CHAPTER 5 . GEOLOGICAL SURVEY OF COŞAN & EZAN MINING AREAS

5. Geological Survey of Coşan and Ezan Mining Areas

5-1 Geology of Kopdağ Area

Geological survey of Kopdağ area (including Coşan and Ezan areas) was carried out in the summer last year (1978). Based on the results obtained through the study, general geology of Kopdağ area and geological succession in the area are shown in Fig. 5-1 and 5-2.

Geology of the area consists of limestone of the Upper Jurassic-Lower Cretaceous, calcareous sedimentary rocks deposited during Miocene-Pliocene, terrace and talus deposits of Plio.-Pleistocene and alluvial deposits. These rocks extend in the ENE-WSW direction, generally gently dipping to the north. Thus, the sediments become younger toward the north.

Kopdağ area belongs to the so-called ophiolite belt, and is occupied by ultrabasic rocks, basic-intermediate igneous rocks, forming cumulate structure parallel to the bedding of sedimentary rocks.

For convenience sake, Mesozoic limestone is tentatively named "Meyramdağ limestone", and calcareous sedimentary rocks of Tertiary period are called "Kopdağ limestone". The ophiolite belt can be divided into the following three zones: 1) "southern harzburgite zone" lower part of the ophiolite belt, 2) "northern dunite zone" middle part of the belt, 3) northern harzburgite zone" upper part of the belt.

5-1-1 Sedimentary Rocks

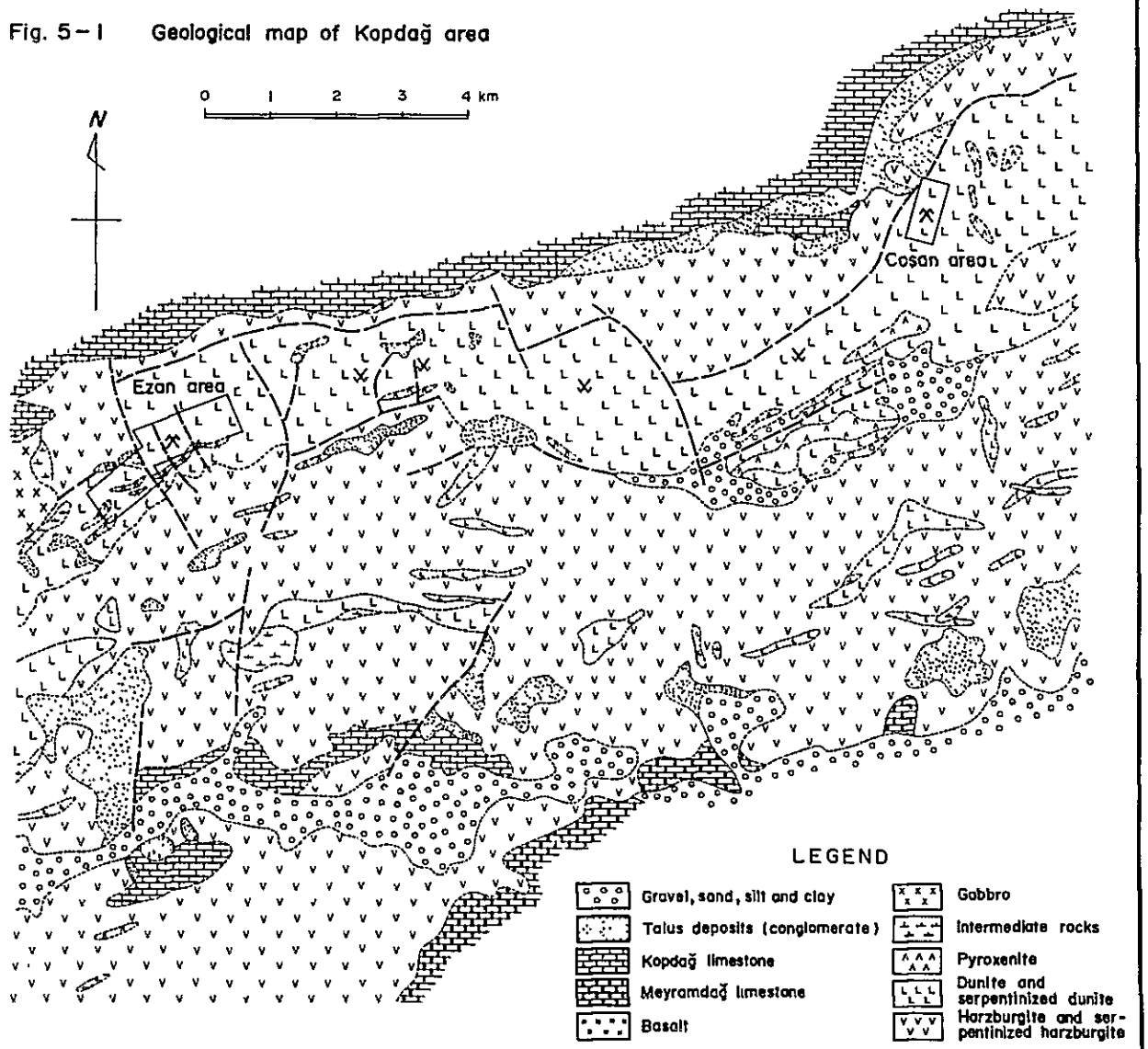
Meyramdag limestone; This rock occupies the southern zone of the area extending from west to east and generally dips 20° - 30° north. It is more than 500 meters thick. Meyramdağ limestone is composed of a large quantity of limestone, calcareous mudstone, and siltstone intercalated with gypsum. Limestone is creamy white, fine-grained and well stratified, it sometimes alters to saccharoidal texture at contact with ultrabasic rocks, alteration was not observed in limestone without contact part.

Ammonite which was found in the limestone indicates that the limestone can be Uppermost Jurassic to Lower Cretaceous.

Microscopically, the limestone has oolitic texture and is composed of equigranular, very fine-grained calcite. A small amount of argillaceous material is included.

Kopdağ limestone; This limestone is widespread in the northernmost part of the area. A small amount of this rock is distributed at the summits of mountains along Karasu. This limestone unconformably overlies ultrabasic rocks and shows very gentle dip to the north. Kopdağ limestone is associated with intercalated calcareous sandstone, fine conglomerate, siltstone, mudstone and gypsum. The fossils from the limestone indicate that the formation can be correlated to Miocene to Pliocene epochs.

Fig. 5－1　Geological map of Kopdağ area



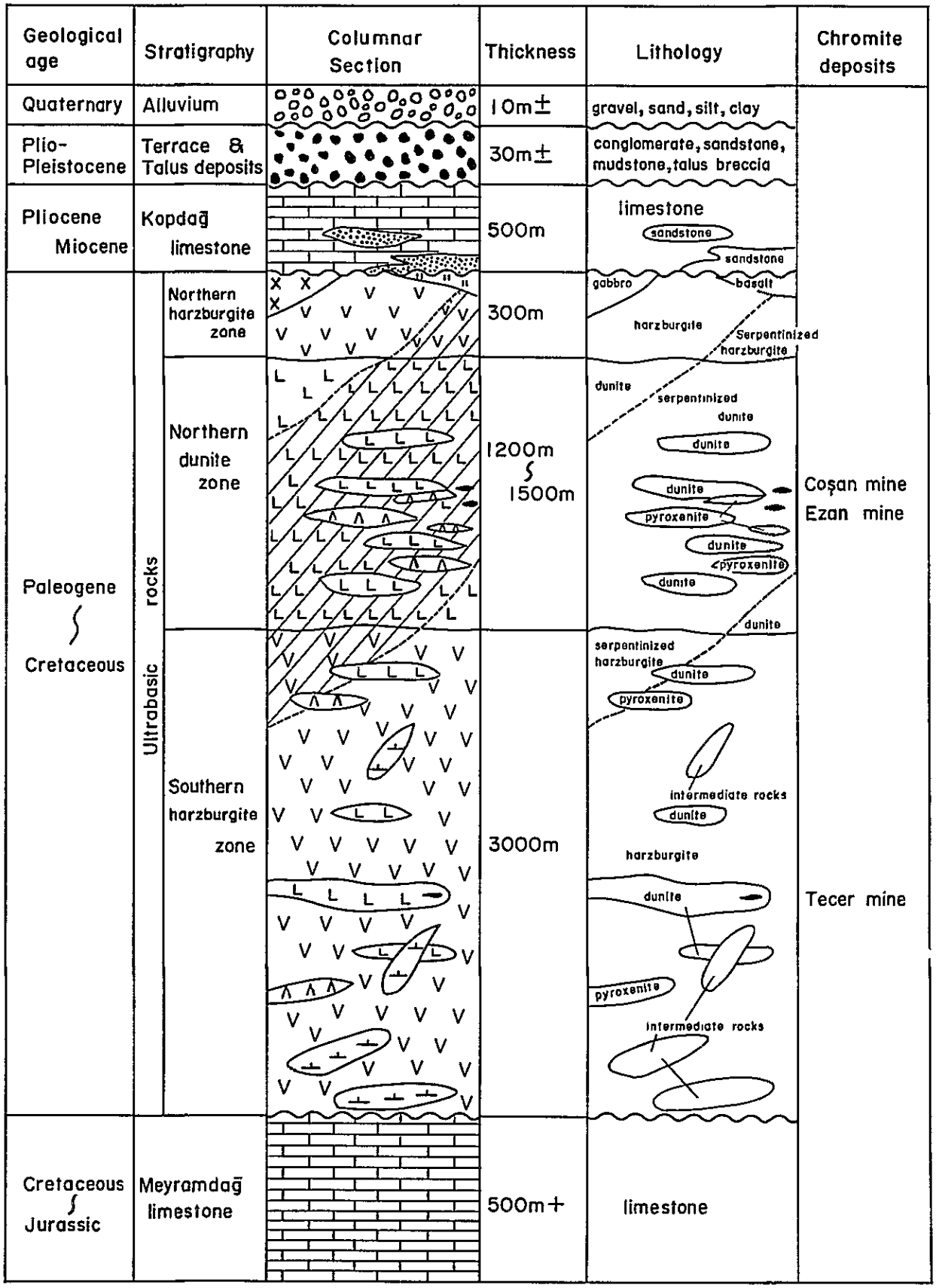


Fig. 5 – 2 Geological succession in Kopdağ area

Talus deposits and terrace deposits; Talus deposits are distributed everywhere in the area of ultrabasic rocks. The shape of a deposit is quite irregular and its extent does not in general exceed 200 meters. Its thickness is less than several tens of meters. It covers unconformably ultrabasic rocks, Kopdağ limestone, etc. It is brownish khaki colored, poorly sorted, and generally not well stratified.

It is composed of big angular-subangular blocks of rocks such as ultrabasic rocks, gobbro-diorite, limestone. Near chrome deposits, blocks of chromite are common. Large amount of blocks in comparison with matrix is characteristic. Cementing materials are mostly fine-grained carbonate minerals.

Terrace deposits are developed around Karasu. They extend in several directions and have several dip angles. They unconformably cover ultrabasic rocks. These deposits are composed mainly of conglomerate with intercalated layers of mudstone, siltstone and sandstone. Several kinds of rocks such as ultrabasic rocks, limestone, gabbro, diorite etc. are included. Carbonate and silica minerals are the dominant cementing materials.

Alluvial deposits; Alluvial deposits occur along the Karasu river. The extension and thickness of the deposits show variations from place to place. Unconsolidated soil, clay, silt and gravel are common in the deposits.

5-1-2 Ophiolite Belt

Ophiolite belt can be divided into the following three zones: 1) southern harzburgite zone, 2) northern dunite zone, and 3) northern harzburgite zone in ascending order. Characteristic features of these three zones are briefly described below:

Southern harzburgite zone; The zone occupies the lower horizon in the ophiolite belt extending from west to east. Harzburgite is preponderant in this zone, but a small amount of dunite is present. Furthermore pyroxenite, dykes and bosses of basic-intermediate igneous rocks occur in this zone, which extends more than 40 km, striking ENE-WSW and dipping 20 - 40° north. Differentiated rock facies changing from dunite to pyroxenite are present here in the harzburgite belt. Harzburgite is generally replaced by serpentine minerals. Megascopically, harzburgite is dark green and associated with coarse-grained pyroxene crystals; olivine and orthopyroxene (enstatite) are the essential minerals. Most of the olivine is altered to chrysotile, antigorite and lizaludite. Enstatite is commonly altered to bustite.

Dunite occurs generally as lenticular blocks in harzburgite. In some cases, however, dunite forms stratified zones and rarely appears as dunite dykes. Dunite is olive green to olive gray and coarse-grained. It has more or less undergone serpentinization, but grade of serpentinization is slighter than that of the northern dunite zone. A number of small chromite

ore deposits, consisting of olivine, chromite and magnetite, occur in lenticular form in the preceding rock facies. On the whole, olivine is more or less altered to serpentine, brucite, carbonate minerals, asbestos and talc, but pseudomorphs of olivine can be observed under microscope.

Generally, pyroxenite occurs in harzburgite as dykes, but it is parallel to the zones of ultrabasic rock in some places. Its length varies from several hundred meters to several tens of meters, its thickness from several tens of meters to tens of centimeters. It is dark green in color and more or less serpentinized.

Differentiated dykes consisting of basic-intermediate igneous rocks are also observed. These can be classified as diorite, dioritic porphyrite, quartz dioritic porphyrite, quartz porphyry etc. However, rock facies variation is remarkable and graditional in dykes and it is difficult to distinguish rock facies from one another.

The above-mentioned dyke rocks are at maximum 2 - 3 km long, and 10 - 15 meters thick, they have several directions of intrusion, such as N-S, NE-SW, WNW-ESE.

Northern dunite zone; This zone occupies the middle horizon in the ophiolite belt, running from ENE to WSW. The large-scale chromite ore deposits of Coşan and Ezan mines occur in this zone, Strictly speaking, this zone is composed of serpentinzed dunite, foliated serpentinite, massive serpentinite of dunite origin and pyroxenite. The above-stated composite

type ultramafics attain 18 km in length and from 1200 to 1500 meters in thickness. The dip is 20° - 70° north. These rock have been wholly serpentinized. Serpentinized dunite is compact, dark grey - brownish grey in color. Typical rock facies is observed in Ezan area.

Generally speaking, serpentinite of dunite origin consists of serpentine, brucite, chromite and magnetite, sometimes asbestos and talc, pseudomorphs of olivine can be observed under microscope. As a result of x-ray diffraction, serpentine and clay were found to be composed of chrysotile, antigorite, lizardite, hydromagnetite and pyroaurite.

In Ezan area, serpentinite subjected to hydrothermal alteration and weathering, becomes fragile and occurs as powdery sediment at or near the surface in Ezan area, dense vein network was observed especially in the foliated serpentinite in Ezan area, the veins are composed of asbestos, talc and hydromagnesite, forming so called "bird drop structure". The original rock facies of the serpentite is distinguishable in most cases by the presence of pseudomorphs of olivine and pyroxene, and mesh-texture, bustite is not present.

Pyroxenite occurs as dykes or sheets, its extent is small, generally less than 1 km in length and 10 - 20 meters in thickness. The color of pyroxenite varies from brown to dark green-pale green owing to the grade of serpentinization. Microscopically the pyroxenite

is composed of equidimensional clinopyroxene (diopside) with small amount of olivine and chromite.

Northern harzburgite zone; This zone occupies the upper horizon of the ophiolite belt. It has NE-SW strike and 40° NW dip. The thickness is estimated to be more than 300 meters. This zone is in fault contact with the northern dunite zone, and is overlain by harzburgite, gabbro, and basalt. It has been clarified microscopically that harzburgite is intensely serpentinized and includes coarse-grained pyroxene crystals. Rock facies of harzburgite changes from dunite to pyroxenite. However, in general, it is composed of olivine and accessory orthopyroxene (enstatite). In some cases, harzburgite includes a small amount of clinopyroxene.

Gabbro occurs as stocks and bosses in the northern part of the ophiolite belt. It intrudes into dunite and harzburgite and is unconformably overlain by the Kopdağ limestone. Zone of gabbro is parallel to the zone of ultrabasic rocks. Gabbro is holocrystalline and deep green in color. Microscopically, it consists of greenish brown anhedral hornblende, which includes augite and plagioclase (andesine-labradorite). The plagioclase grains are roughly equidimensional or lathshaped. Basalt is present only at the boundary between the Kopdağ limestone and ultrabasic rocks. Judging from its mode of occurrence, the basalt body

is presumed to be of small size, less than 100 meters long and less than 20 meters thick. The basalt is surrounded by a tuffaceous facies.

5-2 Geology of Coşan and Ezan Mining Area

5-2-1 Geology of Coşan Mining Area

Investigated area is included in the northern dunite zone. Geological map of Coşan area and geological profiles are shown in Fig. 5-3 and 5-4. Massive serpentinite, foliated serpentinite, serpentinized dunite, pyroxenite and talus deposits occur in the area. It is mostly covered with debris of massive serpentinite.

The debris makes geological investigation difficult, and trenches and open pits are indispensable for geologic investigation. Dunite can be divided into two kinds of rock facies in the area. One of them is dark gray colored, massive and fine-grained, contains chromite ores, and is tentatively named massive serpentinite. Microscopically, the rock facies is mainly composed of serpentine (more than 90%), chromite and magnetite. It is associated with a vein network of brucite and talc. Olivine is completely altered to serpentine, which is composed of chrysotile, antigorite and lizardite, forming a mesh texture, in which chromite is common. The other facies is dark to gray-dark brown and more coarse-grained and strongly serpentinized. It is called serpeninized dunite. Chromite bands are commonly found in this rock facies.

Veinlets of hydromagnesite, asbestos and talc are present at intervals of several centimeters to several tens of centimeters. Microscopically, the rock consists of the same minerals as the former, but brucite forms envelopes around pseudomorphs of olivine.

It is green to dark gray colored. Part of gray colored pyroxenite is wehlitic. Green colored pyroxenite is mostly composed of diopside. Pyroxenite occurs in dunite. Thickness of the rock varies from several tens of centimeters to several meters. It is notable that most of pyroxenite occurs at the footwall side of banded chromite ore. Microscopically, it is composed of coarse-grained clinopyroxene and olivine. Olivine is mostly altered to serpentine. Brucite fills pseudomorphs of olivine. Clinopyroxene is coarse-grained. It is partly replaced by serpentine.

Foliated serpentinite is the host rock of the chromite ore deposits. It is pale green and fragile. As a result of X-ray diffraction, chrysotile, brucite and chromite were found. The original rock is considered to be dunite.

Talus deposits are restricted to the northern part of this area. They are brown colored angular-subangular breccia, composed of ultrabasic rocks, chromite, and limestone.

5-2-2 Geology of the Ezan Mining Area

The investigation area and Coşan area are in the same horizon of the northern dunite zone. Geological map and geological profiles of this area are shown in Fig. 5-5 and 5-6.

The area is composed of serpentinized dunite and serpentinite, pyroxenite, harzburgite and talus deposits. The rocks in the area have undergone strong serpentinization. Two kinds of dunite are present as in the Coşan area. One of them is dark gray to olive colored, hard and fine-grained. It occurs mainly in north eastern part of Sulu Ocak and Tepebaşı, and is similar to massive serpentinite which is distributed in the Coşan area.

Microscopically, olivine, chromite and magnetite are present. Olivine is completely altered to serpentine, which has a mesh structure. Veinlets of brucite and magnesite are developed in the mesh structure.

The other dunite is brown-gray colored and strongly serpentinized, it is called serpentinized dunite.

Microscopically, olivine is completely altered to serpentine and brucite. Chromite, magnesite, magnetite and talc form mesh structure. Serpentinized dunite is distributed near the chromite ore deposits, which occur in concordance with foliated serpentinite. It may be called serpentinite, but it has remarkable mesh structure and bustite structure is not recognized. Therefore it is shown on the geological map of Ezan area as serpentinized dunite. Foliated serpentinite is pale green to grayish white and fragile. Most of it is powdery,

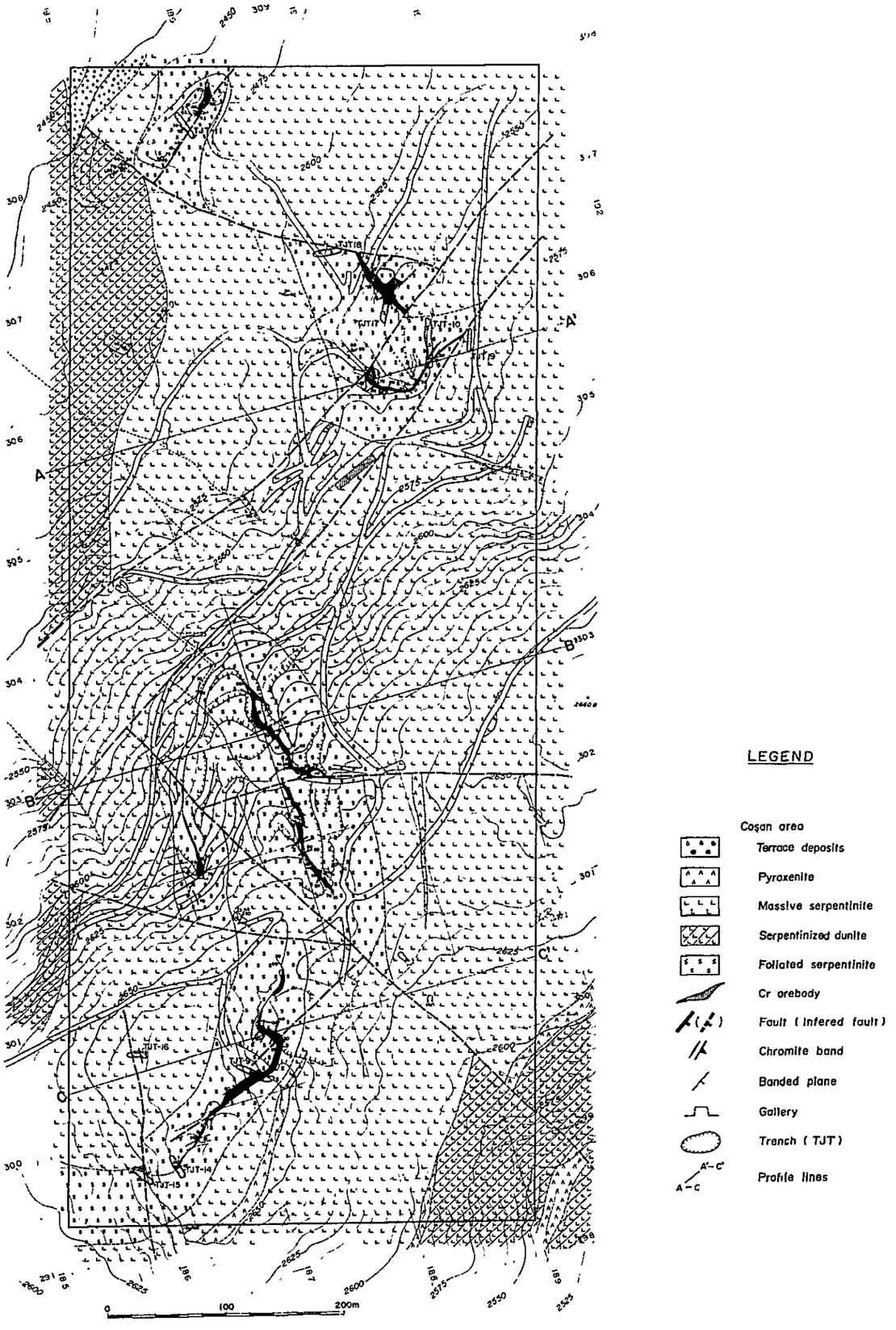
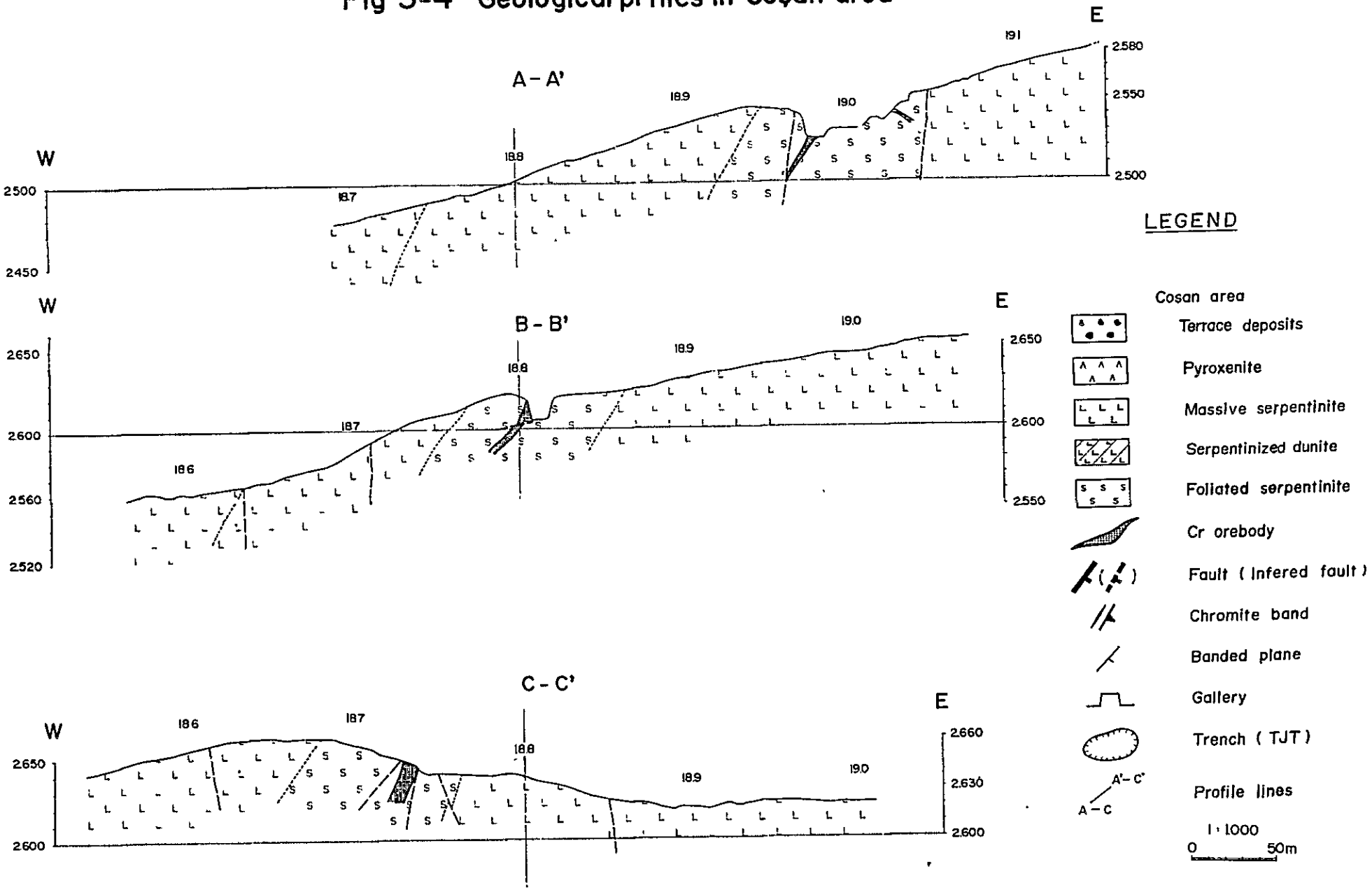


Fig. 5-3 Geological map of Coşan area

Fig 5-4 Geological prfiles in Coşan area



its original rock is considered to have been dunite, which has been completely altered to serpentinite by serpentinization. Foliated serpentinite grades into serpentinized dunite. It is the host rock of the chromite ore deposits and is characterized by the presence of hydromagnesite with bird drop structure. As a result of X-ray diffractive analysis, chrysotile, antigorite, lizardite, brucite, pyroaurite, magnesiochromite, etc. were recognized.

Pyroxenite is brown-green, and occurs in sheets near the southern part of this area. Especially, the footwall side of the ore body extension is several meters to several tens of meters in thickness and several hundred meters in length.

Most of the pyroxenite alternates with dunite, forming a band from several centimeters to several tens of meters thick, is concordant with one of the chromite ore deposits. Green colored pyroxenite includes a large amount of chrome diopside. Microscopically, it is composed of equidimensional diopside with small amount of orthopyroxene, olivine and chromite. Olivine is completely altered to serpentine. Diopside is partly altered to chlorite, clay minerals and calcite along the cleavage.

Talus deposits are widely distributed near Armutlu. They are brown colored, and composed of angular-subangular breccia of rocks such as harzburgite, serpentinized dunite, massive serpentinite, pyroxenite, chromite etc. Large amount of breccia in comparison with matrix is characteristic. Cementing materials are mostly fine-grained carbonate minerals.

5-3 Geological Structure

5-3-1 Structure of sedimentary and ultrabasic rocks

As the investigated area is situated at the center of Alpine orogenic belt, several tectonic lines, due to vigorous orogenic movement, are anticipated. Based on the results of the survey in 1978 and 1979, geological structure around Kopdağ area has been clarified as follows:

In general, sedimentary and igneous rocks in the area become younger from south to north, the trend of geological structure is WSW-ENE.

The Meyramdağ limestone strikes E-W and dips 20 - 30° north, and is disturbed only at the contact with ultrabasic rocks. Minor faults, folds and thrusts are commonly present. The Kopdağ limestone generally strikes E-W and dips 20° north, and is disturbed only at the boundary with ultrabasic rocks. This may be due to the presence of a fault between them or difference of their competency at the time of oscillatory movement after deposition. The ultrabasic rocks have NE-SW strike and 40° NW dip defined by banding structure. No difference between chromite bandings and olivine pyroxene bandings was found. Direction of pyroxenite is almost identical with that of chromite deposits and chromite bandings at the Ezan and Coşan areas. Small asbestos bandings are frequently present in serpentinized dunite around faults. Direction of asbestos bandings and faults is mainly vertical, and asbestos occurs in what are considered tension cracks.

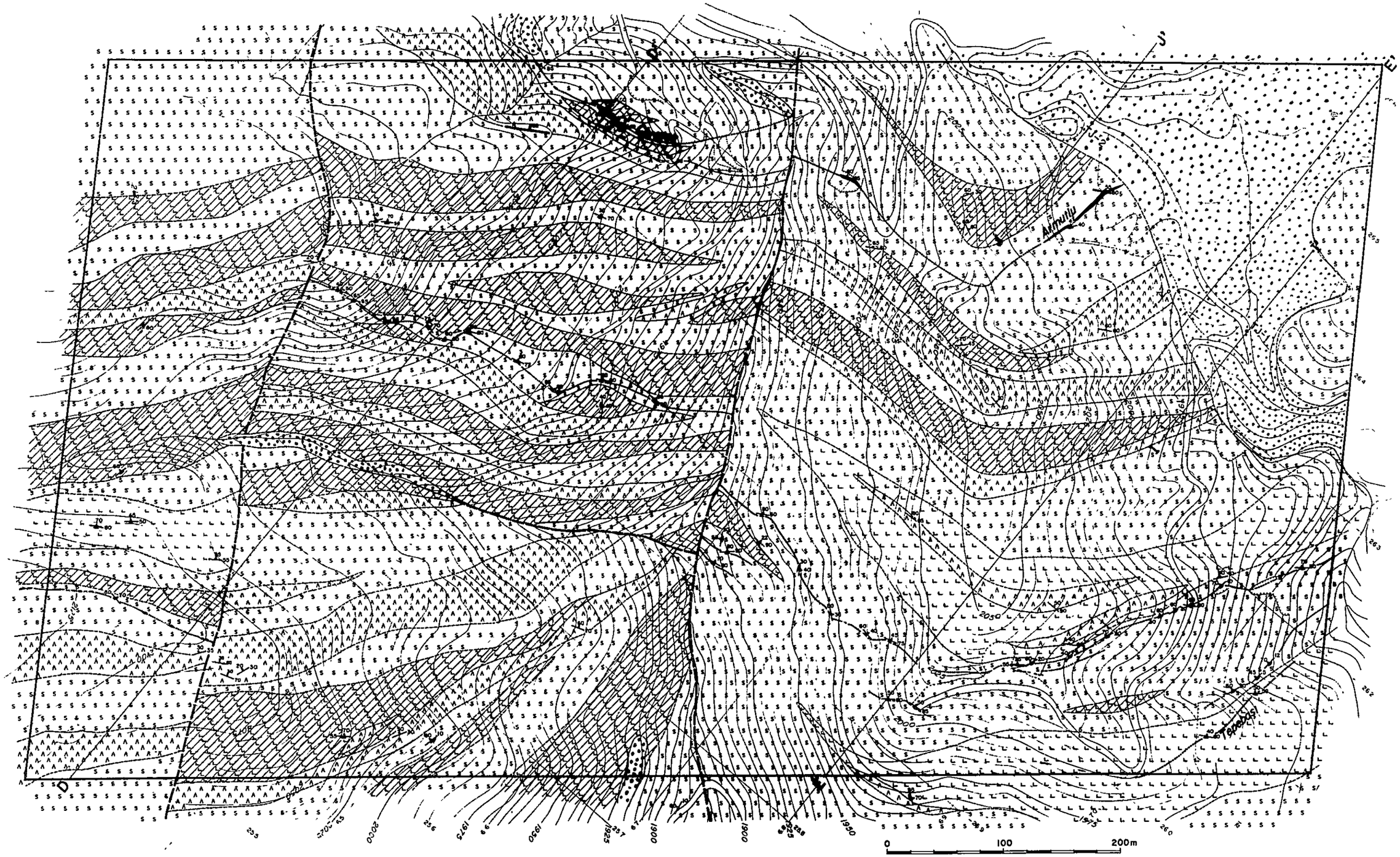
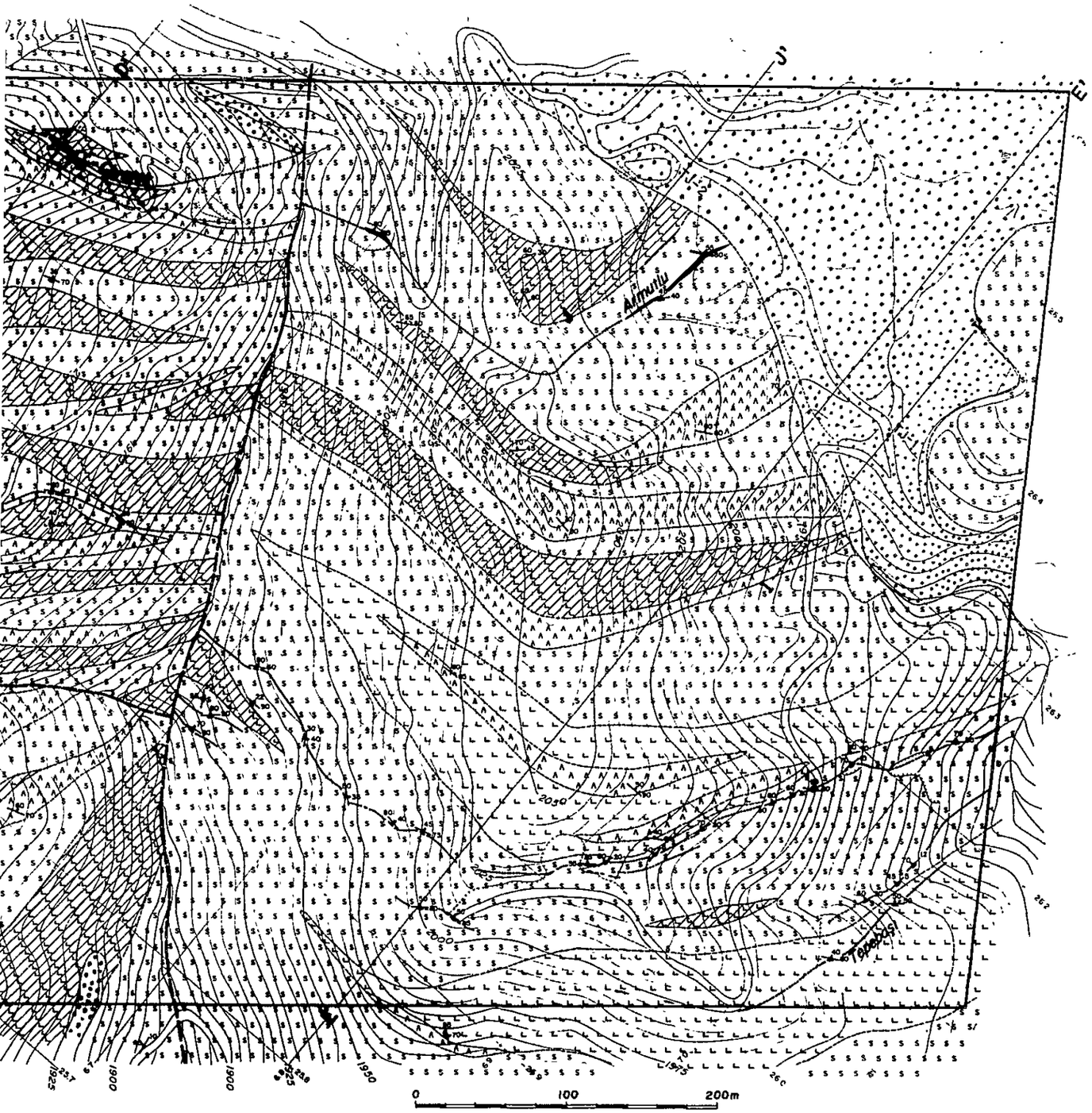


Fig. 5-5 Geological map of Ezan area (A)

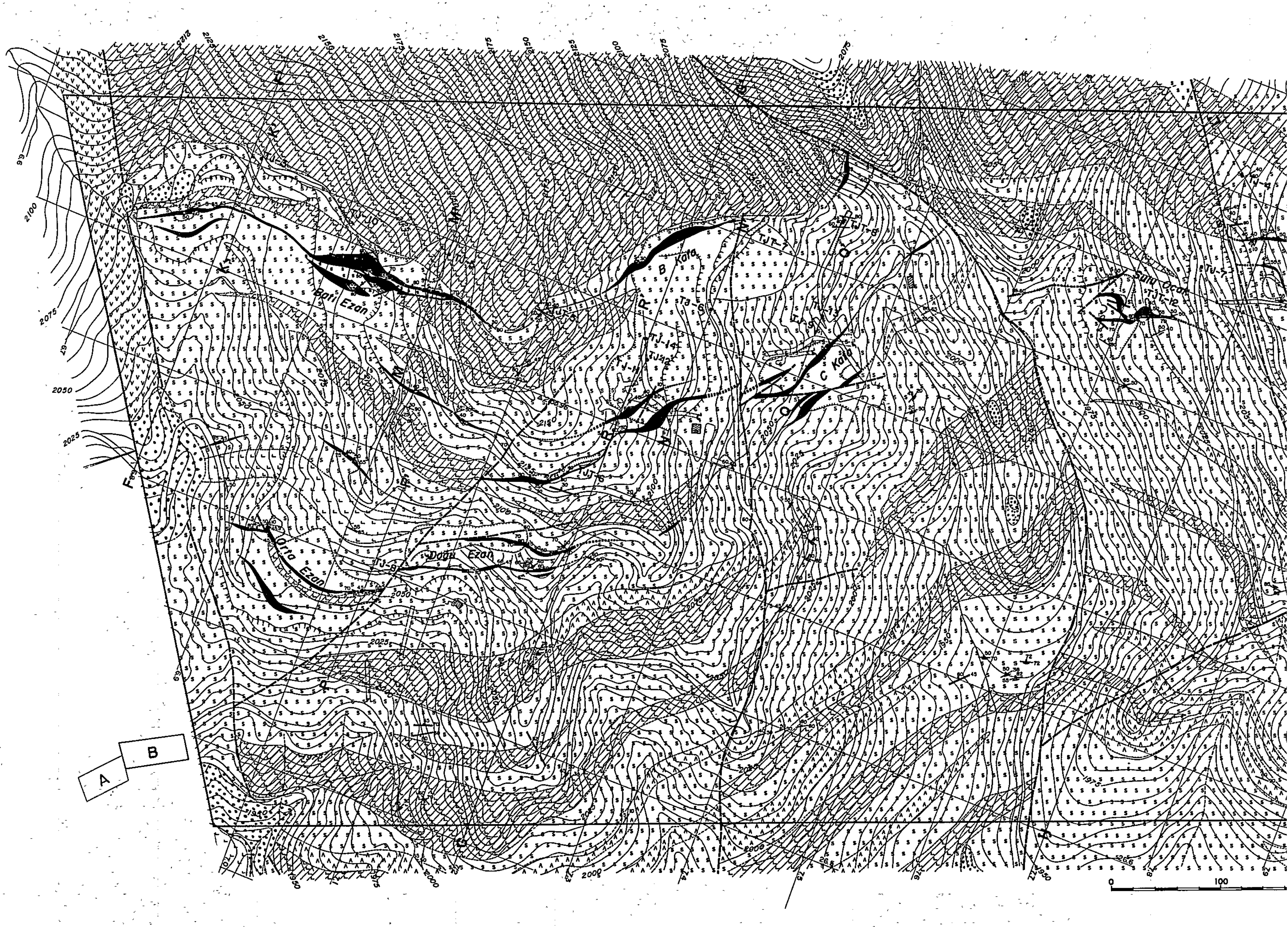


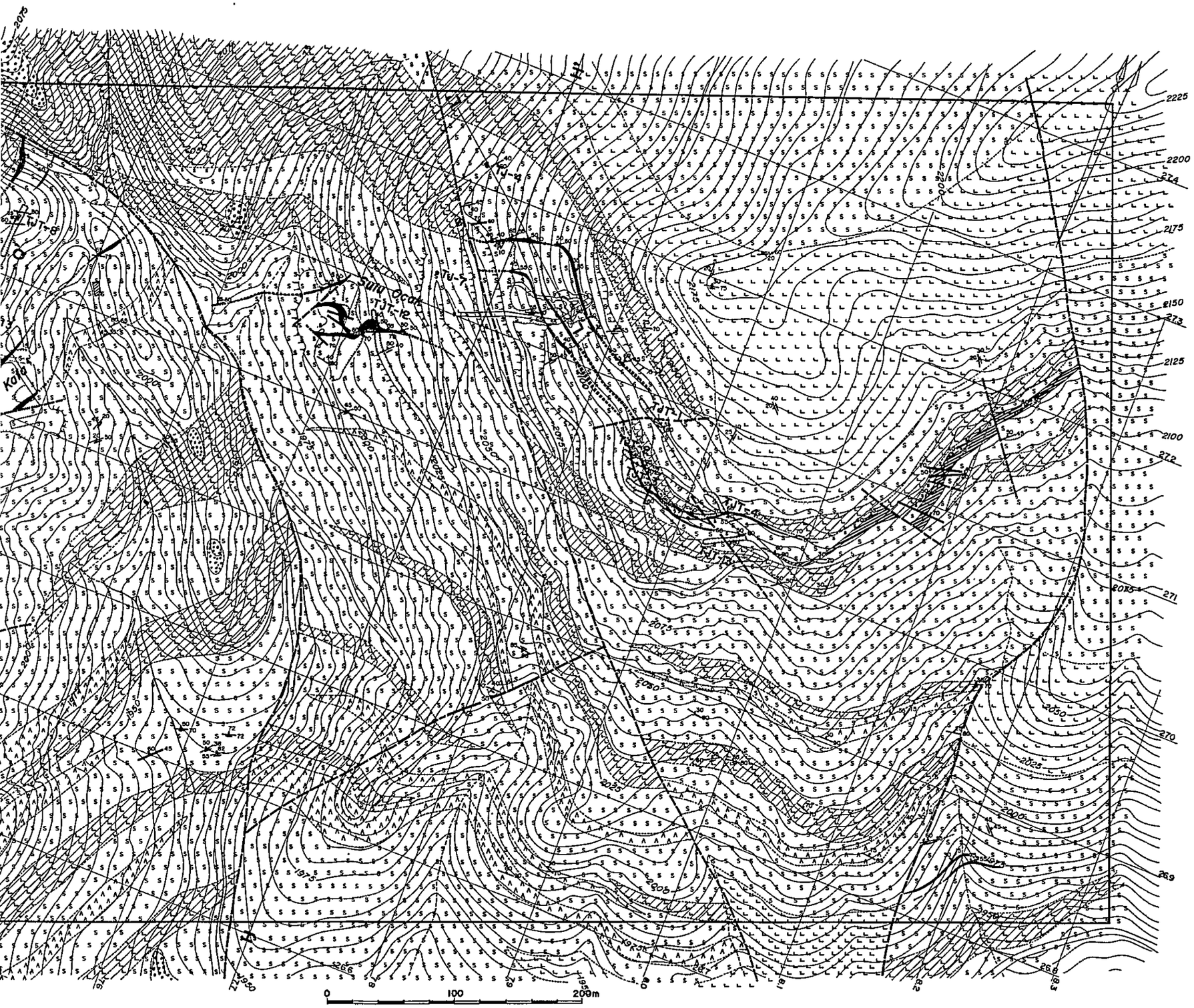
LEGEND

Ezan area

- Terrace deposits
- Clinopyroxenite
- Massive serpentinite
- Serpentinized dunite
- Foliated serpentinite
- Harzburgite
- Cr orebody
- Cr banded orebody (low grade)
- Infered ore horizon
- Fault (Infered fault)
- Chromite band
- Banded plane
- Gallery (Closed gallery)
- Drilling hole (TJ)
- Trench (TJT)
- D'-P' / D-P — Profile lines

Fig. 5-5 Geological map of Ezan area (A)


Batı Ezan
Orta Ezan
Doğu Ezan
B Kafa
C Kafa
Sulu Ocak
A
B
0
100



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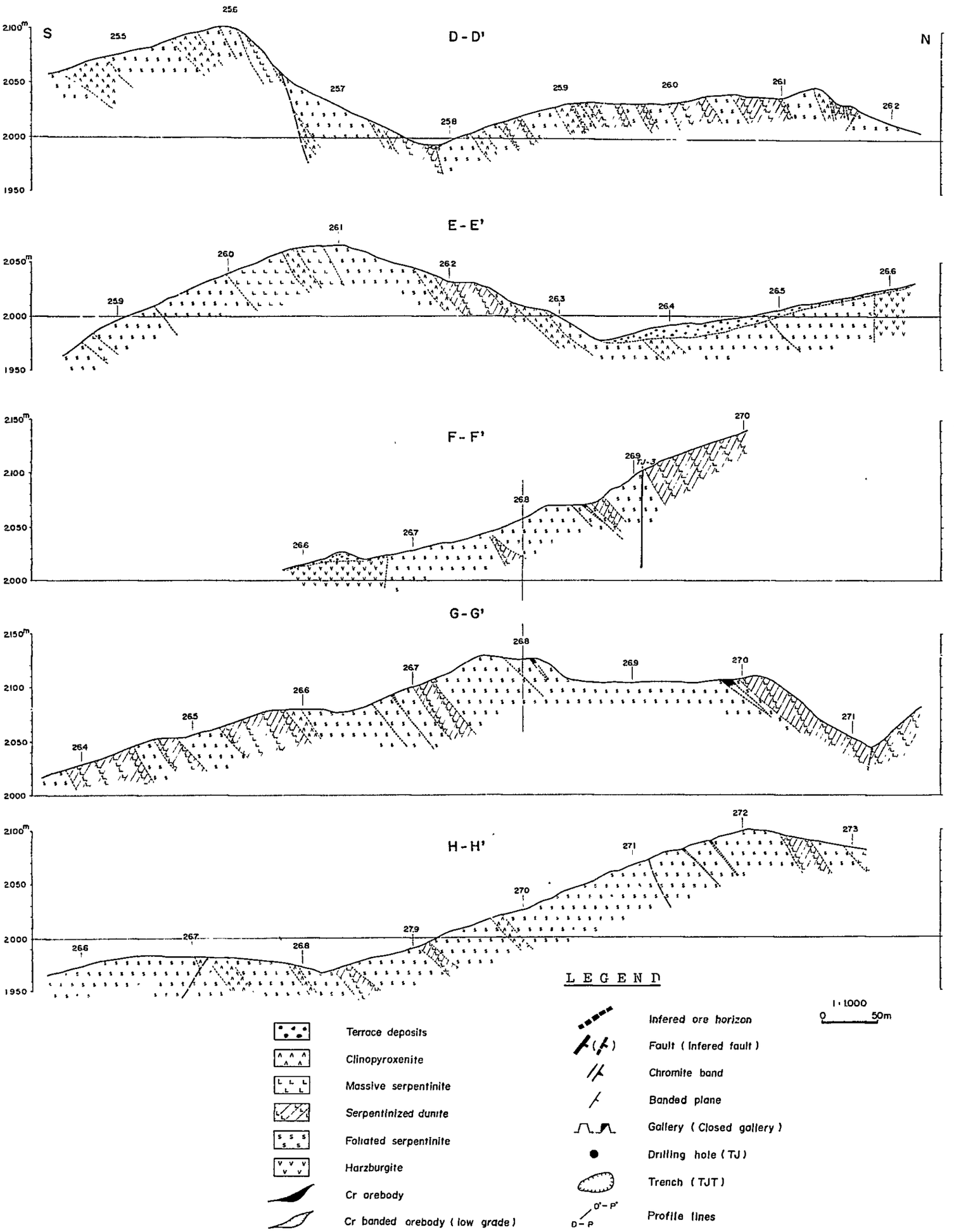
- Chromite band
- Banded plane
- Gallery (Closed gallery)
- Drilling hole (TJ)
- Trench (TJT)
- Profile lines (D'-P', D-P)

Fig. 5-5 Geological map of Ezan area (B)

Fig 5-6 Geological profiles in Ezan area



Ultrabasic rocks and related igneous rocks were deposited from south to north. The sequence of deposition is as follows: harzburgite and pyroxenite - dunite and pyroxenite - gabbro - diorite - basalt. This sequence suggests tectonite - cumulate sequence in ophiolite, even though an imperfect one. However, in the northernmost part of the ultrabasic rocks, harzburgite zone, which seems to occupy higher horizon than dunite is present. Genetical interpretation of this harzburgite has not been made yet.

5-3-2 Faults and Folds

Faults and folds in the area seem to have occurred at the time of or after the formation of igneous rocks. Except for minor faults and folds in limestone at the boundary with ultrabasic rocks, faults and folds can be divided into two systems, N-S and E-W.

The former system has several directions: NE - SW, N-S, NW-SE with 400 meters maximum horizontal dislocation. Faults near Ezan mine can be given as example of this fault type. Ultrabasic rocks in Ezan mine show block dislocation. The latter system (E-W system) is not evident in the area. Its age of formation may be older than that of the N-S system. Its direction is ENE-WSE, which means almost parallel to the extension of ultrabasic rocks. Direction of gabbro-diorite intrusions and serpentinized zone also follows this direction.

Therefore, these faults may be related to the principal direction of tectonic movement at the time of Alpine orogenesis. Minor folds are present only at the boundary of ultrabasic rocks and the Meyramdağ limestone and at the boundary of ultrabasic rocks and the Kopdağ limestone, and in the Ezan ore deposits.

5-3-3 Tectonic Movement and Igneous Activity

History of deposition of the lithological sequences, tectonic movements and igneous activity are briefly enumerated as follows:

(1) From the end of the Jurassic to early Cretaceous, flysh sediments, which were mostly calcareous, formed a thick sedimentary pile in the area. Strong subsidence might have been present through this period.

(2) Due to the Alpine orogenic movement, intrusion of ultrabasic rocks took place from the Cretaceous period, and might have continued to Paleogene. The order of intrusion was southern harzburgite zone - northern dunite zone. Without intermission, several kinds of igneous rocks intruded. The order of intrusion was gabbro - diorite - diorite porphyrite - quartz porphyry - volcanic rocks.

(3) Later, major faults which belong to the E-W system took place. The amount of gabbro and basalt in the area is too small for an ophiolite. It might be that this deficiency is related to the presence of the faults. And it is also possible that the lower harzburgite of the northern harzburgite zone was uplifted by the same fault movement.

(4) Not much later, sedimentation of a large amount of calcareous material started, accompanied in the beginning by local volcanic activity. It continued from Paleogene to Pliocene, and faults which belong to the NW system developed at this time. These faults are commonly present in Ezan area. This movement is the so-called "germano type orogenesis".

(5) After the Pliocene epoch, tectonic movement in the area changed to up-lift. Talus and terrace deposits might have been deposited after the Pleistocene.

(6) The area is still unstable as it belongs to the active northeastern Anatolia fault zone.

5-4 Chromite Deposits

The area mapped this year (1979) includes two mines currently being exploited, Coşan and Ezan. Both of them are situated in the northern dunite zone. Chromite mines have been exploited by open pits and underground methods.

5-4-1 Coşan Mine

Coşan mine is located on the right bank of Iskınlığındere, 7 km from Sıçankale Y. in N65°E direction. Its altitude ranges from 2450 to 2670 meters. It belongs administratively to Kop, Bayburt, and Gümüşhane. Truck is available from Bayburt or from Sıçankale Y. via Delavlardağ and it takes 2.5 hours from Bayburt and 0.5 hour from Sıçankale.

The mine is worked from June to October, due to climatic conditions.

Coşan mine belongs to a private company, which is managed by Egemetal Co. This mine was established in 1973, and now it produces approximately 10,000 tone of lumpy ore a year. Average grade of ore is 41 - 42% Cr_2O_3. Total workers in the mine are 30 to 40. Mining equipment consists of one bulldozer, one shovel truck and two dump trucks. After handpicking, lumpy ore is transferred to storage at Karatas and then transported to Trabzon for sale by truck.

5-4-2 Ezan Mine

Ezan mine is located on the mountainside of İsliyayla Tape at an altitude of 1,930 - 2,100 meters. It is 5 km west from Sıçankale Y. Truck is available during summer season and it takes 30 minutes from Sıçankale Y. Operation is limited to the period from June to October, due to climatic conditions.

Ezan mine belongs to a private company which is managed by KROMIT Mining Co. This mine was opened in 1954, and production of lumpy ore is as follows:

1970	22,000 T
1971	24,000 T
1972	26,000 T
1973	28,000 T
1974	28,000 T
1975	28,000 T
1976	28,000 T
1977	28,000 T
1978	18,000 T

and it may produce 40,000 tons in 1979. Average grade of ore is approximately 45% Cr_2O_3. Total number of workers in the mine are 134. Lumpy ore is transferred by 10 trucks. The ore deposits run from east to west, ore body is composed of Sulu Ocak, C Kafa, B Kafa, Doğu Ezan, Orta Ezan, Batı Ezan, Armutlu, Tepebaşı, and Civelek. Amount of production and average grade of each ore body are as follows:

Ore body	Total production	Grade Cr_2O_3
Orta Ezan	75,000 T	44 - 46%
Batı Ezan	50,000	46
Sulu Ocak	40,000	44 - 48
C Kafa	40,000	36 - 42

Ore body	Total production	Grade Cr_2O_3
B Kafa	30,000 T	38 - 44%
Doğu Ezan	25,000	34 - 44
Armutlu	3,000	

Armultu orebody was developed in 1978.

After handpicking, lumpy ore is mainly transferred to storage at Erbaş station by truck and then transported to İskenderun by railroad. A small amount of lumpy ore is transferred to storage at Karataş and then transported to Trabzon by truck.

5-5 Characteristic Features of the Chromite Deposits

5-5-1 Mode of Occurrence of the Chromite Deposits

The chromite ore deposits were classified into two main characteristic types by Thayer (1969): Stratiform type and Podiform type. Typical example of the former is Bushveld Complex. The latter type of chromite deposits are mostly found in the Alpine orogenic belt, thus this type of chromite ore deposit is frequently called "Alpine chromite deposit". The chromite ore deposits in the investigated area belong to the Podiform type (or the Alpine chromite ore deposits).

Shape of the orebody in the area is mainly lenticular, banded, irregular-band, etc. The chromite ore deposit zone is almost identical with serpentinized zone. Though serpentinization itself is not directly

related to the chromite mineralization, chrome ore deposits occur in the dunite which is apt to be serpentinized, therefore serpentinization is one of the useful indications in exploration.

Distribution of chromite zone follows ENE-WSW direction, which is identical with one of the main directions of dunite and pyroxenite. The directions of ore zone is also identical with unit orebody in Ezan, its direction is ENE-WSW, but it is N-S in Coşan.

Directions of chromite banding and unit orebody are approximately the same, but directions near fault zone are different.

Strikeside extension of orebody at Ezan mine is 200 meters maximum, but it is commonly less than that, width of the orebody is from 20 meters at maximum to less than several meters.

Generally, hanging side of orebody is in contact with the host rock by the fault. There are many minor faults in the orebodies. Especially, high grade ore occurs near faults.

At Tepebaşı and B Kafa, minor folds are present in the orebody. This phenomenon is exceptional and is considered to suggest the presence of local structural movement after or at the time of chromite deposition.

5-5-2 Chromite Ore

Type of ore deposits in the area is Podiform, it is frequently called "Alpine chromite ore deposits", and the ore is called "Alpine chrome ore". The Alpine chrome ore is generally classified into the following 4 types: "Massive", "Nodular", "Disseminated", "Banded".

The ore in the area is mainly disseminated, associated with a small amount of massive ore, sometimes nodular and banded types of ore observed. Massive ore occurs at Sulu Ocak, Batı Ezan, etc. Usually, the massive ore is composed of coarse-grained chromite, grain size of the chromite is approximately 5 millimeters, but in Sulu Ocak and Tepebaşı, it is approximately 0.8 to 1 centimeter.

Massive ore is generally accompanied by kaemmererite and uvarovite, which are considered to be secondary alteration products of chromite by hydrothermal solution. Kaemmererite is violet colored, and occurs mostly in deposits in Ezan mine. Kaemmererite occurs in a part of Coşan mine. Especially wonderful crystals, about 5 millimeters long, occur along crack or fault in the ore from Doğu Ezan. Uvarovite is green colored, and occurs in Sulu Ocak, B Kafa, etc.

Nodular chrome ore occurs in the central part of Coşan mine. The size of a nodule consisting of aggregates of chromite attains 0.5 to 2 centimeters. Most of chromite ore in the area is disseminated. Disseminated chromite ore is classified into 2 types by Bamba (1978): massive chromitite and lineated chromitite. Massive chromitite occurs in Sulu Ocak, B Kafa, C Kafa, Batı Ezan, Orta Ezan, Armutlu etc. The chromite which forms massive chromitite is euhedral or subhedral, and shows homogenous concentration.

Lineated chromitite shows flowage, and occurs in Sulu Ocak, B Kafa, Orta Ezan, Batı Ezan, Armutlu, and Coşan. Cumulate structure is frequently recognized in the lineated chromitite.

Banded ore occurs commonly in Ezan mine and Caşan mine. Layer of chromite is from 1 millimeter to several centimeters thick. Banded ore extending several meters in length occurs in the eastern Sulu Ocak. It is difficult to distinguish the banded ore from lineated chromitite. Amount of gangue mineral of banded ore, which occurs between chromite layers, is much higher than that of lineated chromitite, the grade of banded ore is low. The gangue mineral is serpentine.

5-5-3 Ore Minerals and Gangue Minerals

Essential ore mineral is chromite, chromite consisting the disseminated ore is brown in thin section, and is frequently associated with abundant ferritchromite along fracture or cleavage planes.

As for metallic minerals, a small amount of magnetite is common in chromite. Magnetite is anhedral, fine-grained and occurs as irregular dots along craks in chromite. Pyrite is rarelly found. It is fine-grained and is present in gangue minerals of chromite ore.

Chromian gangue minerals are kaemmererite and uvarovite. Both of them are restictedly found along cracks in massive chromite ore.

Other gangue minerals are mostly serpentine which is altered from olivine and pyroxene. Hydromagnesite, magnesiochromite, stichtite, talc, brucite, asbestos, pyroaurite, artinite, chlorite, etc. are also present.

5-6 Characteristics of Chromite Deposits of Coşan and Ezan Mines

Several characteristic features of chromite deposits of Coşan and Ezan chromite deposits are described below:

(1) Coşan deposits are frequently dislocated by faults and the disturbance makes correlation of chromite layers difficult. However, it has been concluded that Coşan deposits consist of only one ore horizon. In Ezan mine, concentration of chromite is considered to be present at least in three ore horizons.

(2) Grade of serpentization in Ezan mine is much more pervasive than that of Coşan mine. Sometimes serpentinite in Ezan mine is invaded by hydromagnesite veinlets. Serpentinite penetrated by the vein network weathers to serpentinite powder.

(3) Bird drop structure, caused by invasion of hydromagnesite, is frequently found in Ezan, but such feature is not observed in Coşan.

(4) The thickness of orebodies in Ezan mine is extremely variable, but, that in Coşan is more stable and continuous.

(5) Minor folds are present in the orebody at a part of Ezan mine, but those are rather rare at Coşan.

(6) In Ezan, block movement predominates, and orebodies are separated into several blocks dislocated by the faults of N-S system. But orebodies in Coşan are cut by faults of irregular directions.

5-7 Trench

Because Coşan and Ezan areas are covered by debris of ultra-basic rocks, geology and ore deposits of those areas are not clear, and the purpose of the trench was to clarify the continuity of chromite ore horizon. Three trenches were excavated in Ezan area, locality of each trench is shown in Fig. 5-7, volume of each trench and results of chemical analysis of the trench are shown in Table 5-1 and 5-2. Trenching was carried out by a bulldozer, which was made in West Germany. Fig. 5-8 and 5-9 show a sketch of the trench.

5-7-1 Purpose of Each Trench

Purpose of each trench is as follows:

TJT-1 (Sulu Ocak); To determine the extent of the eastern part of Sulu Ocak orebody

TJT-2 (Sulu Ocak); To determine the extent of the eastern part of Sulu Ocak orebody

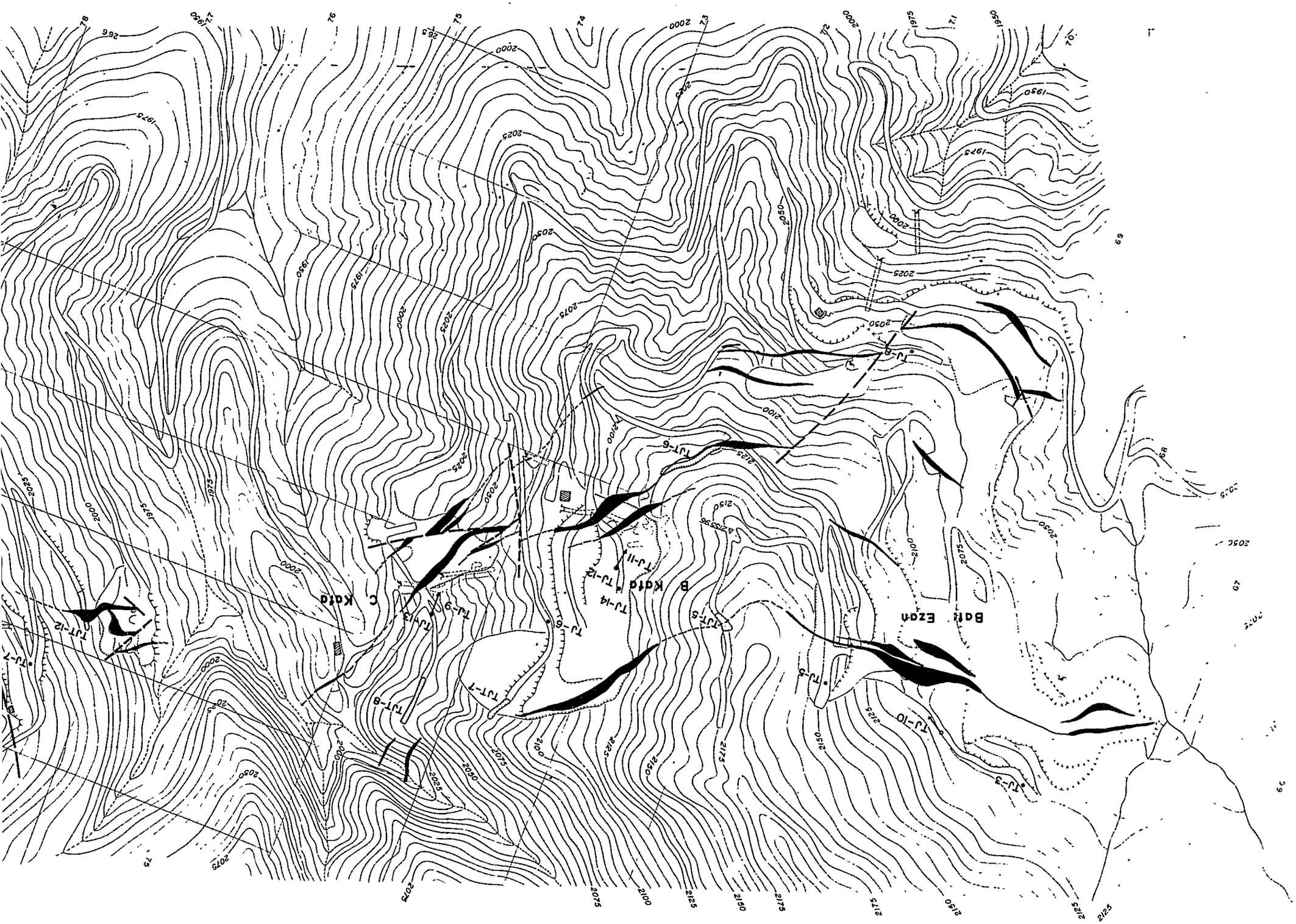
TJT-3 (Solu Ocak); To determine the extent of the farther eastern part of the orebody which was found by TJT-1 and TJT-2.

5-7-2 Results of Each Trench (Fig. 5-8 and 5-9)

TJT-1 (Sulu Ocak); Lenticular massive ore was encountered by the trench. The maximum thickness is 40 centimeters. Average grade of the ore is 34.79% Cr_2O_3, 17.75% Al_2O_3, 19.90% MgO, 15.99% FeO + Fe_2O_3 and 7.57% SiO_2.

TJT-2 (Sulu Ocak); Two ore beds, 1 meter thick and 20 centimeters thick, were encountered by this trench. Grade of the massive ore of 1 meter thickness is 46.33% Cr_2O_3, 15.97% Al_2O_3, 16.07% MgO, 17.54% FeO + Fe_2O_3 and 4.07% SiO_2. Grade of the banded ore of 20 centimeters thickness is 27.23% Cr_2O_3, 7.23% Al_2O_3, 25.48% MgO, 15.90% FeO + Fe_2O_3 and 14.45% SiO_2. As a result, it was found that the Sulu Ocak orebody extends father east.

TJT-3 (Sulu Ocak); Lenticular ores were encountered by the trench. The ores are present for about 40 meters and are of high grade. Maximum thickness is about 5 meters, but it is extremely variable. Average grade of the disseminated ore is 34.90% Cr_2O_3, 18.93% Al_2O_3, 20.61% MgO, 15.10% FeO + Fe_2O_3 and 8.79% SiO_2. As a result, it was found that the Sulu Ocak orebody extends farther east.


Bağ Ezan
B Kata
C Kata
TJ-1
TJ-2
TJ-3
TJ-4
TJ-5
TJ-6
TJ-7
TJ-8
TJ-9
TJ-10
TJ-11
TJ-12
TJ-13
TJ-14
TJT-1
TJT-2
TJT-3
TJT-4
TJT-5
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TJT-7
1950
1975
2000
2025
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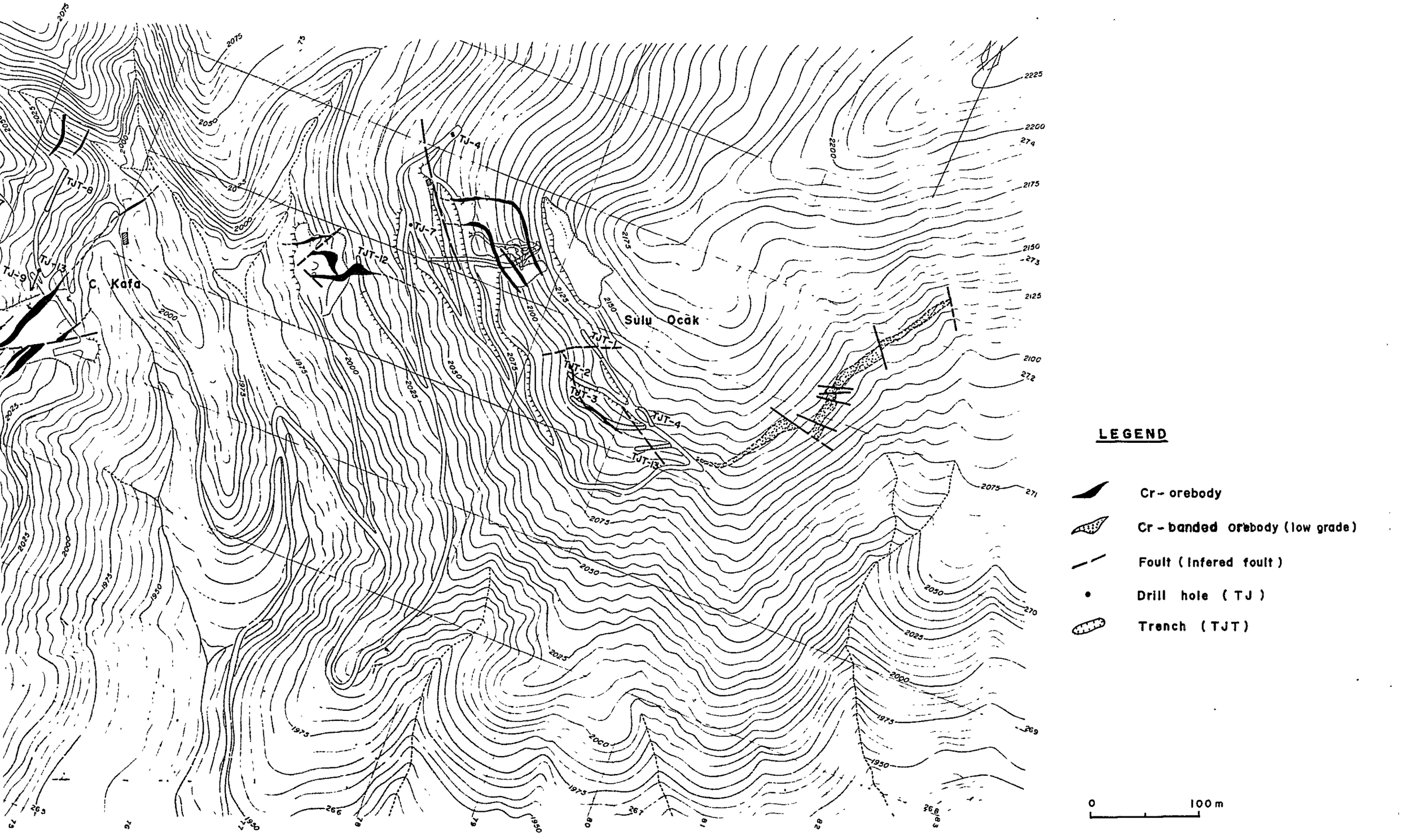


Fig. 5-7 (A) Location map of trenches, drill holes (Ezan area)

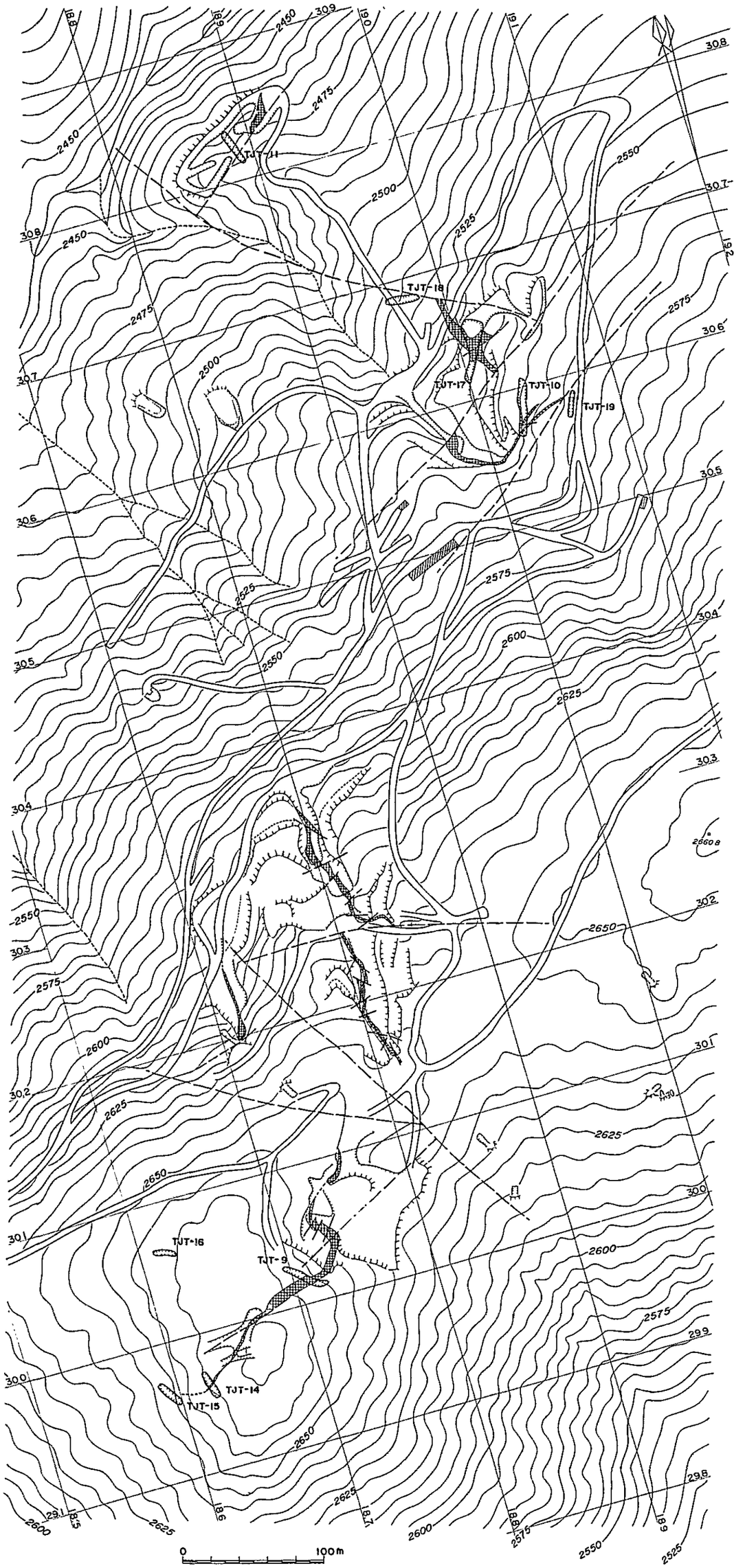
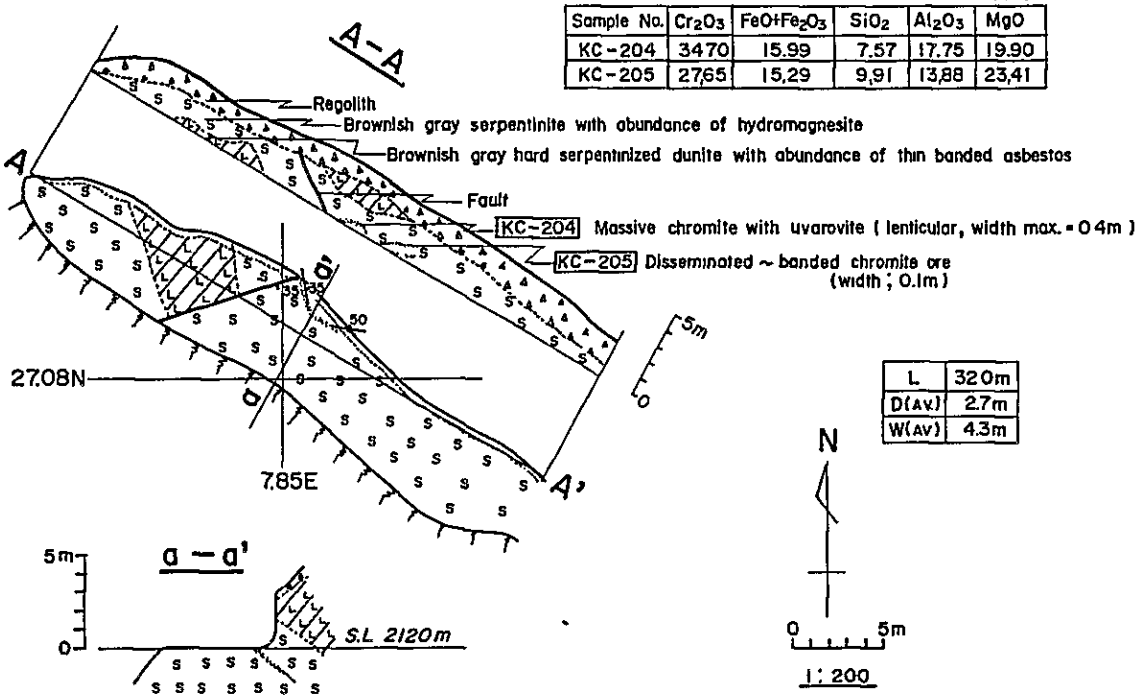


Fig. 5-7 (B) Location map of trenches (Coşan area)

TJT - 1 (Sulu Ocak, Volume ; 185m³)

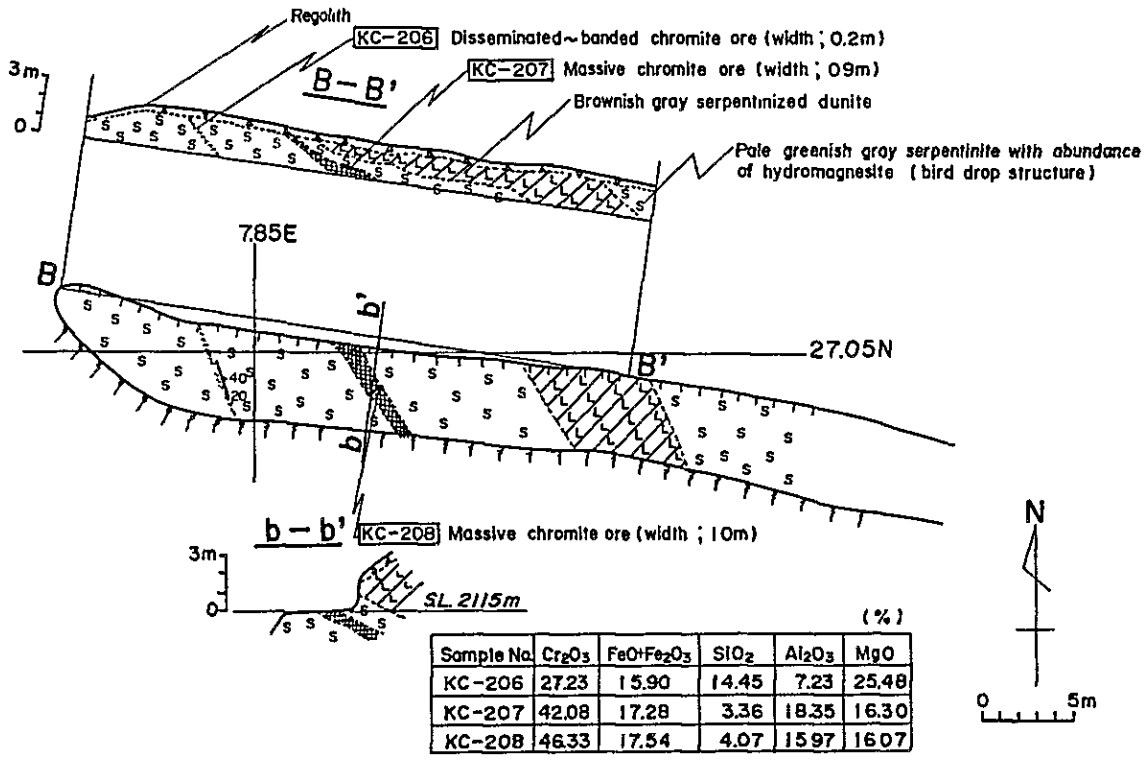
(%)

Sample No.	Cr_2O_3	$FeO+Fe_2O_3$	SiO_2	Al_2O_3	MgO
KC-204	34.70	15.99	7.57	17.75	19.90
KC-205	27.65	15.29	9.91	13.88	23.41



TJT-2 (Sulu Ocak, Volume ; 125m³)

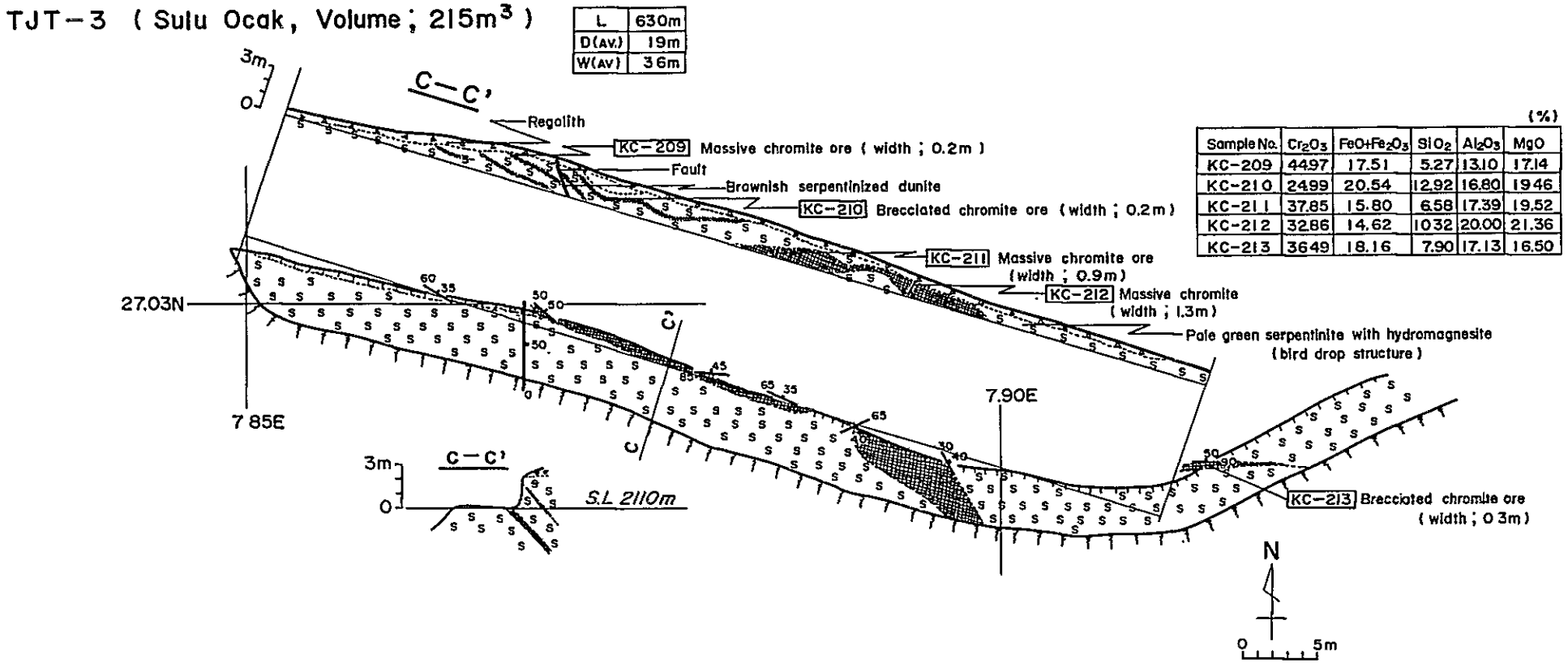
L	31.5m
D(Av.)	1.7m
W(Av.)	4.2m



(%)

Sample No.	Cr_2O_3	$FeO+Fe_2O_3$	SiO_2	Al_2O_3	MgO
KC-206	27.23	15.90	14.45	7.23	25.48
KC-207	42.08	17.28	3.36	18.35	16.30
KC-208	46.33	17.54	4.07	15.97	16.07

Fig. 5-8 Geological sketch of trench (TJT-1~TJT-2)



(%)

Sample No.	Cr_2O_3	$FeO+Fe_2O_3$	SiO_2	Al_2O_3	MgO
KC-209	44.97	17.51	5.27	13.10	17.14
KC-210	24.99	20.54	12.92	16.80	19.46
KC-211	37.85	15.80	6.58	17.39	19.52
KC-212	32.86	14.62	10.32	20.00	21.36
KC-213	36.49	18.16	7.90	17.13	16.50

Fig. 5-9 Geological sketch of trench (TJT-3)

Table 5-1 List of Trenches

Trench no.	Area	Volume of the trench	Remarks
TJT-1	Ezan	185 m^3	Massive ore (lenticular)
TJT-2	Ezan	125 m^3	Massive ore (lenticular)
TJT-3	Ezan	215 m^3	Massive ore (lenticular)
Total		525 m^3	

Table 5-2 Results of Chemical Analysis (Trench)

Trench no.	Area	Sample no.	Cr_2O_3	$FeO+Fe_2O_3$	SiO_2	Al_2O_3	MgO
TJT-1	Sulu Ocak	KC-204	34.70	15.99	7.57	17.75	19.90
		KC-205	27.65	15.29	9.91	13.88	23.41
TJT-2	Sulu Ocak	KC-206	27.23	15.90	14.45	7.23	25.48
		KC-207	42.08	17.28	3.36	18.35	16.30
		KC-208	46.33	17.54	4.07	15.97	16.07
TJT-3	Sulu Ocak	KC-209	44.97	17.51	5.27	13.10	17.14
		KC-210	24.99	20.54	12.92	16.80	19.46
		KC-211	37.85	15.80	6.58	17.39	19.52
		KC-212	32.86	14.62	10.32	20.00	21.36
		KC-213	36.49	18.16	7.90	17.13	16.50

5-8 Purpose and Result of Drill Hole

Although twelve drill holes were planned based on the results of 1978 geological survey, fourteen drill holes carried out in 1979 and 1980. Fig. 5-7 shows localities of drill holes.

5-8-1 Purpose of Each Drill Hole

TJ-1 (Armutlu); Several ore horizons are present between about 250 meters from Batı Ezan to Orta Ezan. There is more than 300 meters from Armutlu to Tepebaşı, concealed orebodies are inferred to be present in this interval. Therefore, TJ-1 drill hole was carried out for the purpose of exploration for a lower part of Armutlu orebody.

TJ-2 (Armutlu); TJ-2 drill hole was carried out in order to find the extension to dipside of Armutlu orebody.

TJ-3 (Batı Ezan); Two open pits are present in Batı Ezan, they are located in the eastern and western part of Batı Ezan. TJ-3 drill hole is located in the western part of Batı Ezan. This drill hole was carried out in order to find the extension to dipside at Batı Ezan orebody. It was about 50 meters below the outcrop of orebody.

TJ-4 (Sulu Ocak); Several ore horizons are present in Sulu Ocak. TJ-4 drill hole was carried out in order to find the extension to dipside at Sulu Ocak orebody. It was about 45 meters below the outcrop of the orebody.

TJ-5 (Batı Ezan); TJ-5 drill hole is located in the eastern part of Batı Ezan, and was carried out in order to find the extension to dipside at Batı Ezan orebody. It was about 50 meters below the outcrop of the orebody.

TJ-6 (Eastern part of B Kafa); Two ore horizons, upper and lower, are present in B Kafa. TJ-6 drill hole was carried out in order to find the extension to dipside at lower part of B Kafa orebody. It was about 50 meters below the outcrop of orebody.

TJ-7 (Sulu Ocak); TJ-7 drill hole was carried out in order to find extension to dipside of Sulu Ocak orebody. It was about 30 meters below the outcrop of orebody.

TJ-8 (Orta Ezan); TJ-8 drill hole was carried out in order to find extension to dipside of Orta Ezan orebody. It was about 50 meters below the outcrop of the orebody.

TJ-9 (C Kafa); TJ-9 drill hole was carried out in order to find extension to dipside of C Kafa orebody. It was about 30 - 40 meters below the outcrop of the orebody.

TJ-10 (Batı Ezan); TJ-10 drill hole was carried out in order to find extension to dipside of Batı Ezan orebody. It was about 40 meters below the orebody.

TJ-11 (B Kafa); TJ-11 drill hole was carried out in order to find extension to dipside of B Kafa orebody. It was about 30 and 60 meters below the orebody.

TJ-12 (B Kafa); TJ-12 drill hole was carried out in order to find extension to dipside of B Kafa orebody. It was about 50 and 90 meters below the outcrop of the orebody, due to intersect the orebody by TJ-11 drill hole.

TJ-13 (C Kafa); TJ-13 drill hole was carried out in order to find extension to dipside of C Kafa orebody, due to intersect the orebody by TJ-9 drill hole.

TJ-14 (B Kafa); TJ-14 drill hole was carried out in order to find extension to dipside of B Kafa orebody. It was about 80 meters below the outcrop of the body, due to intersect the orebody by TJ-12 drill hole.

5-8-2 Results of each drill hole (Fig. 5-10 ∿ 5-23)

TJ-1 (Armutlu); The drill core is composed mainly of serpentinized dunite. The core is as follows:

0.00 - 5.20 m; Talus breccia deposit composed of angular-subangular of rocks such as serpentinite, serpentinized dunite, harzburgite, pyroxenite, chromite, etc. Size of breccia is from 1 to 5 cm. Matrix is composed of carbonate minerals.

5.20 - 7.60 m; Grey foliated serpentinite. Two centimeters thick band of magnetite and chromite is present.

7.60 - 76.95 m; Dark grey serpentinized dunite. Drill core is sheared and brecciated at several points it is considered to be the result of a fault, although chromite bands, which are about 1 cm thick, are present.

Results: Ore horizon could not be intersected by the drill hole.

Interpretation: Armutlu orebody seems to be cut by faults.

TJ-2 (Armutlu); The drill core is composed mainly of serpentinized dunite. The core is as follows:

0.00 - 10.30 m; (no core) Brown sludge. Seems to be talus deposit.

10.30 - 13.30 m; (no core) Pale green sludge. Seems to be foliated serpentinite.

13.30 -25.25 m; Sheared zone. The breccia is composed of dark grey serpentinized dunite. Size of breccia is less than 3 cm. The cementing material is mainly pale green serpentine. As a result of X-ray diffraction, serpentine from 23.20 m was found to consist of chrysotile and antigorite.

25.25 - 45.15 m; Dark grey serpentinized dunite. The core is sheared and brecciated. Pale green antigorite is present in cracks.

45.15 - 53.65m; Sheared zone. The breccia is composed of dark grey serpentinized dunite. Size of breccia is at maximum less than 1 cm. Cementing material is mainly pale green serpentine.

53.65 - 65.20 m; Dark grey serpentinized dunite. The core is sheared and brecciated. Pale green antigorite is present in cracks. Disseminated magnetite is partly present.

Results: Ore horizon was not intersected by the drill hole.

Interpretation: Armutlu orebody seems to be cut by faults.

TJ-3 (Batı Ezan); The drill core is composed mainly of serpentinized dunite. The core is as follows:

0.00 - 15.20 m; (no core) Mainly brown-grey to pale green serpentine sludge. Seems to be serpentinized dunite.

15.20 - 61.95m; Dark grey serpentinized dunite. The rock includes many several millimeters thick asbestos bands. Very small amount of disseminated chromite is present.
At about 55.00 m a thin layer of chromite is observed.

61.95 - 84.40 m; Mainly sheared dunite. Dark grey serpentinized dunite is present at the depth of 65.40 - 66.00 m and 77.55 - 78.50 m. The breccia in sheared zone is composed of dark grey serpentinized dunite, and size of the breccia is less than 5 cm, cementing materials are pale green serpentine and grey-white clay.

84.40 - 91.10 m; Dark gray serpentinized dunite. The rock is sheared, and size of the rock fragments is less than 5 centimeters. The rock includes many several millimeters thick asbestos bands. A very small amount of disseminated and banded chromite is present.

Results: Ore horizon was not intersected by the drill hole.

Interpretation: Batı Ezan orebody seems to be cut by faults.

TJ-4 (Sulu Ocak); The drill core is composed mainly of serpentinized dunite. The core is as follows:

0.00 - 10.65 m; (no core) Gray colored sludge composed mainly of serpentine and hydromagnesite. It seems to be foliated serpentine.

10.65 - 24.00 m; Brownish gray serpentinized dunite. Pale green pyroxenite is present at the depth of 20.10 - 20.40 meters. Veinlets of pale green serpentine and white colored hydromagnesite are present. A very small amount of disseminated and banded chromite are present.

24.00 - 24.50 m; Grey clay.

24.50 - 50.15 m; Sheared zone composed of clay and serpentine and sheared dunite. The breccia is gray serpentinized dunite. Cementing materials are pale green serpentine and gray clay (brucite). Size of the breccia is at maximum 10 centimeters. Most of the breccia is less than 1 centimeter. As a result of X-ray diffraction, grey colored clay from 45 meters was found to consist of chrysotile, antigorite, and brucite.

Results: Ore horizon was not intersected by the drill hole.

Interpretation: Sulu Ocak orebody seems to be cut by faults.

TJ-5 (Batı Ezan); The core is composed mainly of sheared dunite. The core is as follows:

0.00 - 42.80 m; (no core) Brownish gray sludge from 0.0 to 34.85 meters. It seems to be serpentinized dunite. Gray sludge from 34.85 to 42.80 meters. It is composed of serpentine, uvarovite, magnetite, chromite, etc. It seems to be a sheared zone.

42.80 - 47.15 m; Dark gray sheared dunite. The breccia is composed of dark gray serpentinized dunite. Size of the breccia is less than 4 centimeters.

47.15 - 47.55 m; Mainly gray clay accompanied by a small amount of serpentine and serpentinized dunite breccia.

47.55 - 48.50 m; Dark gray serpentinized dunite.

48.50 - 53.75 m; Sheared zone composed of pale gray clay, pale green serpentine, and dark gray serpentinized dunite breccia.

53.75 - 70.50 m; Dark gray serpentinized dunite accompanied by disseminated chromite at the depth of 56.50 - 65.00 meters. Serpentinized dunite is commonly accompanied by several millimeters thick asbestos band.

70.50 - 102.20 m; Sheared zone composed of gray clay, pale green serpentine, and dark gray serpentinized dunite breccia. Dark gray dunite, which includes a very small amount of disseminated chromite, is present at the depth of 74.35 - 74.55 meters, 75.45 - 77.50 meters, 79.90 - 81.30 meters and 89.70 - 90.50 meters.

Results: Ore horizon was not intersected by the drill hole.

Interpretation: Batı Ezan orebody seems to be cut by faults.

TJ-6 (Eastern part of B Kafa); The core is composed mainly of sheared serpentinized dunite and serpentinized dunite. The core is as follows:

0.00 - 30.53 m; (no core) Gray sludge composed mainly of pale green serpentine, gray serpentinized dunite, magnetite, chromite and hydromagnesite. It seems to be foliated serpentinite and serpentinized dunite.

30.53 - 32.50 m; Sheared zone composed mainly of pale green serpentine. It is accompanied by gray serpentinized dunite breccia.

32.50 - 34.50 m; Gray serpentinized dunite accompanied by veinlets of hydromagnesite in cracks. Many several centimeters thick asbestos bands accompanied by a very small amount of magnetite and chromite are present.

34.50 - 41.95 m; Sheared zone composed of gray serpentinized dunite breccia, pale green serpentine and gray clay. As a result of X-ray diffraction, gray colored clay from 35 meters was found to consist of chrysotile, antigorite and brucite.

41.95 - 43.75 m; Gray serpentinized dunite accompanied by veinlets of hydromagnesite in cracks. Several centimeters thick asbestos band is present. A very small amount of chromite is present.

43.75 - 42.10m; (no core) Gray sludge composed of gray serpentinized dunite and pale green serpentine. It includes large amount of magnetite grains and a very small amount of chromite. It seems to be serpentinized dunite.

Results: Ore horizon was not intersected by the drill hole.

Interpretation: The orebody seems to be cut by faults.

TJ-7 (Sulu Ocak); It is composed mainly of sheared dunite. The core is as follows:

0.00 - 12.20 m; (no core) Brownish gray sludge. It seems to be sheared dunite.

12.20 - 22.40 m; Sheared zone. The breccia is composed mainly of gray serpentinized dunite, but massive chromite breccia is present around the depth of 16.20 meters. Its size ranges from 0.5 to 2 centimeters. Cementing materials are pale green serpentine and gray clay, which consists of chrysotile and pyroaurite.

Results: Ore horizon was not intersected by the drill hole.

Interpretation: The drill machine broke down and drilling had to be stopped at 22.40 meters.

TJ-8 (Orta Ezan); The core is composed mainly of serpentinized dunite. The core is as follows:

0.00 - 30.50 m; (no core) Gray sludge. It seems to be serpentinized dunite.

30.50 - 32.85 m; Sheared zone. The core is composed mainly of serpentinized dunite and serpentine. The breccia is composed of dark gray serpentinized dunite.

Cementing material is mainly pale green colored serpentine.

32.85 - 34.75 m; Dark gray serpentinized dunite accompanied by a very small amount of disseminated chromite.

34.75 - 38.70 m; Sheared zone. The breccia is composed of gray colored serpentinized dunite which includes many several millimeters thick asbestos bands. Cementing material is pale green serpentine.

38.70 - 45.75 m; Dark gray serpentinized dunite accompanied by many several millimeters thick asbestos bands. Sheared zone is present from 40.30 to 40.40 meters.

45.75 - 52.05 m; Sheared zone. The breccia in sheared zone is composed of dary gray serpentinized dunite. Cementing material is pale green serpentine.

52.05 - 82.50 m; Mainly dark gray serpentinized dunite. Sheared zones are present from 54.30 to 55.55 meters, from 69.20 to 71.30 meters, and from 71.60 to 73.20 meters. The beccia in sheared zones is dark gray serpentinized dunite, accompanied by many several

millimeters thick asbestos bands. Cementing material is pale green serpentine and white to pale gray clay. 1-2 centimeter wide magnetite band is present at the depth of about 68.00 meters and 69.00 meters. A very small amount of chromite grains is present. Kaemmererite occurs in cracks at the depth of about 80.20 meters.

Results: Ore horizon was not intersected by the drill hole.

Interpretation: The orebody seems to be cut by faults.

TJ-9 (C Kafa); The drill core is composed mainly of foliated serpentinite. The core is as follows:

0.00 - 9.15 m; (no core) Grey sludge. Seems to be foliated serpentinite.

9.15 - 10.25 m; Gray foliated serpentinite. A large amount of chrysotile is present.

10.25 - 20.50m; Gray serpentinized dunite. The core is brecciated, pale green chrysotile is present in cracks.

20.50 - 23.75 m; Dary grey serpentinized dunite. Pale chrysotile is present in cracks.

23.75 - 25.10 m; (no core) Grey sludge. Seems to be foliated serpentinite.

25.10 - 26.50 m; Grey foliated serpentinite. A large amount of chrysotile is present.

26.50 - 28.15 m; Grey serpentinized dunite. Pale green chrysotile is present in cracks.

28.15 - 29.15 m; Disseminated chromite ore. Cr_2O_3:31.92%

29.15 - 47.40 m; Grey foliated serpentinite. A large of chrysotile and banded chromite ore of low grade (33.50 - 33.70 meters) are present.

Results: Ore horizon was intersected by the drill hole.

Interpretation: C Kafa orebody continues about 30 m below surface, then extension of orebody is expected farther deep part.

TJ-10 (Batı Ezan); The drill core is composed mainly of serpentinized dunite. The core is as follows:

0.00 - 9.15 m; (no core) Grey sludge. Seems to be foliated sepentinite.

9.15 - 17.00 m; Grey foliated serpentinite with a small amount of magnetite and chromite.

17.00 - 19.80 m; Dark grey brecciated serpentinized dunite.

19.80 - 22.85 m; (no core) Grey sludge. Seems to be brecciated dunite or sheared dunite.

22.85 - 49.80 m; Dark grey massive serpentinized dunite with chrysotile veinlet. Chromite dot and kaemmererite are present at 37.60 m.

49.80 - 56.40 m; Dark grey massive serpentinized dunite with magnetite veinlet.

56.40 - 59.45 m; Passing through gallery.

59.45 - 62.00 m; Dark grey brecciated serpentinized dunite.

62.00 - 62.50 m; Chromite ore. Cr_2O_3:44.20%

Results: The hanging wall of ore horizon was intersected by the drill hole. As the hole passed through gallery, it was difficult to carry out drilling work.

Interpretation: Batı Ezan orebody seems to continue about 50 m below surface.

TJ-11 (B Kafa); The drill core is composed of foliated serpentinite and serpentinized dunite. The core is as follows:

0.00 - 9.15 m; (no core) Grey sludge. Seems to be foliated serpentinite.

9.15 - 14.15 m; Grey foliated serpentinite with a large amount of chrysotile.

14.15 - 25.15 m; Dark grey brecciated serpentinized dunite. Chromite band is present at 24.05 m (width, 15 cm).

25.15 - 36.00 m; Dark grey serpentinized dunite with magnetite. Chromite bands are present at 31.30 m (width, 1 cm) and 32.85 m (width, 2 cm).

36.00 - 38.75 m; Disseminated chromite ore with chrysotile veinlet. Cr_2O_3:28.84%

38.75 - 66.35 m; The core is composed mainly of dark grey serpentinized dunite. Disseminated chromite is observed at 43.00 m (width, 30 cm), 43.90 m (width, 20 cm), 44.65 m (width, 35 cm) and 48.10 m (width, 20 cm).

66.35 - 66.85 m; Disseminated chromite ore with kaemmererite. Cr_2O_3:28.48%.

66.85 - 81.40 m; Dark green massive serpentinized dunite.

Results: Ore horizons were intersected by the drill hole.

Interpretation: B Kafa orebody continues about 30 m and 60 m below surface. The faults are inferred to be under consideration of gallery.

TJ-12 (B Kafa); The drill core is composed mainly of foliated serpentinite and serpentinized dunite. The core is as follows:

0.00 - 12.00 m; (no core) Grey sludge. Seems to be foliated serpentinite.

12.00 - 20.80 m; Grey foliated serpentinite with a large amount of chrysotile.

20.80 - 26.70 m; Grey brecciated serpentinized dunite.

26.70 - 46.60 m; Dark grey serpentinized dunite with magnetite.

46.60 - 51.00 m; Massive chromite ore with kaemmererite. Cr_2O_3:36.69%

51.00 - 78.00 m; The core is composed mainly of dark grey brecciated serpentinized dunite.

78.00 - 80.60 m; White clay (fault zone?)

80.60 - 85.30 m; Grey brecciated serpentinized dunite with chromite disseminated. Cr_2O_3:24.45%

85.30 - 88.20 m; Dark grey massive serpentinized dunite.

88.20 - 89.30 m; Massive chromite ore with kaemmererite. Cr_2O_3:40.85%

89.30 - 106.0 m; Dark green massive serpenitinized dunite.

Results: Ore horizons were intersected by the drill hole.

Interpretation: B Kafa orebody continues about 50 m and 80 m below surface. The extension of orebody is expected farther deep part.

TJ-13 (C Kafa); The drill core is composed mainly of foliated serpentinite. The core is as follows:

0.00 - 12.30 m; (no core) Grey sludge. Seems to be foliated serpentinite.

12.30 - 32.45 m; Grey foliated serpentinite with a large amount of chrysotile.

32.45 - 35.45 m; Grey brecciated serpentinized dunite.

34.45 - 42.00 m; Chromite ore. Massive chromite ore grades downward into disseminated chromite ore.

35.45 - 40.50 m; Cr_2O_3 26.84%

40.50 - 42.00 m; Cr_2O_3 12.76%

42.00 - 58.90 m; The core is composed of foliated serpentinite and serpentinized dunite.

58.90 - 63.95 m; (no core) Brown sludge. Seems to be foliated serpentinite.

Results: Ore horizon was intersected by the drill hole.

Interpretation: C Kafa orebody extends to dipside and continues about 40 m below the outcrop of orebody, its width increases from 1.000 m (TJ-9) to 6.55 m (TJ-13).

TJ-14 (B Kafa); The drill core is composed mainly of foliated serpentinite and serpentinized dunite. The core is as follows:

0.00 - 15.15 m; (no core) Grey sludge. Seems to be foliated serpentinite.

15.15 - 54.00 m; The core is composed mainly of foliated serpentinite. Dark grey serpentinized dunite with a small amount of magnetite and chrysotile veinlet is present at the depth of 28.40 - 32.60 m and 34.50 - 39.80 m.

54.00 - 63.70 m; Dark green massive serpentinized dunite with a small amount of magnetite and antigorite.

63.70 - 67.35 m; Disseminated chromite ore. Cr_2O_3:32.44%

67.35 - 100.3 m; Dark grey massive serpentinized dunite with a small amount of chromite and chrysotile veinlet.

Fig.5-10 Geological log of TJ-1

Drill hole No.	TJ-1	Depth	0.00m ~76.95m	Date	19.Jul.'79 / 11.Sep.'79	Scale	1:200	Co-ordinates	26.356N / 6.846E.

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m		0.50			0.00~0.50m brown sludge
			3.80	Talus deposits	0.50~5.20m breccia——serpentinite, dunite, harzburgite, pyroxenite, chromite, diorite (φ=1cm~5cm) matrix——carbonate
		5.20			
				Serpentinite	olive color chromite-bearing magnetite band (width, 2cm, dip; 50°)
		7.60			
		8.10			8.10~9.45m dark gray serpentinized and brecciated dunite (φmax=3cm) sludge is olive in color
10		9.45			
			3.20		dark gray serpentinized dunite, chromite and magnetite dissemination, pale green serpentine (antigorite) in cracks, breccia size; φmax=10cm
					12.50m chromite band (width; 2mm, dip, 50°)
				Dunite	
					16.00m chromite band (width; 1mm)
20					
		21.50	6.15	Sheared dunite	pale greenish gray serpentine is rich. breccia size, φmax=1cm
		21.90			dark gray serpentinized dunite, pale green antigorite in cracks coarse grained calcite (4~5mm) in crack
			5.45	Dunite	pale green serpentine (antigorite) is conspicuous breccia size, φmax=4cm
30					
			3.90		32.00m pyroxene band (dip, 45°)
					small size breccia, pale green antigorite is conspicuous
			2.80		
40		39.60			
		40.15		Sheared dunite	Sheared zone (fault), breccia size, φmax=5cm
			2.53	Dunite	Serpentine in cracks
		44.80			
		45.20		Sheared dunite	pale green serpentine (antigorite) is conspicuous
				Dunite	
		47.10			46.40m chromite band (width, 1mm, dip, 60°)
		47.60		Sheared dunite	sheared zone (fault)
					dark gray serpentinized dunite
					49.10m chromite band (dip, 70°)
50			8.05		50.50m coarse-grained chromite dunite (width, 10cm, dip, 30°)
					51.90m pale green pyroxene band (dip, 35°)
				Dunite	52.60~61.10m pale green serpentine (antigorite) is conspicuous
			6.85		
60					61.10m~62.00m dark gray hard dunite, breccia size, φmax=10cm chromite band (width, 1mm dip, 40°)
		65.90	4.70		
		66.90		Sheared dunite	pale green serpentine is rich
					66.90m~ dark gray serpentinized dunite
70					
			5.70		71.00m small size breccia, pale green serpentine (antigorite) is rich.
				Dunite	
		76.95	3.10		75.50m~ breccia size, φmax=2cm
80					
90					
100					

Fig. 5-11 Geological log of TJ-2

Drill hole No.	TJ-2	Depth	0.00m ~65.20m	Date	28.Jul.'79 / 14.Aug.'79	Scale	1:200	Co-ordinates	26.422N / 6630E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m				Talus deposite	brown sludge
10		10.30		Serpentinite	pale green sludge
	L A L A L	13.30			13.30~15.95m breccia— dark gray dunite (φmax=1cm angular) matrix —— pale greenish gray serpentine
	L A L A L				15.95~16.55m breccia— dark gray brecciated dunite (φmax=5cm) matrix — greenish serpentine
20	L A L A L		3.10	Sheared dunite	16.55~21.75m breccia — dark gray dunite matrix ——pale greenish gray serpentine
	L A L A L	21.75			dark gray band (dip, 45°)
	L A L A L	22.40			21.75~22.40m gray sludge
	L A L A L	25.25			
	L L L				25.25~41.15m dark gray serpentinized dunite containing magnetite
30	L L L		6.40		
	L L L			Dunite	33.50m pale green serpentine (antigorite) in cracks
	L L L		4.60		
40	L L L		3.20		
	L L L				
	L L L	45.15			
	L L L				fault zone pale greenish gray serpentine is conspicuous breccia—— dark gray dunite (φmax. 1cm) matrix —— pale greenish gray serpentine
50	L L L		4.30		
		50.60			50.60~52.00m pale green sludge
		52.00			breccia— — dark gray dunite
	L A L A L	53.65	1.35	Sheared dunite	matrix— — pale green serpentine (antigorite)
	L L L				53.65m~ gray serpentinized dunite pale green serpentine (antigorite) in cracks
	L L L		1.00		
60	L L L			Dunite	
	L L L				
	L L L	65.20	2.50		64.00m disseminated magnetite
70					
80					
90					
100					

Fig. 5-12 Geological log of TJ-3

Drill hole No.	TJ-3	Depth	0.00m ~91.10m	Date	29.Jul.'79 2.Oct.'79	Scale	1:200	Co-ordinates	29.905N 6.810E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m					
				Dunite	0.00~15.20m brownish gray~pale greenish gray sludge, serpentine is abundant.
10					
		15.20			
	L L L L L L		3.95		15.20m~ dark gray serpentinized dunite a small amount of chromite dot, thin band of asbestos is abundant (dip, 50°)
20	L L L L L L L L L				23.60m breccia size, φaverage=3cm, max.=10cm
	L L L L L L		4.20		27.00m white~pale green serpentine (antigorite) in cracks
30	L L L L L L L L L				31.50m fault (dip; 35°) pale green serpentine (antigorite), thin band of asbestos is abundant,
	L L L L L L		4.60	Dunite	a small amount of chromite dot
40	L L L L L L L L L				41.50m small size breccia, φ=1~2cm
	L L L L L L		2.55		
	L L L L L L				49.10~49.20m pale green serpentine (antigorite)
50	L L L L L L L L L		2.90		dark gray, small size breccia, φaverage=1~2cm
	L L L L L L				55.00m chromite dot band (dip; 50°)
	L L L L L L				57.60m a small amount of kaemmererite
60		59.80	2.40		58.20m magnetite band (width; 2mm), a small amount of chromite dot
		61.45			59.80~61.45m gray sludge
		61.95			61.45~61.95m dark gray serpentinized dunite
	L Δ L Δ L L Δ L Δ L				61.95m fault (dip, 80°) with kaemmererite
	L Δ L Δ L			Sheared dunite	small size breccia; φmax 5cm
		65.40			
	L L L L	66.00		Dunite	65.40~66.00m massive serpentinized dunite containing magnetite band (width, 3mm dip; 60°)
	L Δ L Δ L		3.60		66.00m pale green serpentine (antigorite dip, 30° fault)
		68.20			66.40m chromite band (width, 2mm, dip; 80°)
70				Sheared dunite	66.50m magnetite band (width; 5mm, dip, 60°)
		70.25			67.00m disseminated chromite (width, 5mm)
	L Δ L Δ L				68.20~70.25m gray sludge (pale green serpentine, gray dunite, chromite, magnetite, and kaemmererite)
	L Δ L Δ L				70.25m~ sheared zone, dark gray dunite (φmax.=1cm), pale green serpentine and whitish gray clay
		74.55			
	L L L L L L		5.85		74.55m~ dark gray serpentinized dunite (hard) pale green serpentine rich in cracks chromite dot and kaemmererite in crack, asbestos band is remarkable
		77.50		Dunite	77.50 pale green serpentine (fault) (width=5cm, dip, 70°)
80	L Δ L Δ L L Δ L Δ L	78.50			78.50~81.80m sheared zone, small size breccia, (dark gray dunite and pale green serpentine)
		81.80	4.80	Sheared dunite	81.80~84.40m gray sludge (dark gray dunite, pale green serpentine, magnetite and chromite)
		84.40			84.40m~ dark gray, breccia size, φmax.=5cm, asbestos band is remarkable a small amount of chromite dot, pale green serpentine in cracks
	L L L L L L L L L		1.90	Dunite	86.60m chromite dot band (dip 70°), breccia size, φmax=15cm
90		90.80			
		91.10	1.30		90.80~91.10m gray sludge
100					

Fig. 5-13 Geological log of TJ-4

Drill hole No.	TJ-4	Depth	0.00m ~50.15m	Date	12. Aug. '79 / 14. Sep. '79	Scale	1:200	Co-ordinates	27.216 N / 7.660 E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m				Serpentinite	0.00~10.65m gray sludge, serpentine and hydromagnesite are abundant
10		10.65			massive brownish gray, serpentinized dunite velvet of white hydromagnesite and thin band of white asbestos
					11.00m fault (dip; 30°) 11.90m pale green serpentine (fault, dip; 40°) 14.10m fault (dip, 30°)
				Dunite	14.50m chromite dotted band (dip, 25°) 15.50m magnetite band (width; 2mm)
					18.30m pale green serpentine (fault, dip, 50°)
20		20.10 20.40	8.85	Pyroxenite	pale greenish gray pyroxenite containing magnetite (width, 4mm)
				Dunite	gray breccia size; φmax=10cm
		24.00 24.50	3.50	Clay	grayish white clay (fault)
				Sheared dunite	small breccia size, φmax=2cm
		27.40 28.40			27.40~28.40m gray sludge small breccia size; φmax=5cm
30		31.50	3.05		31.50~32.00m gray sludge
		32.00 33.00		Sheared dunite	32.00~33.00m small breccia size
		34.60			33.00~34.60m gray sludge
				Sheared dunite	small breccia size; φmax=5cm gray clay, small brecciated dunite (φmax=10cm, average=1cm) and pale green serpentine
40			3.25		
		48.50			
		49.25	4.50		48.50~49.25m gray sludge gray breccia size; φmax=7cm
50		50.15			
60					
70					
80					
90					
100					

Fig.5-14 Geological log of TJ-5

Drill hole No.	TJ-5	Depth	000m ~102.20m	Date	9. Sep.'79 / 3. Oct.'79	Scale	1:200	Co-ordinates	26.888N / 7.000E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m					
10				Dunite	brownish gray sludge composed of serpentinized dunite
20					
30					
		34.85		Sheared dunite	34.85~42.80m gray sludge containing serpentine, uvarovite, magnetite and chromite
40		42.80			dark gray breccia size; φ max.= 4cm
		47.15		Clay	gray clay ≫ serpentine + dark gray dunite breccia
		47.55			
		48.50		Dunite	dark gray, serpentinized dunite
50			4.20	Sheared dunite	whitish gray clay, ploe green serpentine and brecciated dunite (φ max.=10cm)
		53.50			53.50~53.75m gray sludge
		53.75			53.75~ dark gray serpentinized dunite with thin asbestos band and chromite dot
		56.50			54.50~56.50m gray sludge
		57.30			56.50~57.30m disseminated chromite band (width. 2cm)
			2.00		57.30~59.60m gray sludge
60		59.60			59.60~60.10m disseminated chromite
		60.10			60.10~60.40m gray sludge with abundant magnetite
		60.40			60.40~60.50m disseminated chromite
		60.50		Dunite	60.50~62.90m dark gray, asbestos band, partly disseminated chromite
		62.90			62.90~63.15m gray sludge
		63.15			63.15~65.50m disseminated chromite (width, 2cm)
		65.50			
		66.20			65.50~66.20m gray sludge, pale green serpentine is abundant
		67.00	5.95		
		67.75			gray breccia size; φ max.= 5cm
70		70.50			
		74.35		Sheared dunite	70.50~ gray clay, serpentine and gray dunite
		74.55			74.35~74.55m a small amount of disseminated chromite
		75.45			
		77.50		Dunite	75.45m~75.90m a small amount of disseminated chromite (fault) (dip. 40°)
		79.90		Sheared dunite	
80		81.30	11.30	Dunite	dark gray serpetinized dunite with chromite band (dip; 70°)
		82.50			81.30~ dark gray dunite, breccia size; φ max.=3m
		83.20			82.50~83.20m pale green~gray sludge
		87.00		Sheared dunite	
		87.55			87.00~87.55m gray sludge
		89.70			brecciated, dark gray dunite with asbestos band
90		90.50	6.70	Dunite	89.70~90.50m dark gray serpentinized dunite
					90.50~ dark gray serpentinized dunite, pale green serpentine and whitish gray clay
		96.50		Sheared dunite	strongly sheared zone, small breccia size, φ max.=2~3cm
100		99.90			99.90~100.75m gray sludge, pale green serpentine is aburdant.
		100.75			101.00~101.90m gray sludge
		101.00			101.90~102.20m sheared zone, dark gray dunite, gray clay, pale green serpentine and a small amount of chromite dot
		101.90	7.00		
		102.20			

Fig. 5-15 Geological log of TJ-6

Drill hole No.	TJ-6	Depth	0.00m ~52.10m	Date	4. Sep.'79 / 3. Oct. '79	Scale	1:200	Co-ordinates	26.926N / 7.245E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m					
10					
				Serpentinite	gray sludge composed of pale green serpentine and gray sepentinized dunite containing hydromagnesite, a small amount of magnetite and chromite
20					
30					
	L L L L L	30.53		Sheared dunite	pale green serpentine is abundant, a small amount of chromite and magnetite
	L L L	32.50		Dunite	32.50-34.50m gray serpentinized dunite with hydromagnesite veinlet in cracks abundant asbestos band, a small amount of chromite and magnetite
	L L L L L	34.50			
	L L L L L	36.95	3.75	Sheared dunite	gray clay and breccia (ϕ_{max} = 5cm) with a small amount of chromite 3695-4060m gray sludge with pale green serpentine and gray serpentinized dunite
40		40.60			4060-41.30m breccia size, ϕ_{max} = 7cm
	L L L L L	41.30	0.10		41.30-41.95m gray sludge with pale green serpentine and gray dunite
	L L L L L	41.95			41.95m~ gray serpentinized dunite with hydromagnesite veinlet in cracks (brecciated core) thin band of asbestos is abundant, a small amout of chromite
		43.75	1.50		
50				Dunite	43.75-52.10m gray sludge with pale green serpentine, gray serpentinized dunite, abundant magnetite and a small amount of chromite
		52.10	0		
60					
70					
80					
90					
100					

Fig.5-16 Geological log of TJ-7

Drill hole No.	TJ-7	Depth	0.00m ~22.40m	Date	19.Sep.'79 / 2.Oct.'79	Scale	1:200	Co-ordinates	27.125N / 7.655E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m					brown gray sludge
				Sheared dunite	
10					
	LALAL	12.20	0.80	Sheared dunite	gray serpentinized dunite, pale green serpentine, white hydromagnesite, and white-gray clay
	LALAL				16.20m sub-round brecciated chromite ore is observed in clay
	LALAL				17.30m~ brecciated, pale brown-gray serpentinized dunite (φ max.=10cm) with a minor amount of disseminated chromite
20	LALAL		2.05		
	LALAL	22.40	0.70		
30					
40					
50					
60					
70					
80					
90					
100					

Fig.5-17 Geological log of TJ-8

Drill hole No.	TJ-8	Depth	0.00m ~82.50m	Date	16. Sep.'79 / 2. Oct.'79	Scale	1:200	Co-ordinates	26.600N / 7.035E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m					
10				Dunite	gray sludge composed of serpentinized dunite
20					
30					
		30.30			
				Sheared dunite	sheared zone composed of dark gray dunite breccia, pale green serpentine and a small amount of chromite dot
		32.85			
			2.80	Dunite	dark gray massive dunite with chromite dot
		34.75			
					34.75~37.30m gray sludge, pale green serpentine is abundant
		37.30			
			1.40		37.30m~ pale green serpentine, thin bands of asbestos and magnetite.
40		38.70			
				Dunite	dark gray dunite with thin band of asbestos
		45.75	4.75		
		47.45		Sheared dunite	45.70~47.45m gray sludge
		48.50			small brecciated dunite and pale green serpentine.
50			1.60		
		52.05			48.50-52.05m gray sludge with pale green serpentine
				Dunite	dark gray serpentinized dunite breccia size ; 7cm, asbetos band (dip ; 10°)
		54.30			
		55.55		Sheared dunite	gray small brecciated dunite and white clay
			2.70		dark gray dunite with thin band of asbestos
60					59.50m chromite dot band (width , 1cm , dip ; 60°)
			5.70	Dunite	64.40m~ massive dunite with asbestos band (dip ; 20°)
					66.40,68.00,69.00m magnetite dot band (width;1-2cm, dip;30°-50°)
70		69.20			
			6.95	Sheared dunite	breccia ; dunite (ϕmax.=5cm) pale green serpentine and whitish gray clay
		73.20			73.20m~ dark gray serpentinized dunite (breccia size, ϕmax.=10cm) thin band of asbestos is abundant.
					74.65-75.00m a small amout of chromite and magnetite dot in asbestos band thin band of asbestos (dip , 30°) pale green serpentine in cracks
80			4.40	Dunite	
					80.20m a minor amount of kaemmererite in cracks
		82.50	1.95		82.50m
90					
100					

Fig. 5-18 Geological log of TJ-9

Drill hole No.	TJ – 9	Depth	0.00m ~ 47.40 m	Date	17 July '80 / 30 July '80	Scale	1 : 200	Co-ordinates	26.960N / 7.342 E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m				Grey sludge	Foliated serpentinite
		9.15			
10		10.25	0.20	Serpentinite	Foliated serpentinite with a large amount of chrysotile
			0.80		
				Dunite	Brecciated serpentinized dunite with a large amount of chrysotile
20		20.50	2.09		
		23.75	1.60		Serpentinized dunite (pale green serpentine in cracks)
		25.10		Grey sludge	Foliated serpentinite
		26.50		Serpentinite	Foliated serpentinite with a large amount of chrysotile
		28.15	1.90	Dunite	Serpentinized dunite (chrysotile in cracks and magnetite dot)
		29.15	0.70	Chromite ore	Massive chromite ore Cr_2O_3 : 31.92 %
30					
			2.70		
					36.00, chrysotile (x-ray diffraction)
			2.35	Serpentinite	Foliated serpentinite with a large amount of chrysotile
40					
			1.10		
					47.00 lizardite (x-ray diffraction)
		47.40	1.50		
50					
		38.25	14.9	39 %	
60					
70					
80					
90					
100					

Fig. 5-19 Geological log of TJ-10

Drill hole No.	TJ – 10	Depth	0.00m ~ 62.50 m	Date	21 st July '80 ~ 8 Sep. '80	Scale	1 : 200	Co-ordinates	26. 891 N / 6 891 E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m				Grey sludge	Foliated serpentinite
		9.15			
10			2.00	Serpentinite	Foliated serpentinite with a small amount of magnetite and chromite 15.00 lizardite (x-ray diffraction)
		17.00			
		19.80	3.30	Dunite	Dark grey brecciated serpentinized dunite
20				Grey sludge	Foliated serpentinite
		22.85			26.00 chrysotile (x-ray diffraction)
				Dunite	Dark grey, massive serpentinized dunite with chrysotile veinlets 28.00 chrysotile (x ray diffraction)
			3.00		
30		31.00			
		32.00		Serpentinite	Foliated serpentinite with a large amount of chrysotile
			6.10		34 – 35.70 magnetite veinlets are conspicuous
					35.30 lizardite (x-ray diffraction) 37.60 (width 5cm) chromite dot & kammererite
40			5.16		
				Dunite	Dark grey, massive serpentinized dunite with a large amount of lizardite
			3.95		
50			3.00		
					53.80 lizardite (x-ray diffraction)
		56.40	6.10		
					passing through gallery
60		59.45		Dunite	Brecciated serpentinized dunite
		62.00	1.50	Chromite ore	Chromite ore (soft, powder) Cr_2O_3 44.20%
		62.50			
70					
80					
90					
100					

Fig. 5-20 Geological log of TJ-11

Drill hole No.	TJ-11	Depth	0.00m ~ 81.40 m	Date	23 July, '80 ~ 1 AUG., '80	Scale	1:200	Co-ordinates	26,864 N, 7,206 E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m				Grey sludge	
		9.15			
10			2.70	Serpentinite	Foliated serpentinite with a large amount of chrysotile
		14.15			
			5.65	Dunite	Brecciated serpentinized dunite
		17.40			
				Dunite	Serpentinized dunite (chrysotile veinlets are conspicuous) magnetite dot
20					20.50 chrysotile (x-ray diffraction)
		21.80	4.25		
				Dunite	23.60 lizardite (x-ray diffraction)
			2.95		Sheared dunite, 24.05; chromite band (width, 1.5 cm)
		25.75			
				Dunite	26.55 chrysotile (x-ray diffraction)
30					Serpentinized dunite with magnetite
			9.75		31.3 chromite band (width; 1 cm)
					32.85 chromite band (width, 2 cm)
					34.00 lizardite (x-ray diffraction)
			4.15		35.40 disseminated chromite (width 10 cm)
		36.00			
				Chromite ore	Disseminated chromite ore with chrysotile veinlets Cr_2O_3; 28.84 %
		38.75	2.85		
40					
			3.40	Dunite	Serpentinized dunite
					43.00 disseminated chromite width, 30 cm Cr_2O_3 25% (estimated)
			4.25		43.90 " " " 20 cm 20% "
					44.85 " " " 35 cm 15% "
50					48.10 " " " 20 cm 20% "
		50.95	3.80		
		52.00	0.30	Dunite	Sheared dunite
				Dunite	Serpentinized dunite 53.3 chromite dot (1 cm)
		53.80	1.70		
				Dunite	Sheared dunite 54.7 chromite dot (3 cm)
		56.00	1.65		
				Dunite	Serpentinized dunite
		59.00	3.80		
60					
				Dunite	Brecciated serpentinized dunite
			2.35		63.00 lizardite (x-ray diffraction)
		63.15		Dunite	Serpentinized dunite 64.40~66.35 chromite dot
		66.35			
		66.85		Chromite ore	Disseminated chromite ore with kammererite Cr_2O_3, 28.48 %
			3.55		
				Dunite	Brecciated serpentinized dunite with chrysotile veinlet
70		71.20			
			4.30		
				Dunite	Serpentinized dunite
80					
		81.40	9.10		
90					
		72.25	64.5	89 %	
100					

Fig. 5-21 Geological log of TJ-12

Drill hole No.	TJ-12	Depth	0.00m ~106.00 m	Date	2nd AUG.'80 / 28 AUG.'80	Scale	1:200	Co-ordinates	26.864 N / 7.206 E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m					
				Grey sludge	Foliated serpentinite
10		12.00			
			5.10	Serpentinite	Foliated serpentinite with a large amount of chrysotile
20		20.80	3.75		
				Dunite	Brecciated serpentinized dunite
		26.70	3.80		
30			3.35		26.7~37.20 Chrysotile is conspicuous
			3.70	Dunite	Serpentinized dunite with a small amount of chromite and magnetite
40			4.55		37.20~46.60 antigorite is conspicuous
		46.60	4.00		
			2.80	Chromite ore	Massive chromite ore with koemmererite Cr_2O_3 : 36.69 % dip: 60°
50		51.00	3.75	Dunite	51.10 disseminated chromite (width: 5cm) Serpentinized dunite with chrysotile veinlets
		56.70	3.75		55.10 chromite band (width: 2 cm)
				Dunite	Brecciated serpentinized dunite
60		59.25	4.25	Dunite	Massive serpentinized dunite with a small amount of magnetite
		64.20			
			4.95		Brecciated serpentinized dunite
70			6.10	Dunite	
			5.05		
		78.00		Clay	white clay
80		80.60	3.75		
			2.80	Chromite ore	Brecciated serpentinized dunite with disseminated chromite Cr_2O_3: 24.45 %
		85.30		Dunite	Massive serpentinized dunite
		87.40		Dunite	Brecciated serpentinized dunite
		88.20		Chromite ore	Massive chromite ore with koemmererite (dip: 50°) Cr_2O_3: 40.85%
90		89.30	6.10		
			6.10	Dunite	Serpentinized dunite with antigorite
100			5.95		
		106	2.25		

94 85.85 91 %

Fig. 5-22 Geological log of TJ-13

Drill hole No.	TJ-13	Depth	0.00m ~63.95 m	Date	2nd AUG.'80 / 27 AUG.,'80	Scale	1:200	Co-ordinates	26.960 N / 7.342 E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m					
				Grey sludge	
10					
		12.30			
			1.00		
20					
			2.35	Serpentinite	Foliated serpentinite with a large amount of chrysotile and hydromagnesite
			5.65		
30					
			2.45		
		32.45			
			2.85	Dunite	Brecciated serpentinized dunite with grey clay (chrysotile ?)
		35.45			
	A			Chromite ore	Massive chromite zone — A 35.45—40.50 Cr_2O_3 26.84 %; B 40.50~42.00 Cr_2O_3 12.76 %; gradually change
40	B		5.00		Disseminated chromite zone
		42.00			
				Serpentinite	Foliated serpentinite
		48.70	6.25		
50					
				Dunite	Brecciated serpentinized dunite
		53.80	2.55		
				Serpentinite	Foliated serpentinite
		58.90	2.30		
60					
				Brown sludge	Foliated serpentinite
		63.95			
70					
		51.65	31.40	61 %	
80					
90					
100					

Fig. 5-23 Geological log of TJ-14

Drill hole No.	TJ – 14	Depth	0.00m ~ 100.30 m	Date	21 Sep., '80 – 29 Sep., '80	Scale	1 : 200	Co-ordinates	26.882 N / 7.198 E

Depth	Column	Boundary depth	Core (m)	Rock name	Remarks
m					
				Grey sludge	Foliated serpentinite
10					
		15.15			
				Serpentinite	Foliated serpentinite
		19.00	2.80		
20				Dunite	Brecciated serpentinized dunite -25.30 Chromite vein (width, 2 cm, dip, 50°)
		26.60	5.60		
		28.40		Serpentinite	Foliated serpentinite with a large amount of lizardite
30				Dunite	Pale grey, massive serpentinized dunite with a small amount of magnetite and chrysotile veinlets
		32.60	6.10		
		34.50		Serpentinite	Foliated serpentinite
			6.10	Dunite	Dark grey, massive serpentinized dunite with a small amount of magnetite and chrysotile veinlets
40		39.80			
			6.10		
				Serpentinite	46.00 Chrysotile (X-ray diffraction) Foliated serpentinite
50			6.10		
		54.00			
			5.70	Dunite	Dark green, massive serpentinized dunite with a small amount of magnetite and antigorite
60					
			3.40		
		63.70			65.00 lizardite (X-ray diffraction)
				Chromite ore	Disseminated chromite ore Dip of boundary, 20° Cr_2O_3 32.44%
		67.35			
			6.10		
70					-69.50 } Chromite dot is conspicuous -71.30 }
			6.10		
				Dunite	Dark grey, massive serpentinized dunite with a small amount of chromite and chrysotile veinlets
80			6.10		
					84.00 lizardite (X-ray diffraction)
			6.10		
90					
					91.70 chrysotile (X-ray diffraction)
		92.00			
			6.10		
				Dunite	Brecciated serpentinized dunite with chrysotile veinlets
100		100.30	6.60		

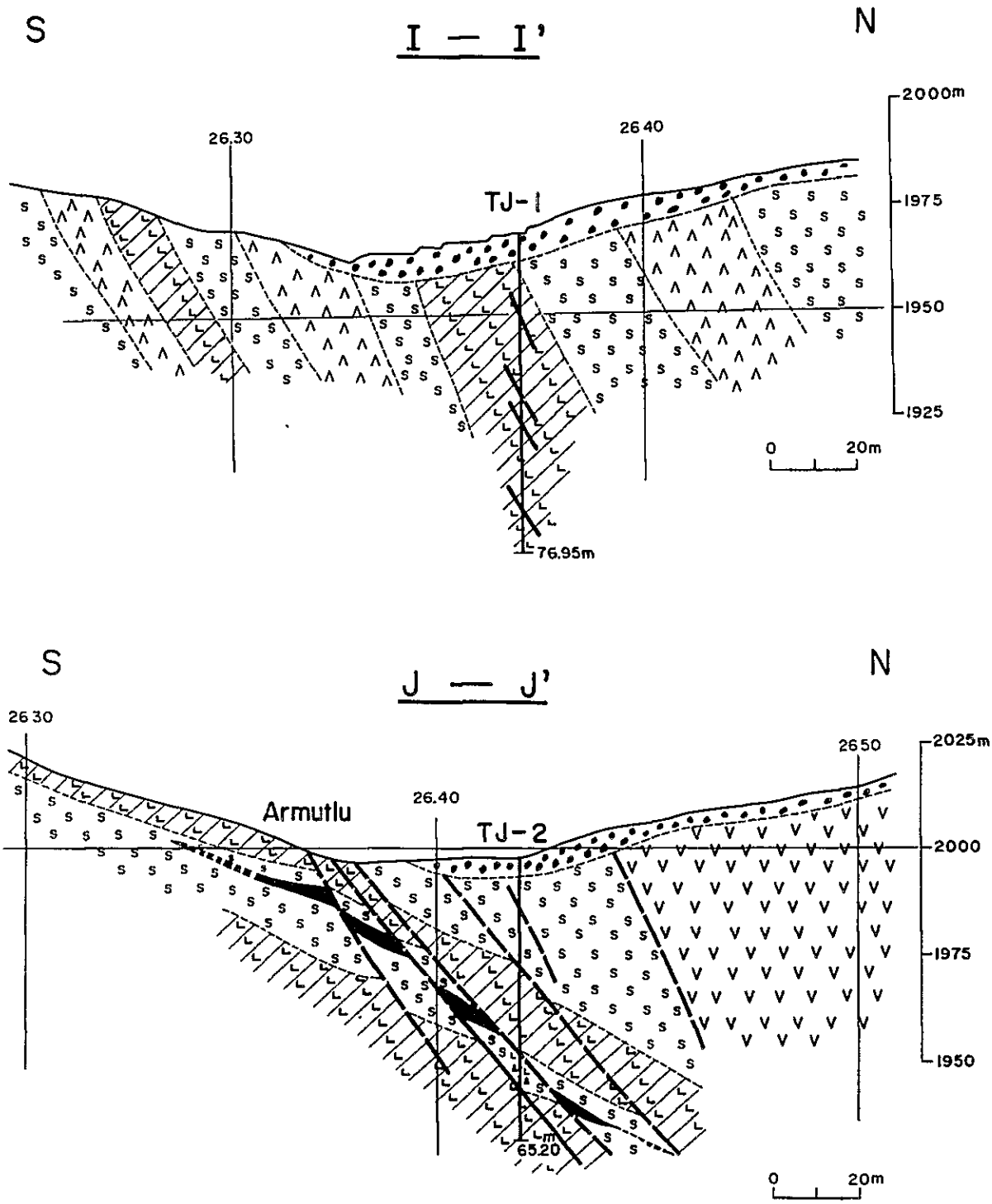


Fig. 5-24 Geological profile of TJ-1 & TJ-2

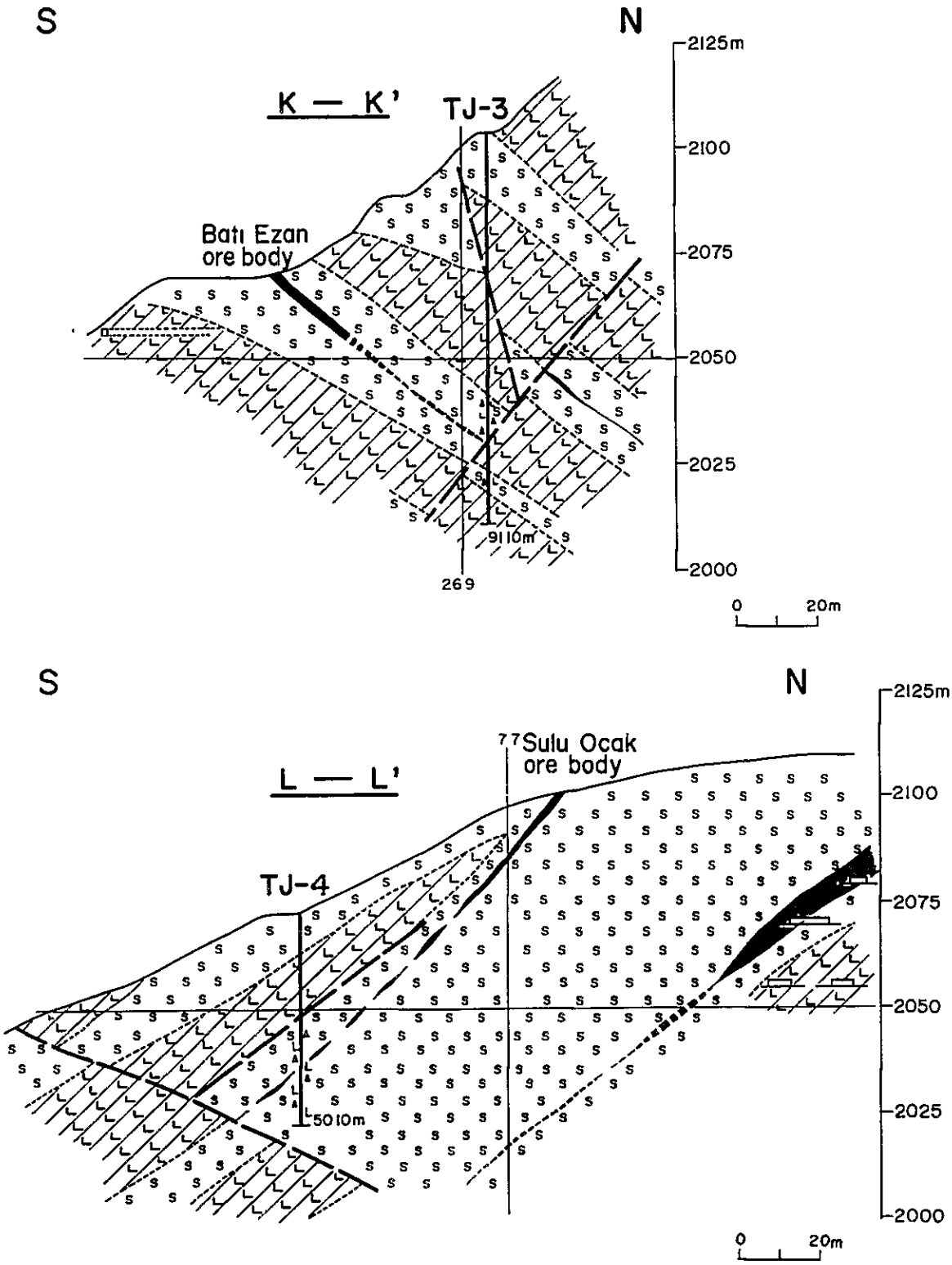


Fig. 5-25 Geological profile of TJ-3 & TJ-4

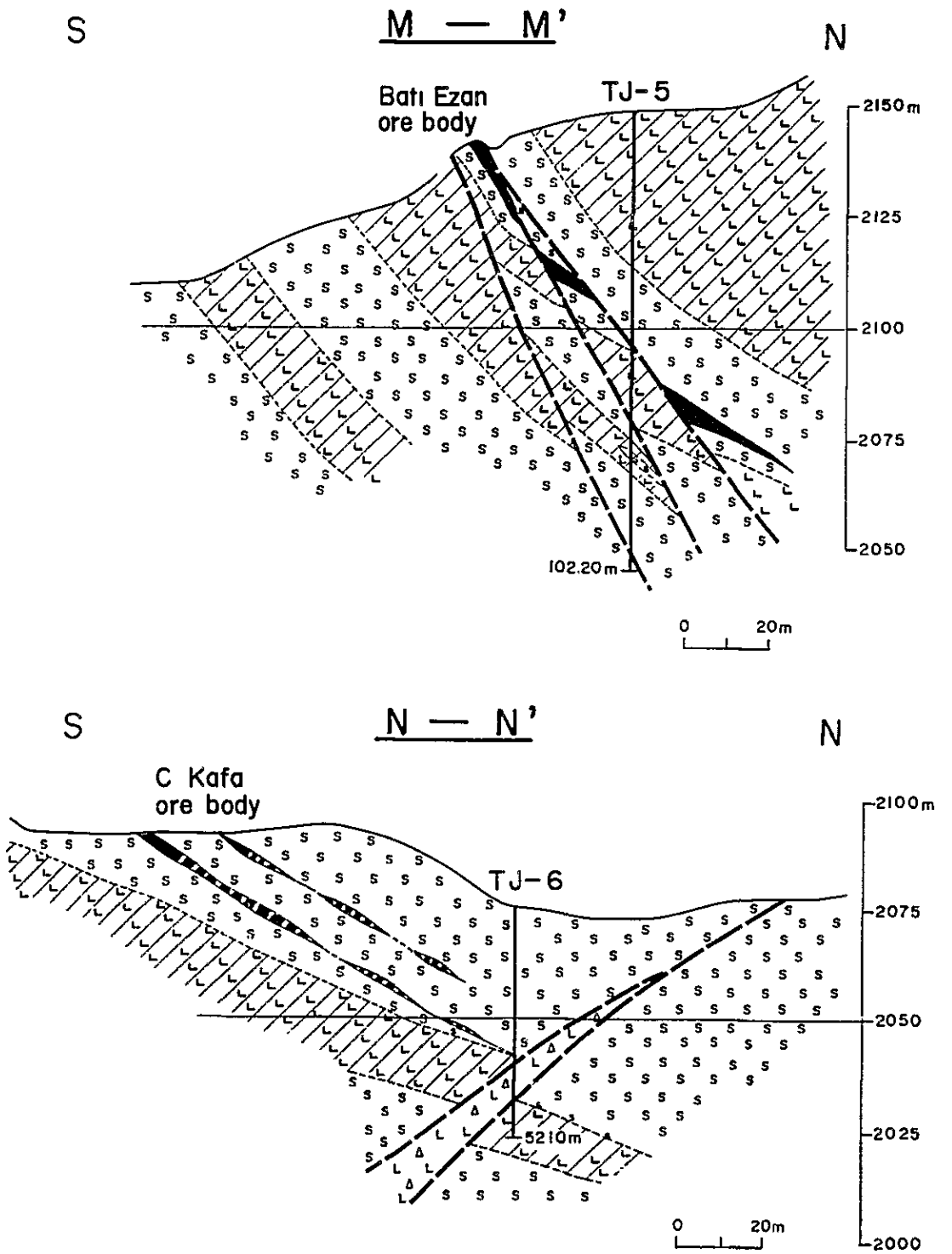


Fig. 5-26 Geological profile of TJ-5 & TJ-6

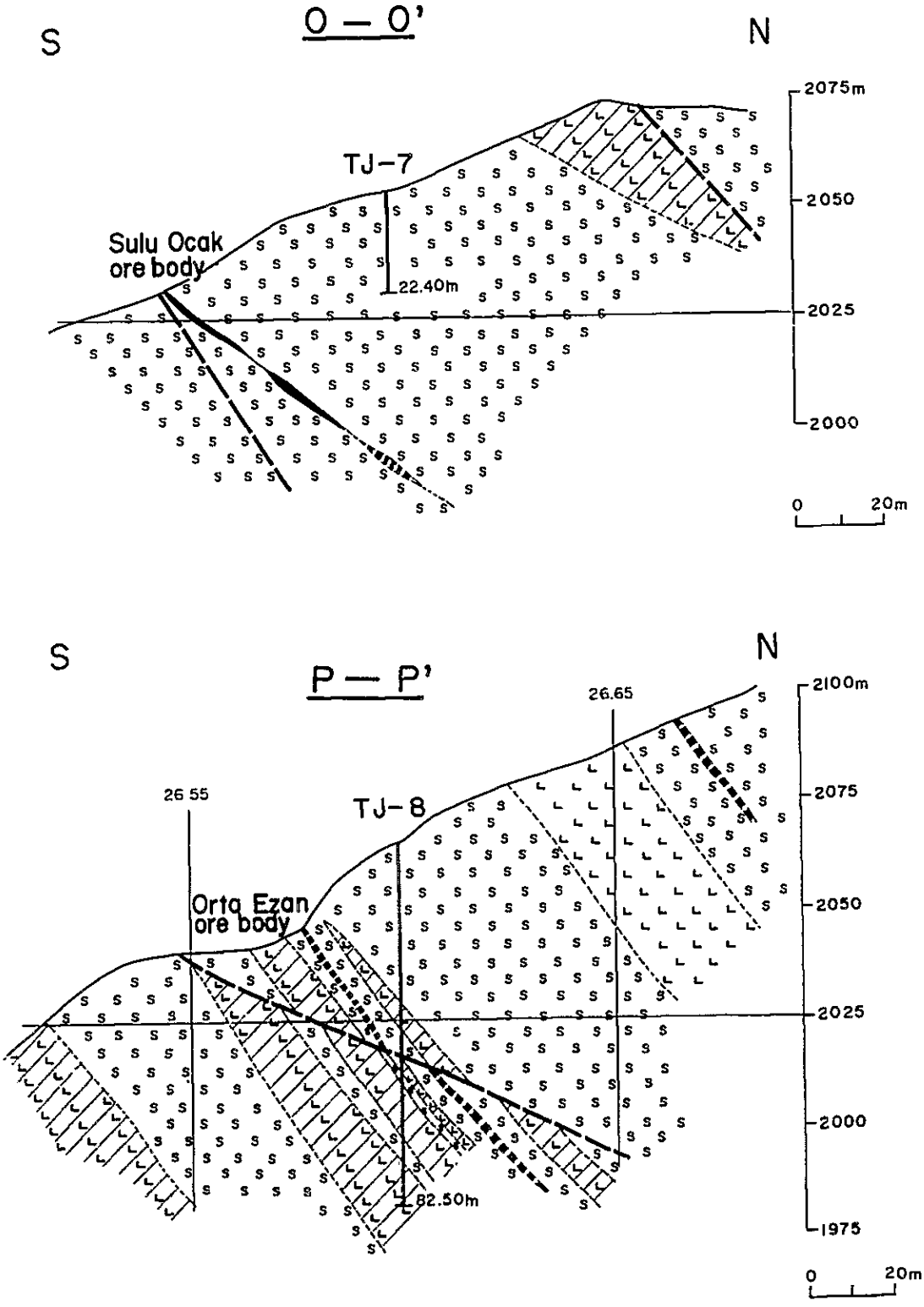


Fig. 5-27 Geological profile of TJ-7 & TJ-8

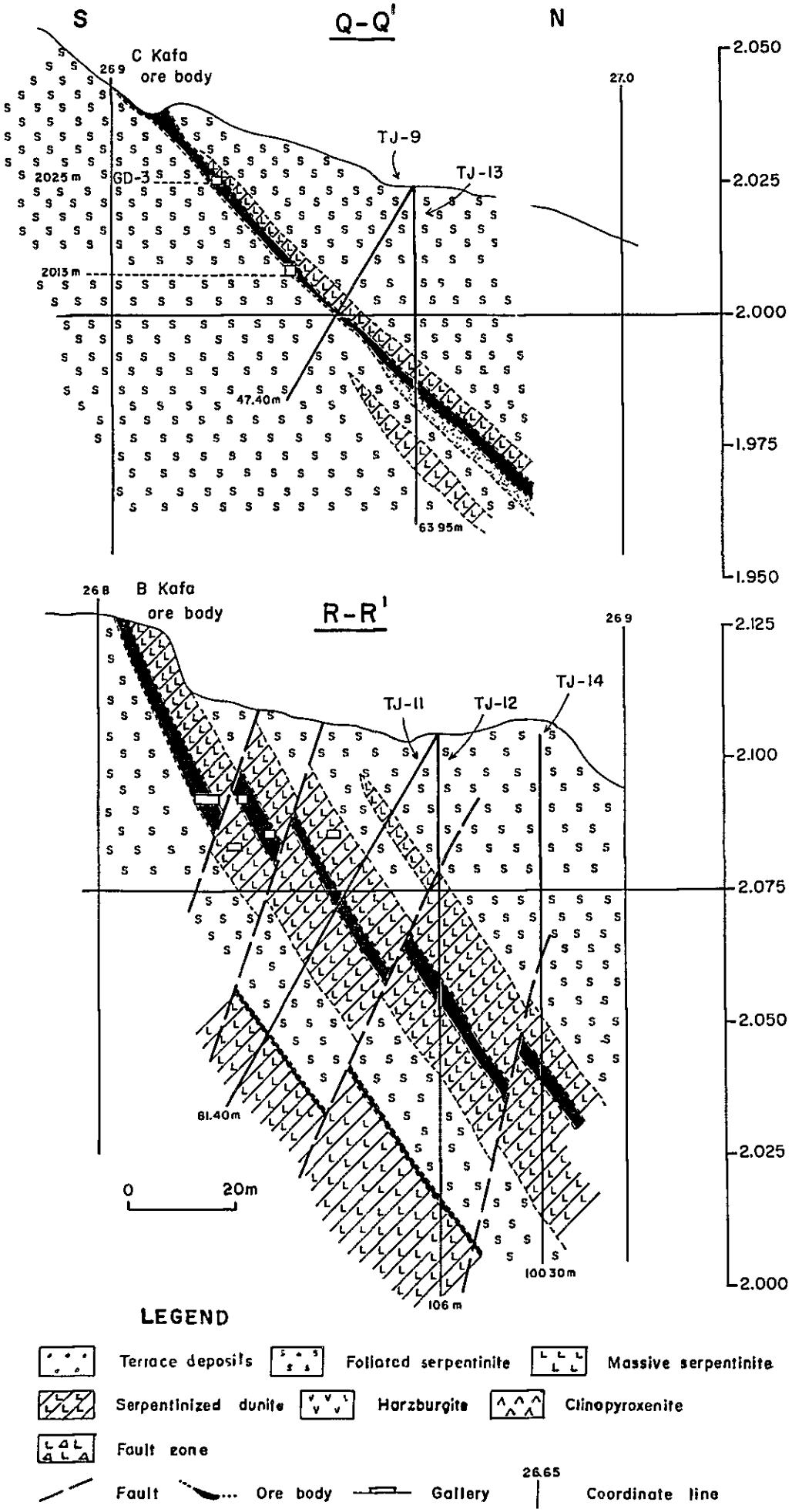


Fig. 5 - 28 Geological profile of TJ-9 ~ TJ - 14

Table 5-3 Results of Chemical Analysis
(Drill hole)

	Depth (m)	Width (m)	Core (m)	Cr_2O_3	FeO + Fe_2O_3	SiO_2	Al_2O_3	Mgo	Cr_2O_3 Average
TJ-9	28.15-29.15	1.00	0.60	31.92	17.58	14.68	8.26	24.40	31.92
TJ-11	36.00-36.25	0.25	0.25	24.91	12.37	19.28	8.20	30.13	
	36.25-37.45	1.20	1.20	26.84	12.52	17.14	9.32	29.24	28.84
	37.45-38.75	1.30	1.10	31.45	13.26	15.10	11.73	26.57	
	66.35-66.85	0.50	0.40	28.48	14.30	19.00	10.22	24.30	28.48
TJ-12	46.60-49.60	3.00	2.10	37.41	14.75	11.00	11.70	23.60	36.69
	49.60-51.00	1.40	1.05	35.14	15.00	15.06	11.90	21.86	
	80.60-81.60	1.00	1.00	27.18	14.30	17.60	6.38	28.47	
	81.60-83.05	1.45	1.45	19.51	12.10	21.48	6.13	32.60	24.45
	83.05-84.65	1.60	1.55	27.51	13.11	17.20	8.12	28.82	
	84.65-85.30	0.65	0.65	23.76	13.26	18.98	6.02	30.66	
	88.20-89.30	1.10	1.10	40.85	16.54	8.96	13.00	19.73	40.85
TJ-13	35.45-37.15	1.70	1.65	34.10	15.65	13.08	9.71	23.73	
	37.15-40.20	3.05	2.15	22.30	12.81	19.72	6.87	30.80	26.84
	40.20-40.50	0.30	0.30	31.89	15.10	13.42	10.00	25.91	
	40.50-42.00	1.50	1.50	12.76	10.43	26.60	3.73	36.52	12.76
TJ-14	63.70-64.35	0.55	0.50	30.95	14.42	16.50	9.45	24.60	
	64.35-65.35	1.00	1.00	32.25	14.32	14.00	10.64	24.82	32.44
	65.35-66.35	1.00	1.00	32.69	14.20	14.08	10.12	24.90	
	66.35-67.35	1.00	1.00	33.21	14.00	14.00	10.38	24.46	
TJ-10	62.00-62.50	0.50	0.13	44.20	17.85	7.90	11.85	17.25	44.20

Results: Ore horizon was intersected by the drill hole.

Interpretation: B Kafa orebody continues about 80 m below the outcrop of orebody.

5-8-3 Discussion of Drilling Results

The total drilling length was 542.6 meters in 1979 and 461.55 meters in 1980. Results of the drilling can be summarized as follows:

(1) Many faults were found in the hanging wall of the orebodies and sometimes cut the orebodies. Complicated dislocations were recognized in the vicinity of each orebody.

(2) Geology of Ezan and Coşan areas consists mainly of foliated serpentinite and serpentinized dunite, which is sheared by block movement of N-S system and tectonic lines of NEE-SWW direction.

(3) Although drill holes were planned in the hanging wall and below 50 meters from the outcrops, lower part of orebody was not intersected by the drill holes, due to the reasons given in (1) and (2).

(4) On the basis of 1979 drilling, drill holes were planned in the Batı Ezan, B Kafa and C Kafa, extension to dipside of each orebody was intersected by all drill holes.

5-9 Comparison with the 1978 Results

The results in 1978 are compared with the results in this year's survey.

The results are as follows:

(1) In Ezan area, serpentinite as used in 1978, was divided into two rock types in 1979; foliated serpentinite and serpentinized dunite. The division will facilitate determining the trend of the ore horizon.

(2) Direction of most of pyroxenite is parallel to serpentinized dunite and the ore deposits. Pyroxenite is commonly interbedded with serpentinized dunite.

(3) Continuity of the deposits could be defined by trench.

(4) As a result of fourteen drill holes, it became clear that the ore deposits are cut by many faults.
The lower part of orebody could be intersected by the six drill holes.

(5) Massive chromite occurred mostly in sheared zones and fault zones.

(6) Cumulate structure is frequently present in disseminated ores in the Coşan and Ezan mine areas.

(7) Ultrabasic rocks in the Ezan areas show block dislocations.

(8) Coşan ore deposits consist of only one horizon, directions of chromite banding were mostly identical with the directions of orebodies.

5-10 Conclusions

The investigation in 1979 is summarized as follows:

(1) The largest part of the area is composed of ophiolite belt, which intrudes into the Meyramdağ limestone of Upper most Jurassic - Lower Cretaceous, and is overlain by the Kopdağ limestone of Miocene - Pliocene. Ophiolite belt is divided into three zones, Coşan and Ezan mine areas are in the northern dunite zone, which lies in the middle part of the belt. The zone consists mainly of serpentinite of dunite origin. The serpentinite is divided into massive serpentinite, foliated serpentinite and serpentinized dunite, based on features observed in the field. Chromite ore deposits are embedded in the foliated serpentinite. The ore in the area is mainly disseminated, with a small amount of associated massive ore, sometimes nodular and banded types of ore were also observed.

(2) Faults of N-S system causing block movement and NEE - SWW faults along major tectonic lines are observed in the Ezan area, and faults of irregular direction in the Coşan area. The former contains at least three ore horizons, but the latter only one ore horizon. Cumulate structure is present in the disseminated ore.

(3) Chrome minerals consist of chromite, kaemmererite, uvarovite. Ferritchromite is observed at the margin of and in the cracks in chromite, magnetite along cracks in chromite, and pyrite in the gangue minerals.

(4) As a result of X-ray diffraction, minerals of the serpentine group and clay are inferred as follows:

Massive serpentinite	Chrysotile, lizardite and antigorite
Serpentinized dunite	Chrysotile, antigorite and brucite
Foliated serpentinite	Chrysotile, antigorite, hydromagnesite, brucite and pyroaurite (in Ezan mine) Chrysotile (in Coşan mine)