GEOLOGY OF EASTERN AND SOUTHEASTERN ANATOLIA
(Part II) *

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STRUCTURAL GEOLOGY

The broad structural regions, such as eugeosynclinal region, miogeosynclinal region, together with the former's secondary orogenetic belts and massifs, are known through their stratigraphic peculiarities, magmatic evolution, structural setup, underground resources and physiographic traits. The tectonic divide between eugeosyncline and miogeosyncline is induced through geanticline of Upper Cretaceous - Paleocene, which is exposed in the west, but deduced through a lagoonal trend to the northeast of Siirt, and further east a line connecting Hakkari to Salaran Mountain, where an interfingering of the sediments of each environment is observed. The intersections of a syncline with an axial low made wide depressions that became filled with younger deposits, and at least leveled off as plains (ova). The Tectonic Map shows the locations and the names of the eugeosyncline; namely, from north to south: Anatolids, Taurids, Iranids; the massifs; the miogeosyncline boundaries; and the main folds, faults and overthrusts.

Massifs

The massifs of anticlinorial character are «en echelon», doubly plungingor not, with salients and recesses. Presumably they are not the fragments of a shield. Bitlis massif after plunging westward reappears in the Pütürge massif; jointly they make the backbone of Eastern Anatolia. Over the intervening Ergani-Erzincan no virgation is detected. The structural components of the normal anticlinoria are not differentiated, but greenstone and extended overthrusting are displayed. The northern massifs over the Anatolids are thrown into major and minor folds. They also exhibit faults, foliation mainly parallel to the bedding, rock cleavage, shearing, etc. Overfolding is not consistent in direction. Differential erosion between the softer crystalline rocks and the Permian limestone cover made contrasting physiographic features.

1. Eugeosyncline

Folds- — Alpine folds are conspicuous over the eugeosynclinal domain. The structural highs expose the Upper Cretaceous - Paleocene, while the lows are occupied by Neogene and Quaternary fillings. The Van orogenic phase makes a lasting and outstanding pattern. The folds parallel the massifs, being moulded around the salients, recesses and plunges. The simple or compound anticlines are conspicuous in the sceneries. The overfoldings are not exaggerated. There is some disharmonic folding between

the competent and incompetent members. The latter may be locally coarsely foliated, which has a more distinct pattern than the bedding.

The longitudinal tectonic zones are differentiated by Ami, while the transversal tectonic elements are distinguished by Parejas. The components of the, eugeosynclinc named Iranids, Taurids and Anatolids conform to the field observations. The first-order Van axial high lies in the map area, while the first-order Malatya axial low is outside of it. Both of them make their appearance earlier than the Permian period.

Iranids: Its domain is largely occupied by Bitlis and Pütürge massifs. The Permian limestone is mainly preserved along the structural lows. The greenstone of Upper Cretaceous - Paleocene age is unusually abundant along the axial lows. There is no Tertiary andesite or basalt. The rigid mass of Bitlis massif is bounded by thrusts in opposite directions, and the southern overthrusts are imbricated. This is also true for the Pütürge massif; klippes and tectonic windows are the results of erosion.

Taurids: Over this area the massifs are smaller and their cover, assumed to be Permian, is more crystallized. The Middle Eocene is of flysch facies. The sedimentation is continuous from Lutetian to Oligocene, inclusive. The sedimentary Miocene is in scattered outcrops and these are less widespread than the contemporaneous andesitic lavas, which have hidden the basement rocks. There are a few probable faults. There is no overthrust. Young basalt sheets are restricted. With the appearance of the first-order «Van virgation» Van Lake's depression is born. The western portion of northern Bitlis foredeep possesses molasse. Azakpur anticline is a westerly plunging half structure, the southern limb is most probably eroded through fluviatile erosion, as no evidence is found to support the graben idea for Muş Plain.

Anatolids : The massifs are few in number, furthermore a deeper going erosion took off their Permian cover. Further north and over the Trabzon sheet, Permian is of detrital facies. Jurassic and Lower Cretaceous are first of flysch facies and then of limestone composition. The greenstone is widespread and it is largely altered into serpentine. Lutetian is of a flysch facies. Miocene is a molasse over the western sector. Andesitic lavas occupy less space then the sedimentary Miocene. The overthrusting is of moment. The overthrusting is exceptionally thrown to the north at Söylemez and at Doğubayazıt. To the northeast of Aşkale, the bundle of folds curve to the northeast, and this is due to a tectonic development of vast fold arcs between the Aras River and the southeastern corner of the Black Sea. To skip the Iranids as a secondary orogenetic belt, to claim from north to south progressing tectonic evolution (Ketin, 1959) are not in agreement with actual field observations.

Faults.— Iranids: The normal faults affecting the competent Lutetian limestone member of the Başet overthrust are later than the thrust faults, as are also those cutting the competent Midyat limestone in the Southeastern Anatolian major overthrust farther south. Near Gelyedere, a fault between Permian limestone and Upper Cretaceous-Paleocene is reverse at its eastern extremity, but normal along its western portion, and the movement along its trend is rotational. There are a few secondary faults nearby Çatak county. There may be sheeting parallel to faulting, brecciation, gouge, etc,

Taurids: The faults are neither numerous nor of moment. The Erzürük and Mürüdü faults near Elazığ are disclosed through aligned cinder cones. Şahmanis fault,

to the northeast of the city, is deduced by offset streams; Gönük and Haçin faults are obvious through various criteria, such as: sudden linear contact of Upper Cretaceous - Paleocene with lacustrine Upper Miocene sedimentaries and lavas, travertine depositing sources, mineral springs, Kös thermal spring, and the Azizan depression which is a sag pond with a subsequent outlet. Varto fault is deduced by continuous scarp of Kem hill, the iron flats between its valleys and a sudden contact of lavas and sedimentaries. Cerme fault is deduced from aligned travertine-depositing springs and two oil seepages. Vank fault is deduced by landsliding and physiographic criteria. Kahnispi, to the north of Patnos county, is a high-angle normal fault. Van fortress seems to be bound by two parallel faults. Edremit faults are hypothetical.

Anatolids: Most of the mapped faults are probable rather then assured. Erzincan faults are deduced from offset streams, wind gaps, aligned cinder cones, thermal springs, mineral springs, etc. There are four faults in the north, essentially parallel and left lateral. It is the same with Cencige fault farther east. The data fail to demonstrate that large plains (ova) are graben.

Erzurum faults trend WSW-ENE and they make a 120° angle with those at Erzincan. The talus cones to the west of the city are transected by a small high-angle fault. The faults over Hasankale Plain are not well exposed. The faults to the north of Tahir Pass are secondary in importance. To the south of Tuzluca county, there are two small parallel faults affecting the base of Oligocene. The faults at Doğubayazıt are deduced from the morphology and lithologic trends. They trend E-W and seem to be strike-slip faults. The Üçtepeler - Atçukuru fault ends in a flexure near Üstürken.

Overthrusts-— The most outstanding contribution of the present study is to establish the existence of alpine-type tectonics with nearly horizontal overthrust sheets, imbricated overthrusts, klippen and tectonic windows. Sason county is a type locality for observing all of these features. Farther east, in the neighbourhood of Körkandil, an uplift stretching from Sanuh Village to Hişet Creek likewise affords direct observation of alpine-type overthrusts, but they are difficult of access.

Iranids: «BitIis - Pütürge massifs front overthrust» is the most persistent feature, which parallels the Southern Anatolian major overthrust; together they perform an imbricated structure. Bitlis massif is thrust over Upper Cretaceous - Paleocene, toward the north along the north side and toward the south along the south side, but Pütürge massif in the map area is solely overthrust toward the south. The overthrusting does not follow the trend of the greenstone. Ergani-Erzincan axial low is exceptionally rich in the ophiolitic suite. Associated lesser structures are the Guleman, Kasan, Pirajman, Biricik overthrusts, Continuation of the frontal overthrusts between the two massifs is not obvious. There are less important local features, such as Pinzor overthrust, Giran wedge, Pervari overthrust, etc. Although shorter than the Southeastern Anatolian major overthrust, the Bitlis - Pütürge massifs front overthrust is more important in possessing klippes, tectonic windows, and horizontal thrust planes. It ends to the east of Arabi Mountain; farther east Karadağ overthrust and Berkovi overthrust have throws in the opposite direction. There are Kasor, Gebebuki, Segeran klippen, and also Tanzı, and Vilu tectonic windows. The width of the overthrust is 17 km at Baykan, 27 km at Sason, 18 km at Kulp, 15 km to the east of Lice, 13 km at Karabeğan, 7.5 km at Çüngüş.

Southeastern Anatolian major overthrust: It starts from Bembo village in the western part of, Şemdinli county, and continues uninterrruptedly to where it leaves the

map area south of Çüngüş village. It represents the overthrusting of the eugeosynclinc over the miogeosyncline and for this reason it may be called «flysch zone's front overthrust». It does not display any klippe or tectonic window. The width is 9 km at the southeastern corner, 11 km at Ergani, which is a maximum over the trend of Ergani - Erzincan axial low. At the extreme east the overthrust does not wrap around, but there is a second overthrust directed to the north. There are other overthrusts toward the north, such as Menkova overthrust, which arc born at a later date, possibly because of a renewed compression by Syrian - Arabian block. The overthrust curved around the Korkandil uplift, which was not overridden. Where the overthrust is observable underneath Pliocene (Tahtreşa conglomerate) at the creeks, it is shown on the Tectonic Map by dashes. As the Upper Miocene - Pliocene of the border trough is overridden, the overthrusting is penecontemporaneous with Pliocene.

Gevaş overthrust: It is directed to the north, along the northern border of the Bitlis massif. The width of the northern overthrust is almost the half that of the southern one. At Arpet Creek, to the west of Gevaş county, Permian limestone is thrust over Upper Cretaceous - Paleocene. There are a few crystalline limestone klippen to the north of the county seat.

Overthrusting toward the northeast and northwest at Guleman is fairly well known through the overridden marine Lower - Middle Miocene, where Rosier suggested a surficial tectonic. The Pirajman, Kasan and Biricik overthrusts take part in the imbrication. Along Baset overthrust over the eastern plunge sector of Bitlis massif, the Upper Cretaceous - Paleocene flysch is thrust over Lutetian limestone in a nortwestern direction. The Upper Cretaceous - Paleocene is thrust again with Karadağ overthrust, in a northwestern direction over mica-schist. With Menkova overthrust the Upper Cretaceous - Paleocene is thrust over Lutetian in a northerly direction, and its width is 2 5 km. Along the trend of the break, a transformation into an overfold is present.

A n a t o l i d s : Saptiran overthrust is 160 km long and 5 km wide. Over the eastern end the Lower Cretaceous flysch is thrust over serpentine and limestone of Upper Cretaceous - Paleocene age, while over the western portion the Upper Cretaceous - Paleocene is thrust over Lower-Middle Miocene.

Asutka overthrust displays mica-schist thrust over Lias; the width is 5 km. It is directed to the north.

Kömür overthrust is hard to follow, as Upper Cretaceous - Paleocene flysch beds are thrust over the similar-looking Lower-Middle Miocene molasse beds. To the south of Sürek village a small-scale overturned syncline is made by southerly overriding.

Sipikör overthrust: Upper Cretaceous - Paleocene is thrust over Miocene; the width is 6 km.

Kiği overthrust: Upper Cretaceous Paleocene is thrust over Miocene; the width is 3 km.

Viranşehir overthrust is 25 km long and 2 km wide. The Upper Cretaceous-Paleocene is thrust over Lutetian flysch, the width being 2 km.

Kolanlı overthrust: Upper Cretaceous - Paleocene is thrust over marine Miocene.

Kızıldağ overthrust: Upper Cretaceous - Paleocene is thrust over marine Miocene.

Doğubayazıt overthrusts: There are northerly directed imbricated overthrusts. At Kalus hill, the highly crystallized limestone of the Carboniferous is thrust over the Lutetian limestone. Further east, detrital Eocene is thrust over limy Lutetian. Further north, from Kayaburun to Nazik village, Miocene displays an overthrusting.

2. Miogeosyncline

As a whole, the miogeosyncline over the map area is a plateau. The stratigraphic sequence is continuous from early Paleozoic to Recent, and it is unlike that over the eugeosyncline. The structural features and the structural evolution of the miogeosyncline likewise differ from those of the eugeosyncline. During the late Tertiary there was a molasse deposition along the deeper, rapidly subsiding trough, while toward and over the slowly subsiding Syrian - Arabian platform there were elastics and carbonates. Even the structures over these sectors differ: The folding is concentric, and there are surficial breaks, mainly conspicuous on competent limestone members. The alternation of competent and incompetent strata make disharmonic folding. Although the trends are consistent, there are a few sudden deviations. Some recent effects of gravitational tectonics are due to soft detritals lying over the brittle limestone basement.

Marginal uplifts. — These are peculiar features of the border trough area. They are mostly upthrusts rather than true overthrusts. Some are small, others large. They tend to be «en echelon», mostly doubly plunging, breeched, asymmetrical, conspicuous in the scenery, with salients and recesses, and cut by subsidiary faults.

The middle Büyükzap anticlinorium is a peculiar one in the south, and it reminds of Bitlis massif. Gamer anticline lies to its south, and Cudi anticlinorium to its southeast. Cilo anticlinorium is inferred, and its presumed Upper Jurassic - Turonian core is «en echelon» with the middle Büyükzap anticlinorium. The Gilo series, deployed over it, has been forcibly pushed apart by profuse rocks of the ophiolitic suite. Hazro uplift is a compound structure made up of Hazro and Kilise mountains. Bade, Dodan and to a certain degree Pora and Herda anticlines are well-defined and simple.

Folds. — The large area of Midyat limestone to the south of Siirt displays more or less extended, straight or slightly sinuous, «en echelon», slightly overturned, mostly doubly plunging flexure folds. To the eastern extension of the twin Kera upthrust, the structural relief grows with the size of the structure, the breeching is also proportional. The competent Midyat limestone over the limbs being more or less undulatory, there are places where it seems to be overturned, as for example to the south of Eruh county, but laterally the normal relationship is again resumed. Furthermore, in these abnormal cases their Kermav core is less asymmetrical.

Korkandil Mountain, which is like a watch tower, is «en echelon» with Mihrina anticline. Its athwart trend is only apparent, and it is due to a faulty base map, as explained in «Introduction». The Upper Jurassic - Turonian limestone, to the east of Hişet village, and the Lower - Middle Miocene limestone, to the west of the same, arc symmetrical and the bending is due to a recess in the Bitlis massif, which may be called «Hişet embayment». Then, it is obvious that trends of many folds, faults, intrusives, extrusives and physiographic features are due to a moulding of younger formations around the salients and recesses of Bitlis and similar massifs.

With incompetent members there may be fold bundles of intricate nature. The buckling may be close or open, symmetrical or not.

Faults. — The faults in incompetent rocks are rather inconspicuous in the field, and so geophysical surveying is needed to search for oil. Those open to observation accompany the brittle, competent members. They are high-angled, longitudinal or transversal, rather with undulatory plane, and of little importance, such as the transverse faults affecting Çermik anticline and Hanir anticline. The Zor fault is reverse and the southern block is heaved. There are a few important branches which may look as faults. The faulting is younger than upthrusting. There are aligned cinder cones to the north of Elazığ, which disclosed two dislocations. The erosional window to the south of Pirajman affords mylonitic Upper Cretaceous - Paleocene limestone, which is easily disintegrated.

Upthrusts. — The alpine type overthrusts fail over the domain of the miogeosyncline. There are only upthrusts, most of which are restricted to the competent members; they are directed to the south over their southern limb.

Middle Büyükzap upthrust (or Rejgar - Samedar - Gönherçi anticlinorium): It is 180 km long and the dislocation follows the salients and recesses of the anticlinorium. Either at Mergeh, at the eastern end, or at Güzereş, at the western extremity, the beds assume a normal attitude by tracing an «S» fold. The width is of a few km. The plane is undulatory and it is accompanied by drag, shattering, brecciation, sheeting and foliation. There is a small reverse fault over the west bank of Zavita Greek. Tanin, Mijin and İzme upthrusts are along the northern flank of the Middle Büyükzap anticlinorium. The overthrusts of the eugeosyncline and the upthrusts of the miogeosyncline make together an imbricated structure of regional scale.

Sekerek - Becüh upthrust: It is «en echelon» with the Middle Büyükzap upthrust. It is transformed into an overturned fault at its western extremity.

Kera twin upthrust (or the front upthrust of border folds): There is a large slice of Midyat limestone between two parallel longitudinal upthrusts. There are also a few faults at the eastern portion, and there the northern one branches out. Farther cast there are high-angled longitudinal and transversal faults which heaved the Devonian of Habur Greek. Over the western sector of the Kera twin upthrust, Midyat limestone displays a flexure folding. There is also, near Finik, a structural terrace of Midyat limestone.

Dühük upthrust: Midyat limestone is first thrust to the south over Kermav formation. Later at Girega hill, Becirman limestone is thrust to the north over Midyat and Gercüş.

Basiret upthrust is long, while Şehşivati upthrust is not; Eruh upthrust seems to be important.

The shallow-facies Upper Tertiary deposited over the Syrian - Arabian block follow a boundary line bypassing Diyarbakır - Siverek - Mardin and they are nearer to Çermik county over the map area. They lie in front of Ergani - Erzincan axial low. But the underlying block's vicissitudes are not conspicuous in that sector. The northerly directed upthrust may be due to the effects of the block. Diyarbakır - Siirt basin's basalt flows should be related with the tension of the same.

EARTHQUAKES

It is commonly believed that the destructive quakes are related to tectonic fault troughs, that once a graben is shaken the seism is transmitted to the next one in the

same longitudinal line, and so on. The plains, which are most stricken by catastrophic impulses, are either aligned in the synclinal trends separated by thresholds lying over the path of the axial highs, or they are located at the intersection of a syncline with an axial low. Evidence that the plains are fault troughs is wanting. The left lateral faults of Erzincan Plain are athwart the axis of the plain, and the quakes along them arc due to a mechanism explained by the elastic rebound theory.

İ. Ketin suggested that earthquakes originate in an arc bordering the middle Anatolian block in Central Anatolia, and that the block itself being consolidated by widespread volcanics is of a seismic character; but this working hypothesis is not pertinent to the massifs of Eastern and Southeastern Anatolia. The most spectacular and persistent overthrust sheets of Pliocene age are not affected by catastrophic shocks; the most spectacular volcanic area of Eastern Anatolia is prone to disastrous seisms. Iğdır, Doğubayazıt, Pasinler, Erzurum, Tercan, Erzincan, Çaldıran, Patnos, Malazgirt, Bulanık, Hınıs, Varto, Karlıova over the the Anatolids; Van, Muş, Bingöl, Elazığ over the Taurids are first-order seismic areas. The miogeosyncline is nearly aseismic. The second-order seismic area lies in between the former and the latter.

DIASTROPHIC HISTORY

Over the eugeosyncline the breaks in sedimentation are of importance, the magmatism was active, mountain-building episodes were strongly active, and angular unconformities are prevalent. No correlation has yet been made between metamorphics of the massifs and fossiliferous rock units of the miogeosyncline. There must have been Caledonian and Varistic tectonic movements, as the massifs are not detached portions of a shield. The following phases were of importance: Pfalz, Dogger, Younger Simmeric, Austric, Van phase (end Paleocene), Pyreneic, Savic, Young Steiric, Wallachian, Passadenic. The Van phase was almost paroxysmal, as an enduring regional architecture is born. The alpine trends conform with the strikes of the massifs. Younger orogenetic impulses resulted in very little modification of the structural picture. Episodes of relief in stresses caused intermittent igneous activities. Wallachian phase produced the most spectacularly imbricated overthrusts and upthrusts. There are nappes of subsequent shear thrust nature. Most of the faults are younger than the overthrusts. Volcanic vents are most conspicuous around the depression occupied by Van Lake; they are shown on the Tectonic Map. Travertine deposits, thermal and mineral springs, and hydrothermal alteration are products of subsiding volcanic activity. The geomorphic evolution linked with epeirogenesis carried to completion the various erosional surfaces, terraces, etc.

In the area of the miogeosyncline, stratigraphic breaks are uncommon, magmatism is nearly wanting, the mountain-building episodes were persistently moderate, disconformity is a rule, and there were upthrusts, but not true overthrusts. The following phases were of nearly the same strength: Sardinic (?), Ardennic, Bretonic, Austric, Pfalz, Old Simmeric, sub-Hercynian, Van phase, Pyrenean, Young Steiric, Wallachian and Pasadenic. The sub-Hercynian phase performed a definite structural make-up for the border trough area.

PHYSIOGRAPHY

The physiography of Eastern and Southeastern Anatolia is complicated. The features are evolved under the control of two sets of structural cross trends superposed at 45°, the branches of which are directed E-W, N-S, SW-NE and SE-NW. These four directions are the prevailing trends of mountains, valleys, streams, folds, faults, volcanic fissures, etc. These trends are caused by an undulatory basic pattern of the longitudinal and transversal axes of the «en echelon» fold bundles. The dislocations, the magmatic manifestation, the arrangement of the physiographic units, etc. are subdued to this scheme. In the main, the features are well-exposed through deep carving affording the third dimension, and a general lack of soil and vegetation brings in bareness,

Massifs

There are evindences of rejuvenation from maturity to old age, but the successive episodes are not yet fully known. The pattern of highs and lows is confused at a first glance, as the trends are disconnected by a complex fluviatile evolution. So the heterogenous and polycyclic features are customary.

Mountain ranges

The land forms conform to the structure and a morphologic relief is conspicuous. The structural architecture, that controlled the evolution of the present topographic pattern, originated during the sub-Hercynian phase in the area of the miogeosyncline and during the Van phase in the domain of the eugeosyncline. Within the eugeosynclinal area the present ridges coincide with anticlines and anticlinoria, whereas the valleys coincide with synclines and synclinoria. Some valleys in the north are occupied by plains (ova). Beside this broad pattern there are local complex fold mountains, complex mountains, lava plateaus, lava domes, etc.

Over the border trough, the Diyarbakır-Siirt plateau is the dominant physiographic feature. In addition, there are a few well-defined simple or compound fold mountains, such as Bade, Dodan, Hazro, etc., which are deeply carved.

To the north of the Cizre Plain, there is a narrow close fold at the foot of the mountain. Then there are very open, nearly flat-topped, inconspicuous folds, and these are degrading by the fluviatile erosion. The cuestas nearby the piedmont are peculiar to the area. The creeks grow shallow toward south.

Volcanics

There are magnificent volcanic mountains in the northeast, such as Büyük Ağrı Dağ, Küçük Ağrı Dağ, Tendürek, Süphan, Nemrut, etc. There are also plateaus that are lava fields. In them, faults are not conspicuous. The volcanic lands are rough, and they stand higher than the neighbouring sedimentaries. The upper portions of the larger ridges and hills are somewhat smoothly rounded, while the lower portions are steeply carved. Valleys outside the plains are steep-sided, not alluviated, and with V-shaped profile. The widespread tuff tracts are barren, swiftly eroded, with peculiar features, such as pyramids. The recent basalt flows may form structural surfaces, such as at Karayazı, Diyarbakır - Siirt basin. The cones at Mürüdü to the north of Elazığ and Tendürek, in the north are fresh features,

Drainage

Aras (Araks) in the northeast, Dicle (Tigris) in the south, and Fırat (Euphrates) in the southwest are the main rivers of the map area. The longitudinal sectors of these and their tributaries are longer than their transverse courses, which are due to capture, super-imposition, and headward erosion. So a rectangular pattern is established. Locally, for instance at Bingöl, a radial drainage is evolved. In the southeast of the map area, the drainage is dendritic. Now, the drainage is integrated, and the country is swiftly degrading, as very low base levels are reached. The front of the mountain range is fantastically carved in the south, where aligned water gaps open to the south. Because of the precipitous canyons in competent limestone and quartzite, this strip is called «rebel» by the inhabitants. Over the northern slope of the Karaköse massif the outlook is similar.

As gradients are steep, the streams are tumultuous and limpid; there are also cascades, rapids, and gorges. Over the main and secondary branches, are encountered braided channels, dry valleys and suspended valleys. The discharge in spring may be two to four times the summer rate. Besides, underflow from the aprons feeds the streams enormously.

Aras River cuts the internal arc of the Internal Eastern Taurus over an axial low. Dicle has received very many tributaries through epigenesis, capture, and headward erosion. Karasu, Murat and Fırat possess many epigenetic gorges over the various divides. Botan and Fırat, flowing along deeply entrenched valleys, are not useful for irrigation. Masiro has cut deep canyons near the Körkandil uplift over the path of an axial high. Its secondary branches are mostly dendritic in their upper course, but braided near their junction with the main stream. Büyükzap, the largest branch of Dicle, possesses numerous captured and epigenetic sectors. Nehil Brook draining Yüksekova is captured by Büyükzap. Şemdinli Stream is highly dendritic and most active, as it has a lower base level than streams in the Yüksekova district.

Rusor Stream formed slant terraces behind the Kasrık water gap, such as those behind Sansa Gorge at Tercan county, and behind Çesali Gorge at Camekari to the northwest of Körkandil Mountain, Nerdoş Stream is deeply entrenched over the Upper Jurassic - Turonian limestone, as is Habur Stream over the Upper Cretaceous - Paleocene.

Lakes

There are 29 lakes, large and small, on the Van sheet, the origins of which are as follows: Damming by lava flows: Van, Balık, Nazik, Menteş, Çimenli, Sultan, Hamurpet. Damming by alluvium: Evhacı. Damming by talus cone: Hazar. Differential erosion: Keşiş, İmranis, Göle, Şor, Reşan. Ponding along the stream course: Çenge, Şeyhli, Hasangodan, Akgöl, Kaz. Grater lake: Nemrut, Eastern Tendürek. Cirque lake: Süphan, Çalyan. Reservoir in a basaltic depression: Süte, Şor. Solution sink (salt); Kaz. Artificial damming: Abbas. Maar lake: Aygır. Depression made by intersection of an axial low with a syncline: Arin, Erçek. Sinkhole: Aygır.

Van Lake's history is hard to reconstitute. The primordial Van depression starts with westward plunging first-order simple Van virgation. Upon the upheaval of the western block of the SW-NE trending Ağrı-Ala-Suphan-Nemrut linear, together with the advent of lava and tuff, Van basin was separated from Muş basin, possibly during the outset of the Miocene period. The drainage, after the lacustrine Upper Miocene period,

evolved independently in those two basins. Muş basin was captured by a second-ranking tributary of Fırat River. The early Bitlis River, over the northern slope of Bitlis massif, used to flow northward and join the stream draining Van basin. Reşan Stream, which is a tributary of Fırat River, captured the early Bitlis River, reversing its drainage, as well as the one over the Van depression. The outburst of Nemrut volcano during Recent time, its lava alternating with welded tuff, filled in the Bitlis Stream and again dammed the Van depression. Van Lake's level fluctuated with the vicissitudes of the climate during the recent period. The high-level terraces are ill-preserved. According to Dreissensia, the water level once reached 1750 meters. Bitlis Stream is, at present, actively eroding headward, and a future capture is imminent. The lake's water contains 8 gr of soda per liter.

The SW-NE-trending northern portion of Van Lake follows a subsidiary dislocation parallel to an Upper Cretaceous - Paleocene fold axis. A stream, that cut through the anticline, flooded the lake and raised the water. This evolution reminds one of the Bosphorus at İstanbul.

Erçek Lake lies over the thalweg of an old stream, which has lost its lower course through piracy by Karasu. After the subsidence of Van Lake's water level, a dwindling lake persisted behind a narrow threshold.

Over the caldera of Nemrut volcano there arc five lakes, but the largest has a horseshoe shape. The water drives mainly through precipitation, but some water from a few hot springs is added;

Hazar Lake is significant, as it helps to visualize a future plain like Uluova near Elazığ, formed by coalescing talus cones. Hazar Lake formed when two opposing talus cones dammed its eastern end; there was some underflow from beneath the natural dam. An artificially opened trench in the latter exposed the nature of the deposits together with their fossil content: Radix, Chara, Ostracodes, etc. The lake's level fell off 1 meter after the completion of the Hazar Power Plant, and this has dried up swamps all over the lowlands. As its water is unfit for irrigation, Hösnük Brook is being deviated into the lake in order to sweeten its water.

Plains (ova)

«Ova», in Turkish, does not correspond to a geological or geomorphological unit of a definite genesis; there are ovas of different origin, but still the term is a useful one. The larger ones are mostly tectonic in origin, while the smaller ones belong to several genetic subdivisions. In Eastern Anatolia, the evidence fails to indicate tectonic trench faults (graben). Over the map area, the ovas may be aligned in synclines or synclinoria of Upper Cretaceous - Paleocene derivation, or be located at the intersection of an axial low with a syncline or synclinorium. They are in essence aggradational forms rather than degradational. The troughs main filling is Neogene, supplemented by Quaternary and Recent talus cones and alluviums. The thresholds, separating the aligned ovas, lie over the path of axial highs. Typically a large ova of Erzincan type is made up of opposing coalescing alluvial fans and the stream is nearer to the narrower slope. This is a bajada type. An ova of Tercan type is due to a hindrance of the exportation of alluvial material behind a narrow gorge. Recent talus cones may spread over these slanting surfaces.

The left lateral faults of Erzincan Ovası did not alter the main unit. A few streams bring in prodigious alluvium; the swiftly weathering waste of the slopes and the abundant wash are building fans of impressive size, such as Varkirt at Erzincan, and Harinket at Elazığ. The drillings for underground water reported fabulous thicknesses of 200 - 300 m. The truncated fronts of the fans make them stand as terraces with respect to the stream bed.

To the northeast of Muş Plain, flysch beds fail to supply the type of material needed to build high alluvial cones and the mica-schists fail even more; consequently, the plains are more flat, and coalescing cones almost inconspicuous.

MORPHOLOGICAL GEOLOGY

The results of aggradation and degradation in the map area depend greatly on the fact that mechanical disintegration exceeds chemical weathering. The mica-schists are superficially weathered, and little slope waste is evolved; the stream beds in mica-schists are deep, narrow, and not alluviated, while the ridges are rounded.

The Silurian quartzite, in the south, forms widespread dip slopes. The Devonian is a weak formation and gave rise to continuous depressions. The Permo-Carboniferous, like the other competent formations, such as Silurian quaitzite, Permian limestone, Upper Jurassic - Turonian limestone, etc., make up sheer canyons, precipitous escarpments or wide dip slopes. The limestones arc subject to solution over their exposed dip slopes. The Permian limestone is a cliff-making unit and displays rejuvenated bold features, such as pyramids, serrate ridges, etc. The karstification is in its first stage. The Upper Jurassic - Turonian is deeply carved and exhibits steep-sided canyons, suspended dry valleys, and steep gradients; the thalweg is discontinuous through cascadas, potholes, grooving, etc. Features such as dip slopes, mushroom rocks, pillars, serrate ridges, pyramids, hogbacks, etc. are familiar.

The Lower Cretaceous limestone and flysch make contrasting landforms, the former being barren, dry, somewhat karstic, with smooth ridges, but entrenched valleys.

The Trias, Kermav, Gercüş are incompetent weak formations and arc deeply eroded to make depressions.

The Upper Cretaceous - Paleocene is represented by peculiarly variable, but recognizable sceneries. The differential erosion between strong and weak lithologies may cause extraordinary carving. The drainage over the flysch is dendritic.

Midyat limestone is notable for its nearly continuous cliffs, pyramids, escarpments and isoclinal ridges. «Katu» in local language means a saw, i.e. a sierra, such as Katumihent, Katuzer, Katubastik, etc.

Eocene flysch is less carved than the Upper Cretaceous - Paleocene one. The clayey flysch may locally display a badland topography.

The Lower - Middle Miocene limestone is just beginning to develop solution features, even though there are sinks, dry hanging valleys, shallow and small solution subsidences, terra rossa. Limestones form the higher ground. The molasse, and the alternating shale, marl and fine detritals crop out in the depressions. There are wide barren tracts, which are due to excessive degradation, where the small valleys are

mostly devoid of alluvium. The lacustrine Upper Miocene is a soft formation, and its low-standing profile is in constrast with the dominating contemporaneous volcanics. The former may suffer from landsliding. The Upper Miocene - Pliocene in the south is degraded swiftly, and it occurs that the streams arc heavily loaded during the flood periods. There are degradational and aggradational Quaternary features; the latter may contain the products of the fast erosion of the rugged land.

ECONOMIC GEOLOGY

The underground resourcess of the Eastern and Southeastern Anatolia are diversified, more or lees important, exploited or not, and above all need systematical detailing. There are metallics, non-metallics, underground water, mineral and thermal springs, and ground water. The occurrences are briefly cited by alphabetic order.

Alum is reported east of Erzincan.

Antimony is mentioned in Elazığ province.

Asbestos occurs near Bezeno village's summer residence to the north of Nogaylan, Şemdinli county. There are transverse long fibers of a few cm in the rocks of serpentine. Another occurrence is near Aşkale.

Barite deposits of the Bilir mine to the west of Muş city have one million tons of possible reserve, in a replacement deposit. The barite is pure. The mountain path, leading from Narh township to Hişet village and over the «Katu», shows fragments of barite on Lower - Middle Miocene limestone tract.

Brick and tile are being processed commercially near large agglomerations. Building stone, lime and millstone are not scarce, but there is not yet a stone industry. Chert is exploited to the south of Ergani and used as flux at Maden's smelting plant. The chert is picked from the reworked top surface of Upper Cretaceous - Paleocene.

Cement manufacturing can depend on the Tertiary shale, marl, marly limestone and limestone. There is a cement factory at Elazığ,

Chromite is bound to the ophiolitic suite of Upper Cretaceous - Paleocene age. Elazığ is an outstanding chromite and copper province. There Guleman is exceptional in that the chromite-bearing area is 35 km long and 12 km large. The deposits are veins in peridotite and pyroxenite, and lenses in dunite and serpentine, diffuse along the contact zones. There is an open-cut exploitation. There are 15 occurrences, and the new ones ate being explored. The reserve is 700,000 tons. Other occurrences, found elsewhere, are yet unimportant, such as those to the north of Aşkale, at Tunceli province, at Tercan county, Diyarbakır, Siirt, Bitlis, etc.

Cobalt contained in the copper ore at Maden averages 0.27 %.

Galena occurs at several places near Pirajman village, Dicle county, Diyarbakır, along with some malachite and azurite. The gangue of the metasomatic ore is barite. The reserve is not deemed enough for an exploitation.

Graphite together with limonite is encountered at Tahmanis to the east of Gevaş county.

Ground water is being tapped from the coalescing fans of the plains (ova) and in large quantities; for example many drillings at Uluova yield around 200 I/sec. The widespread limestone expanses are dry.

Gypsum is common in Lower- Middle Miocene sediments. A plaster industry is wanting.

Hydroelectricity is most promising with the deeply entrenched streams, and there are very many suitable dam sites, especially over quartzite of the Middle Büyükzap anticlinorium. There are a few working plants, such as those at Siirt, Erzincan, Ağrı, etc.

Iron, as magnetite with apatite, is found in veins or in disseminations near Avnik, Silvan township, Genç county. The gangue is quartz and silicate minerals; the reserve is 150,000 tons. There are hematite deposits in İliç, county at the contact of intrusives with limestone. There are iron oxides at several localities of Elazığ province. Near Pinzor village (Şepil locality), there is specularite in red-brown gneiss. Hematite and specularite in the form of streaks, together with veins of quartz, are found in crystalline schists or crystalline limestones near Müküs township.

Lignite is common in the lacustrine Upper Miocene, but the seams encountered as yet are rarely exploitable. Those at Horasan and Şahmanis are worth mentioning. Kükürtlü lignite mine is the most outstanding; it lies to the south of A§kale, where the workings reach a depth of 200 m. There are three seams, whose thicknesses range between 0.90- 1.10 m; their length is not yet known; the reserve is 500,000 tons.

Magnesite is in veins and lenses in serpentine.

Nickel contained in Maden's blister copper averages 0.03 %,

There are surface showings of oil, such as seepages and exudations of bitumen. The most important oil seepage of the area is at Körzot. This seepage is in a zone of dislocation and the oil is thought to originate in the underlying Permian limestone. Attempts at exploitation failed. In İlanlı locality, near Zilan Creek, Erciş county, a few specks of black oil seep through the alluvium. The occurence is related to a dislocation that affects the tuffs and andesites.

Some dry bitumen is encountered with Miocene sandstone at Bezeli Creek, Çukurca county. At Zivengok there are seeps of live oil and also some asphaltic dikes. In Dicle county there are live oil seepages from Lower - Middle Miocene limestone. There are asphaltic sands at Simak Creek, Şehşap village, Hazro county. A test drilling for oil at Hanek, Handuf, Kitri encountered similar asphaltic sands. At Neftik locality, Neftik village, Karaağıl township, Bulanık county, Muş, thick, live oil appears on the the surfaces of two pools.

At Neftik locality, Katranlı village, Tekman county, Erzurum, thick black oil seeps out of alluvium; the surrounding bedrock is andesitic lava of Upper Miocene age, but the lava overlies marine Lower - Middle Miocene. At the boundary of Pulk and Şebke villages, of Erzincan territory, some oil seeps through soft lacustrine Upper Miocene deposits. The Upper Cretaceous - Paleocene flysch at Divanhüseyin exudes some black oil.

Oil expectations are more promising over the miogeosyncline than in the southern territory of the eugcosyncline, where a discovery from beneath the overthrust sheet

is improbable. The flysch beds are not naphtogenic; the intercalated limestones might be either source beds or reservoir rocks, or both, but a sufficient cover is wanting. The widespread ophiolitic suite is an adverse factor. Over the area of the border folds there are fairly well-defined anticlinal strucfures, which are unexposed, but discoverable through geophysical surveying; but the oil may be flushed out. The targets are successively Lutetian limestone (but it is not fetid), Upper Jurassic-Turonian limestone, Permo-Carboniferous limestone, and Devonian sands. The Upper Jurassic - Turonian limestone is the reservoir rock at the Raman and Garzan oil fields. Kermav, Gercüş and, still better, Siirt series arc cover beds, the last being more efficient through cvaporites, Drilling along the Hazro uplift was unsuccessful. The Upper Miocene-Pliocene deposits might form an effective cover for deeper oil-beaxing reservoirs, if present. No salt plug is expected.

Over the eugeosyncline the silled basins of Miocene area lack an efficient cover, and no salt dome is yet in prospect. The lacustrine Upper Miocene in the northern part of the map area is unpromising; it is faulted and fissured; besides the sediments mtertongue or alternate with volcanics and pyroclastics.

Over the Muş Plain Permian limestone is a promising target for oil, as it could be both a source bed and a reservoir rock.

Edremit structure, south of Van, is unpromising, because geophysical surveying shows it is not closed at depth, and it is cut by longitudinal and transverse faults. There, again, the Permian limestone would be the target.

Pyrite and chalcopyrite, covellite, chalcosite, etc. are exploited since historic times at Elazığ province's Maden county. The ore follows an E-W-trending dislocation along which the ore fluids presumably rose. The body is in contact with serpentine in the south, but with diabase and flysch beds in the north. Diabase is mineralized, but not the serpentine. The local reddish Upper Cretaceous - Paleocene afforded an impermeable cover to the mineralization. There is low-grade, disseminated ore and also high-grade ore. The mining is by open-cut method.

In northern Şirvan county, between Akçazer road and Hizne Creek, malachite and hematite are encountered in andesite and Upper Cretaceous - Paleocene. There are abandoned workings. Also west of Maden village, tuffs and andesites are hydrothermally altered and contain pyrite, chalcopyrite, specularitc, and other metallic minerals.

Salt is produced for local use at many places within the map area. It is mainly derived from brines, which are evaporated in salt pans. The brines are common in marine and lacustrine Miocene deposits. Rock salt in Oligocene beds is exploited in antique workings in Tuzluca county.

Siirt province possesses nine productive salinas Pervari county has 90 salt showings. Van and Muş provinces also possess some useful salinas. The Upper Cretaceous-Paleocene displays a few brines, such as those situated in northwestern Beytişebab county (Tuzluca village), to the west of Tahtreşa Mountain (Toranis village), to the north of Narh township, to the northeast of Siirt (to the north of Bünyan Gorge). Sand and gravel are common along alluviated streams and stream terraces.

Soda could be extracted from Van Lake's water.

Sulphur and orpiment appear as insignificant showings in tuffs or with travertine.

Thermal, mineral and soda springs are common. The latter occur to the east of Erzincan city along the highway, to the east of Iğdır county, and in the territory of Iğdır State Farm. Mineral springs are found on the periphery of volcanic mountains, such as Ağrı and Tendürek, or in volcanic terranes, or in sedimentary rocks of Miocene age at Erzurum, Erzincan, Bingöl, Elazığ. Travertine deposits abound to the south of Van, to the south of Diyadin, to the north of Muş, etc.

HISTORICAL GEOLOGY

The massifs in the north may be the metamorphosed eugeosynclinal equivalents of the fossiliferous formations in the miogeosyncline, and not be remnants of a pre-Cambrian shield. The details of the primordial eugeosyncline are not known. The pelitics, arenites and a few rudites — and, possibly, graywacke and flysch — are regionally metamorphosed into various schists and gneisses. The carbonate rocks and pure quartzose sandstones appear locally as minor but repeated occurrences. There were various intrusives and extrusives. The Caledonian and Varistic movements presumably caused breaks in deposition and formed stable and positive nuclei. The massifs have a core of rocks with mesozone minerals, together with various intrusives and extrusives, and a shell of rocks with epizone minerals, accompanied only by greenstone, but there is no conspicuous hiatus between the zones. At places, over the miogeosyncline and the eugeosyncline, there are transitional beds made up of alternating schist, limestone and quartzite between crystalline rocks and the overlying Permian limestone unit, which means that the break in sedimentation was not of importance and the paleogeographic transformation was trifling.

Lime was deposited during the Permian period in a rather shallow and warm marine environment, where conditions favored the development of Fusulinidae, Gastropods and Algae. Pfalz phase threw pre-Permian rocks into bundles of close folds, while the strong limestone made protective carapaces, especially over the more conspicuous uplifts. The uplifts were «en echelon», possessed strongly marked salients and recesses, and later persisted as massifs.

In the Aras basin, however, the evolution was different. There the sedimentation was continuous through the Trias. The Paleozoic is fossiliferous and made up of fine and coarse detritals and carbonates. Westward-plunging Karaköse massif originated during the Pfalz phase.

Far to the south, over the miogeosyncline, situated between a boundary ridge with the eugeosyncline and the Syrian-Arabian block, the stratigraphic, structural and magmatic evolutions were unlike those over the eugeosyncline. There is uncertainty as to the age of a uniform, conformable, slightly crystalline and seemingly unfossiliferous limestone over an axial high. If it is Cambrian, then the Sardic phase is present. It is mild, progressive, and causing disconformity, as it is usual for the border-trough area.

The next sedimentary cycle accumulated quartz sand that represents a redeposition of older quartzose sands derived possibly from the Syrian-Arabian block. There were short episodes in which marl, siltstone, or, occasionally, laminated limestone were deposited in restricted areas. The limestone lenses resemble those exposed in Han Stream, which are assumed to be Cambrian. The turbidity of the energetic environment was not suitable for organic life other than worms, Cruziana and other animals

that thrived on the bottom. Minor amounts of tuff, which was partly reworked, mingled with the sediments.

Further to the southeast, black slate, siltstone, and some green sandstones show preserved Graptolites. The Ardennic phase made gentle, doubly plunging, «en echelon», lasting anticlinoria, the largest being the Middle Büyükzap anticlinorium, which displays some similarity to Bitlis massif.

A renewed transgressive marine invasion, brought in shale, limy shale and then sandy shale. Life was prolific and the conditions favored the preservation of diffuse bituminous substance later to make the shale black. Then a sudden change caused wholesale destruction of animals, which made smothered surfaces. Toward the end of the sedimentary cycle, cross-laminated sand accumulated uniformly over the shoals; this sand incorporated transported hydrocarbons to become bituminous. Bretonic phase, plus the added effects of the later deformations, made slates.

In the northeastern pait of the map area, during the same Devonian period, there are alternating shale, pure quartzose sandstone, lime and graywacke in conformable relationship that are intruded by spilite and andesite.

In the southeast of the map area, over the Hazro uplift, a lacustrine environment was established, in which variegated clay and lime deposited during Carboniferous period. The swamp forests prospered, to be preserved later on as lignite. The sequence met with the effects of Austric phase.

In the northeast of the map area, Carboniferous sedimentation was quite similar to that of the overlying conformable marine Permian, when black limestone was deposited along with subsidiary yellowish clayey shale.

In the southeast of the map area, marine sedimentary cycle embraces Permo-Carboniferous. The invanding sea, accumulated under uniform conditions fine lime, limy shale and clayey lime. The disseminated organic matter is preserved to give fetid limestones. The organic life prospered at times. There were a few transient basins which received highly organic shale and limy shale later to give poor oil shale. At times the environment was shallow and energetic enough to give rise to laminated limestone. Toward the end of the cycle some red materials, and possibly terra rossa, mingled with the depositig lime.

In the northeastern part of the map area, the widespread limestone deposition is known through fossils to be Permian in age. The eugeosyncline is wholly invaded. Silt and sand were deposited over the shoals and locally elsewhere, but lime deposition was widespread. There are a few transitional lenses and interbeds of lime and sand and fine detritals. The limestone is less affected by dynamometamorphism than the fine detritals, which are transformed into mica-schists. Permian limestone is observable at present only as carapaces over axial highs, which are the massifs, so the synclinoria may have had unlike deposition. Hence, the biohermal character of the limestone can perhaps be attributed to deposition along paleogeographic ridges. The Pfalz phase, which was only mild in the south, was severe in the north. During the subsequent phases of orogeny, erosion and quiescence, the limestone carapaces have deteriorated, since the Pfalz phase, and in places the rock has ben been re-crystallized and subjected to solution phenomena.

In the south of the map area, the transgressive Trias sea was peculiar in that it was shallow and deposited variegated, soft strata. Fine detrital sediments accumulated

at the outset, and later on continued to accumulate over the highs. Elsewhere varicolored shale, limy shale, marl, and limestone exhibiting well-developed ripple marks indicate shallow depth and nearby wave action. Sudden minor changes of environmental conditions resulted in phosphate nodules and smothered surfaces. The climate was warm and humid; red materials washed into southern sea from the eroding eugeosynclinal area. Over the uplifted areas the top of the Trias series is offlapping, where the Upper Trias is bound to be absent. Old Cimeric phase later produced mild folding, progressive uplift, and moderate erosion.

Over the Anatolids in the north, in the northern part of the map area, a flysch deposited with a few limestone lenses with prolific Ammonites during Lias period. Dogger phase is energetic. Malm is in transgressive overlap over Lias and the area received first marine pure lime and then sandy and pebbly lime. The Ammonites thrived again. The sediments were folded and upheaved during the early Cimeric phase. Upper Jurassic sedimentaries are missing. It seems that during the whole of the Jurassic period the Taurid and Iranid area was exunded and subjected to erosion.

In the south and over the border trough only the Upper Jurassic - Turonian is known from fossil evidence, and the presence of the Lower and Middle Jurassic in the thick sequence is but conjectural. The Jurassic sea advanced from the south, and the environmental conditions favored the establishment of an Urgonian facies. A thick sequence of limestone locally contains interbeds of marly lime, marl, saridy lime, and quartzose sand. There were also episodes of stagnant conditions giving rise to black limestone and oil shale over the shoals; during periods of shallower water conditions, laminated, ripple-marked sands and limy sand accumulated. The pelagic and benthonic organisms, at times, found suitable living conditions in temporary bathyal and deep neritic environments. There is also disseminated bituminous matter in the fine - textured deposits. Subsequent dolomitization and ancestral weathering make this unit the reservoir rock of the Southeastern Anatolian oil province.

As the orogenic flysch deposition of the eugeosyncline intertongues with the competent Upper Jurassic - Turonian limestone, the former is partly contemporaneous with the latter. Sub - Hercynian phase of orogeny over the miogeosyncline buckled the Upper Jurassic-Turonian strata. This phase gave the border trough area its main and lasting structural pattern, and the younger of the two carapace-making limestones was folded into anticlinoria that controlled subsequent transgressions. There are a few intrusive diabases over the sectors of the axial lows. During Lower Cretaceous period, over the Anatolids in the north, persistently uniform limestones of Urgonian facies were deposited over an uplift, which later have given rise to Munzur Chain. Still farther north, over the Kop Mountains, there were successively deposited: first pure, thinly bedded, finely textured limestones, in relatively quiet conditions; then flysch beds, during a period when disturbances were taking place; and, later, some gray-purple-green limestones, in the shallow seas toward the end of the period. The Austric phase gave rise to intense close folding.

The environmental conditions during the sedimentary cycle, that followed the Austric phase, were basically different in the eugeosyncline in the north and in the miogeosyncline in the south. The dividing ridge between them is inferred to follow a lagoonal trend to the northeast of Siirt, and a closely pressed uplifted zone to the northeast of Diyarbakır. There is Kermav formation in the south and Hakkari complex in the north, which are contemporaneous. Kermav formation is disconformable and it

is made up of closely alternating gray shale, marly shale, silty marl, which were interrupted possibly over the highs and toward the end of the cycle, first by sparse limestone interbeds and then by a uniform limestone, which is called «Becirman limcstone», that intertongues with the main body of the sediments. Over the axial highs, such as the Cudi anticlinorium, the cycle,starts with sandstone and sandy limestone, together with thick-shelled Alectryonia and other fossils. The «muddy conglomerate» is an odd lithologic unit which is caused by turbidity currents and gravitational gliding. Limestone and conglomerate beds glided down over soft marl and their uneven fragments mixed with settling mud, so the old blocks are by no means tectonic in origin. Energetic currents and turbidity produced graded bedding and winnowing; and the sparse fossils are more or less reworked and hence broken. The age span is known mainly through the microfossils in the limited limestone intercalations. The post-Austric transgression reached the Körkandil uplift late. There the base is red marl and pebbly sandstone, and the top is Kermav beds that are thinner than usual. Southeast of Hakkari city and eastward from there, a highland is present and in that direction the deposition wedges out with pebbly red layers.

Over the eugeosyncline an orogenic flysch deposition, complicated by abundant initial magmatic products and limestone intercalations, predominated during the Upper Cretaceous - Paleocene period. Intricacies and irregularities in the sedimentary unit are due to «effusion tectonics» and turbidity currents. The synorogenetic facies yielded first thinly textured and shaly deposits, and then coarsely textured and sandy flysch beds; during the paroxysmal phase, synorogenetic plutonism has given rise to acid intrusions. A few granite and granodiorite bodies, that are intrusive into ophiolitic rocks, suffered erosion and their reworked products are included as pebbles and blocks in contemporaneously deposited conglomerate. Andesite and dacite are younger. The ultramafics, together with the sedimentaries in which they are included, are affected by dynamometamorphism. The competent restricted greenstone or limestone units included in the competent sedimentaries are not klippen. Disconnected limestone bodies could be visualized as lensing bodies by taking out the invading ophiolites, such as the ones at Değirmen Pass over the Hasankale - Hınıs highway. The turbidity hindered animal life, but there were biohermal limestones which permitted the age span of the sedimentary cycle to be dated as Upper Cretaceous - Paleocene. The latter is used as synonymous with the Eonummulitic of Haug.

There were manifold subsidiary environments. In the main, the trough received uniform flysch deposition, while over the submerged ridges a variegated lithologic association, made up of white limestone, greenstone, and red radiolarian chert, with subsidiary flysch, was accumulated. The same lithologies are observable over the miogeosyncline area along Cilo uplift, where the similar Cilo series represents an overflow of the eugeosyncline in that district.

There were also transient and local lagoonal basins and troughs. Toward the end of the main sedimentary cycle, limestone with essentially small Nummulites and other fossils tended to take over, starting first as sparse interbeds or intertonguing units, then becoming more abundant toward the top, and in some places ending with solid limestone. But the top horizons are mostly eroded off, especially in the west.

Through the most active Van phase the whole of the area received its permanent and characteristic architecture. The first-order simple Van virgation, that gave rise to the primordial Van depression, dates from that time.

The precursor movements of the Van phase in the south caused strong upheaval of the Bitlis massif, and exposed it to swift degradation under a warm, humid climate yielding red deposits. Lagoons formed, which also received abundant delta deposits from the highlands in the north. The outset of the sedimentary cycle was marine, later on there were also transitory marine episodes which made thin zoogene limestone lensing horizons. Gypsum is less frequent. The thick accumulation of conglomerate strata and the subsidiary fine detritals were thrown into gentle buckling with the main Van phase. Gercüş fails over the highlands to the east of Hakkari city.

A widely transgressive sea after the Van phase left deposits that are different in the eugeosyncline and the miogeosyncline. While over the former domain the sedimentation was continuous all through Lutetian and Oligocene periods, over the latter area the deposition ceased after Middle Eocene period.

In the northern part of the map area the sea advanced over a country having a great structural relief. Flysch beds were deposited in the deeper troughs. Near Tunceli, the lowest flysch strata are reddish, and the upper contain limestone intercalations; farther south and west, greenish shale and marl include limestone interbeds, which become more frequent toward the top. South of Hınıs, the flysch beds contain large, red conglomerate lensis or intertongues like those in the Gercüş formation; the sequence also contains andesite, andesitic breccia, and agglomerate. To the east of the eastern plunge sector of Bitlis massif, flysch beds are more red and much coarser than the Upper Cretaceous - Paleocene ones. Their equivalents over shoals on the back of Bitlis massif are evenly bedded, black limestones. Over the Anatolid belt the flysch starts with a thick basal conglomerate, but grades upward into clayey flysch beds without any roundstone.

South and west of Elazığ, nodular and pebbly limestone, along with yellowish-pinkish, coarse-textured and slightly marly limestone, that lie with angular unconformity over Permian limestone, constitute an outlier and should be correlated with Upper Eocene strata farther to the west. The latter show transgressive overlap to the northeast of Karlıova, where Upper Eocene basal conglomerates repose on the Upper Cretaceous - Paleocene. By contrast, in the north, lagoonal conditions prevailed after a transitory marine episode, and gave rise to a vari-colored sequence of fine and coarse detritals with gypsum and salt, but also with basalt lava intercalations.

In the northeastern corner of the map area, at Doğubayazıt, Lutetian sediments start with marly limestone and marl, and end with purer limestone. The evenness of the bedding and the regularity of the sequence, together with the physiographic peculiarities, remind one of Midyat beds over the miogeosyncline.

Over the border trough, a warm sea advanced from the south and in an epicontinental neritic environment were deposited Midyat beds, made up of uniformly white, evenly bedded and regularly packed, brittle, zoogene limestone. Some horizons are chalky, and the base contains marly intercalation. The sea was reduced to a narrow and shallow trough east of Hakkari city, where richly fossiliferous and thin-bedded, marly limestones accumulated. At Terzengi, in the neighbourhood of Beytişebab, Midyat beds overlap the Upper Jurassic - Turonian limestone, and they contain red lensing conglomerate beds reminding of Gercüş formation. The map fails to show Midyat beds at Hazro; this may be due either to non-deposition or to inability to differentiate Midyat limestone from similar-looking Silvan limestone of Lower - Middle Miocene age.

Pyrenean phase, in the miogeosyncline, and Savic phase, in the eugeosyncline, served to end sedimentation with gentle folding and uplift that induced erosion.

The overlapping Miocene sea has likewise invaded an uneven country, where the structural relief, although attenuated, lead the transgression. To the east of Siirt and farther north, there were first simple channels and, then exunded areas. The main divides were possibly, not inundated. The orogenic sedimentation ended, and a post-orogenic molasse facies evolved. The deeper longitudinal troughs, or their portions, received molasse, the shallow sectors sustained limestone, and the moderately deep sectors maintained alternating shale, marl and limestone.

The molasse facies is an alternating sequence of light gray - green marl, siltstone, lensing sandstone. The limestone interbeds are not necessarily present, but they arc valuable to indicate the age of the poorly fossiliferous sequence. There are, in the south, large lensing conglomerates, which are delta deposits from the northern chain. Over the longitudinal highs the series starts with limestone. Molasse beds and the biohermal limestone deposits are in interfingering relationship. The molasse beds in the neighbourhood of Körkandil uplift are intertonguing with locally developed lagoonal deposits. There are some lava flows and bedded or unbedded tuffs intertonguing with early Lower - Middle marine Miocene deposits, such as shale, marl, limestone of the domain of the eugeosyncline. There were fugitive and, local evaporational episodes to give rise to thick lensing gypsum intercalations with marine deposits and even with limestone. The system in that domain was rather closely folded during the Young Steiric phase, the country was upheaved and then eroded. The sequence is mildly buckled in the miogeosyncline, as is usual.

Large fresh-water lakes formed over the eugeosyncline at the outset of the Upper Miocene period. The lacustrine sedimentation is complicated through the admixture of lenticular fluviatile deposits, as well as the continental contribution. The former is an alternance of undulating green marl, shale, siltstone, thin-bedded limestone and typical vacuolar white lacustrine limestone; the coarse sandstone and conglomerate belonging to the latter, which is almost undifferentiated. Over the intermontane depression solely the detritals accumulated, which may be made up of highly uneven, ill-to well-bedded conglomerate.

The thresholds separating the basins oscillated and occasionally functioned as sills, so that the separated basins evolved differently and sustained complex faunal association. The episodes of evaporation interfered at variable vigor, giving rise to various saliferous deposits to pure salt and gypsum accumulation. The sedimentary cycle ends probably with limestone. The correlating units are hard to find. An odd sedimentation in the direction of eastern highlands, such as one situated to the south and east of Siirt.

The subsequent volcanism is of an acid nature, and successively hornblende-andesite, trachyte and rhyolite are evolved, at an unusual scale in the northeastern territory. There were occasional outpourings over the denudated tracts, and where the pyroclastics are emitted abundantly. The final volcanism yielded basalt. Büyük Ağrı - Ala - Suphan and Nemrut volcanoes are aligned over an important linear, which was born during the early Miocene period. Küçük Ağrı - Tendürek volcanoes, and also Köse, Sığınık mamelons, are over the trends of paralleling and less important linears. The volcanoes changed habit. The mentioned major linear's west block separated Van

depression from Muş trough through an upheaval earlier than Miocene period and also with the aid of lavas and pyroclastics. The large Mürüdü basalt cone to the north of Elazığ is, at least partly, of lacustrine Upper Miocene age. The lacustrine Upper Miocene sediments were gently buckled during moderately active Rhodanic phase. The country is upheaved as a whole and exposed later on to epeirogeny.

Over the miogeosyncline the sedimentation is continuous all through the Upper Miocene and Pliocene. The pinkish, interbedded, soft, fine and coarse detritals are evenly bedded and rather regularly packed. They are of intricate origin and seemingly unfossiliferous. So the stratigraphic and paleontologic inductions and deductions are hindered. The environment seems to be lacustrine, which also has received abundant alluvium carried by mountain brooks, presumably with continental deposits. In the area of Cizre the coarse and fine detritals, which overlie the thin basal limestone sequence, display thin intercalated basaltic lava sheets. There a terminal white limestone conglomerate is thought to be Pliocene.

The Pliocene period is a degradational one in the north, and then the coarse detritals are preserved at places and over the axial lows, as for example to the south-east of Körkandil uplift at Tahtresa Mountain's conglomerate strata, which overlie by angular unconformity the Upper Cretaceous - Paleocene. To the southeast of Billoris, thermal springs and thickly bedded, tilted conglomerate is possibly a similar remnant, as it stands higher than the horizontal terraces.

The Upper Miocene - Pliocene of the border trough is very gently folded during Wallachian phase, and the country is gradually and slightly upheaved and delivered to mild denudation. Quaternary basalt flowed over the slightly truncated surface of the Upper Miocene - Pliocene.

It is noticeable that the same Wallachian phase triggered a subsequent shear-thrust of very unusual scale and scope, all along the Iranid belt, which is the most active and energetic component of the eugeosyncline. The main thrust is directed to the south, betraying the most active direction of compression. So the content of the eugeosyncline is thrown over the miogeosynclinal area. There are a few overthrusts directed to the north, which are due to later compressive stresses of the Syrian-Arabian block. There are various aggradational and degradational Quaternary features. Alluvium is common over the longitudinal sectors of the streams, but wanting over the transverse courses. As the transportation of the alluvium is delayed behind the gorges, slant-surfaced terraces are built up, and these are intertonguing with slope waste and talus cones, such as Tercan Plain, behind Sansa Gorge. The Neogene filling of the basins was completed through Quaternary and Recent alluviums and coalescing alluvial cones, formed by side streams issuing from the main divides; the main stream runs nearer the shorter slope. These flat-bottomed and scarcely eroded longitudinal and transversal, wide or limited expanses make up the plains (ova), which are noteworthy features of the physiography of Eastern Anatolia, and the proofs are lacking for their fault-trench origin.

The draihage is integrated through capture, epigeny and headward erosion. The fluviatile degradation is fast-paced as low base levels are reached. Bitlis Stream used to flow south and one time drained Van basin through capture of the northern slope's brook which headed north. During Recent time, Nemrut lavas and welded tuffs erupted during powerful outburst, which took off the upper half of the cone,

dammed the Bitlis Gorge, and Van Lake was born. Its level fluctuated according to the climatic changes. During the Recent age, there were changes of habit as andesitic main foundations of Ağrı, Tendürek and possibly Mürüdü yielded basalt flows. There is a fissure basalt plateau at Karayazı.

The glacial period brought in glaciers over the established drainage pattern. The remnants of larger glaciers are now present over Ağrı, Suphan, Cilo; elsewhere there are cirques, nivation-formed basins and some moraine. The former drainage pattern is not modified. Pasadenic phase is active, as witnessed by a fault cutting through an old alluvial fan in the vicinity of Erzurum.

The Eastern and Southeastern Anatolia is the most rugged sector of Turkey, with numerous interesting scientific ploblems and natural beauties.

Note: For maps and bibliography see *M.T.A. Bulletin* no. 66 (Foreign edition).