bedded, regularly packed, and hard, and that occasionally contains hydrocarbons, cherts, and styloliths. The transition beds may be absent either due to non-deposition or erosion. In the transition beds near Mergeh village was found *Pleurodictyum sinangensis* (Reed) denoting a Carboniferous age. To the east of the same village, limestone reposes directly over Devonian slate, and the younger sequence may hold discontinuous quartzite beds.

At Dügoh the formation starts with a limestone breccia containing first whitish and then black limestone pebbles. The limestone is at places strained, when seen under the microscope, besides it may be dissolved and recrystallized. As the limestone is ordinarely dense and brittle the megafossils are hard to detach in good shape. The Fusulinidae abound at certain horizons, but even these are incompletely determined: *Parafusulina, Polidiexodina* and *Pseudoschwagerina* are, successively, of Lower, Middle and Upper Permian; but the most probable age is Middle Permian. *Plectogyra* belongs to the same age span.

Permian, (pm). — On the Hazro uplift, overlying and overlapping the lacustrine Carboniferous, a hard ferruginous, green, quartzose sandstone of 200 m thickness is overlain by marly limestone and limestone, also of 200 m thickness. An early, gray, slightly marly limestone is algal; it contains besides Algae : *Ammodiscus, Endothyra, Lunucammina, Schellwienella crenistria* (Phill.), *Bellerophon, Productus, Girvanella, Gymnocodium, Mizzia yabei* (Karpinsky).

Trias (Goyan formation) (t) . — In the Border trough a disconformity separates the Mesozoic and the Paleozoic. The Trias is soft, variegated, it is a valuable marker in between the underlying Permo-Carboniferous and the overlying similar Upper Jurassic-Turonian limestone. The outcrops are discontinuous through later erosion; the thicker sequences are preserved along the structural lows and mainly over the plunge sector of the Middle Büyük Zap anticlinorium, over the southern limb of Gamer anticline, and at Hezil canyon. An identical patch is seen near Kovan village, over the plunge sector of Bitlis massif. The sea advanced from south, and it destroyed the limits of the Border troughs.

The name of the formation derives from the Goyan area. The lowest beds are not everywhere similar. Near Alus. village, there is either flysch-like association of sandstone and limy sandstone or bedded, cream-colored limestone. At the top of the formation are gray, laminated and sometimes micaceous marl and thin-bedded gray limestone, which make up the transition beds with the overlying system, i.e. Upper Jurassic - Turonian, which is often disconformable.

The marine beds are made up, successively, of well-bedded limestone with green limestone interbeds; thin-bedded, brown, red and purple marl; greenish thin-bedded limestone; thin-bedded gray limestone. Current and interference ripple marks are common, denoting shallow-water deposition.

At Hazro, Triassic deposition begins with marly limestone, which is occasionally sandy, and continues with thin-bedded, red limestone containing Graptolites and other fossils; then follows sandy clay with phosphate nodules and reddish marl.

There are discontinuous, yellow or gray or purple, very thinly bedded limestones and marl limestones, whose stratigraphic position is not clear, as for example those along Han stream and over the Upper Cretaceous - Paleocene domaine. No fossils are encountered in them, neither in the field nor in thin sections, so their assignment to Trias or Upper Jurassic - Turonian remains conjectural.

The smothered surfaces are stricken by dissolution, however there are : *Pesudomonotis (Claraia) clarai* Emmrich, *Myophoria ovata* Goldfuss, *M. laevigata* Alberti, *M.* aff. *praeorbiculina* Bittner, *Gyroporella* sp.

The thickness of the formation ranges between 200 m and 400 m.

Upper Jurassic - Turonian (Cudi group in the Cizre sheet, massif limestone or Mardin group in the Diyarbakır sheet) (jm). — A carapace of competent limestone is conspicuous over the axial highs such as Hazro uplift, Cudi anticlinorium, Middle Büyük Zap anticlinorium, Körkandil uplift, Zeril - Çatak anticlinorium. The precipitous front range water gaps of Cudi anticlinorium afford natural sections, and so the formation has taken its name from this mountain There are other sections, nearly 2000 m high, over the southernsl ope of Cilo and Sümbül Mountains further east. These are the outcrops in the Cizre sheet of the reservoir rock of the southern

Anatolian Oil Province. There is a similarity with the Permo - Carboniferous limestone, as well as with the overlying Upper Cretaceous -Paleocene limestone. The differenciation is possible in the field through the aid of a good light incidence, which enhances the difference in shades. The Jurassic limestone is gray - black, coarse - grained, thick - bedded, regularly packed, hard, brittle, sparsely fossiliferous, and rarely cherty or nodular. It gives rise to sheer canyons and to natural monuments by stream carving. Besides limestones there are black or otherwise colored shale, bituminous shale, siltstone, marly limestone and even quartzite. These lithologies afford manifold associations and transitions The black, well-bedded, fetid limestone weathers brown. Cudi Mountain's limestone is typically gray - black, but buff by weathering, coarsely grained, thickly bedded, highly bituminous. As previously mentioned (see «Cilo series» of the eugeosyncline's Upper Cretaceous - Paleocene chapter), the Upper Jurassic - Turonian limestone is observed to be interfingering with orogenic flysch along a line connecting Salaran Mountain to the west of Şemdinli county with the north of Sümbül Mountain, near Hakkari city. At Arsan Pass of Cilo Mountain, the flysch - like beds of the Upper Cretaceous -Paleocene contain reworked Upper Jurassic - Turonian limestone pebbles belonging to the underlying stratum.

Near Çukurca there are large lensing, thin-bedded, yellow or red, purple or variegated marly limestones, the stratigraphic position of which is surmised because of the scanty paleontologic evidence, and the tectonicalfy altered boundary lines. This topic was also discussed in the previous chapter.

Over Hazro uplift, near Şimşim village, a yellow-red, finely textured, hard, slightly marly limestone is overlain by sandy, fetid, unfossiliferous limestone. At Kilise Mountain there is a basal conglomerate, followed by *Ammonites* - bearing pseudo - breccia and then 20 m thick stylolithic limestone with Lias *Ammonites.* The top dolomitic limestone is Middle - Upper Jurassic in age.

The spot samples of limestone in thin section are grumose to pseudo - oolithic, their microfossil content afforded a Cenomanian - Turonian age span. The other fossil findings are not conclusive as to age: *Globigerina cretacea* var. *subcarpatica* nov. var. Tokay, *Globotruncana stephani* Gandolfi, *Globotruncana alpina* Bolli *Calpionella oblonga* Cadish, *C. alpina* Lor., *Tintinnopsella carpathica* (Murg. & Filip.), *T.* cf. *batafferi* Cad.

Uppermost Jurassic from nearby Sümbül Mountain is known by *Rhynchonella pachytheca* Zeuchner, *Itieria cabanetiana* d'Orb., *Nerinea, Dictyoconus walnutensis* Mazenot, *Dalmaniceras punctatum* Djan., *Spiticeras subgutatum* Djan., *Berriasella broussei* Mazenot, *Belemnites* cf. *subfusiformis* Blainville, *Neocosmoceras, Berriasella* aff. *simplicostata* (Mazenot); Barremian in between Geliasin and Belkis Mountain is determined through *Ctenostreon* or *Pecten., Trichites, Harpagodes (Pteroceras)* cf. *desori, Arca* cf. *gabrieltis* d'Orb., *Fusus* cf. *neocomiensis* d'Orb., *Heteraster couloni* Agass., *Exogyra* cf. *couloni* Coquand, *Nerinea, Natica pellati* Matheron, *Toxaster* cf. *retusus* Lmk.

At Hacertum Mountain the Lower Cretaceous is 800 m thick. There should be significant break in sedimentation as it overlies directly the Devonian beds at Şehsap. The Gercüş Raman and Kentalan drillings for oil found thicknesses of, respectively, 639 m, 1000 m, 1030 m; the usual thickness ranges between 400 and 1000 m.

Upper Cretaceous - Paleocene (Kermav formation and Becirman limestone) (krep) . —- This is mainly a green-colored soft series, standing in between the underlying black Upper Jurassic - Turonian and the overlying red Upper Paleocene

Gercüş formation. Once it was called «Green series» by Moses. Maxson applied «Şırnak formation» to the lower part, and «Kermav formation» to the upper part, but the former denomination is abandoned. The older and younger lithologic units are disconformable, as is usual in the miogeosyncline, but at rare intances and locally an angular unconformity is observable.

To the west and northwest of Şırnak county a white limestone intertonguing member, in the upper section of the Kermav beds, is called «Becirman limestone». It is asphaltic near Kerbent village. Neither microfossils nor macrofossils determined in processed samples in thin sections gave a Danian age, so an earlier assignment to that stage is unfounded. A break in sedimentation for Danian is forwarded also by A. Ten Dam.

The structurally low area in between Körkandil and Cudi uplifts is wide in the west, but narrows eastward, where the onlapping coarse, reddish-purplish sediments wedge out over the surelevated area to the southeast of Hakkari province. Farther east there is Cilo series which represents a southern onslough of the orogenic flysch facies. The Kermav formation also thins out westward in the direction of Mardin province, where its base is a marly limestone, and its top is in gradational transition with red conglomerate beds of Gercüş.

The Kermav sedimentary cycle begins with flaggy beds and *Orbitolina* limestone, the latter may be brecciated or pebbly. This is a key horizon in oil drilling. In the main, the formation is made up of alternating marl weathering into spheroids or needles, shale, coarse or fine-textured sandstone, interchangeable marly limestone and impure limestone. Over the northern limb of the Cudi anticlinorium the base is a black limestone or a green one through admixture of glauconite. The limestone is evenly bedded, occasionally marly and contains large *Alectryonia*. Then there is an alternation of thick-bedded limestone, gray-blue marl, and marly limestone. The top is made up of flysch-looking beds with limestone interbeds. The green Kermav beds fail over the plunge sector of Cudi anticlinorium, where gray, thinly-bedded or laminated marly limestone takes over. There are features of turbidity currents, although to a lesser degree than in the eugeosyncline. To the southwest of Şırnak both green Kermav formation and red Gercüş formation exhibit lensing intercalations of either type.

The onlapping Kermav formation reached the Körkandil's uplifted area late. There it is thin and of shallow water facies, and is accompanied by red beds. For example, at Doğan Pass black, marly, easily weathered *Hippurites* limestone overlies the Upper Jurassic - Turonian limestone. Farther north, basal red marl and conglomerate are followed by the usual greenish Kermav beds. The upper section's sandstone and limestone contain *Hippurites* of Campanian age. Farther southwest, and in the direction of Kaval Mountain, Kermav formation is absent either through non - deposition or erosion and Midyat beds overstep Upper Jurassic-Turonian.

At Hazro a gray-green, marly'shale is in angular unconformity, and it encloses first thin-bedded, dense, gray limestone and chert, and then sandy marl interbeds. The system is 500 m thick. As there are wedging lithologic units, there were a few episodes of hiatus.

The Becirman limestone wraps around the mountain to the northwest of Şırnak and it is intertonguing with green Kermav beds. It consists of limestone interbeds that appear near the top of the series, and become increasingly abundant upward until limestone predominates.

Along the dislocational trends the Kermav beds may be badly strained and look like mica-schist, as the case is to the west of Segerek- Becuh upthrust.

The macrofossils are scarce. The age span is known mainly through microfossils and it is Upper Cretaceous - Paleocene: *Globigerina pseudobulloides* Plumer, *G. cretacea* d'Orb., G. *aspera* Ehrenberg, *Lockhartia daviesi* A. Ten Dam, *Spiroplectammina* cf. *expansa* Plummer, *Globotruncana conica* White, *G. stuarti* de Lapparent, *Globorotalites micheliana* d'Orb., *Omphalocyclus macroporus* Lmk., *Orbitoides media* d'Arch., *Loftusia, Siderolites calcitropoides* Lmk., *Inoceramus* cf. *regularis* var. *baltica* Böhm.

The drillings for oil found 350 m at Hermis, 850 m at Raman, and a possible maximum thickness is 1000 m.

Upper Paleocene (Gercüş formation) (ep). — There are coarse, red conglomerate beds in gradational transition with Kermav formation. Although also called «Red beds», only the name «Gercüş formation» survived. The sequence is predominantly red, thick - bedded, coarse roundstone strata, in which there are subsidiary sandstone, shale and marl. Intercalated lenses of marine limestone may be present near the base and at the top. The coarse - textured lithologies are prone to thicker bedding, the fine ones to thinner stratification. The formation is mainly lagoonal and partly continental with transitory marine transgressions.

Near Şırnak, Becirman limestone is overlain by gray and red limy shale or red marl with conglomerate interbeds. Gypsum is infrequent. Fossiliferous limestone intercalations occur near Kiriseri hill and Kirim creek to the northwest of Şırnak. In the eastern portion of Diyarbakır - Siirt basin are widespread and continuous Gercüş outcrops, but they form only a symmetrical strip around Körkandil uplift. The Gercüş beds are also displayed at the core of a breeched anticline farther west. The competent members make amphitheaters all around the central depression. The green Kermav, red Gercüş and white Midyat are concentrically and beautifully exposed.

The Gercüş formation is also present at the exposed core of the anticlines to the south of Bitlis massif. At the Dodan water gap only pebbles of Upper Cretaceous - Paleocene are present. At Zor canyon there are whitish limestone intercalations in Gercüş beds, and there are fine to coarse, red detrital interbeds in the overlying white Midyat Limestone. At some places the Gercüş and Midyat are conformable, at others disconformable.

Over Hazro uplift the red beds are less coarse and more marly, and there are a few intercalated greenish or whitish limestone lenses. Neither micro-nor megafossils are found in the alternating green marl and limestone, exposed to the south of Tercil village.

The precursor of vigorous movements of the Van orogenic phase upheaved the highlands, and then swift degradation under special climatic conditions furnished the coarse conglomerate. The thickness of the Gercüş is highly variable. The measured section at Harbol and Kasrik gorge is 400 m, at Raman 270 m, and the maximum should amount to 1000 m. The fossils determined are for an Upper Paleocene age: *Nummulites burdigaliensis* de la Harpe, *N. parvulus* Cushman, *N. praelucasi* H. Douv., *Lockhartia conditti* (Nuttal), *Rotalia trochidiformis* (Lamarck), etc.

Lutetian (Midyat beds in southwest, and Bedevi formation in southeast) (el). — There are large tracts of a cliff - making, white limestone called : (a) Midyat

beds in the southwest, (b) Bedevi formation along a narrow channel to the east of Hakkari. city. The two grade into one another laterally.

a) A white-cream, evenly bedded, regularly packed, abundantly fossiliferous, biostromal, hard, angular fracturing, brittle, cliff-making, dry limestone is one of the typical lithologic units of the Border trough. The sequence is disconformable over the Upper Jurassic - Turonian or Kermav, or Gercüş; but locally an angular unconformity is observable. The basal beds are not everywhere the same. Westward they become marly. At Derzengi the typical Midyat section displays red conglomerate, marl and breccia intercalations. The sequence contains soft, chalky limestone in one or more beds toward the top, where small, button-like Echinids may make a local marker. The chalky limestone is due to partial upheaval and weathering. Chalky limestone may be even present at the base, as for example near Aval village.

In Erzurum sheet and over the Hazro uplift no Midyat beds are shown on the map. This absence may be due to a lack of differentiation between Midyat limestone and Lower - Middle Miocene limestones, which are much alike in the field and need detailing. The uniform limestone sequences over the southern slope of Bitlis massif, such as are seen at Minar, Pirajman, etc. look somewhat different than those farther south, which are classical. Those at the extreme southeast, at Kalecik Mountain, look like Midyat beds and they may begin with a basal conglomerate; they are of shallow environmet and may be barrier reefs. The limestone in the overthrust sheet of Ergani is also somewhat peculiar, but farther to the north it unconformably covers the orogenic flysch zone. At Samili village, in the northwest part of Kavak township and south of Hazar Lake, exists a restricted outcrop of a sandy, black, hard, thick-bedded limestone.

The chalky limestone is nearly barren of fossils. The microcrystalline limestone is ordinarily rich in fossils, but these are difficult to detach as the rock is compact and dense. The fossils determined are as follows: *Nummulites burdigaliensis* de la Harpe, *N. gallensis* A. Heim, *N. laevigatus* Brug., *N. subatacicus* H. Douv., *Assilina spira* de Roissy, *Gypsina globulus* (Reuss), *Alveolina, Flosculina*.

b) The usual Midyat beds cease to exist east of Hakkari city, and they give place to a gray-black limestone weathering in brown hues; farther east the limestone is marly and soft. This narrow strip of Nummulite-bearing rock is a most valuable marker in mapping. There is rather a good section across the Bedevi pass, hence the name of the formation. A basal conglomerate, 1-2 m thick, or else a basal limestone that contains small pebbles, covers an uneven topography. Above it is gray marl full of *Alveolina* but without Nummulites, which in turn is followed by richly nummulitic gray limestone. The marl may be more or less schistose and reddish. At Mezre it exhibits a rough cleavage. Further east there is an alternation of gray marly limestone, nodular limestone, and greenish shale, with lensing gray limestone interbeds. Bedevi formation at Nogaylan is in angular unconformity over the red pebbly sandstone. The unconformable sequence at Bay village starts with limestone. The strip is very thin and even discontinuous to the north of Sat and Sim Mountains; this may be due to an overthrusting and also to an advanced erosion before the thrusting. There are red intercalations to the north of Cilo Mountain. The sedimentary cycle may end with a limy conglomerate or a nodular limestone. At Bay village the fossils determined are as follows: *Assilina douvillei* Abrard & Fabye, *A. placentula* (Desh.), *A. spira* de Roissy, *Cardium* cf. *bonelii* Bell., *Cardium* nov. sp., *Chlamys* cf. *studeri* M. E., *Crassatella* cf. *semicostata* d'Arch,, *Discocyclina archiaci* Schlumb., *Lucina* cf. *prominensis* Opph., *L.*

cf. *nokbahensis* Opph., *L.* cf. *thebaica* Zitfc, *Modiola* cf. *hastata* Desh., *Nummulites* cf. *burdigalensis* de la Harpe, *N. gallensis* A. Heim, *N. uroniensis* A. Heim, *Orbitolites complanatus* Lmk., *Operculina.*

The Midyat beds are 150-250 m thick; the Bedevi formation is usually thinner, but it may amount to a maximum of 300 m.

. *Marine Lower - Middle Miocene (md).* — The earliest Miocene is marine and the sediments are in transgressive overlap over the Permo - Carboniferous, Trias, Upper Jurassic - Turonian, Upper Cretaceous - Paleocene. The deepest axis of the Border trough exhibits continuous molasse beds. The same are also encountered to the east of Körkandil uplift, in the southeast corner of the map area, at Çukurca county.

Beygur series: A sea invading from the south first deposited green-gray molasse beds over a highly uneven country, then a whitish and fossiliferous horizon of limestone, and finally red, fine and coarse detritals. The molasse begins either with alternating red marl, red marly limestone, and red conglomerate; or with gray, soft marl and gray sandy limestone; or with red sandstone. The molasse beds are in green - gray shades and they are made up of various marls, sandstones and rare limestones. The molasse is overlain by more or less well-bedded, white, rather soft, occasionally richly fossiliferous limestone, which at times may be pebbly and brecciated. The overlying evenly bedded sequence of red marl, sandstone, and conglomerate is regressive.

At Çukurca county the sedimentary rocks are not true molasse beds. There are interbedded soft red marl, green sandstone, pebbly sandstone, and coarsely textured limestone. These are prone to large - scale, continuous slumps and glides. The limestone intercalations are frequent and well developed.

The system is in transgressive overlap in the area of Körkandil Mountain. There a red conglomerate may overlap Upper Jurassic-Turonian limestone. Then follows a sequence of green to red marl, sandstone, polygenic conglomerate, and biohermal, light - colored limestone. These lithologies may be lensing or interfingering. There are also lagoonal beds at Mollamirge, which are established as a local facies in lateral transition with the marine sequence. The lagoonal beds are not persistent, soft, weak and crumpling green - red marls, sandstones, conglomerates and limestones in manifold oscillations. There exist salt springs. Akır saltworks lie over the variegated marl. In this neighbourhood the marine Miocene, overlying the Kermav formation, starts with alternating red conglomerate and marl, and continues with red beds. Near Narh township there are molasse-looking strata with limestone interbeds, which become more frequent and widespread toward the top.

Along with Katubastik to the west of Hişet, village the series starts with rather thin-bedded, green-red marl or conglomerate and continues with a thick sequence of well-bedded limestone. Toward Sanuh village, farther west, and through lateral transition, there is a marly, coarsely textured, gray, occasionally richly fossiliferous limestone. Over the whole district there is a cyclic sedimentation. The overall thickness of the molasse amounts to a few hundred meters.

To the southwest of the map area, a molasse was deposited in the deeper parts, or during deeper episodes of the trough, while limestone was deposited along the axial highs or during the shallower episodes. The molasse beds become reddish toward Bitlis massif. The vicissitudes of the environmental conditions cause their interfingering. There are a few type localities and type sections nearby Dicle county. There are large and

thick lenses of gray conglomerate in the molasse beds, as for example in between Cacas township and Sinda village. These are delta deposits at the front of the degrading Bitlis massif. They are similar to Nagelfluh in Switzerland, and make a member called «Hazi conglomerates The fossils from these molasse beds and limestone intercalations are nearly similar to those enumerated previously in the chapter of the eugeosynclinal Miocene.

The overall thickness of molasse in the southern foredeep may amount to 1000 m.

The molasse is evolved only in the eastern stretch of the northern foredeep of Bitlis massif; over the western stretch, and north of Muş, green marl, shale, and white limestone were deposited.

The limestone deposited over western stretch of the northern foredeep of Bitlis massif may be widespread and gently folded into a carapace, such as those exposed over Bade, Dodan and Silvan anticlines. The last is so typical that it served to designate «Silvan formation» after the name of the county seat. To the north of Dodan anticline, the series begins with red marl. The drilling for a dam site at Malabadi traversed white limestone, yellowish or reddish marly limestone, pink marl, and gypsum. Pink marl lenses in between the limestone strata also appear to the north of Hazro.

Near Lice county and farther east the limestone intercalations are wider, more frequent, and more prominent over Upper Cretaceous - Paleocene substratum. The Miocene limestone is in places thicker than 100 m.

Lacustrine- continental - lagoonal Upper Miocene-Pliocene (Siirt series) (mü-pl)-— These deposits accumulated steadily over the structural lows of the Border trough during the Upper Miocene period and possibly continued without interruption during the Pliocene period. The deepest trough lies in the direction of Diyarbakir and there are prolongations of increasing shallowness from Siirt eastward. There is a disconformity with the Lower-Middle Miocene limestone. Among the names «Şirvan formation», «Garzan formation», and «Siirt series» the last one is widely acknowledged. A good section is observable in between Siirt - Bitlis Highway's junction and Baykan county. Here disconformably above the Lower - Middle Miocene carapace limestone is a sequence of pink, coarse and fine, weakly cemented detritals, occasionally with minor amounts of evaporites. They exhibit features produced by recent gravitational sliding over the competent limestone substratum.

There is a narrow strip of limestone at Garzan which interfingers laterally with the above-mentioned sequence; it is a member called «Garzan limestone». The pink detritals below it may exhibit gypsum.

Over Cizre plain the sequence is somewhat similar to that at Diyarbakır - Siirt basin. The lowest is a marine limestone 10 m thick; then come fine and coarse, gray detritals, of which the competent units stand up as cuestas The bedding dips less toward south. The top is a white limestone conglomerate, which may represent Pliocene.

The Siirt series is thought to be equivalent to the Upper Fars - Bachtiari (Upper Miocene), while Asmari limestone is of Oligocene - Lower Miocene age. The Siirt series may attain 1500 m in thickness.

Pliocene (pl). — To the northeast of Billoris thermal springs of Siirt, overlying the truncated Siirt series beds, there afe elevated and tilted gray conglomerate strata, which lie higher than Botan terraces. Being weakly cemented by sandstone, the

round pebbles loosen easily. Possibly there were swiftly degrading highlands, the coarse detritals of which are occasionally and locally preserved.

Quaternary

Recent alluvium (Qy).— It is common along the large valleys of the longitudinal streams and over the structural lows. The latter are large plains (ova).

Old alluvium (Qe).— The old, along with recent alluvium completes the Neogene filling of the plains. They are one-sided or paired, and cyclic terraces. There are also a few structural surfaces. Well-defined, continuous terraces are nearly lacking at the periphery of larger lakes; and those which do exist bear the effect of recent erosion Behind the narrow gorges the exportation of alluvium is delayed, and this has caused slant surfaced terrace systems, which are occasionally capped by recent talus cones, as is the case with Tercan and Bingöl plains.

Slope waste, talus cone. — As the physical disintegration overwhelms the chemical weathering, and as the area as a whole reached a very low base level, there are abundant slope waste and high talus cones. There are also coalescing alluvial fans which make aprons along both sides of the plains, leaving the stream lodged nearer the shorter mountain slope. Where the fronts of the fans are truncated by the stream, they stand as a terrace. There are antique cities over larger alluvial fans such as Erzincan, Erzurum, Elazığ, etc.

Karstification .— There is in general a young stage of the karst cycle with vauclusian springs, doline, sink, cockpit landscape, dry valley, clint, karst lake, etc. together with limestone of various ages. Those making dip slopes are fantastically affected.

Landslides- — There are many weak lithologies striken by slow and fast mass movement. The competent beds may be undermined and then break loose and glide down the slope.

Glaciation- — There are dwindled living glaciers over the eastern sector of the map area. Besides, there are cirques and nivation formed basins over the lofty divides. The glaciation borrowed an old drainage system, but it did not alter it. The limit of the perennial snow at Suphan Mountain lies at 3600 m. There is a cirque and a cirque lake at the top, and there are two larger and older cirques at 3000 m on the northern slope of the mountain. There is a glacier 1.5 km long at the south border of the crater, which descends to an altitude of 3400 m.

The limit of the perennial snow over Gilo Mountains lies at 3400-3500 m; it was 700 m lower during the glacial period, and the older glaciers descended to 2000 m of altitude. Today there are nearly 20 dwindling glaciers over the northern slope. The largest, coming down from Geliaşin peak, is 4 km long. The erosional features and the deposits derived from former glaciers are being destroyed by recent stream erosion. Degradational features of glacial origin include U-shaped valleys, hanging glacial valleys, trough shoulders, truncated spurs, glacial steps, glacial basins now occupied with lakes, giant stairways, cirques, compound cirques, fretted uplands, serrate ridges, glacial horns and «roches moutonnees». Products of glacial deposition are the different kinds of moraines and morainic belts.

Travertine. — Cold, warm, and hot springs with or without CO_2 and H_2S are abundant, many deposit travertine. Some may be aligned along dislocation trends. At places they built temporary mounds, they shifted place along the fissures, as is obviously observable to the south of Diyadin. The most noteworthy deposits lie to the south of Van city. Some travertine deposits alternate with sheets of talus cone, as for example near Çatak county. They are widespread travertine interbeds with the lacustrine Miocene sediments, caused by abundant limestone springs flowing into the lake.

Thermal springs — There are springs of various temperatures with or without CO_2 or H_2S. There exist also cold and sulphidric fumaroles which escape from the cracks over volcanic terranes.

Mineral springs- — There are abundant mineral springs at about 6 km of Çaldıran township, to the south of Başkale county, at Sarısu to the east of Doğubeyazıt, at Iğdır State Farm, and at about 2 km to the east of Erzincan.

Igneous rocks

The magmatic phases and their evolution in the massifs are not yet known. Over the eugeosyncline domaine the phases and evolutions differ from one secondary orogenic belt to another. There, the alpine magmatic cycles are fairly well known. Over the miogeosyncline area are only a few showings of volcanics. Near the Iranid belt there exists an intrusive serpentine cutting across the Kermav beds. Diyarbakır-Siirt basin's truncated Upper Miocene - Pliocene deposits are overlain by basalt flows issuing from Karadağ further south.

Acid intrusives (granite, granodiorite, diorite, etc.) (p). There are scattered concordant (sill) and discordant (dike, stock) intrusive bodies in the massifs and in the Upper Cretaceous - Paleocene series.

The intrusive granite is encountered near the core of the ophiolitic suite. It produces somewhat narrow metamorphic contact zones with spilites and other rocks. A few of the mapped intrusives have granodiorite composition, especially to the southwest of the map area. To the east of Elazığ, to the north of Hoş village, and among the pebbles and cobbles of a large conglomerate lens in Upper Cretaceous - Paleocene flysch beds there are granodiorite blocks up to 50 cm in diameter, which denote the contemporaneity of the acid intrusion with the sedimentary cycle.

A few samples taken from the previously mapped occurrences over the western half of Bitlis massif were not identified as granite in thin section.

Basic intrusives (gabbro, quartz gabbro, diabase, serpentine, etc.) (p). — The basic intrusives form sills or dikes in paragneiss. Near Diyadin county, gabbro at the contact of granite with paragneiss contains melanocratic beerbashite segregations. It received orthose infiltration through contact-metamorphism, and it displays the effects of granitization. The paragneiss is the oldest, then come gabbro as a sill or dike, and then granite, the youngest. The submarine basalt intrusions are found as diabase and spilite. The relative ages of the green rocks with occasional pillow lavas are not yet fully known. They may belong to one or several of the Caledonian, Varistic or Alpine orogenies. Aplite dikes and dacite are older than the basic intrusives. Along the progressively subsiding zones of the eugesyncline, there were basic rocks (ophiolitic suite with or without pillow lava), ultrabasic rocks (peridotite or dunite) and spilitic lava. There are compound bodies, i.e. injection complexes. There are rocks made up of ad-

mixtures of sedimentaries with reworked volcanics. The ophiolitic suite may be altered into greenstone through subsequent orogenic action; the suite includes chlorite, hornblende, glaucophane and talc schists. The peridotite by hydration is transformed into serpentine. The association of graywacke with spilite is not a rule. The possibly continuous basic intrusives (aridesite, rhyolite) toward the end of the magmatic phase (protectonic, initial magmatic) are linked with lasting orogenetic movements.

With the advent of the paroxysm a synorogenic (syntectonic) plutonism (conformable acid intrusions) occurred. The subsequent volcanism is of acidic nature. The pyroclastics may be absent, scarce or abundant. The final volcanism (post - tectonic, post - orogenic) which follows important denudation and the ispstatic adjustment, is basaltic. The continental phase starts with block - faulting. There are basalt flows and basaltic differentiates. There are cinder cones and spatter cones which through their alignment disclose the dislocations.

The fine pyroclastics, still fused after they fall to earth, heaped into welded tuff (ignimbrite) are to be encountered in the southeast of Nemrut (Rahva Düzü, Bitlis creek).

Greenstone. — The xenoliths of Lower Cretaceous limestone and crystalline schist in greenstone over the Kop Mountain show that the ophiolitic suite is younger than Lower Cretaceous. Other observations prove the heterogenous ophiolitic family to be contemporaneous with Upper Cretaceous - Paleocene strata. The ultramafics intruded into the mafics. The larger bodies are often complex associations of different types, such as at Erk Mountain to the east of Van city. These are not laccoliths but widespread flat lenses. The effects of dynamometamorphism are conspicuous. The greenstone came through fissures and they are essentially *in situ*. The tectonic movements modified their contacts, and so, at many places, it is difficult to decide whether the emplacement is primary or secondary, but the greenstones are not overthrusted following their fissures There are many conformable and unconformable andesites, and they seldom display pillow structure; they have intruded into greenstone, but still they are of Upper Cretaceous - Paleocene age.

The ophiolitic suite exhibits greatest development over the axial lows, such as Menkova - Mezre, Ergani - Erzincan. Longitudinal trends of ophiolite may correspond with dislocations. The contact effects upon the sedimentaries are hard to notice. A foliated structure in a few sedimentaries is due to intrusion nearly contemporaneous with deposition. The greenstone may be transected by some acid intrusion.

Over the Iranids, the greenstone intruded various schists and crystalline limestone of the Bitlis massif, and the phyllites to the south of Hazar Lake, and the marble to the west of Elazığ. Değirmen pass along Erzurum - Hınıs highway is a typical locality for observing the intricacies of greenstone intrusion. Red, green and purple ophiolitic rocks with frequent pillow lavas are characteristic for the Iranids; while green and mostly serpentinized peridotites are distinctive for the Anatolids. Over the Border trough, the top Silurian beds interfinger with bedded or laminated, occasionally variegated acid tuff; in addition, diabase and spilitic basalt without olivine form dikes in the quartzite. A dacitic lava occurs in Devonian beds.

Andesite (a).— Various andesites, pyroclastics, and basalt occupy large expanses over the northeastern sector of the map area, where the volcanism lasted intermittently from Oligocene up to recent time. Extrusion took place through both central and

fissure vents. Andesite is widespread all along the Taurids, while tuff is abundant on its eastern portion. Over the Anatolids andesite gains in importance to the east of Erzincan, while younger basalt takes over to the northeast.

The volcanics stand higher than the sedimentaries, and they have hidden the underlying rocks and structures. Their composition remains constant laterally, but changes vertically from layer to layer. There are difficulties in differentiating the andesite from basalt, in thin sections as well as in the field, and some disagreement arises among the petrographers. Basalt is seldom accompanied by tuff. Moreover in field mapping, porphyritic texture is a more diagnostic feature of andesite than color, fabric, organic structure, etc. Andesite may well display the last feature as observed along the Bayburt-Of highway's Upper Cretaceous - Paleocene of Pontid facies. There are a few recognizable mamelons over the andesitic areas.

The first eruptions were of intermediate composition, mainly hornblende andesite extruded before differentiation. At the beginning, basalt was subordinate, but progressive differentiation evolved trachyte, rhyolite, basalt, etc. Andesite and pyroclastics arc not abundant in the marine Lower - Middle Miocene, but are present on a larger scale in the lacustrine Miocene. There are widespread sheets alternating with sedimentary rocks, and they may be sills. Some effusives are possibly penecontemporaneous with gentle folding. The individual flows are not always conspicuous. Andesite may be brecciated, and laminated or cross-laminated. Sheeting may parallel the old land surface. To the south of Hınıs county, the flysch beds of Lutetian age contain a few intercalations of andesite, agglomerate, and andesitic breccia.

The volcanic piles have been building up since the beginning of the Miocene period. They are common to the northeast of the map area, where volcanic cones, parasitic cones, and cinder cones are beautifully displayed, and their alignment discloses the dislocations indicated over the Tectonic Map. Büyük Ağrı - Ala - Suphan linear is the most important of the Van district; a less important parallel one is Küçük Ağrı - Tendürek - Tatvan linear. There, volcanism started with an andesitic phase, then came a basaltic episode, then andesite continued again, then basaltic activity, and finally volcanism ended with welded tuff. The viscous andesitic lava tongues at places broke loose to give rise to large blocks and to talus cones that yielded breccia.

Suphan Mountain: This is a strato-volcano made up of andesite, obsidian, etc. The cone-building andesite lava is gray, hornblende-bearing and coarse-grained. There is a scoria mound inside the caldera. The diameter of the pre-glacial crater is 4000 m and the main summit lies to the northeast of the crater. The outbreak which yielded tuff is earlier than the obsidian. Recent obsidian lies over the basalt flows.

Aladağ: In the district of Ala Mountain the individual sheets are not conspicuous.

Nemrut Mountain: The main body is gray hornblende andesite in which ejectamenta alternate with lava flows. As subsequent eruptions occurred at gradually lower levels, from aligned parasitic cones over the southern flank, the foundation is covered by large amounts of recent eruption products, such as fragmental pumice. Over the eastern slope too there are tuffs with pumice and lava fragments interbedded with obsidian. The upper half of the vast cone was truncated by unusually powerful explosion. The present caldera is young and it is filled with a large horseshoe shaped lake which occupies 1/3 of the caldera. The collapse depression at the top is wider

than the caldera itself. The explosive materials together with obsidian built up round topped knolls inside the caldera. A pelean eruption brought in tuffs. There is also a katmanian variety of the «nuees ardentes». The «nuees ardentes» of the second order yielded ordinary tuff. Inside the crater there is a moffete emitting CO_2. The streams running down the Nemrut half cone deposited alternating siltstone with rounded pumice and tuff.

North of Tercan county, sedimentary Miocene rocks and serpentine are covered by a volcanic breccia, which in turn is overlain by lava that may be brecciated and even scoriaceous. The breccia and the lava have porphyritic texture which indicates that they are probably andesites.

The aligned andesitic cones to the east of Erzincan disclose dislocations. The cinder cones display block lava. Andesite interfingers with the lacustrine Miocene. Mollakoy knoll, to the south of Erzincan plain, is a large cinder cone exhibiting pumice and lava fragments; it lies on the trend of a longitudinal dislocation.

The packed lava flows may be deeply and fantastically carved through erosion. Their front may be cut out by streams, but the stepped linear boundaries in the direction of the valleys are not faulted. Andesite is hydrothermally altered to the west of Kiği, to the northeast of Hozat, and elsewhere.

Pyroclastics. — Pyroclastics of Miocene age, mostly tuff, are not extensive in the west, but in the east crop out over sizable areas devoid 9f other rocks. The tuffs are fine or coarsely textured, friable or not, occasionally pebbly and blocky, thinly bedded and cross - bedded, and in places show penecontemporaneous deformation. A badland topography is infrequent. There may be a few areas with pyramids, etc. The tuffs are mostly of andesite. Some underlie the lava flows, others are interbedded with lava. There are also volcanic breccias and conglomerates, and tuffs with pebbles and blocks of pumice and lava. Tuff with marine Miocene limestone may lie at the base of the Lower-Middle Miocene. The lava flows commonly contain blocks of limestone that were in front of the advancing flows. Lacustrine tuff intertongues with lacustrine Upper Miocene limestone.

Over the border trough the top Silurian quartzite beds interfinger with bedded or laminated, red and green or variegated or spotted acid tuff. The same material where reworked made a penecontemporaneous feldspathic sandstone.

Welded tuff. — There are widespread welded tuffs over the Rahva plain, which borders the southwestern corner of Van Lake, and farther down along Bitlis River valley. To the south of the city of Bitlis only basaltic lavas are observable. To the south of Reçlok village, at the sharpest bend of the highway, a basaltic flow is observable in between terrace gravels. This witnesses for a recent age of the flow.

The level beds are cut nearly 50 m by stream erosion, and the flats stand as paired terraces. The welded tuff filled irregularities of the underlying topographic relief. Typically it is black-gray, spotted, sandy and even pumice pebbly, soft, easily weathered, in thin layers rather than thickly bedded, columnar jointed, and inerbedded with pumice. A diagnosis under microscope is needed for recognition.

Basalt (b). - To the north of Timar township, on the east bank of Van Lake, basalt reposes on a truncated surface of Lower - Middle Miocene sandstone and conglomerate, and it is overlain by conformable clay and sandstone. The oldest basalt is

encountered in the northeastern sector of the map area, where the basalt flows alternate with gypsiferous strata. Nearby Serdarabat regulating weir the youngest flows and tuffs are between and above terrace deposits. Further south there are basalt flows of various ages ranging from Eocene till recent time. The youngest are the most fluid. The widespread sheets are scoriaceous. Some exhibit spheroidal weathering. Columnar jointig is frequent.

Basalt flows in Erciş county to the west of Van Lake overlie either Lower-Middle Miocene limestone or an agglomerate and tuff horizon over the limestone. At Zilan Creek basalt covers pink-white tuffs that in turn overlie andesite. At Diyadin and Malazgirt counties, basalt intertongues with lacustrine Upper Miocene. At Pülür village, near Malazgirt county, are large pillows, which indicate the basalt poured into a body of water. There may be tongues of tuff, or of lava and tuff in between the lacustrine Upper Miocene deposits. One may encounter black volcanic ash, lapilli, volcanic bombs nearly 1 meter long, pumice scoria, pumice blocks, etc. to the north of Tendürek. In the basalt fields there are parasite cones, puys, cinder cones, spatter cones, scoria mounds. Some basalt flowed down recent valleys.

Tendürek: It exhibits double cone. A large basaltic dome is built over an andesitic pedestal. The volcano changed habit and has shown pelean (lapilli and pumice) and Hawaian (basalt, etc.) types of activity. There is pumice in the western crater. An explosive type of basalt magma has given rise to scoriaceous, pumiceous lapilli, which display graded bedding. An explosion destroyed the top, and tuff derived from magma is spread around. Over the andesitic basement of the eastern cone basalt flowed out from a gap in the crater. The former rock is gray, seen from afar, while the latter is black. To the north of Soğuksu village a travertine deposit, mingled with talus materials, also contains basalt blocks, which means that the basalt flows are of recent age.

The front of the lava flows is made up of heaved blocks, which stand up a "few meters from the plain's level. There is no pahoehoe, but surfaces exhibit large polygonal sub-rounded blocks, which are due to reworking. There are simple or compound scoria mounds, pressure ridges, lava tunnels, squeeze-ups, lava funnels. The cinder cone at Gevrişamyan is older than the recent lavas of Tendürek. After the last explosion, which emitted pumice, the mountain entered a solfatara stage during historical time. The crestal depression lodges a fresh-water lake approximately 150 m long and 75 m wide. There are hot springs at the periphery of the volcano.

Both Büyük Ağrı and Küçük Ağrı make up a volcanic association, and each one is a strato-volcano. A paroxysmal outburst formed a caldera of volcanic type. Büyük Ağrı poured out more lava. Its main edifice is made up of an augite-hypersthcne-andesite. There are also more basic and more acid lavas. An outflow from the summit was followed by andesitic outpouring from the flank, and the parasitic cones are aligned along a dislocational trend. There are scoria mounds and squeeze-ups. Near the summit andesite appears at places from . beneath the basalt, that is of recent age. Küçük Ağrı lost its upper portion through exploding gases and only a neck is left over. To the southeast of it there is a black lava, area, which is situated somewhat higher than the alluvial plain. Actual limit of the permanent snow lies at 4000 m. There is a neve of more than 10 km^2 over the top, which feeds two glaciers.

At Karayazı county there are widespread, level, packed basalt flows. Their structural surface is at places overlain by tuff and then a lava flow again. There are pressure ridges, cracked blisters.

To the north of Elazığ a large basaltic cone displays a crater. There are aligned cinder cones denoting dislocation. Very restricted structural surfaces are present. Basalt lava flowed down a creek to the north of Sarini, and recent stream sculptured it to a depth of nearly 50 m thick.

Over Diyarbakır - Siirt plateau basalt sheets issuing from Karacadağ cover the truncated surface of the Upper Cretaceous - Paleocene and spread out almost horizontally.

At Cizre county, basalt flows are interbedded with the Upper Miocene - Pliocene sedimentaries, and the stream erosion exhibited their columnar jointing. There is a steptoe of Midyat limestone to the west of the county seat.

Dacite (l).—Dacite is almost contemporaneous with andesite, and it is to be encountered to the north and south of Çaldıran. plain, at Sığınık to the north of Aleskirt, etc. At Tanin Mountain a dacitic lava has erupted through the Devonian beds.

Trachyte (t). Trachyte is found at the railroad cut to the east of Pasinler, at Ortuzu, to the southeast of Erzurum plain, at Mercimek hill to the north of Muş plain and along Murat River.

(Continued in M.T.A. Bulletin no. 67)

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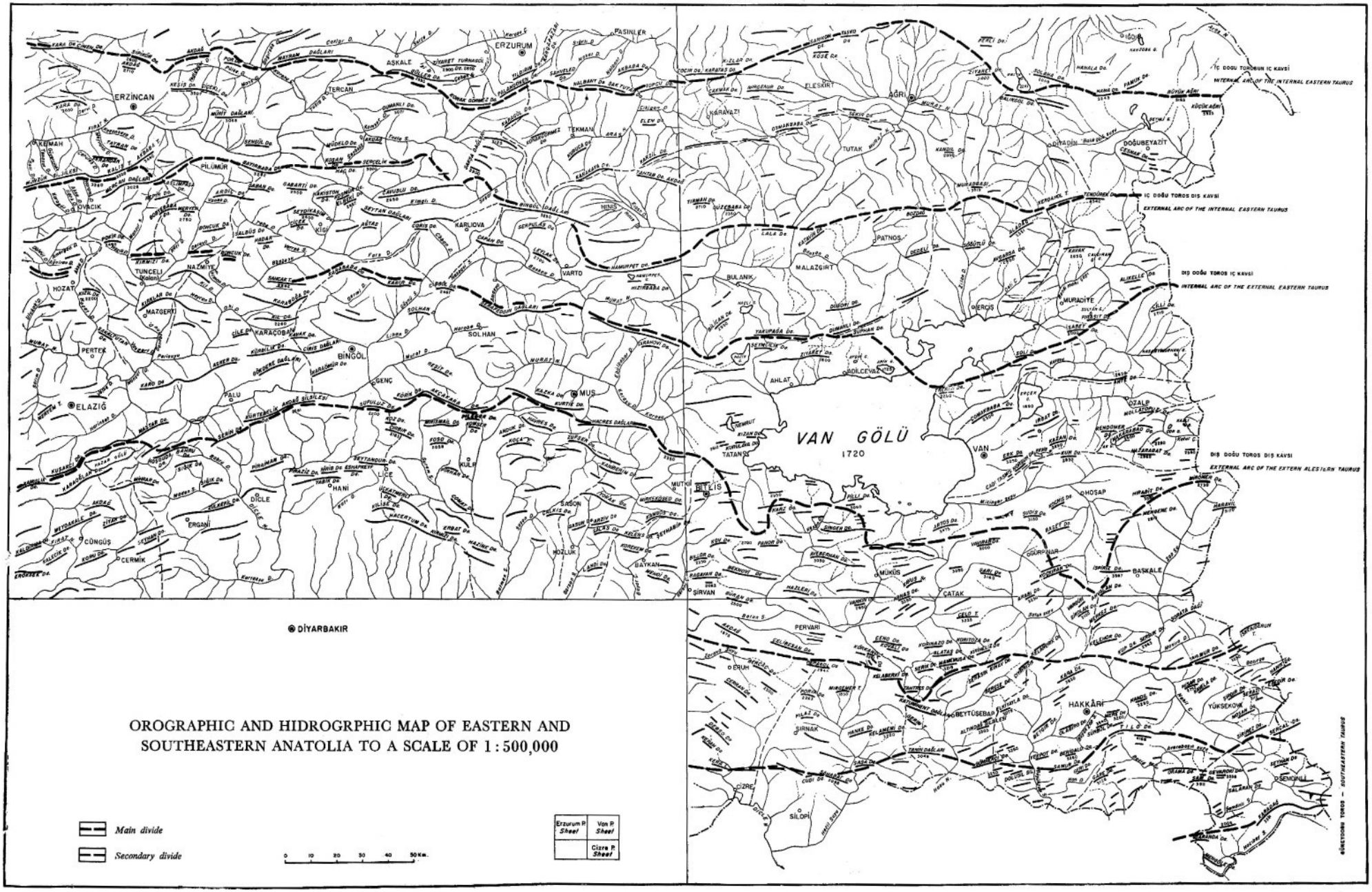


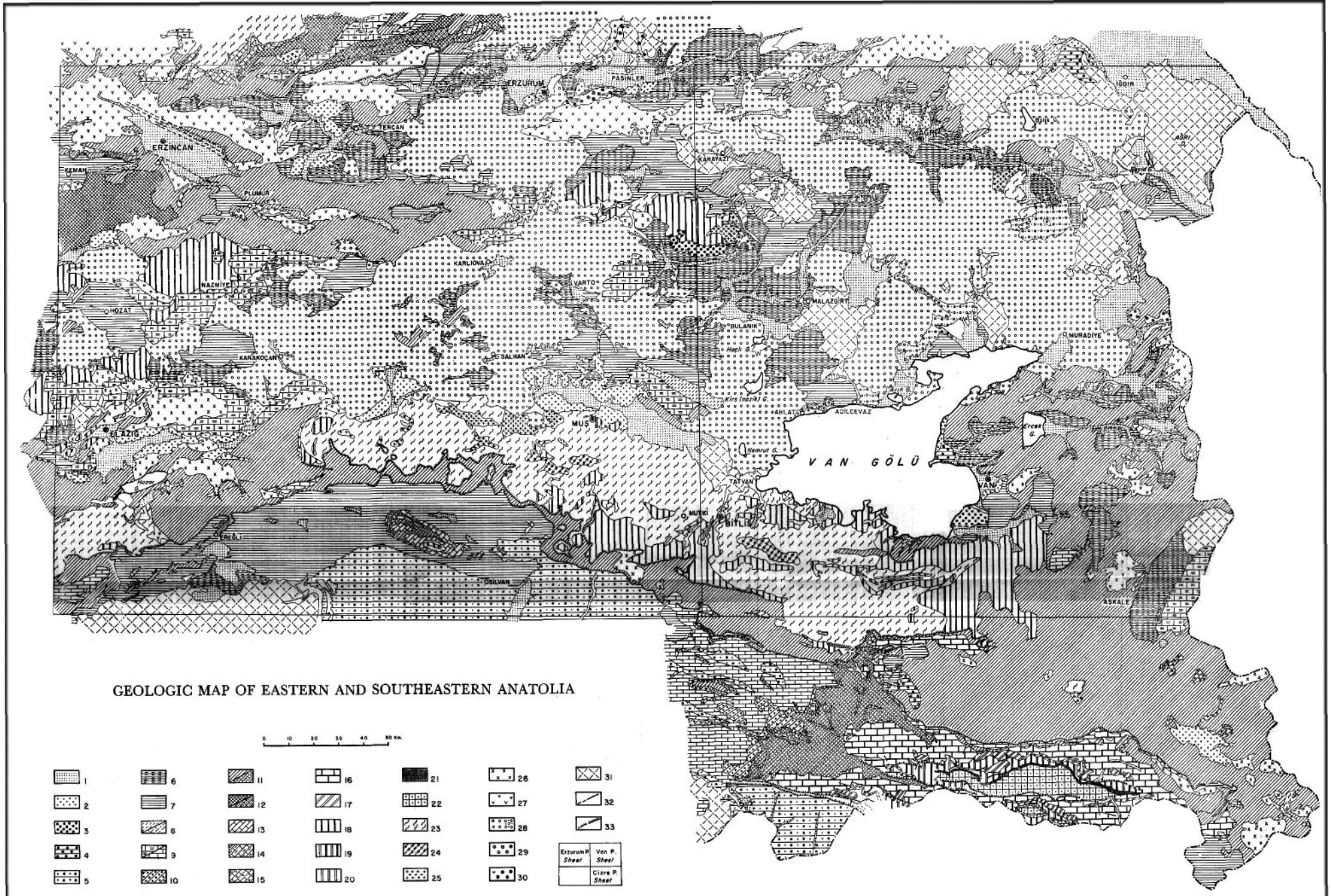
OROGRAPHIC AND HIDROGRPHIC MAP OF EASTERN AND SOUTHEASTERN ANATOLIA TO A SCALE OF 1 : 500,000

Main divide

Secondary divide

0 10 20 30 40 50 Km.

Erzurum P. Sheet	Van P. Sheet
	Cizre P. Sheet



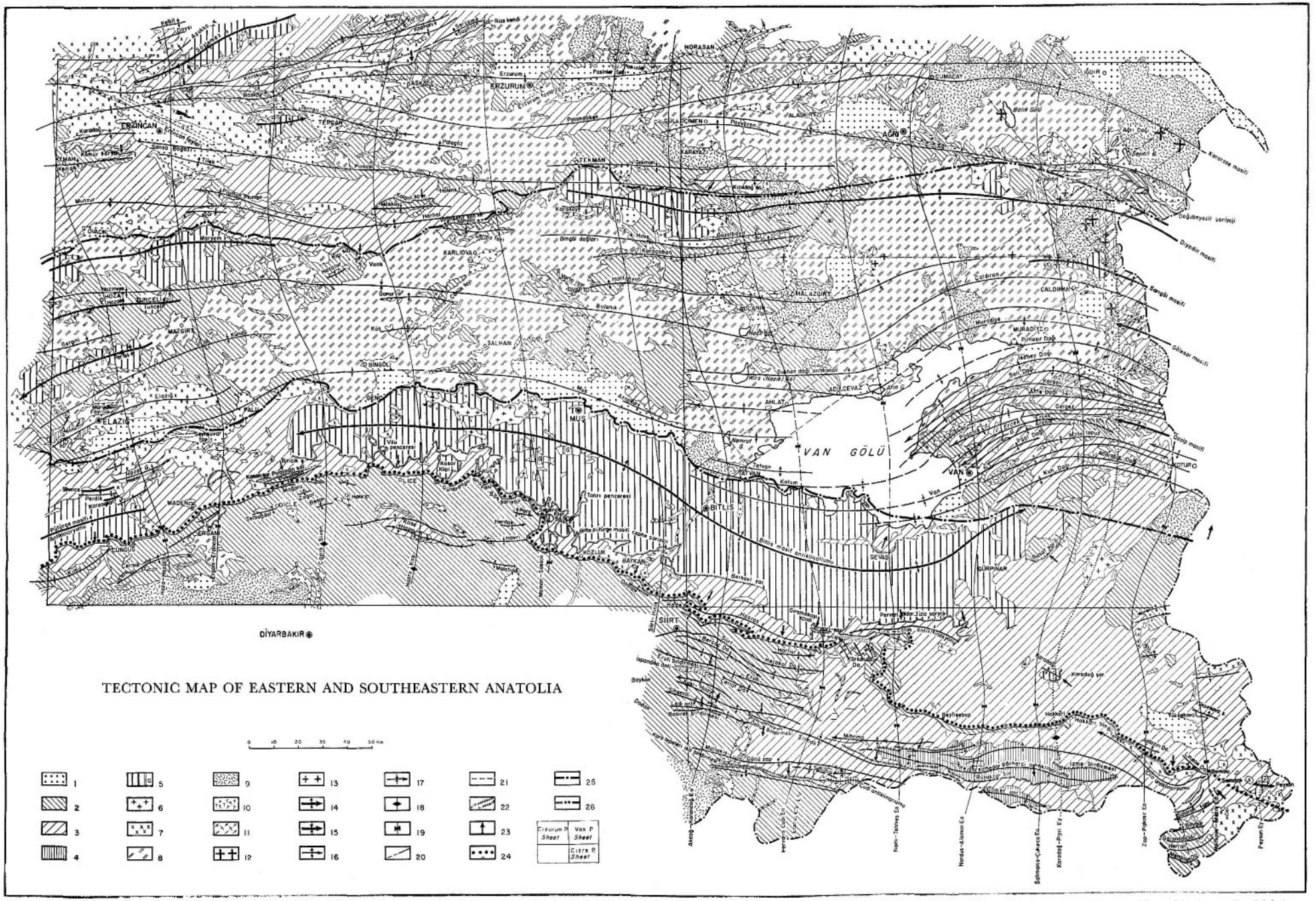
GEOLOGIC MAP OF EASTERN AND SOUTHEASTERN ANATOLIA

0 10 20 30 40 50 Km.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

Erzurum P. Sheet	Van P. Sheet
	Cizre P. Sheet

1 - Young alluvium; 2 - Old alluvium; 3 - Travertine; 4 - Pliocene; 5 - Mio - Pliocene; 6 - Pontian; 7 - Lower - Middle Miocene; 8 - Oligocene (olj - Gypsiferous series); 9 - Middle Eocene flysch (L - Lutetian limestone); 10 - Paleocene (Gercüş formation); 11 - Upper Cretaceous - Paleocene (krpa - Kermav formation); 12 - Lower Cretaceous (krfa - flysch); 13 - Malm; 14 - Dogger; 15 - Lias; 16 - Upper Jurassic - Turonian; 17 - Trias; 18 - Permian; 19 - Permo - Carboniferous; 20 - Carboniferous; 21 - Devonian; 22 - Silurian; 23 - Pre - Permian; 24 - Gneiss; 25 - Acid intrusives; 26 - Basic intrusives; 27 - Serpentine; 28 - Andesite (andesitic tuff); 29 - Dacite; 30 - Trachyte; 31 - Basalt β - basaltic tuff; 32 - Fault; 33 - Overthrust and upthrust.



TECTONIC MAP OF EASTERN AND SOUTHEASTERN ANATOLIA

0 10 20 30 40 50 Km

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

1 - Quaternary; 2 - Tertiary; 3 - Mesozoic; 4 - Paleozoic; 5 - Basement complex (G-gneiss); 6 - Acid intrusives; 7 - Basic intrusives; 8 - Andesite; 9 - Basalt; 10 - Trachyte; 11 - Tuff; 12 - Volcanic cone or mamelon; 13 - Cinder cone; 14 - Caledonian anticline and its plunge; 15 - Caledonian syncline and its plunge; 16 - Alpine anticline and its plunge; 17 - Alpine syncline and its plunge; 18 - Axial high; 19 - Axial low; 20 - Fault; 21 - Volcanic fault; 22 - Overthrust or upthrust; 23 - Overturn and its direction; 24 - Limit of the border folds with Iranids; 25 - Limit of the Iranids with Taurids; 26 - Limit of the Taurids with Anatolids.