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# INTER-MOUNTAIN BASINS IN EASTERN ANATOLIA AND THEIR OIL POSSIBILITIES*

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ABSTRACT. — As a result of the exploration for petroleum in Turkey, many petroleum structures have been discovered in SE Anatolia. In Thrace some important natural gas reserves were discovered in 1970.

Besides these two petroleum regions, it has been observed through the studies made by M.T.A. Institute, that some inter-mountain basins, especially in Eastern Anatolia, might be very important for petroleum.

Four Tertiary depressions lying within the old metamorphic uplifts of Anatolid-Taurid units, between the Pontid tectonic unit in the north and the south tectonic belt, have been distinguished. These depressions which are named as Sivas Basin, Erzurum Basin, Tekman-Karayazı Basin and Muş-Hınıs Basin, lie in an E-W direction and they are narrow basins in which thousands of meters thick sediments were deposited. Both, the tectonic characteristics and the characteristics of these basins are important from the petroleum point of view.

## INTRODUCTION

In the last few years oil exploration in Turkey has developed fast. Exploration has been particularly located in SE Anatolia (where a discovery was made in 1946), partly in Thrace and even some off-shore activities have been initiated.

These exploratory activities, in the above-mentioned districts, have lead to the discovery of some petroleum and gas regions important for our country. Other parts of Anatolia did not attract the attention of the petroleum searchers because of the geological and tectonic conditions.

As a result of the heavy geological, geophysical and reconnaissance drilling activities performed by M.T.A. Institute in Eastern Anatolia, some small and large inter-mountain basins have been recognized as important for the petroleum possibilities.

This paper has been written with the purpose of indicating the characteristics and importance of petroleum in inter-mountain basins, in the study and exploration of which the authors of this-article have also co-operated.

It is our duty to thank the General Directorate of the M.T.A. Institute and the persons concerned with the Petroleum Department for their great help in our activities and in the preparation of this paper.

## GEOLOGICAL AND TECTONIC STRUCTURE OF EASTERN ANATOLIA IN GENERAL

Eastern Anatolia can be divided into three units due to its general tectonic lines: 1) Pontids in the north, 2) Anatolid-Taurid unit in the middle, 3) Border folds in the south.

The Pontid unit in the north, includes the mountain chain that runs parallel to Black Sea. In this region Pontids are represented by crystalline rocks in the core, granite intrusions and old Mesozoic volcanic deposits overlying them. Generally, block tectonic is dominating.

The geological units included in the central part are: the locally metamorphic crystalline uplifts, the deep inter-mountain Tertiary basins and, in general, the Mesozoik ultrabasics and the post-Tertiary volcanism are all regarded as one unit, under the name of «Anatolid-Taurid». In principle, in Central and Western Anatolia, this unit is regarded as composed of two different units, under the names of Anatolid and Taurid (Ketin, 1966).

Border folds unit in the south forms the first trough of Alpine geosyncline in Anatolia. A regular system of folds is dominant. A continuous sedimentation starting from infra-Cambrian, including Pliocene, is developed, in a shallow sea facies. Metamorphism and magmatic intrusions have not been seen in this unit.

## INTER-MOUNTAIN BASINS

In Eastern Anatolia, in the Anatolid-Taurid unit situated between the Pontids in the north and Border folds in the south, among the old massifs, long and narrow depressions lying in the E-W direction have occurred. These depressions are filled with very thick, prevailingly Tertiary deposits.

In general they have many similarities with each other. Although there are variations in the facies characteristics of each basin, it is observed that the clastic deposits are dominant in all of them.

Also, in the eastern parts of Eastern Anatolia these basins are covered by thin post-Tertiary volcanics. In nearly all the basins there are petroleum occurrences (Fig. 1).

Four inter-mountain basins which are important for petroleum have been distinguished. These are (Fig. 1) : I) Sivas basin, II) Erzurum basin, III) Tekman-Karayazi basin, IV) Muş-Hınıs-Malazgirt basin.

### Sivas basin

*Geological and tectonic characteristics of the basin.* — This basin has developed in between two uplifts, one in the north, formed by the Kızılırmak massif and its branch in the east, called Kızıldağ metamorphics, and the other one in the south formed by the Akdağ metamorphics and the Divriği massif. It is in the form of a long and narrow depression, 250 km long, 50 km wide lying in the east-west direction. A large part of the basin is bordered by a fault in the north. In the south, all along the basin, a large overthrust has developed runnig from south towards north.

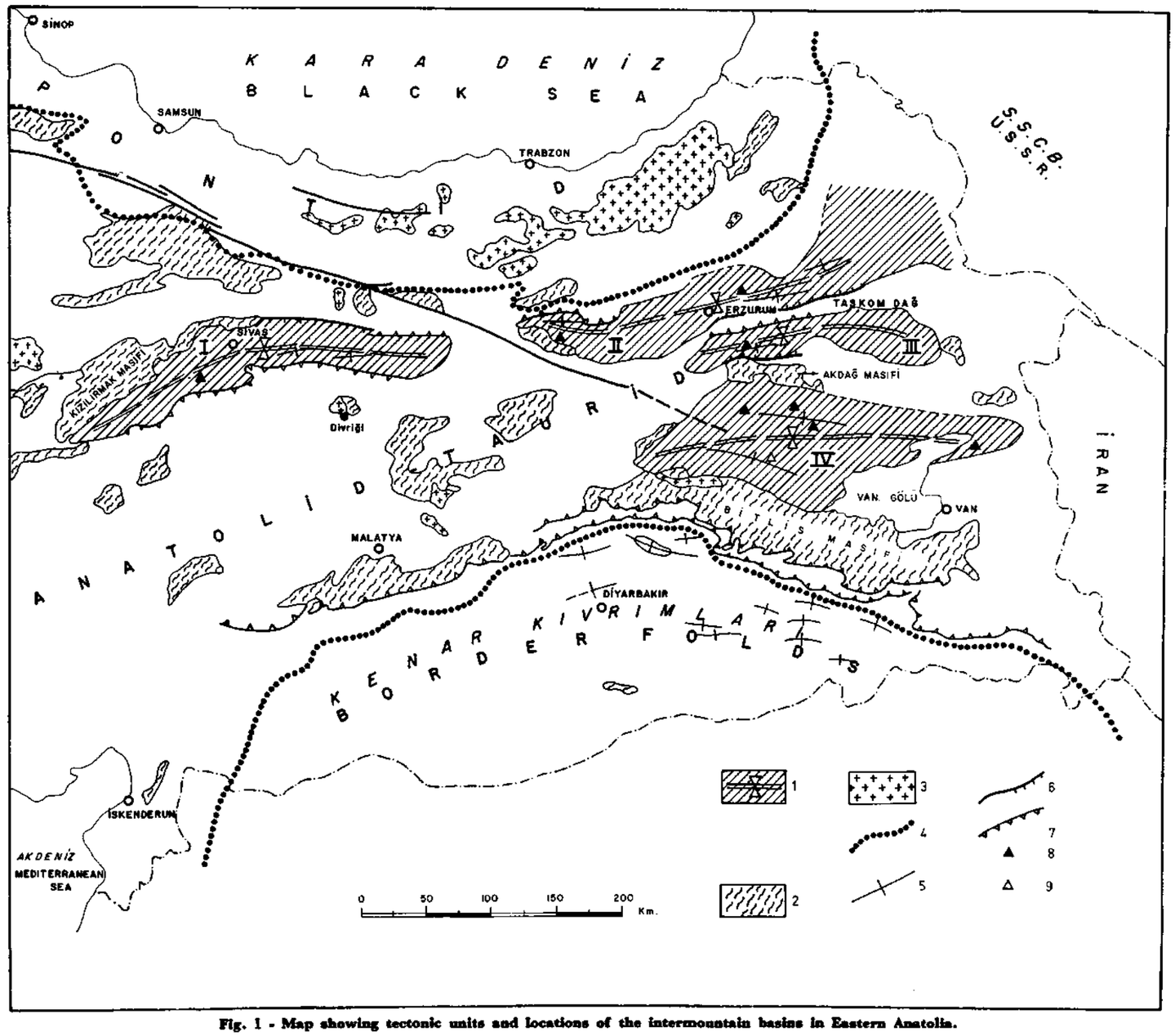


**Fig. 1 - Map showing tectonic units and locations of the intermountain basins in Eastern Anatolia.**

*1 - Intermountain basins:* I) Sivas basin, II) Erzurum basin, III) Tekman basin, IV) Muş-Hınıs-Malazgirt basin; *2 - Metamorphics; 3 - Intrusives; 4 - Border lines of tectonic units; 5 - Anticlines; 6 - Faults; 7 - Thrust faults; 8 - Oil occurrences; 9 - Gas occurrences.*

A Tertiary sedimentation has taken place in the basin, approximately 7000 m thick (Fig. 2). Tertiary begins with Ipresian conglomerates overlying the metamorphics and the Mesozoic limestone and ophiolites with an angular unconformity. These coarse elastics which reach a thickness of 800 m at the borders of the basin, pass into thin elastics, such as sandstone, shale, and marl in the center of the basin.

Sedimentation has continued in the Middle and Upper Eocene without interruption and has mainly developed as an alternation of sandstone, shale and marl. In the east of the basin, layers of volcanic tuffite and breccia were partly included in the sedimentation. In the west of the basin and especially in the Middle Eocene sedimentation has developed mainly as limestone formation. It is observed that mainly marl and shale layers are dominant in the upper levels. In the layers, from place to place, large quantities of Nummulites were found.

Eocene is overlain by Oligocene starting with thin layers of conglomerate and gypsum over them, and developing upwards with alternations of red, violet, and grey-colored sandstone and shale. Sedimentation is very thick; approximately 2000 m were measured. Only Ostracods were found as fossils in the layers.

Miocene starts with conglomerate overlying Oligocene layers with an angular unconformity or sometimes it begins directly with limestone layers. These limestones are a few hundred meters thick, beige-colored, highly fissured and contain large amounts of Lamellibranchia and Algae; they belong to Aquitanian-Burdigalian. At the upper levels, they pass sometimes laterally into marls and shales. These shale and marls contain fossils and are Middle Miocene in age. Upper Miocene is formed by red-colored, coarse-grained sandstone and gypsum. In the west of the basin these red sandstones with gypsum are completely dominant. Aquitanian-Burdigalian limestone and Middle Miocene marls become thinner gradually and are replaced by red sandstone with gypsum towards the west of the basin. The thickness of all the Miocene layers is approximately 1500 m.

*Petroleum possibilities of the basin.*— The Sivas basin, in which a sedimentation with a total thickness of 7000 m has been settled, has some important characteristics for petroleum possibilities. The thick Eocene formation particularly attracts attention as the source rock, the reservoir rock and also as a cap rock. Marl horizons, black-colored, partly with bitumen, are seen and these could be the source rock. Sandstone and limestone layers with high porosity are also important as reservoir rock. These have many different thicknesses at different levels. Besides these, tuffite and volcanic breccia layers also have high porosity and can be important as reservoir rock. Marly horizons deposited in alternation with sandstone and limestone layers represent the cap rock with their very low porosity. These horizons become more dense towards the top.

Oligocene sandstone and shale layers and Miocene limestones are very porous. The gypsum layers and marly horizons in and on top of these have the characteristics of *a* good cap rock. Also, locally oil shale horizons are seen, especially in Miocene marly formations.

All the layers deposited in the Sivas basin are folded. From place to place, structures with their axes lying approximately in the directions of E-W or ENE - WSW are observed. Very frequently, lateral changes of facies have been observed.

These structures and lithological lateral changes are particularly regarded as having an important role as petroleum traps.

**Erzurum basin**

*Geological and tectonic characteristics of the basin.*— This basin lies in between the Pontid block in the north, formed by Pulur, Olur and Artvin metamorphics and Kaçkar intrusives and the ophiolitic Mesozoic uplifts of Palandöken and Taşkom Dağ, and the metamorphics of Erzincan in the south. It is supposed that it gets larger from west to east and probably passes into the U.S.S.R.

The basin is in the form of a deep depression, approximately 50 km wide and 300 km long, its axis trending east-west, in which probably 6500 m thick Tertiary sediments were deposited (Fig. 3).

The Eocene overlies unconformably the metamorphic and the Mesozoic limestone with ophiolite. The Eocene beds are approximately 1200 m thick, they start with conglomerate and develop as alternation of sandstone and shale. On the west of the basin, lateral changes into limestone layers have been observed locally.

The Oligocene is represented by variegated gypsiferous sandstone and shale alternations. It reaches a thickness of 1000 m on the west side of the basin.

Miocene usually starts with variegated colored conglomerate. Sometimes gypsum layers or Aquitanian-Burdigalian limestones form the bottom. Formation develops as the alternation of variegated colored conglomerate, limestone, sandy limestone, gypsum and locally halite, shale and marl.

In the west of the basin, gypsum and limestone deposits gain more importance than in the east. That means, Miocene in the basin shows lateral passage. It is understood that all the Miocene layers become thicker going from west to east and reach a thickness of 2000-2500 m.

Pliocene deposits have an important place in the Erzurum basin. These are formed by alternations of conglomerate, sandstone, shale and siltstone layers. They are usually red, beige, grey, and green colored. At the upper levels of the Pliocene, volcanic breccia, tuff and basalt flows are present. These volcanics cover an important part in the basin. Thickness of only the Pliocene sediments is estimated as approximately 1500 m.

*Petroleum possibilities of the basin.*— The Erzurum basin, in which a sedimentation with a total thickness of 5000 m has been settled, looks important for petroleum possibilities.

Eocene sandstone and limestone layers, Oligocene sandstones, Miocene limestones, Pliocene sandstone horizons, more developed in the east of the basin, have very good reservoir rock characteristics from the point of view of porosity.

Black-colored oil shales occurring within Miocene and Pliocene formations, have important characteristics as cap rock.

All the Tertiary deposits in the basin are folded and they have formed in this narrow basin locally closed structures with axes usually lying in the E-W direction. Also, lithological lateral changes and some faulting might be important as petroleum traps.

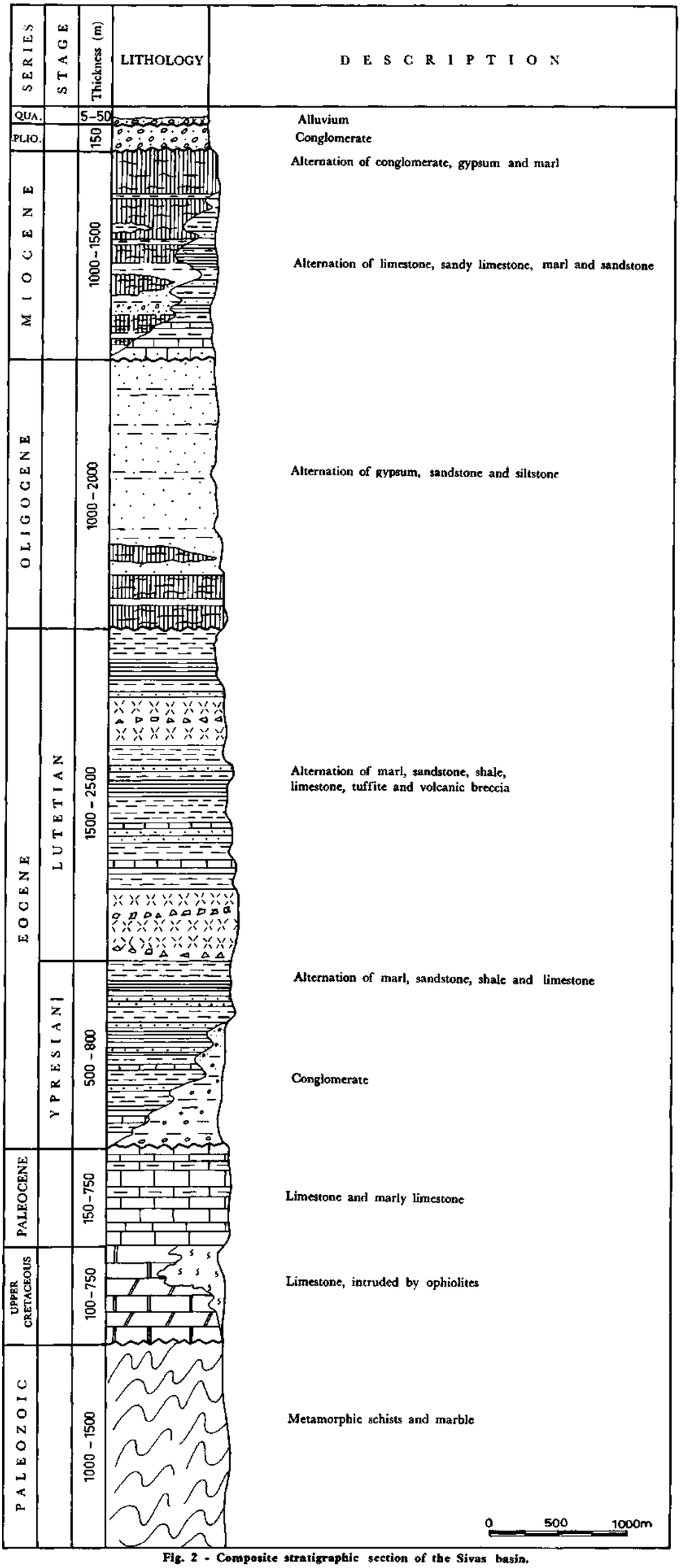


**Fig. 2 - Composite stratigraphic section of the Sivas basin.**

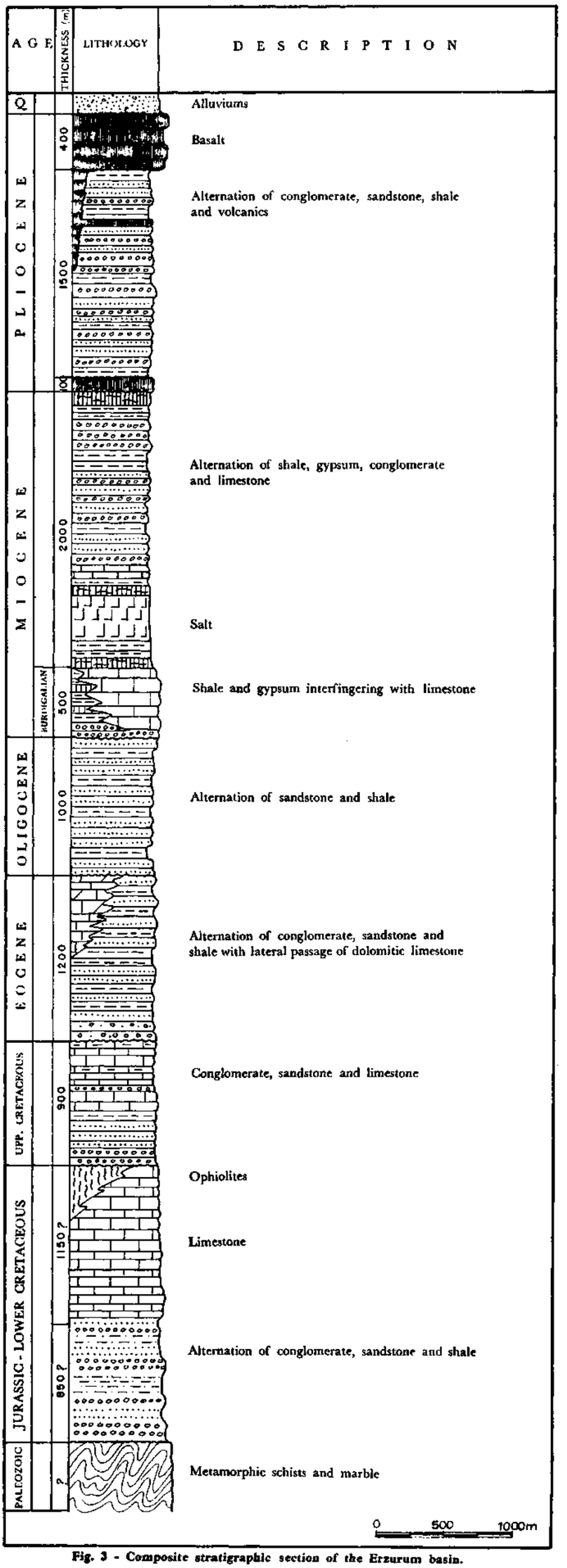


**Fig. 3 - Composite stratigraphic section of the Erzurum basin.**

Two very important and already known petroleum seepages (Pasinler and Neftlik) in the basin could be taken as a sign that oil had been developed in this basin.

**Tekman - Karayazı basin**

*Geological and tectonic characteristics of the basin.* — The Tekman - Karayazı basin is a depression lying in between the Palandöken and Sakaltutan Mountain Chain formed by the ophiolitic series in the north and the Akdağ massif formed by crystalline schist in the south. This depression trending east-west is a narrow basin, 200 km long and 25-30 km wide. Ultrabasic rocks which form the northern border of the basin have been thrust southwards. The contact with the crystalline schists that form the southern border is by fault.

In the basin, Tertiary deposits reaching a thickness of 4500 m were formed. These deposits, outcropping in the center of the basin, are covered with young volcanics (basalt, andesite) in the east and west extention of the basin. The depression in between the two uplifts at the north and the south is filled with Upper Cretaceous, Eocene, Oligocene, Miocene and Pliocene deposits (Fig. 4).

Upper Cretaceous deposits outcropping in a small area at the borders of the basin overlie the old basement transgressively. Upper Cretaceous represented by Maestrichtian is formed by the alternation of reefy and bedded limestone, shale and sandstone.

Eocene, which unconformably overlies the old basement and the Upper Cretaceous formation, is represented by Lutetian. Lutetian, approximately 800 m thick, is formed in general of greenish-grey conglomerate, sandstone and marls. Ophiolites on the north of the basin were thrust over this formation.

Oligocene, which lies unconformably over the Lutetian, and which is approximately 850 m thick, is formed by sandy limestone, and paper shale interbedded with sandstone. Sandstone and sandy limestones contain petroleum drops when they are broken.

Miocene is marine in its lower section and continental in its middle-upper section. Lower Miocene (Burdigalian) which lies unconformably over Oligocene is formed by 1000 m thick sandy marls interbedded with limestone at the bottom and with 150-800 m thick reef limestone in the upper parts.

Continental Middle - Upper Miocene consists of conglomerate, sandstone, marl and also tuff and agglomerate interbedded with gypsum. There is an unconformity between continental Miocene and marine Miocene.

Continental Pliocene, which unconformably overlies the other formations, is formed by alternation of sandstone, conglomerate, limestone, marl, gypsum and agglomerate. All the deposits are covered by young basalts.

*Petroleum possibilities of the basin.* — Although it is a very narrow basin, Tertiary deposits of 4500 m thickness have been recognized in the Tekman-Karayazı basin. Also, there are anticlines in the basin which would make it possible for the petroleum to be trapped. There is a petroleum seepage of good quality around Katranlı village on the western extension of the basin, known for years.

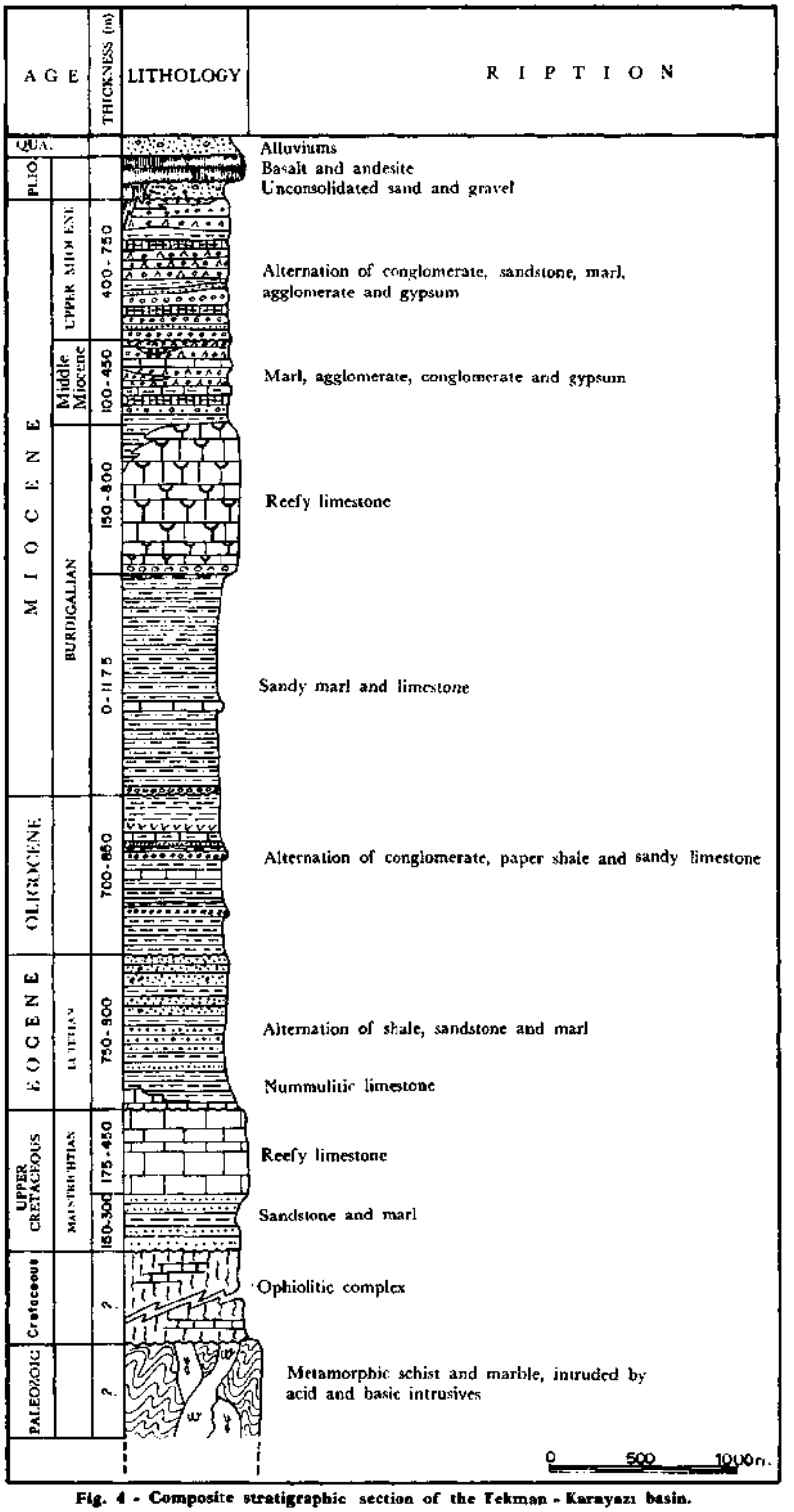


**Fig. 4 - Composite stratigraphic section of the Tekman - Karayazı basin.**

Marls and shales of the Upper Cretaceous and Eocene formations, and especially paper shales of the Oligocene formations, and also marine Miocene marls have characteristics of source rocks. Limestones of the Upper Cretaceous, Eocene sandstone and limestone, sandy limestone within the Oligocene paper shale, and Lower Miocene reef limestones have the characteristics of an ideal reservoir rock.

In the same way, marly levels of the Eocene, Oligocene paper shales, Miocene marls and gypsum levels of the Middle - Upper Miocene represent good cap rock.

The basin shows important oil prospects because of its thick formations, deposited prevailingly in detritic environment, suitable for oil accumulation, and because of the occurrence of numerous trap possibilities. The presence of important oil seepages also proves this.

**Muş - Hınıs - Malazgirt basin**

*Geological and tectonic characteristics of the basin.* — This basin is in between the two big uplifts formed by Akdağ and Taşlıçay (SE of Ağrı) metamorphics in the north and by Bitlis massif in the south.

It is in the form of a depression lying east-west, 250 km long and 85 km wide. In this depression Tertiary sediments approximately 10,500 m thick were deposited (Fig. 5).

The stratigraphic sequence in the basin is, from bottom to top: Upper Cretaceous, Eocene, Oligocene, Miocene and Pliocene. A large part of these Tertiary deposits in the basin is covered by young volcanics, especially the eastern part of the basin.

Upper Cretaceous deposits have the characteristics of reef limestone in north of Hınıs (northern border of the basin) and limestone and marly limestone in the Ahlat-Adilcevaz (north of Lake Van). Upper Cretaceous deposits represented by Maestrichtian are transgressive over Paleozoic crystalline schists and ophiolitic series.

Tertiary deposits that fill the basin start with Lutetian and overlie crystallines unconformably. The Lutetian, 1400 m thick, is generally formed by an alternation of sandstone, limestone and marl with conglomerate at the bottom.

Upper Eocene (Bartonian) deposits are conformably overlying Lutetian. Upper Eocene deposits, 2650 m thick, are formed by the alternation of red conglomerate, sandstone and marls.

Oligocene deposits overlie Upper Eocene deposits unconformably. Oligocene, 2000 m thick, is formed by the alternation of sandstone, limestone and 'marls.

Marine Miocene, which is unconformably overlying Oligocene, is represented by Aquitanian and Burdigalian. Oligocene continues north of Mu§ (which is situated on the west of the basin) and along the direction of Ahlat-Adilcevaz-Erciş (north of Lake Van). Aquitanian, 1100- m thick, is formed by the alternation of sandy limestone and marl and Burdigahan, 700 m thick, is formed by limestones with large quantities of macro and microfossils.

Upper Miocene deposits are formed by the alternation of conglomerate interbedded with gypsum and volcanics, sandstone, and marl and it is unconformably overlying Burdigalian.

Pliocene deposits unconformably overlying the older formations are more of a continental (lacustrine) character and have partly a volcanic facies. These deposits, with a thickness of 1500 m, are formed by conglomerate, sandstone, marl, lacustrine limestone and tuffs. Sometimes oolitic limestone layers are found in this formation.

The basin in general is covered by andesite and basalt flows, which are due to pre-Pliocene and post-Pliocene volcanic activity. The deposits that fill up the basin can only be followed at Muş-Hınıs, the eastern part of the basin being covered by young volcanics.

*Petroleum possibilities of the basin.*— The Muş-Hınıs basin, with sediment deposits reaching a thickness of 10,500m approximately, has very important petroleum possibilities. Upper Cretaceous marls which outcrop along the border of the basin but which lie elsewhere under thick Tertiary deposits, Eocene, Oligocene and marine Miocene (Aquitanian) marls and shales have the characteristics of source rocks. Upper Cretaceous reef limestones, limestone and sandstone levels of Eocene deposits and marine Miocene reef limestones (where they are covered) can be reservoir rock. Marls and shale of the Eocene, Oligocene and Miocene deposits and Upper Miocene and Pliocene marls with gypsum have the characteristics of an ideal cap rock.

There are anticlines trending approximately NW-SE in the basin, which are important. One of the anticlines north of Muş is probably 80 km long and 10 km wide. Another anticline is situated SE of Hınıs. These are the most important structures known in the basin. But, no doubt, it is possible to have important structures in the north of the basin covered by young volcanics. There are, in fact, petroleum seepages of very good quality in these volcanics.

Presence of a thick sedimentation together with important anticlines, and also petroleum seepages at various places (Divanıhüseyin, Tirkiş, Neftlik, Kelereş Deresi, Kurzot) in the basin are satisfactory evidences for petroleum accumulation.

Both the sedimentation and the presence of the structures and also petroleum indications prove the importance of the Muş-Hınıs-Malazgirt basin for petroleum.

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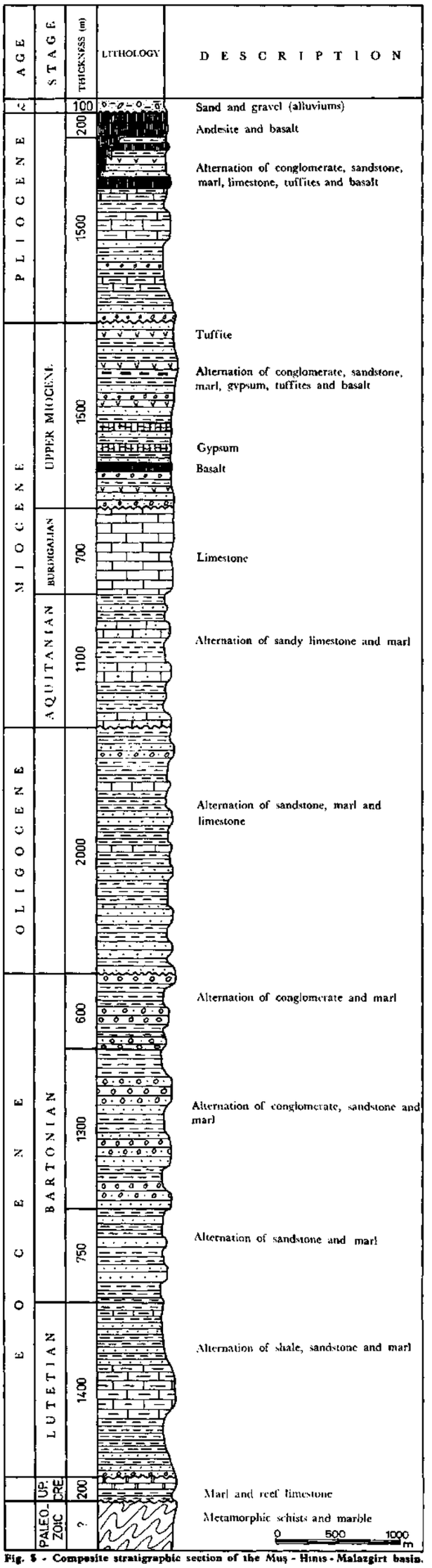


**Fig. 5 - Composite stratigraphic section of the Muş - Hınıs - Malazgirt basin.**

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