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THE BİNGÖL EARTHQUAKE FAULT AND ITS RELATION TO THE NORTH ANATOLIAN FAULT ZONE

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SUMMARY. — According to the macroseismic observations, the epicenter of the Bingöl earthquake, which occurred on May 22, 1971, was found in the area where the Göynüksuyu valley reaches the Çapakçur plain and the intensity of the earthquake was VIII. The geological effects of the earthquake, in a narrow zone starting from Çeltiksuyu and Sarıçiçek villages and running along the Göynüksuyu valley, were perfectly examined. In this article, the zonal development of a left-lateral strike-slip fault, trending in the direction of N 45°E, along the Göynüksuyu valley, between Bingöl and Karlıova, is mentioned. It is put forward that the Bingöl earthquake of 22 May, 1971 is related to this fault zone. A horizontal displacement of about 15 km along the fault zone was geologically discovered. The horizontal displacement after this earthquake was also left-lateral, and measured as much as 25 cm with no vertical slip.

The earthquake was due to the activity of the southern half of this sinistral wrench fault; thus it is believed that this break, going through Karlıova, Göynük, Ağaçeli and Bingöl, may be an active belt which is as dangerous as the North Anatolian fault zone.

In addition, the relationship between the Bingöl fault and the North Anatolian fault zone is also discussed in the article.

I. INTRODUCTION

In the Eastern Anatolia, the Bingöl earthquake of 22 May, 1971, which caused severe damage to Bingöl and the neighboring villages, occurred in the evening at about 6.45 local time (18 43^m 58^s GCT). The instrumental epicenter of the earthquake, 38° 80 N - 40° 50 E, the magnitudes of the shock, 6.0 Mb and 6.7 M_s, and the focal depth, about 3 km, were calculated by USCGS. A day before the main shock, an earthquake with an intermediate intensity had occurred, and the main earthquake was followed by a number of aftershocks for a month.

The area, affected by the Bingöl earthquake was just south of the intersection between the North Anatolian earthquake belt and the other less distinguishable earthquake zone (Ergin, 1966), that lies between the Gulf of İskenderun and Batumi (Caucasia). According to the historical records, the earthquakes in this region were generally distributed in the Kiğı-Karlıova-Varto zone, but they moved southwards and shook Bingöl and surrounding area from time to time. On the other hand, from the present catalogues and records (Ergin, *et al.*, 1967, 1971), no other destructive earthquakes that caused as much life and property loss as this earthquake can be found.

A month later after the earthquake, the authors visited the earthquake region on behalf of the Chair of Geology of the Mining Faculty of the Technical University of Istanbul, and the investigations in the field were carried out in two weeks only. In this short period, the isoseismal map of the earthquake (PI. I) and the geological map of the Göynüksuyu valley between Bingöl and Göynük (P1. II) were produced.

Here we should like to thank Professor Dr. İhsan Ketin, who encouraged us to publish the article and critically read and corrected the manuscripts. Thanks are also due to the Mining Faculty for the economical support and to Dr. Sadrettin Alpan, the General Director of M.T.A., who gave an opportunity to publish the article in this bulletin. We are also indebted to Professor Dr. Atife Dizer and Associate Professor Dr. Ş. Abdüsselamoğlu for the revision of the fossils.

Table - I

History of the earthquakes in Bingöl and the surrounding areas

Date	*Epicenter coordinates*		*Magnitude*	*Area of damage*
955	39.30 N	40.70 E	6	Kiğı-Karlıova
1878	39.30 N	40.70 E	6	Kiğı-Karlıova
1889	38.90 N	40.50 E	6	Bingöl-Elâzığ-Palu-Karlıova
1909	39.32 N	40.35 E	6	Kiğı
12.11.1934	39.00 N	41.00 E	6 M	Solhan
28.5.1940	38.89 N	40.50 E	6	Bingöl
17.8.1949	39.32 N	40.35 E	8	Kiğı-Karlıova
28.3.1954	39.10 N	41.00 E	6.75 M	Göynük-Solhan
7.7.1957	39.16 N	40.50 E	6	(damage, seven wounded)
24.8.1959	39.00 N	40.00 E	4.75 M	Kiğı, near Karakoçan
12.3.1963	39.30 N	40.30 E	4 M	Kiğı
31.8.1965	39.40 N	40.80 E	4.5 M	Between Kiğı and Karlıova (in the east severe damage, 40 wounded)
24.9.1968	39.10 N	40.10 E	5.1 M	In the villages of Bingöl and Elâzığ (two dead, 40 wounded)
25.9.1968	39.20 N	40.20 E	5.1 M	In Kiğı and Bingöl (damage)

II. MACROSEISMIC OBSERVATIONS

The earthquake, also felt severely in the neighboring provinces, destroyed only Bingöl and the villages in the vicinity of the city of Bingöl, together with some villages of Elazığ, near to Bingöl. The region which had the heaviest damage is an elliptical area that extends as far as the villages of Kaplıca, Ilıca and Ağaçeli in the north, Tekören and Ardıçtepe in the east, Yama9 in the south and the city of Bingöl in the west (PI. I).

Due to the earthquake, many cracks and en echelon tension fissures occurred on the alluvial ground surface, especially in the epicentral area between Çeltiksuyu and Kaplıca, further north near the villages of Çobantaşı and Alatepe, and around Ormanardı in the south of Bingöl (Photo 1). The tension gashes were oriented between the directions of N 0° E and N 25° E, and they indicated mostly an en echelon pattern. Thus it was proved that the sense of movement along the fault-break was left-lateral (Fig. 1). As can be seen from the map in Plate II, the directions of the shear zones are generally N 40° to 45° E. The shear zones, which were 50 to 500 meters in length, were traced for a distance of about 35 kilometers, from Ormanardı to Çobantaşı. They were especially common between the villages of Sarısisek and Kaplıca.

In addition, some other shear zones that lined up in the directions of N 15° to 20° E, i.e. somewhat oblique to the main shearing direction, were also encountered. These oblique shear zones were interpreted as *Riedel-in-Riedel* (Tchalenko, 1970).

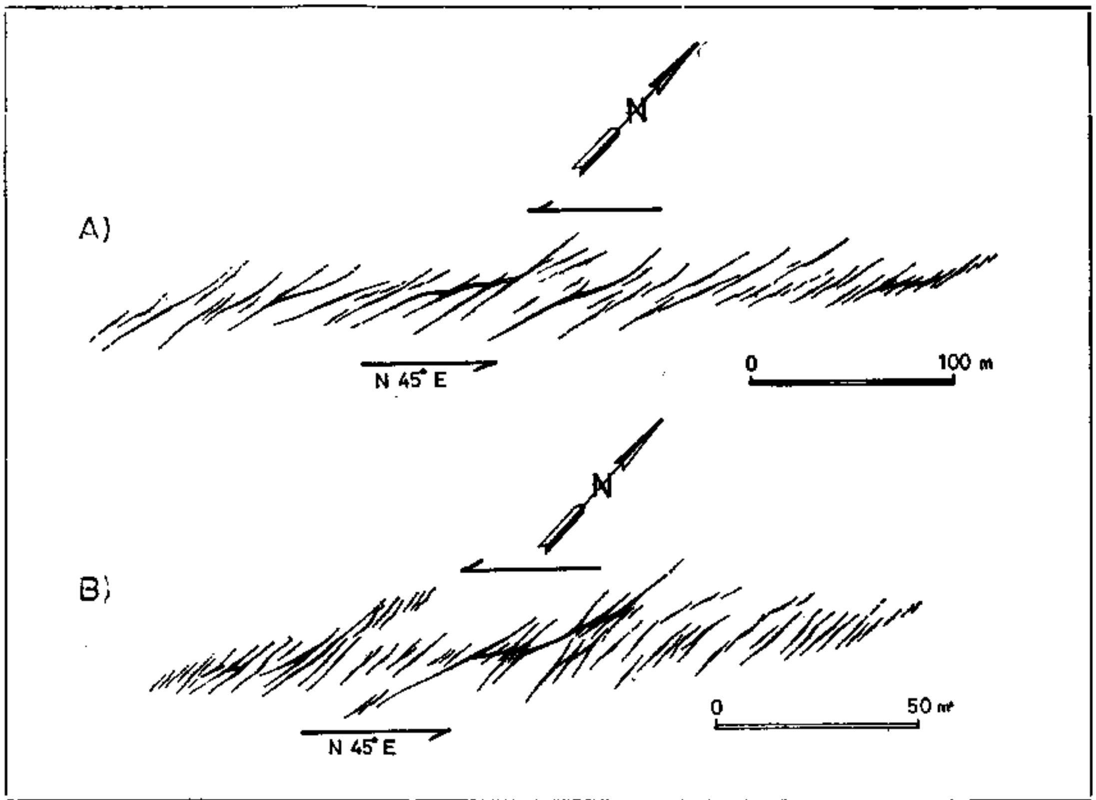

Fig. 1 - Two examples of the shear zones, which occurred around Sarıçiçek village during the Bingöl earthquake of May 22, 1971. The general direction of the shear zones that indicated a left-lateral movement during the earthquake was N 45°E.

Near the village of Sarıçiçek, a shear zone, developed in the direction of about N 45° E, cut a very vague cart track and displaced it 25 centimeters to the left. Along some shear zones seen in the steep ground of the rough land, vertical displacements due to the collapse of the blocks down the dip ofthe slopes were observed, while along those on the horizontal and flat ground no vertical displacements could be seen. Thus this proved that the movement along the fault-break was wholly horizontal.

The epicenter of the earthquake, according to the macroseismic observations, falls in the area where the Göynüksuyu valley reaches the Çapakçur plain and is about 10 km far from Bingöl (Pl. I). By examination of the damage to the village houses, built with a primitive technique, and school buildings, the intensity of the earthquake was estimated as VIII.

III. GEOLOGY OF THE GÖYNÜKSUYU VALLEY

In the geologically mapped area along the Göynüksuyu valley, the formations in turn from the oldest to the youngest are schists (Sch) and marbles (Mr), known as Paleozoic, and Oligocene to Miocene-aged grey marls and shales (olm_1) together with microfossiliferous, yellowish limestones (olm_2). There are also Pliocene to Quaternary basaltic and andesitic lavas (3) and fluvio-lacustrine deposits (plq), and recent alluvium (al). The rocks are defined in turn as follows:

Crystalline schists (Sch) and marbles" (Mr)

The metamorphic rocks consist mostly of blackish-grey-colored calc-schist, chlorite schist and phyllite. Since the contacts between the marbles and schists are usually faulted, the stratigraphical position of the marbles is not well defined. Nevertheless, it has been observed that the marbles, occurring as thick bands and lenses of various sizes, are found in several horizons and these are drawn as individual units on the map. These crystalline schists and marbles outcrop as two island-shaped exposures, one being to the east and south of Göynük, and the other being in the vicinity of the villages of Yenibaşlar, Kaplıca, Ilıca and in the Kösderesi valley. The contacts between the metamorphic rocks and the basaltic lavas and tuffs in the Göynüksuyu valley are completely faulted, and it has also been observed that these two exposures were cut by a sinistral wrench fault zone and horizontally displaced about 15 km from each other (Pl. II).

The Upper Oligocene-Lower Miocene formations

These formations, consisting of fossiliferous clayey marls (olm_1) and limestones (olm_2), rest on the crystalline schists and are covered by the basaltic lavas.

The Lower Miocene limestones (olm_2), exposed in the fault zone between the villages of Ekinyolu and Kaplıca, rest conformably on the Mollusca-bearing grey marls, clayey in some and sandy in other horizons, whose bottom is not seen (Fig. *2A).* The contact of these formations with the basaltic lavas is faulted, and they are widely covered by the old fluvial deposits.

In the thin-sections of the marls, quartz and feldspar grains together with Bryozoa and *Operculina* fossils were frequently found. In the thin-sections taken from the limestones, *Miogypsina, Miogypsinoides, Lepidocyclina (Nephrolepidina), Lepidocyclina (Eulepidina), Miokpidicyclina,*

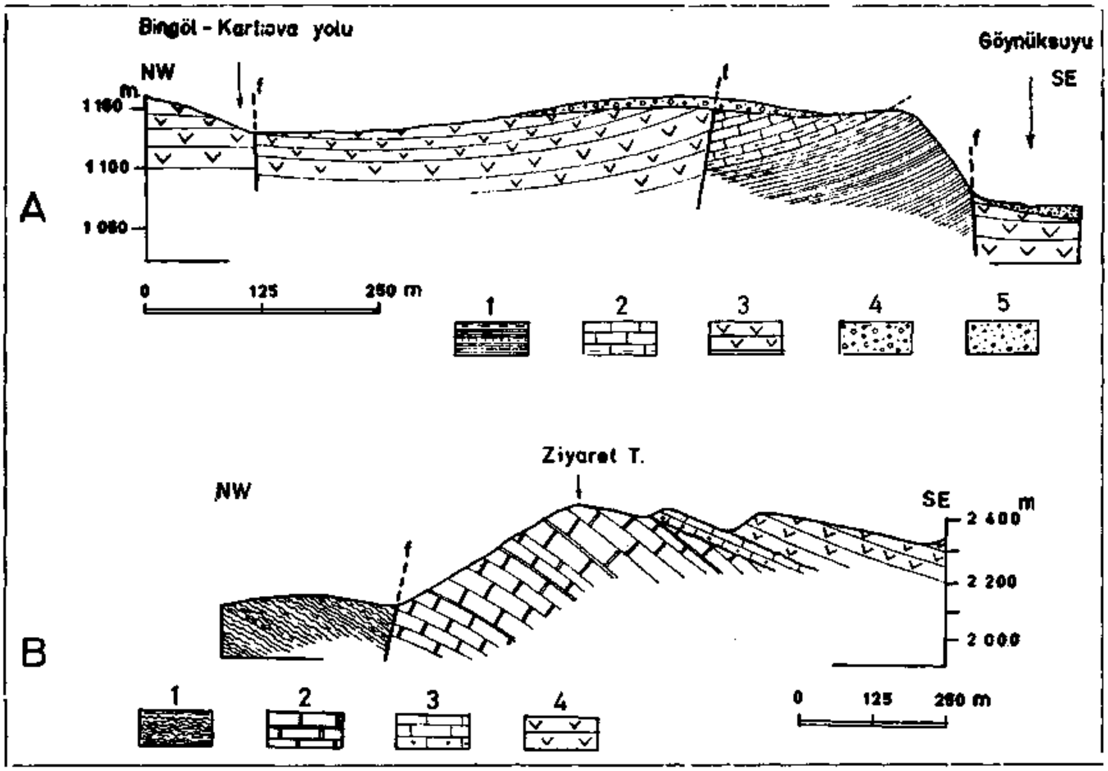

Fig. 2A - Cross-section 2.5 km northeast from the Bingöl-Muş highway, showing the relation between the Oligocene-Miocene formations and volcanic lavas. *1 - Fossiliferous, grey marls* **(Upper Oligocene);** *2 - Foraminifera-bearing yellowish-colored limestones* **(Aquitanian-Lower Burdigalian);** *3 - Basaltic lavas* **(Neogene);** *4 - Continental unconsolidated deposits* **(Pliocene-Quaternary);** *5 - Alluvium* **(Recent).**

Fig. 2B - Cross-section in the south of Göynük, showing the relationships between the metamorphosed rocks and limestones and basaltic lavas. *1 - Schists; 2 - Marbles; 3 - Lower Miocene-aged limestones; 4 - Basaltic lavas.*

Spiroclypeus, and *Lithophyllum* and *Archaeolithothamnium* from Melobesia were observed. Therefore, the age of these limestones is Aquitanian-Lower Burdigalian (A. Dizer, personal communication), and the age of the clayey marls can be Upper Oligocene.

The Miocene limestones in the east of Çobantaşı that show small and isolated exposures rest on the metamorphic rocks with an unconformity. The limestones, starting with thin-bedded microconglomerates at the bottom and being in total about 5 to 10 meters in thickness, are overlain by basaltic lava flows (Fig. *2B).* However, these limestones rest concordantly on a flysch in the south but disordantly on crystalline schists in the north, therefore this fact indicates that during the passage from Upper Oligocene to Miocene, the marine transgression took place from south towards north.

Volcanic rocks (b)

These consist of mostly basaltic, but from place to place andesitic and trachy-andesitic lavas and tuffs. As these rocks spread out in very wide areas and overlie the Lower Miocene limestones and, on the other hand, are interfingered with the Pliocene-Quaternary-aged fluvial deposits in the south of Bingöl (Photo 2), it has been proved that the volcanic activity in the region started in Miocene time and continued up to Quaternary time.

Continental unconsolidated sediments

The fluvial-lacustrine sediments (plq) are spread out between the levels of 1,040 and 1,100 meters above the sea in the Çapakçur plain and they have terraces at three different levels. The layers consisting of pebbles of various sizes or sand grains are cross-bedded and alternating. These formations are also affected by the recent tectonic movements and faulted, as can be seen on Photo 3. But the recent alluvial sediments (al) are found both at the bottom of the valleys and as fans along the Göynüksuyu valley. Alluvium is also seen around the lakes filled or being filled and bogs that line up in the fault zone.

Travertines (t)

There is a line of travertines, caused by the hot and cold water springs along the fault zone.

The region had been previously investigated by F. Baykal (1950). In the Göynüksuyu valley, limestones, described as of Nummulitic (Paleocene) age—that are found to be Aquitanian-Burdigalian in this work—and metamorphosed rocks were distinguished. It was noted that the limestones with small exposures around Çobantaşı (Siği) were interbedded with the basaltic lavas. By reason of this, it was put forward by the preceding author that the volcanism in the region had started in the Eocene time and continued throughout the Neogene,.whereas, during our investigations, it was observed that the basaltic lavas rest on the Miocene limestones (Fig. *2B). İ.* E. Altınlı (1963) states that the Hacıyan (Hacılar) and Göynük faults, shown on the Geological Map of Turkey in 1:500 000-scale, are the contacts between the Upper Cretaceous - Paleocene rocks together with the Miocene-aged lacustrine deposits and the volcanic rocks in the Göynüksuyu valley, and that there exist travertine springs, mineral water springs, hot water springs and sag ponds along these breaks. These Upper Cretaceous-Paleocene formations, mentioned by the writer above, must apparently be those named as Nummulitic (Paleocene) by F. Baykal (1950). In fact, these formations in the investigated region are Upper Oligocene - Lower Miocene in . age.

IV. THE RELATIONSHIP OF THE BİNGÖL FAULT TO THE NORTH ANATOLIAN"FAULT ZONE

The metamorphosed rocks and Oligocene-Miocene formations mentioned in the preceding paragraphs are cut by a fault zone trending in the direction of N 45° E in the Göynüksuyu valley, and the metamorphic rocks are horizontally displaced by as much as 15 kilometers. The sense of displacement is left-lateral with or without a vertical, component (Pl. II and III). This fracture, which may be named *the Göynüksuyu fault zone* or *the Bingöl earthquakefault,* has a width of 2 or 3 km and contains a number of parallel, subparallel, continuous or discontinuous and/or branching faults. The zone as a whole can be recognized by many fault-scarps, hot and cold water springs, a line of numerous ponds, marshes and travertines and some other morphologic evidence.

The Bingöl earthquake fault starts from the south of Bingöl and gains morphologic expression around the village of Sarıçiçek in the Çapakçur plain. The fault zone trending along the Göynüksuyu valley goes through the villages of Ağaçeli, Kaplıca, Alatepe, Çobantaşı, Hacılar, Derinçay, Sudurağı, Devecik, Göynük, Kalecik, Ciligöl, Kıraçtepe and Boncukgöze, and then reaches the Karlıova (Bingöl) plain. After passing Serpmekaya and Sakaören villages, the fault zone, which has a total length of 75 kilometers, joins up with the North Anatolian fault zone in the east of Karlıova.

Some other faults crossing the main fault zone with an acute angle are also observed. The generation of this kind of fault and of the apparently gravitational faults, which are almost parallel to the main fault, is based on the horizontal movements that took place along the main fault zone. For instance, the Kösderesi or Kaplıca fault is a right-lateral wrench fault, and during this earthquake, the surface fault ruptures along the fault occurred due to the movement on the main fault. It is worth mentioning that there exists a hot water spring (Kaplıca) at the point of intersection between this fault and the Göynüksuyu fault zone. In the east of Çobantaşı village, there is another break which is thought to be the corresponding fault of the Kaplıca fault. Along this fault also some cracks and fissures were observed. These two corresponding faults are parallel to the North Anatolian fault zone and they are cut off and left-laterally displaced about 15 kilometers by the Göynüksuyu fault zone (PL II).

The Göynüksuyu fault zone together with those faults belonging to the North Anatolian fault zone and observed by Ketin and Abdüsselamoğlu after the Varto earthquake of August 19, 1966, are shown in Plate III. The relationship between the Göynüksuyu (Bingöl) fault, which is a sinistral wrench fault zone, and the North Anatolian fault, which is a dextral transcurrent fault, can be seen clearly in Plate III.

According to Ketin (1969), the North Anatolian fault, running from the Erzincan plain eastwards, follows the northern boundary of the plain and passes the Sansa gorge and then it cuts the Karasu (Fırat) River and continues along the Elmalıderesi valley to just north of Karlıova. The direction of the trace of this fault is about N 70° W. As can be seen on Plate III, the North Anatolian fault, which appears as a single line along the Elmalıderesi valley, branches off somewhere 20 km from Karlıova. While a pair of faults follow the Şoşarderesi valley, four or five faults, parallel to each other, run east-south-eastwards between Üstükran and the Hasanovasuyu valley. The Göynüksuyu fault makes an angle of 55° to 60° with the North Anatolian fault zone, and the continuity of the Göynüksuyu fault in the northern block of the North Anatolian fault zone is not known.

The mechanism of branching strike-slip faults was, for the first time, explained by Anderson (1942) and the minor faults that diverge from the main dislocation are termed as *splay faults* (Anderson, 1951, p. 167). McKinstry (1953) studied the process of second order shearing and the evolution of Anderson's theory was made by him. Chinnery (1966) solved the same problem by

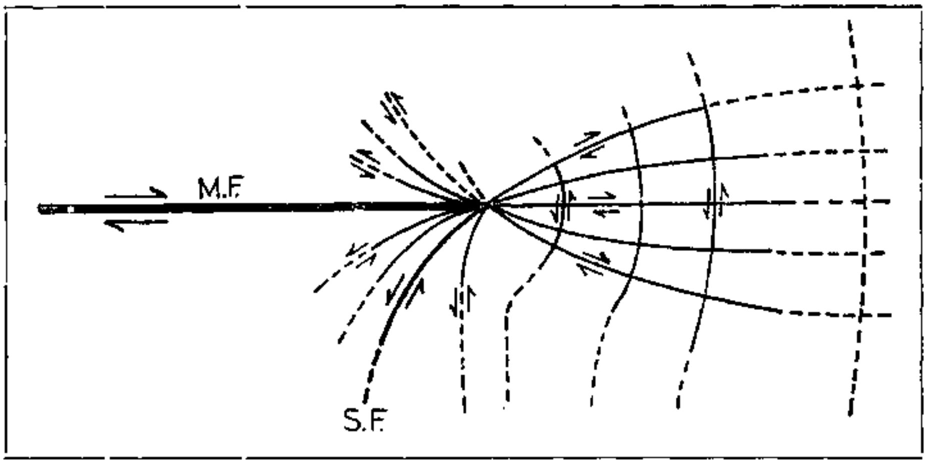

Fig. 3 - Theoretical fault pattern exhibiting the second-order faults that can develop around the end of a master fault (M.F.) due to the strike-slip movement along the main fault (after Chinnery, 1966). On the figure, while *M.F.* corresponds to the North Anatolian fault zone, *S.F.* corresponds to the Göynük-Bingöl fault.

using the dislocation theory and he has found a pattern which is the most suitable for geological implications (Chinnery, 1966). Chinnery's fault model is seen in Figure 3. If one examines closely the geometrical relation between the main fault and the second-order faults on this model, the relationship between the North Anatolian fault zone and the Bingöl earthquake fault can easily be seen from Plate III. While the North Anatolian fault zone, with an appearance of a single fault line along the Elmalıderesi valley, branches out into several faults north-west of Karlıova and gives right-lateral second-order faults with the east-south-east direction; it also causes the development of the Göynüksuyu fault as a complementary second-order shear.

The writers assume that the origin of the earthquakes that have destroyed Bingöl and the surrounding area from time to time is associated with the activities of the Bingöl earthquake fault. This is by means of the secondary effect of right-lateral tearing movements along the North Anatolian fault zone. By considering their geometrical relation and the sense of displacements along them, we can compare the North Anatolian fault zone and the Göynüksuyu (Bingöl) fault with the San Andreas fault and the Garlock fault in California (U.S.A.) (Hill & Dibblee, 1953).

V. CONCLUSIONS

The data obtained from these field studies in such a short time of only two weeks brought to light new and interesting results relevant to the active fault tectonics of Turkey. If there were some geological features that escaped our observations, this is due to the shortage of time and lack of country roads for our quick transport. It is, no doubt, advisable to reexamine the region carefully. Nevertheless, the conclusions which arose from this work can be summarized as follows:

1. The faults (probable faults) of Göynük and Hacılar (Hacıyan) shown on the Erzurum sheet of the Geological Map of Turkey of 1:500,000-scale have been found to be a fault zone of 2 or 3 km width and trending in the N 45°.-E direction.

2. This fault zone, which is 75 km in total length, starts from the south of Bingöl, passes throughout the Göynük valley and joins up with the North Anatolian fault zone in the east of Karlıova.

3. It has been proved by the Bingöl earthquake of May 22, 1971, that this line of fracture which may be named as «the Göynüksuyu fault zone» is seismically active.

4. At the Bingöl earthquake of May 22, 1971, the southern half of this fault zone was ruptured and some shear zones defined by an array of en echelon tension fissures were observed here. The arrangement of the tension fissures in the shear zones indicated a left-lateral movement along the fault zone. The amount of the displacement after this earthquake was measured as much as 25 cm. No vertical displacements were observed along the shear zones.

5. The total displacement along this active fault zone was found to be 15 km.

6. The Göynüksuyu fault makes an angle of 55°-60° with the North Anatolian fault zone and it is thought that it developed as a result of the second-order shearing of the North Anatolian fault zone.

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REFERENCES

ALTINLI, I. E. (1963) : Explanatory text of the Geological Map of Turkey .(Erzurum sheet). *M.T.A. Publ,* Ankara.

ANDERSON, E.M. (1951) : The dynamics of faulting and dyke formation with applications to Britain. *Oliver and Boyd,* London.

BAYKAL, A.F. (1950) : Aperçu geologique des environs des montagnes de Şerafeddin et de Çötela (vilayets de Bingöl et de Diyarbakır, Anatolie orientale). *Revue Fac. Sci. Univ. İstanbul,* ser. B, t. XV, fasc. 2, pp. 134-152, Istanbul.

CHINNERY, M.A. (1966) : Secondary faulting. *Canadian f. Earth. Sci.,* v. 3, pp. 163-189.

ERGİN, K. (1966) : On the epicenter map of Turkey and surrounding area. *Bul. Geol. Soc. Turkey,* v. X, no. 1-2, pp. 122-129, Ankara.

———; GÜÇLÜ, U. & UZ, Z. (1967) : Acatalogue of earthquakes for Turkey and surrounding area (11 A.D. to 1964 A.D.). *Maden Fak. Arz Fiziği Enst. Yayınları,* no. 24, İstanbul.

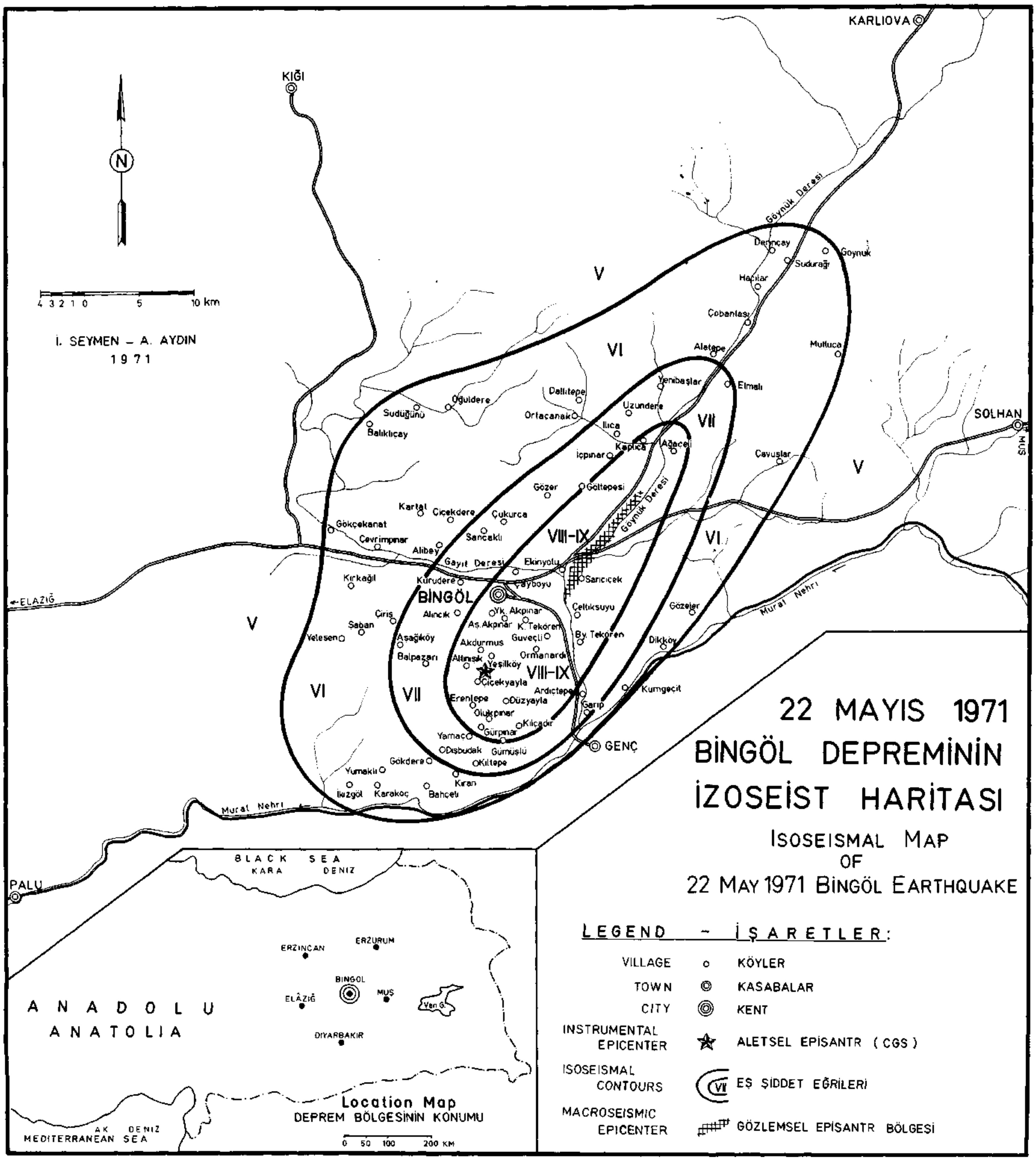
———;———& AKSAY, G. (1971) : A catalogue of earthquakes of Turkey and surrounding area (1965 to 1970). *İ.T.Ü. Maden Fak. Arz Fiziği Enst. Yayınları,* no. 28, İstanbul.

HILL, M.L. & DIBBLEE, T.W. (1953) : San Andreas, Garlock and Big Pine faults, California. *Geol. Soc. Am. Bull.,* v. 64, pp. 443-458.

KETİN, İ. (1969) : Über die nordanatolische Horizontalverschiebung. *M.T.A. Bull.,* no. 72, Ankara.

McKINSTRY, H.E. (1953) : Shears of the second order. *Am. f. Sci.,* v. 251, pp. 401-414.

TCHALENKO, J. S. (1970) : Similarities between shear zones of different magnitudes. *Geol. Soc. Am. Bull.,* v. 81, pp. 1625-1640.


22 MAYIS 1971
BİNGÖL DEPREMİNİN
İZOSEİST HARİTASI
ISOSEISMAL MAP
OF
22 MAY 1971 BİNGÖL EARTHQUAKE
İ. SEYMEN – A. AYDIN
1971
LEGEND – İŞARETLER:
VILLAGE KÖYLER
TOWN KASABALAR
CITY KENT
INSTRUMENTAL EPICENTER ALETSEL EPİSANTR (CGS)
ISOSEISMAL CONTOURS EŞ ŞİDDET EĞRİLERİ
MACROSEISMIC EPICENTER GÖZLEMSEL EPİSANTR BÖLGESİ
Location Map
DEPREM BÖLGESİNİN KONUMU
ANADOLU
ANATOLIA
BLACK SEA
KARA DENIZ
AK DENIZ
MEDITERRANEAN SEA
ERZINCAN
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BİNGÖL
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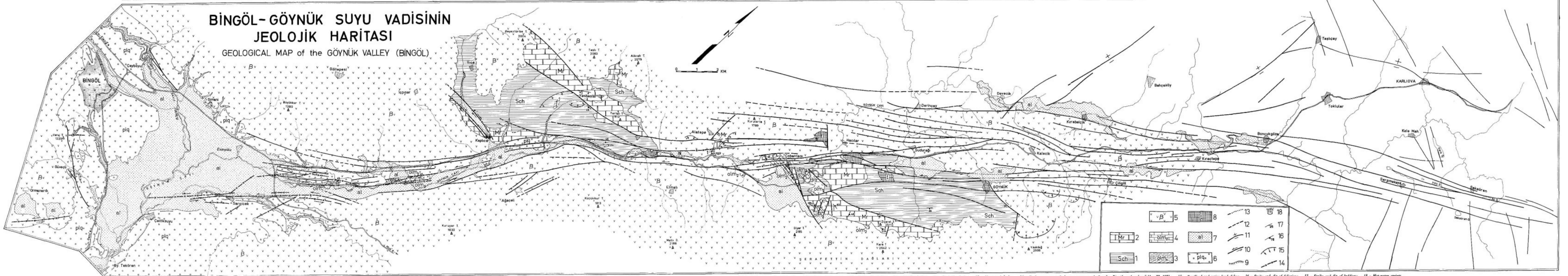
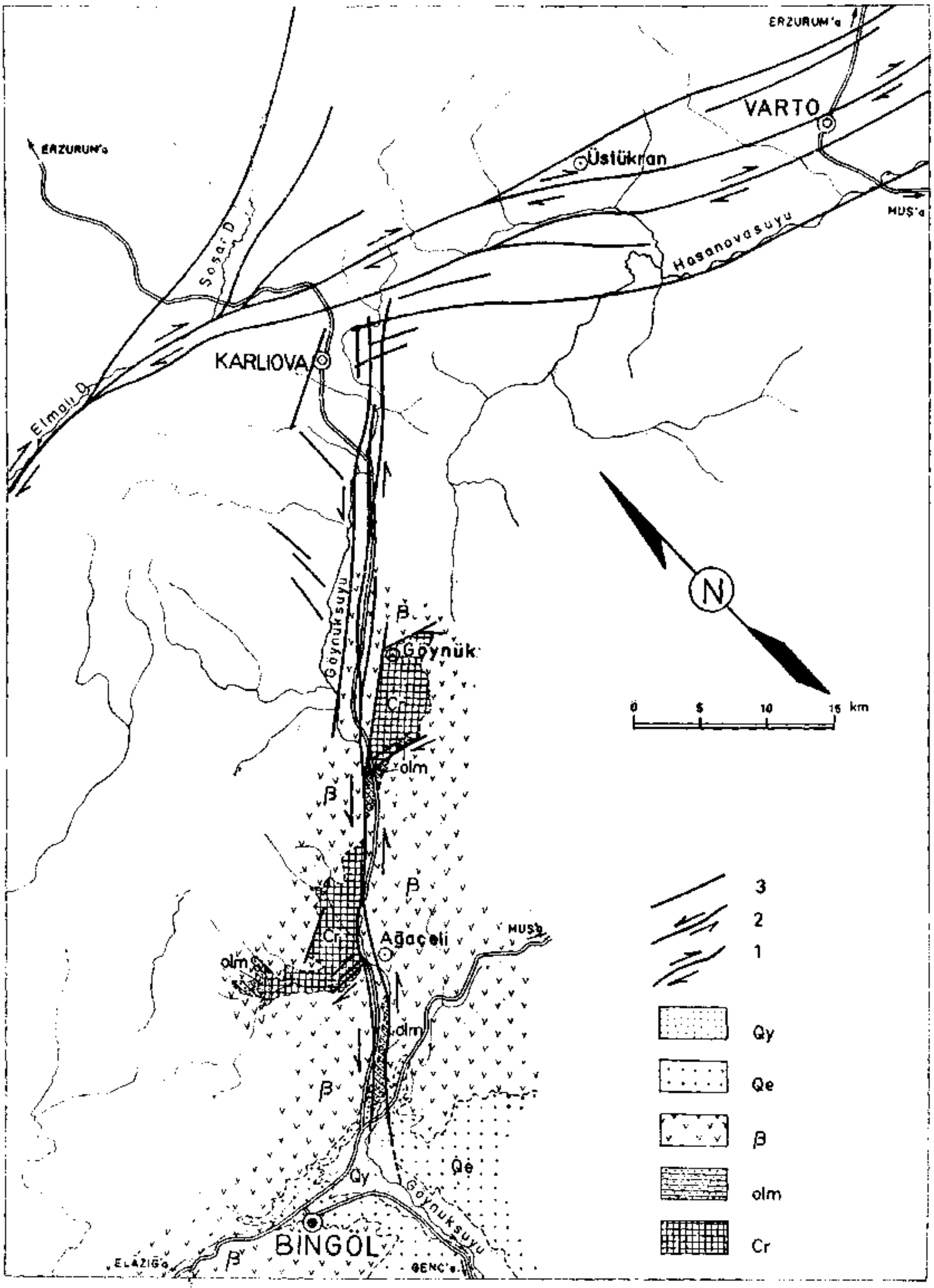


1 - Phyllite, chlorite schists and calcschists; 2 - Marbles (Paleozoic); 3 - Fossilliferous, grey marls (Upper Oligocene); 4 - Foraminifera-bearing yellowish limestones (Aquitanian - Lower Burdigalian); 5 - Basaltic, andesitic lavas and tuffs (Neogene); 6 - Lacustrine deposits (Pliocene-Quaternary); 7 - Alluvium (Recent); 8 - Travertines; 9 - Slopes of terrace; 10 - Strike-slip faults; 11 - Dip-slip faults; 12 - Probable faults; 13 - Unexposed faults; 14 - Fault-ruptures and shear zones occurred after the Bingöl earthquake of May 22, 1971; 15 - Fossilized and active land-slides; 16 - Strike and dip of foliation; 17 - Strike and dip of bedding; 18 - Hot-water springs.



SKETCH MAP SHOWING THE RELATION BETWEEN THE NORTH ANATOLIAN FAULT AND THE BİNGÖL EARTHQUAKE FAULT

Cr - Schists and marbles; olm - Grey fossiliferous marls (Upper Oligocene); *β - Basaltic lavas; Qe - Fluvial-lacustrine deposits; Qy - Alluvium. 1 - Right-lateral, 2 - left-lateral, strike-slip faults; 3 - Faults in general.*

Photo 1 - En échelon tension fissures occurred around Sarıçiçek village. The displacement along the shear zone is left-lateral.

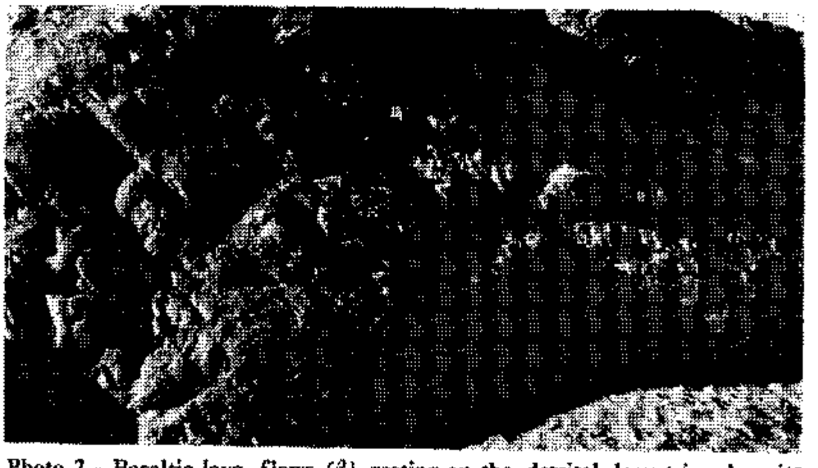


Photo 2 - Basaltic lava flows *(β)*, resting on the detrital lacustrine deposits *(plq)* in the south of Bingöl. Further south in this outcrop, the unconsolidated deposits overlie the basaltic lavas.

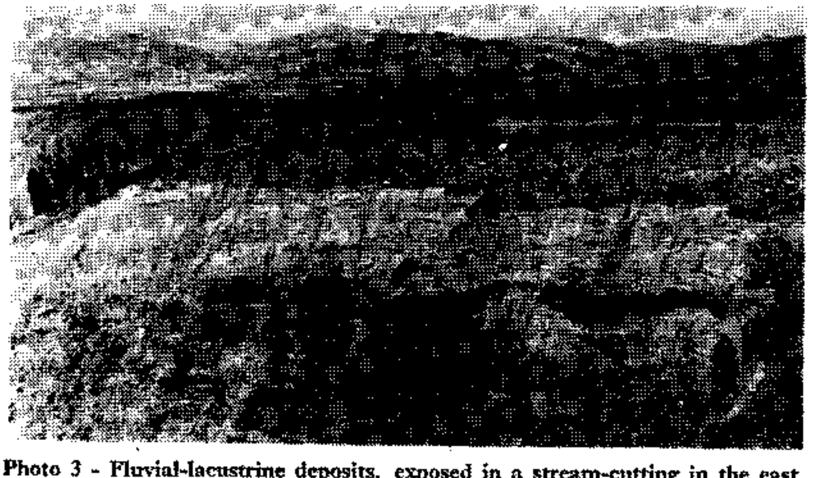


Photo 3 - Fluvial-lacustrine deposits, exposed in a stream-cutting in the east of Sarıçiçek village. These young formations are also affected by the recent tectonic movements and are faulted. In the background are seen the Göynük-suyu valley and basaltic lavas.