GENERAL GEOLOGICAL SETTING AND THE STRUCTURAL FEATURES OF THE GULEMAN PERIDOTITE UNIT AND THE CHROMITE DEPOSITS (ELAZIĞ, EASTERN TURKEY)

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ABSTRACT. — The Guleman peridotite unit covering an area of about 200 km2 is made up of tectonite and cumulate rock groups. Tectonite forms 65 %, the remainder being cumulates. Cumulates broadly encircle and rest on tectonites. Both groups of rocks include chromite deposits but those found in tectonites are far more important than the others. The mineralogy and petrology of the peridotites is briefly described. A thick dunite unit in the Kef area is defined as a transition zone between cumulate and tectonite on the basis of field relations and textural features they exhibit. Batı Kef which is one of the major chromite deposit in the area is situated at the base of this thick dunite unit. Numbers of major chromite deposits are located in harzburgite with a thin dunite envelope around them. Chromite deposits in Guleman are classified as alpine or podiform type but they demonstrate extensive continuation along their strike as well as dip directions. The peridotile unit dealt with here presents rather orderly internal structural patterns. Layering and foliation in the peridotite are invariably found parallel to each other. Chromite bodies which have primary contact relations with the host peridotite are also parallel to the layering and foliation, thus the chromite bodies themselves form an important element in the internal structure of the peridotite. Chromite deposits have been divided into groups on the basis of the local lithological and structural characters of the host peridotite and the characteristic features of the chromite deposits themselves. Some of these chromite deposits are described and their relations to the host peridotite is discussed.

INTRODUCTION

The Guleman area of Elazığ in Eastern Turkey is one the most important chrome ore producing districts in Turkey. Miningroperations have been continuing in the area since 1936, but ore production records from the area can only be traced back to 1941. According to these first records 73,996 tons of ore was produced from the area during the year 1941,66,478 tons of this was from Tosin and 7,518 tons was from Saysin pit. According to the information gathered from Etibank (state mining organization) about 6,300,000 ton chrome ore was produced from their concessions in the area during the years 1936-1981.

Production information could not be gathered from the private mining operations in the area. Records indicate that Turkey's chrome ore production was 22,183,406 ton during the period 1942-1979. These figures show that about 30 %.of Turkey's total chrome ore production came from the Guleman area.

In the early years the bulk of the ore was produced through open pit operations, but by 1950 when the amount of ore which could be mined by these methods became less, underground operations started. To day apart from limited and short term open pit operations on a few low grade deposits almost all production comes from underground operations. It is estimated that over 50,000 m of addits have been driven in the Guleman Etibank concessions since, 1950.

Chromite deposits and the areas around .Guleman have been subjected to various studies. Apart from the chromite deposits, interest has been directed to the area due to the fact that the region is situated along the boundary between the African and Eurasian plates, in the framework of the plate tectonic concept. The presence of copper sulphide mineralizations in Maden has also caused an additional interest in the district.

Some of the studies on Guleman chromite deposits are; Helke (1938, 1955, 1962); Kovenko (1940); Wijkerslooth (1947);Borchert (1952, 1962); Petrascheck (1958, 1959); Thayer (1964); Kendiroğlu (1972); İskit (1973); Ortalan and Erdem (1977); Koç and İzmir (1977); Turmus (1977); Özkan (1977, 1982); Engin (1979); Engin and Sümer (1982); Balcı et al. (1982).

Guleman chromite deposits have been studied in the framework of the MTA -Etibank joint project to find ways of locating concealed ore bodies, to explore the extensions of known deposits and to carry out reserve estimation studies. This paper presents some of the information and ideas developed during this project.

GENERAL GEOLOGICAL SETTING

The Guleman peridotite unit which includes chromite deposits is situated 50 km to the southeast of Elazığ (Fig. 1). On the 1:500 000 scale geological map of Turkey the Guleman peridotite unit appears enclosed in Upper Cretaceous flysch formation.

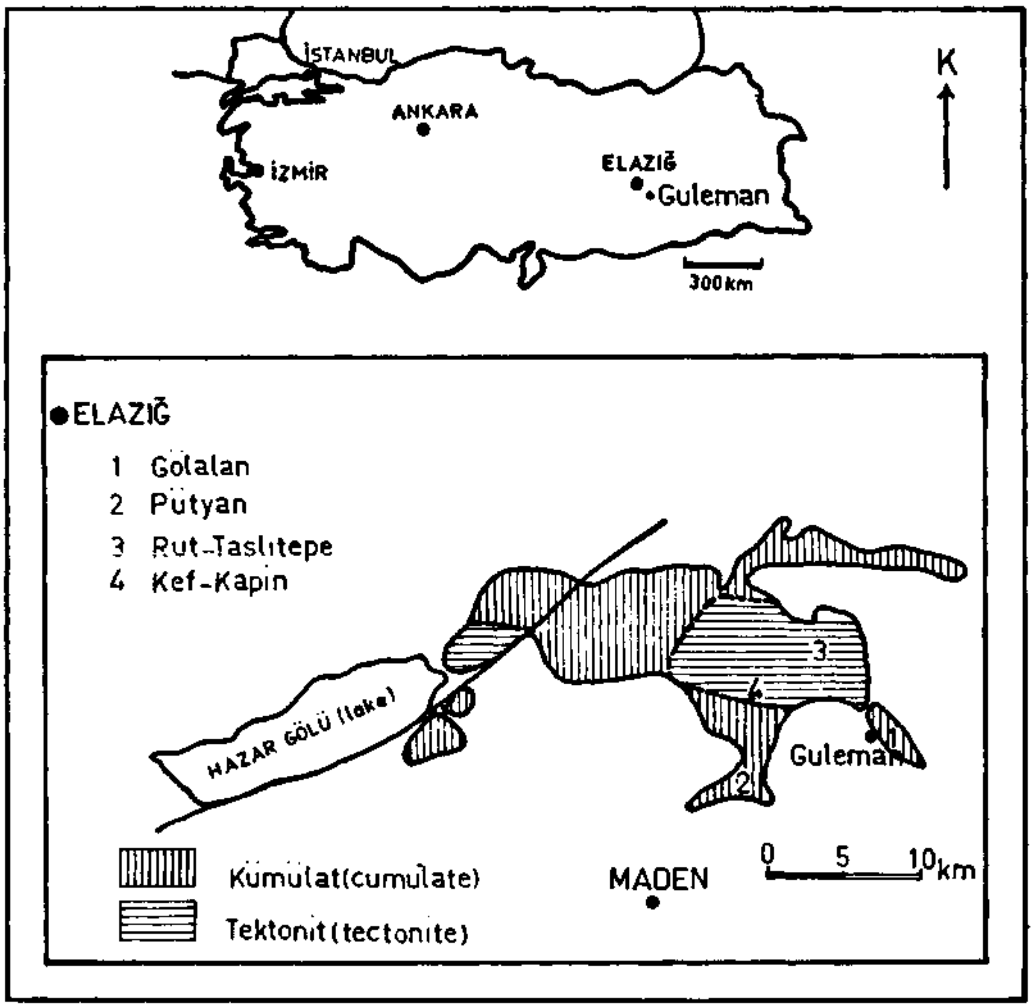

Fig. 1 - Location map of the Guleman area.
General outline of the Guleman peridotite unit and the disposition of the major rock groups.

The rock units present in and around Guleman can in general be divided into three structural units; a) Autocthonous units; b) Neoautocthonous units; c) Allocthonous units.

Lice formation (Schmidt, 1966) represents autocthonous units in the area. It is consists of siltstone and sandstone alternations with some limestone intercalations in places. This unit appears to have developed in flysch facies and does not include any volcanic rocks. The established age of the Lice formation is Lower Miocene.

Neoautocthonous units are characterized by loosely cemented, gently dipping-almost horizontal conglomerates and shallow water limestones with travertine fabric. Pliocene age is ascribed to the Neoautocthonous units because of the similarities present with those of known Pliocene age in the neighbourhood (Ercan et al., 1970).

Lithological and stratigraphical details of Autocthonous and Neoautocthonous units are given in some regional studies in the area (Ketin, 1946, 1948, Ercan et al., 1970; Erdoğan, 1977; Özkaya, 1978; Perinçek, 1979; Özkan, 1982).

Allocthonous units in the area are represented by rocks of the Guleman ophiolitic assemblage. As ultrabasic rocks cover large areas in the Guleman ophiolite assemblage, the main body of this assemblage will be termed the Guleman peridotite unit in this paper.

Overlying the Guleman peridotite lies what one might call a basal conglomerate of allocthonous Upper Cretaceous and Middle Eocene shallow sea sediments. This conglomerate unit passes into sandstone, marl, mudstone, red-green limestone which alternate upwards in the section. This unit also includes limestone olistoliths and lenses of basic volcanics in places. The whole unit is termed as «Lower flysch» by Ercan et al. (1970), «Maden group» by Erdoğan (1977) and «Ergani group» by Sungurlu (1980, personal communication). The same unit is also divided into sub units and mapped accordingly by Özkaya (1978) and Perinçek (1979).

Calc-schists and phyllites are the main metamorphic rocks in the district. They are found as tectonic slices on the peridotite and are considered to be the western extension of the Bitlis massif. They are believed to be Paleozoic-Mesozoic age (Özkan, 1982).

GULEMAN PERIDOTITE UNIT

The Guleman peridotite unit has an east-west elongation covering about 200 km^2 area. Golalan section at the southeastern end and Pütyan extension to the south are exceptions to the general orientation of the peridotite unit (Fig. I).

Rocks of the peridotite unit can be grouped as tectonites and cumulates. Harzburgite and dunite form the tectonite group. Dunite, wehrlite, pyroxenite, troctolite, and gabbroform the cumulate group of rocks. Limited amount of dyke rocks such as dolerite and plagiogranite are also present.

Cumulates appear to have been rather disturbed and encircle the tectonites irregularly. Cumulates cover about 70 km^2 and tectonites cover about 130 km^2 areas in the Guleman peridotite unit (Fig. I). Cumulate group rocks have alternating relations among themselves, but the boundaries are usually sheared.

The layering developed from the alternation in the percentage of various minerals present in the rocks is observed to be parallel to the lithological boundaries of cumulates.

As it was indicated above, tectonites form the central part of the peridotite unit. The boundary between the cumulates and the tectonites is marked with a fault. This boundary appears discernable even on the landsat images. Although in places the rocks are highly serpentinized in general the degree of serpentinization is less in the tectonites than in the cumulates.

CHROMITE DEPOSITS

From the evaluation of surface and underground geological data it is estimated that more than 500 chromite occurences are present in the Guleman peridotite unit. While some of these occurrences are individual bodies of various size others show continuation along their strike and dip directions with some interruptions. The length of these chromite bodies varies from several cm. to several hundred metres. Although the occurrence of chromite is known in the tectonites as well as in the cumulates. In general the occurences in the tectonites are larger and richer in their chromium content than the occurrences in the cumulates.

The Guleman peridotite unit can be divided into subgroups according to the nature of the deposits, lithological characteristics, geographical disposition and the structural position; a) Golalan; b) Pütyan; c) Rut-Taşlıtepe; d) Kefdağ-Kapin-Şabate.

Gölalan Section

This section is situated at the southeastern end of the peridotite unit covering about 6 km^2 (Fig. I). The peridotite body here has a generally NW-SE trend. The cumulate rocks such as dunite, wehrlite, pyroxenite, gabbro cover large areas. The relationship of these rock units to each other is rather complicated and the boundaries are mechanical. Serpentinization, brecciation and slickensides are commonly known. In places landslide topography has developed.

The rocks are usually fully serpentinized concealing the nature of the original rock type. On the other hand in these heavily serpentinized rocks the presence of bastite remains, indicate that some of the serpentinized rocks-were in fact harzburgite.

Records show that mining operations started in the area in 1936. Extensive mining was undertaken in Gölalan, Şimal yarması, Sosin, Taysin, Sitealtı and Kündikan locations. Approximately 65 chromite occurrences are known. Here the deposits are of irregular shape and of variable size. The average size of the ore bodies is estimated to be about 22 m X 4 m X 8 m.

The ore produced from this section was massive, high grade with large chromite crystals. Size of the crystals reaching 2-3 cm in many locations. The amount of silicate matrix (serpentinite) present in the deposits is rather small. This has resulted in the increase of chromium grade of the deposits. Although the average grade of the ore produced in this part can be said to be 48 % Cr_2O_3, grades reaching 54 % Cr_2O_3 are also commonly known.

The relationship of the ore bodies with the host rocks is complicated and the boundaries are mechanical. Accurate internal structural patterns of the peridotite could not be established mainly due to the extensive serpentinization, landslide topography and the melange character of the terrain. Although the general trend of the peridotite here is NW-SE, the orientation of the ore bodies is NE-SW (Ortalan and Erdem 1977).

Alpine type chromite deposits are relatively small and rarely produce more than 1.000.000 tons of ore from a single pod. Thayer (1964) says that there are about a dozen of this size deposits in the world. The Gölalan deposit in this part which produced about 1.200.000 tons of high grade massive ore from a pod which was about 180 m long and 50 m wide, has a special place among alpine type deposits.

As the ore produced from Gölalan was high grade and massive it was then possible to shape the chromite into brick forms to be used as refractory bricks in copper smelters of the near by copper mine in Maden (Fig.l). Several other smaller chromite bodies in Gölalan, near and under the main chromite pod were also discovered and mined (Yüngül, 1956; Ortalan and Erdem, 1977).

According to Etibank's records, ore production in Gölalan started in 1943 and continued until 1977. Production figures increased until 1961 but decreased during the years 1961-1977. Almost all of the deposits in the Gölalan section were mined by opencast mining methods with a limited a-mount of underground operations in places.

According to the data collected, during the years 1943-1977 about 2,000,000 tons of ore were produced from the deposits in the Gölalan section. There has been no mining in the area since 1978.

Pütyan Section

This section extends south like a spur from the main peridotite unit. Here like in the Gölalan section cumulate group rocks cover large areas. Dunite, wehrlite, pyroxenite and gabbro alternate but are of mapable size and have some degree of regularity. The characteristics of the rock types and their relations are similar to the ones in the Gölalan section.

There are about 15 chromite occurrences of various size. The occurrences have irregular pod shapes, they are mainly massive and brecciated. The average grade is about 45 % Cr_2O_3. The av-erage size of the chromite bodies is 7.5 m X 1.5 m x 2.5 m. Although the chromite bodies have mechanical contact relationship with the enclosing serpentinite, an E-W trend appears noticable from the disposition of chromite occurrences being parallel to the elongation of the individual chromite pods. On the other hand map patterns of wehrlite, dunite alternations in serpentinite also appear parallel to the orientation of chromite occurrences (Koç and İzmir, 1977). In this section chromite occurrences are also alligned parallel to the boundary with the surrounding rocks in the southern end of this spur like peridotite body.

Mining activities in this part have been rather limited. Because of some legal complications and relatively poor access about 2500 tons of high grade ore has been extracted and left stockpiled around the outcrops.

Apart from the differences in the size of the occurrences and the amount of ore extracted the Pütyan and Gölalan sections show many similarities in geological setting and chromite type. This makes Pütyan section potentially important for further chromite exploration.

Rut-Taşlıtepe Section

This section is situated in the eastern part of the peridotite unit (Fig. 1). The most important chromite deposits in the region are located in this part. According to production records about 2.200.000 tons of chromite were produced in this section during the 1950-1981 period.

The dominant rock type is harzburgite. Dunite appears as interlayered bands and thin dykes in the harzburgite. Although the rocks are rather fresh in general, the degree of serpentinization in-creases in places.

The harzburgites are coarse grained containing olivine and pyroxenes. The mineral grains usu-ally exceed 3-4 mm. The modal analysis of the harzburgite was calculated to be; 80-90 % olivine, 10-20 % pyroxene (mostly about 13 %) and about 1 % accessory chromite. The largest percentage of pyroxenes are orthopyroxenes but in every specimen at least 1 or 2 grains of clinopyroxenes are detectable.

The harzburgites in this part are characterized by their low pyroxene content. Well developed cleavage traces in olivines make it difficult to distinguish olivine from pyroxenes in the fresh hand specimens. The distinction is easier in the slightly serpentinized rocks.

Olivines and pyroxenes in the harzburgites show sinusoidal boundary relations in thin sections. Deformation lamellae in olivines and kink bands in orthopyroxenes are quite common. Mosaic texture resulted from the recrystallization of olivines can also be seen in most samples. Chromite grains are commonly corroded. Although elongation can not easily be detected in olivines and pyroxenes, foliation can usually be measured from the elongation of chromite grains in the harzburgite.

Harzburgite is a tectonite group rock. All the textural and structural features mentioned here are common characteristics of this group of rocks (Ragan, 1967; Nicolas et al., 1973; Menzies, 1973; England and Davies, 1973; Coleman, 1977; Dick, 1977). Some of the recrystallized olivines exhibiting the mosaic texture partly encircle the large crystals. They also have deformation lamellae, suggesting that the plastic deformation process which caused the recrystallization and the development of deformation lamellae in olivines and the kink bands in orthopyroxenes to a limited extent still continued after the development of the mosaic texture. Clinopyroxene exsolution lamellae in the drthopyroxenes parallel to the (110) cleavage traces are seen in places.

Dunite appears interlayered with the harzburgite. Although the thickness of the dunite bands may be as much as 6-7 m and continuation along the strike direction 50 m, the bands and lenses are more usually only a few cm thick and several m long. Dunite bands sometimes have graditional and sometimes sharp but primary contact relationship with the harzburgite. Dunites defined here have over 95 % olivine.

In the Rut-Taşlıtepe section there is a very prominantly displayed internal structure striking N-S, dipping west with 35-°40° (Fig. 2). Layering is identified by the chromite segregations and from the alternations of olivine and pyroxene rich parts. Foliations are measured from the elongation of chromite grains form the major internal structural elements in the area. As the amount of pyroxene present in the harzburgite in general is'relatively small (about 13 %), layering developed from the alternation of pyroxene and olivine rich parts is not well marked in some parts. Most of the layerings marked on the geological map are measured from the chromite segregations (Fig. 2).

Some of these layerings may not be easily identified in the field but when the sun is at a suitable angle they can be seen from a distance because of the topographical features developed on them, such as olivine rich parts being eroded more and pyroxene rich parts forming the ridges. Layerings and foliations appear to be parallel.

As their positions form a structural element itself, dunite bands and lenses are also parallel to the internal structure of the peridotite.

The internal structural pattern of the peridotite in this part does not show marked irregularities. Because of this no major rotational movement is ascribed to the faults here.

Apart from their economical importance the chromite deposits in the Rut-Taşlıtepe area also have characteristic structural importance. Chromite deposits here are also aligned parallel to the internal structure of the peridotite in this part.

Chromite bodies in the outcrops show continuations along their strike directions forming distinct ore zones. From the correlation of surface and underground data major ore zones can be given as; (a) Rut; (b) Orta Lasir; (c) Uç Lasir; (d) Tepebaşı; (e) Uzundamar 2; (f) Uzundamar 1; (g) Yunuslar; (h) Ayıdamar; (i) Batı Tenkella; (j) Doğu Tenkella (Fig. 2).

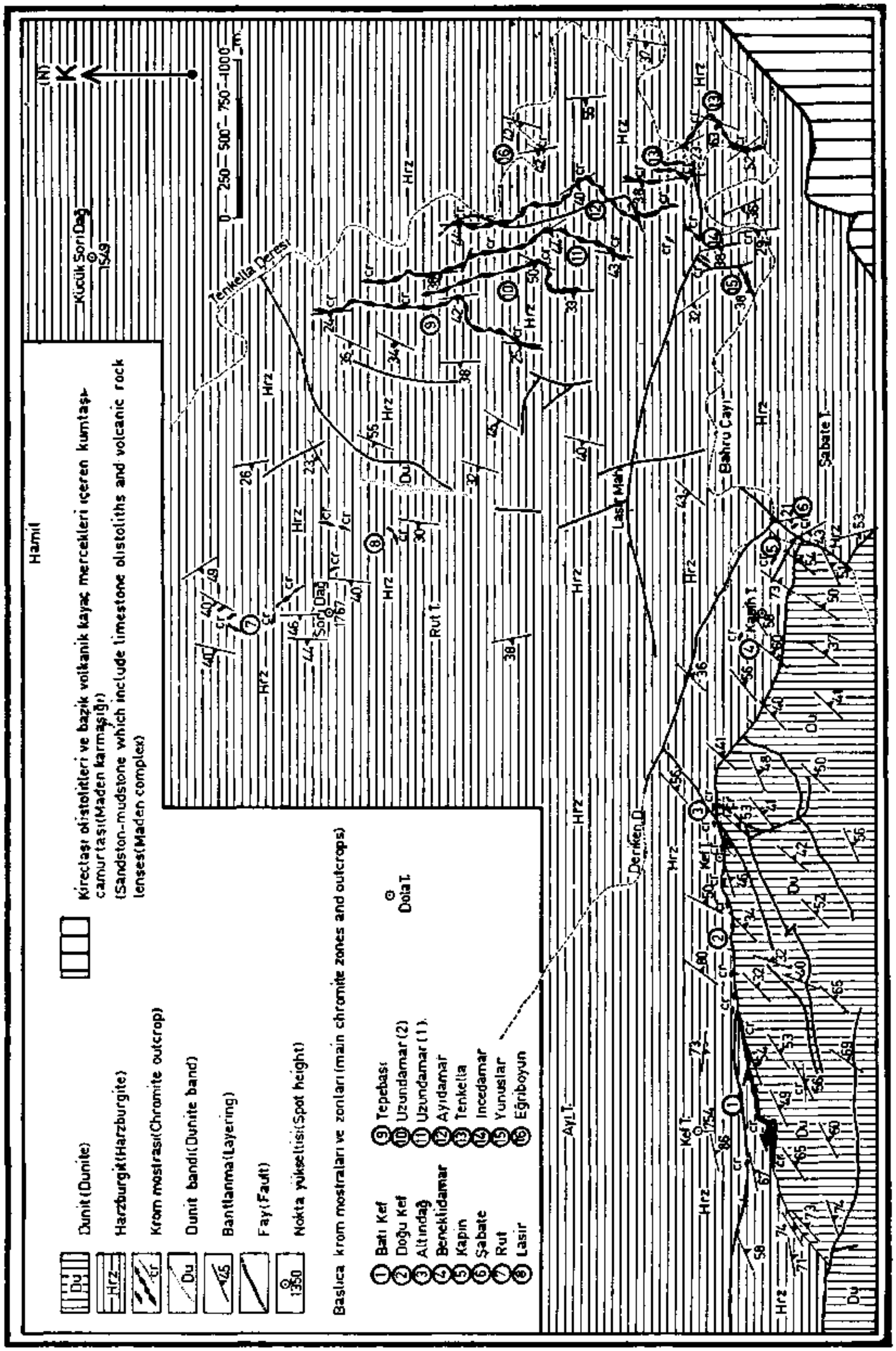

Fig. 2 - Geological map of the Kefdağ-Kapin, Rut-Taşlıtepe chrome ore district, Guleman-Elazığ Eastern Turkey.

Chromite bodies are mostly pod shape varying in thickness along the zones. The average size of a chromite pod can be given as; 20 m x 1.5 m x 7 m. It is common to see the continuation of a 3-5 cm thick chromite band for about 10-20 m without much change in its character then suddenly thickening to the extent of several meters, forming a chromite pod and then becoming thin again. The repetition of this phonemena along the ore zones is a characteristic feature in this part. Figure 3 shows a section of the Ayıdamar chromite zone in the underground workings. Here the chromite zone which mainly has primary contact relationship with the enclosing peridotite has numbers of chromite pods which are joined with thin chromite bands or stringers.

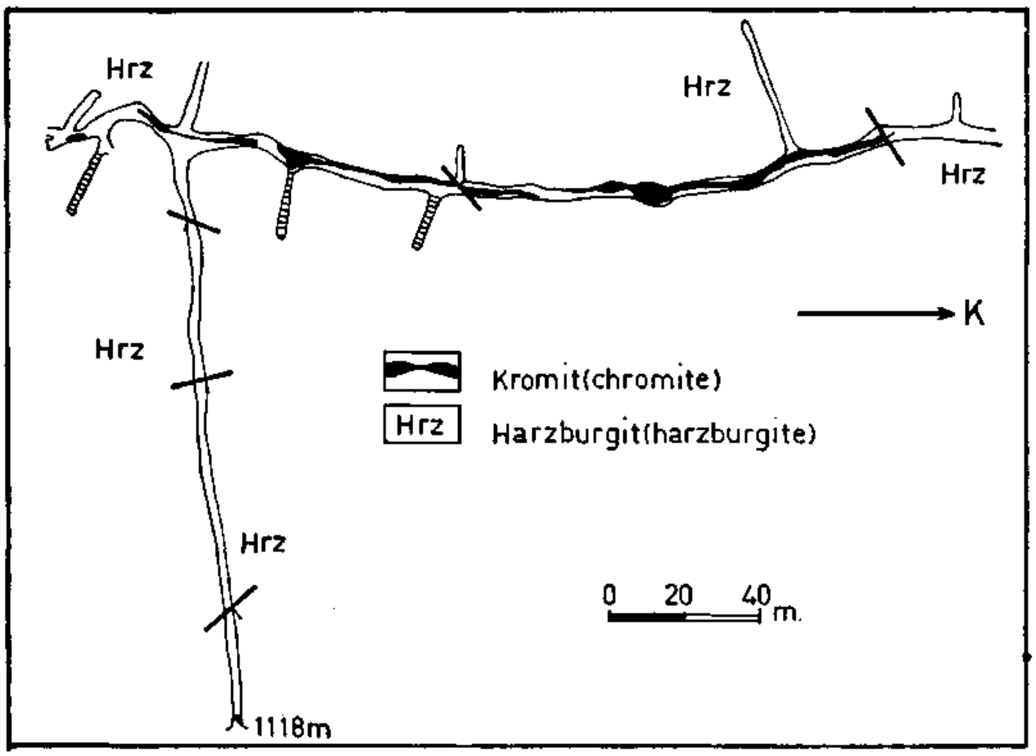

Fig. 3 - Simplified underground geological map of a part of the Ayıdamar chromite zone.

In places due to some structural complications or topographical reasons those thin chromite bands or stringers may not always follow on to join up with the pod.

Most of the chromite occurrences are related with one of these major ore zones. But there are some occurrences whose relations with the well established zones can not be seen readily. The connections of some ore zones with one another such as Yunuslar-Ayıdamar, İncedamar-Ayıdamar, Uzundamar 2-Uzundamar 1, U9 Lasir-Orta Lasir-Rut also need some clarification. All these connections andsome of the structural complications will probably be explained when the detailed surface and under ground geological maps are completed and correlated. Further exploration work based on the assumtion that some of those problematical ore zones such as Uç Lasir-Orta Lasir-Rut are related, will also prove the validity of such assumptions.

Alternate thickening and thining in the chromite bodies along their strike direction can also commonly be seen along the dip directions. Chromite deposits are mainly massive but disseminated and nodular types are also present. The occurrence of various types of chromites in thispart do not give any recognizable pattern.

Some of the information which could have been collected from the outcrops and underground workings is lost due to extensive mining operations. Some data on the size of the chromite bodies on the outcrops and in the underground workings of the chromite zones are given below.

	A	B	C
Tepebaşı zone	50 m	6.5 m	30 m
Uzundamar 2 zone	60 m	4.5 m	2 m
Uzundamar I zone	75 m	3.0 m	5 m
Ayıdamar zone	55 m	3.5 m	10 m
Tenkella zone	30 m	2.5 m	4 m

A - Maximum length of a chromite pod in the outcrop.
B - Maximum thickness of a chromite pod in the outcrop.
C - Maximum thickness of a chromite pod underground.

As previously indicated the alpine type chromite deposits do not generally show much continuation but the most characteristic feature of the chromite deposits in the Rut -Taşlıtepe section is their continuity. Some figures on the continuation of the chromite zones along their strike and dip directions are given below.

	A	B	C	D	B-D	C-D	E	F	G
Rut zone	500 m	1680 m	1514 m	1470 m	210 m	44 m	360 m	75 m	200 m
Orta Lasir zone	125 m	1675 m		1607 m	68 m		120 m		120 m
Uç Lasir zone	75 m	1550 m		1510 m	40 m		75 m		75 m
Tepebaşı zone	1350 m	1440 m	1355 m	1118 m	322 m	237 m	565 m	410 m	485 m
Uzundamar 2 zone	900 m	1395 m	1365 m	1164 m	231 m	201 m	400 m	345 m	370 m
Uzundamar 1 zone	1600 m	1330 m	1270 m	1102 m	228 m	168 m	395 m	290 m	340 m
Ayıdamar zone	1350 m	1300 m	1154 m	1102 m	198 m	54 m	345 m	95 m	220 m
Yunuslar zone	200 m	1090 m	1035 m	985 m	105 m	50 m	185 m	85 m	135 m
Batı Tenkella zone	150 m	1100 m	1011 m	1000 m	89 m	11 m	175 m	15 m	95 m
Doğu Tenkella zone	350 m	1144 m	1000 m	1000 m	114 m		195 m		95 m

A - Length of the ore zone in the outcrops.
B - Highest elevation in the outcrops.
C - Lowest elevation in the outcrops.
D - Lowest elevation of the ore zone (in the addits or in the drill holes).
E - Continuation of the ore zone along the dip direction based on the highest elevation of the outcrop.
F - Continuation of the ore zone along the dip direction based on the lowest elevation of the outcrop.
G - Average extension of the ore zone along the dip direction.
(in calculations 35° is taken as the average dip angle of the ore zones).

A cross section showing the stratigraphic position of the ore zones is given in Fig. 4. Due to structural complications the extensions of the Tepebaşı and Uzundamar I zones may be slightly different from the values given in the table. All of the ore zones mentioned here have continuations below the levels indicated but they have not been explored yet.

In general, surface and underground extensions of the ore zones run parallel. In some places where the ore zone can not be followed any further on the surface the continuation is known underground beyond the limit of the outcrops.

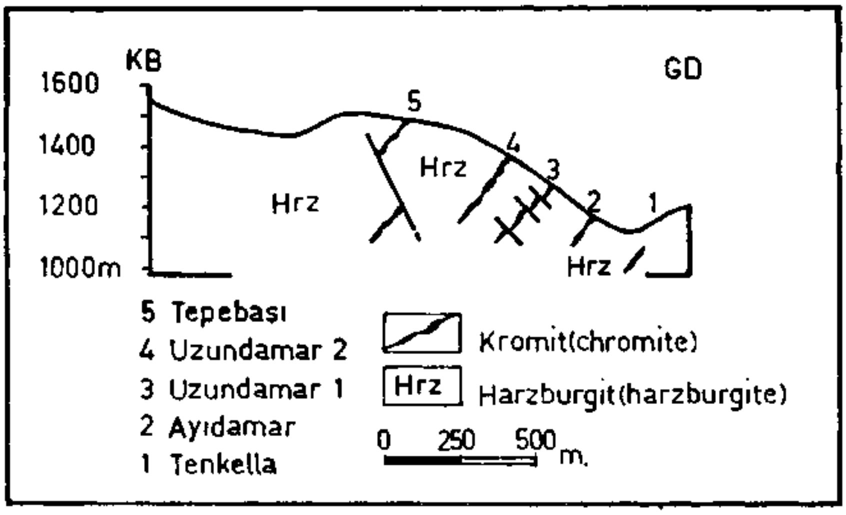

Fig. 4 - Stratigraphical and structural positions of the major chromite zones in the Rut-Taşlıtepe section.

Although massive chromite is the commonest ore type present, others such as nodular and disseminated are also present. Chrome ore produced from this section is mainly of metallurgical grade. According to data obtained from Etibank's records Cr_2O_3 content of the ore produced show variations from 37.48 % to 54.43 %. But the average grade of the ore can be given as 42-48 % Cr_2O_3.

It was mentioned that total ore production from this section was about 2 million tons. As the production records of the ore zones have not been kept separately, the distribution of this total production to the ore zones can not be made accurately.

Although the ore zones in the Rut-Taşlıtepe section are located in harzburgite, a dunite shell varying in thickness from a few cm up to 3 m is always found enveloping the chromite bodies. The boundary relations of the chromite pods with the dunite envelope and the dunite envelope with the harzburgite are mainly primary but sheared in places. Apart from some local variations the boundary planes are aligned parallel to the internal structure of the harzburgite. Shearing particularly along the boundary planes between chromite pods and the dunite shell is believed to have resulted from the differences in their responses to the acting forces.

Pull-apart texture which is believed to have developed as the result of tensional forces during plastic deformation is seen in chromite pods in places. The lineation direction measured from the pull-apart texture appears parallel to the strike direction of the ore zones but plunging south 5°-10°. Occluded slicate textures in chromite which may be indicating a crystal settling process can also be seen in various localities (Jackson, 1961; Thayer, 1969a, 1970).

Apart from dunite bands and lenses in the harzburgite 1-2 cm thick dunite dykes particularly around chromite bodies seen cross cutting chromite and harzburgite. Their continuation is rather limited not usually exceeding 0.5 m- 1 m. Despite arguments that a magma in peridotite composition can not intrude in the dyke forms. The presence of thin dunite dykes in the field is a fact. The presence of these dykes may be due to the weight imposed by the chromite accumulation on the not fully consolidated dunite cover.

Kefdağ-Kapin-Şabate Section

The Kefdağ-Kapin-Şabate section in Guleman covers the area between the southern slopes of Kef Tepe (1754 m) and Deriken dere (Fig. 1,2). This is the second major chromite producing area after the Rut-Taşlıtepe section. Considering the types of chromite deposits present, this section can be divided into various sub sections such as; Batı Kef, Doğu Kef, Altındağ, Beneklidamar,Kapin, Şabate.

Dunite and harzburgite are the major rock types present. In general they are rather fresh but the degree of serpentinization increases along the fault zones. Pyroxenite dykes with limited extensions are also known here and there cutting dunite and harzburgite. Their thickness varies from several cm to 20-30 cm and they can not be followed more than 10-15 m in the field.

Dunite covers an area of about 5 km^2 on the southern slopes of the Kef tepe (1754 m, 1485 m). Harzburgite here is the western continuation of the harzburgites of the Rut-Taşlıtepe section (Fig. 2). In the field harzburgites are distinct with their relatively more rugged appearance and with some oak trees and bushes. Dunites form rounded, smooth topographical features and they have virtually no vegetation cover.

Dunites are redish grey in appearance and are rather fresh. The size of the olivines forming dunites quite often exceed several cm and show well developed cleavage trace. Apart from olivines dunites have chromite grains which appear like black pin-heads in the hand specimen. Although it varies the amount of chromite present in dunites is not usually less than I %. Quite commonly 5-10 % of chromite is found to be present. Chromite accumulations in dunite usually show banded structures. The thickness of individual chromite bands varies from a few mm to several cm. Chromite bands can be seen forming zones several meter thick and in places more than 100 m long.

Elongation of chromite grains marks the foliation in dunites. They appear parallel to the layering developed by chromite accumulations.

As chromites crystallizing in cubic system, elongation of this mineral can not be considered primary, to have developed during the initial crystallization stage. Parallelism between foliations measured from the chromite elongations and layering from the chromite accumulations may represent the kind of plastic deformation they were subjected to during the accumulation of chromits.

Harzburgites here occupies the eastern, western and northern parts of the dunite field. The degree of serpentinization varies. But in general the harzburgites here can be classified as reasonably fresh. The constituent minerals are; olivine, orthopyroxene, clinopyroxene, chromite and serpentine minerals. As was mentioned previously the amount of pyroxene minerals present is about 10-20 %, orthopyroxenes forming the largest percentage. On the other hand in some specimens the amount of clinopyroxene present is about equal to orthopyroxene.

There has not been much difficulty in the identification of serpentinized harzburgites in the field. But a great deal of difficulty has been experienced in identifying fresh samples due to poor distinction between olivine and pyroxenes.

Similar to the presence of dunite bands and lenses in harzburgite, along the main dunite-harzburgite contact zone dunite is found to contain harzburgite bands and lenses. These bands and lenses become 10 m thick in places. The clinopyroxene content of these harzburgite lenses appears more than that of the main body of harzburgite.

The contact relation between the main body of dunite and harzburgite is primary in the Batı Kef section and mechanical in the Doğu Kef section (Fig. 2). In the Batı Kef section the layering is identified from the alternation of olivine and pyroxene rich parts in harzburgite. The primary contact relation between dunite and harzburgite and the layering, measured from the chromite accumulations in dunite, are all parallel.

Some thin pyroxene rich layers in dunite along the dunite-harzburgite boundary zone also appear parallel to the internal structure of the peridotite. This section of dunite which is about 100 m wide along the dunite-harzburgite contact zone has been considered to be dunite-harzburgite transition zone.

In Doğu Kef a big fault zone trending E-W and dipping north with about 65°, follows the dunite-harzburgite boundary (Fig. 2). The harzburgite side (north) of this fault zone appears comparatively more disturbed than the dunite side (south). Dark green-black coloured, brecciated, heavily serpentinized peridotites with faces full of slickensides make this fault zone distinct. In places it is quite difficult to draw boundaries, the northern boundary is particularly troublesome. The width of the zone varies between 10 m - 40 m where the boundaries are well marked. It is common to see in and around this fault zone, faults branching away and then joining up again like a plaited hair pattern. In the dunite area in particular there are also numbers of faults developed parallel to this main fault zone.

In Batı Kef area layerings measured from the alternation of olivine and pyroxene rich parts in harzburgite and from the chromite accumulations in dunite are parallel. They trend NNE-SSW, dipping SE with about 50°. In Doğu Kef although the layering in dunite shows the same regular pattern, the layering in harzburgite here exhibits a disturbed and irregular pattern (Fig. 2).

In the Altındağ-Kapin section the layerings both in dunite and harzburgite are again parallel to each other. But their strike direction appears to be cutting the dunite-harzburgite boundary here almost at right angles (Fig. 2).

The dunite-harzburgite contact relation between Altındağ and Kapin appears in parts rather complicated. Some minor faults have been recognized along the contact, but the map pattern suggests a faulted relationship between the two (Fig. 2). Accepting that the harzburgite which occupies the area between Altındağ-Kapin is adifferent slice overlying the thick dunite unit, than the harzburgite which is underlying the dunite to the north of the area, then the contact zone's being at right angles to the strike direction of the layering can be considered a topographical feature. Because of the structural complications the dunite unit's being sandwiched between the two different harzburgite slices has not yet been well documented.

Batı Kef Deposit. — Mining activitiefc in the area are known to have started in 1939 but available production records start from 1952. According to the data made available about 1.000.000 ton chrome ore was produced from the Batı Kef Deposit during the years 1952-1981.

The Batı Kef deposit has a 1000 m long outcrop in dunite along the dunite-harzburgite contact (Fig. 3). The thickness of the dunite envelope to the north of the outcrop along the contact reaches 4-5 m in places but it is about 40-50 cm generally. A dunite unit also forms the southern side of the outcrop. The thickness of this dunite which is generally termed as «Kef Dunite» is estimated to be about 2500 m. The presence of harzburgite lenses and thin pyroxene rich layers in this dunite along the dunite - harzburgite contact to the south of the chromite outcrop had been mentioned previously.

The Batı Kef deposit starts as a narrow and disseminated strip at the west end. The chromite concentration increasing and the zone widening as it extends eastwards. The maximum width of the outcrop is about 50 m and mainly consist of disseminated and banded type chromite. In the outcrops particularly in the central part of the zone there are places where chromite concentration increases to form massive chromite bands and lenses. In the past these massive bands and lenses were selectively mined.

The contact relationship between the ore body and the host rock dunite is primary, but locally sheared in some places. Along the strike direction of the outcrop NE-SW and NW-SE running faults have cut the pre body. Both systems have caused the displacements of the ore zone but the latter system appears more prominent and to have caused more categorical displacement.

To the east the outcrop again becomes comperatively thinner and more disseminated than the central section similar to the western part. The ending of the outcrop to the east is rather complicated. The big fault zone in the Batı Kef extending from west to east in the harzburgite limits the eastern end of the outcrop. The gradual thinning and the low concentration of chromite here suggests that the outcrop would have had a primary ending even if it was not cut by that fault (Fig. 2). As mentioned previously this fault zone follows the boundary between dunite-harzburgite to the east in the Doğu Kef section.

In the Batı Kef chromite deposit the lowest elevation of the outcrop is 1448 m and the highest elevation is 1580 m. The maximum thickness so far found in the underground is about 45 m. From the drilling data the dip down continuation of the ore body is known to be at 1186 m elevation (İskit, 1973). Taking the dip angles as 50°, the continuation of the ore body along the dip direction is calculated to be about 500 m between the highest elevation of the outcrop and the lowest known depth (1186 m). When calculations are made according to the lowest elevation of the outcrop the continuation works out at about 350 m. This indicates that the Batı Kef chromite body has 1000 m continuation along its strike and about 425 m along its dip direction. The position of the ore body along its dip direction is shown in Fig. 5.

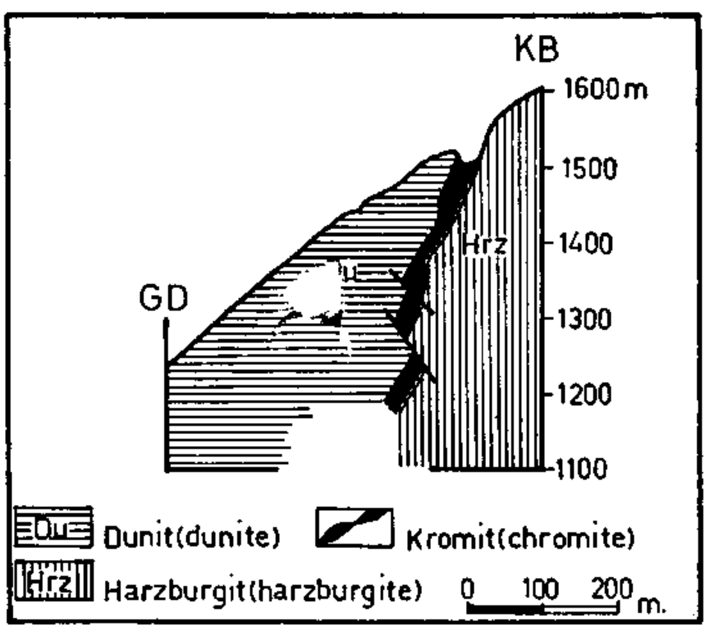

Fig. 5 - Stratigraphical and structural position of the Batı Kef ore body.

The chemical composition of the ore body shows variations from 13.27 % to 46.54 % Cr_2O_3. But İskit (1973) gives the average grade of the deposit as 32.90 % Cr_2O_3.

Doğu Kef Deposit. — There are about 60 chromite bodies of various dimensions along the big fault zone which follows dunite-harzburgite boundary in the Doğu Kef section. Some of these outcrops form groups and some are individual bodies. In Fig. 2 all these occurrences are shown as 8 chromite outcrops.

Although some of the bodies appear in the dunite side, most of the outcrops are in the harzburgite near the southern side of the big fault zone. In more definite terms 8 of these 60 chromite bodies are in dunite the remaining 52 appear in harzburgite.

The maximum length measured in the surface chromite bodies is approximately 35 m and the maximum thickness approximately 4.5 m. The highest elevation of the outcrops is 1610 m and the lowest is 1380 m. The type of ore present in the Doğu Kef section is massive-disseminated and highly brecciated. The relationship of the chromite bodies with the host rock is mechanical and rather complicated. It is often possible to see the remains of the primary dunite shell around the chromite bodies which are in brecciated harzburgite and have mechanical contact relationship with it.

Although chromite bodies exhibit conflicting orientations in localized spots they are in general oriented parallel to the strike and dip direction of the fault zone in which they are located. To have an idea about the extensions of these chromite bodies in the fault zone beforehand is quite impossible.

In Doğu Kef section 1377 m and 1416 m level addits are the lowest level addits driven for the chromite exploration here. They both intercepted various size chromite bodies. The 1416 m level addit is driven 135 m below the outcrop (1550m) in that part. This may give an idea about the continuation of the chromite bodies in the fault zone. The maximum length and thickness of the chromite bodies so far measured in the addits were about 50 m and 7.5 m respectively.

The chemical composition of chromites from the Doğu Kef section show variations from 38.30 % to 43.98 % Cr_2O_3. Mining activities are reported to have started here in the form of exploration work and small scale outcrop mining in about 1938 (Helke, 1939). The amount of ore produced during these operations is estimated to be about 1000 tons. They are left lying in the stock area near to the outcrops or at the entrance to some of the addits. At present there is no ore production from this section.

Apart from those above mentioned massive and brecciated chromite pods, the concentration of chromite grains mostly in the form of thin bands appear increased in a zone in dunite next to the dunite-harzburgite mechanical contact. The width of these zones may become 30 m and their boundaries are transitional. They can be followed for about 650 m with some interruptions along their strike directions.

The zone includes disseminated chromite and chromite bands which range in size from a few mm to a few cm. In places 1 m thick massive chromite bands are also known. The zone runs parallel to the internal structure of the peridotite. But individual chromite bands can not usually be followed more than 4-5 m along their strike direction.

Although no chemical analyses are available but the average grade of the zone is estimated to be about 5-10 % Cr_2O_3.

Altındağ Chromite Body. — The Altındağ chromite body is situated in harzburgite near to the faulted dunite-harzburgite contact zone at the 1349 m elevation to the east of the Doğu Kef occurrences (Fig. 2). The outcrop is 35 m X 2 m x 2 m and has mechanical contact relations with the host rock harzburgite. The remains of dunite cover is commonly seen around the chromite body. The ore here is massive and brecciated, chemical analysis of a sample gave the grade of the chromite as 46,57 % Cr_2O_3.

The position and characters of the Altındağ chromite body appear similar to the Doğu Kef occurrences but differ in orientation. The chromite body here has NW-SE strike direction, dipping SW about 55° in accord with the faulted dunite-harzburgite contact zone which passes about 20 m away from the outcrop.

In 1974 an addit was driven about 30 m below the outcrop to explore the extension but it failed to intercept the ore. At present no mining activity is being conducted here.

Beneklidamar Chromite Body. — The Beneklidamar chromite body is situated in the harzburgite about 350 m from the main dunite-harzburgite zone and 200 m to the NW of Kapin Tepe (1268 m) at 1230 m elevation (Fig. 3). The outcrop consists of two chromite bodies one 20 m and the other 12 m in length. The maximum thickness is about 1.5 m. The ore type here is massive and nodular. The pods are located in a dunite unit which is about 70 m long and 15m wide and has a rather irregular shape. The position of the dunite unit in harzburgite and the chromite pods in dunite are in accord with each other. The pods striking NW-SE, dipping SW about 40°. The boundaries of chromite pods with dunite and dunite with harzburgite are mainly primary but locally sheared in places.

The harzburgite forming the northeastern slopes of a ridge extending between Kef Tepe (1485m) and Kapin Tepe (1268m) is serpentinized and brecciated (Fig. 2). Internal structural features such as layering, foliation and lineation as such are poorly displayed. The general trend of layering and foliation runs NE-SW, dipping SE about 60. Although this trend is in accord with the trends in Batı Kef, Doğu Kef and Altındağ sections, it runs obliquely to the orientation of the Beneklidamar chromite pods (Fig. 2).

In the past a limited amount of exploration work appears to have been done on the Beneklidamar pods. An addit was driven about 30 m below the outcrop but it is not accesible now. The information gathered indicates that nodular type ore was intercepted not in the addit but in a raise joining the addit and the outcrop. The work was abandoned then.

Kapin Chromite Deposit. — The Kapin chromite deposit is situated on a ridge extending from Kapin Tepe (1268 m) to the east and bounded by Bahru Çay and Derikendere streams (Fig. 2). The chromite bodies here are in general aligned along a mainly NW-SE direction in three rows each about 50 m apart.

In the past the ore was produced by open pit methods there by destroying most of the outcrops. There are still about 30 chromite pods of various size in a 300 m x 120 m area. The maximum length and thickness of the outcrops are 15 m and 4 m respectively. But the old photographs of the outcrops show that the pods were much larger before they were destroyed (Helke, 1939).

Despite some local changes the orientation of chromite pods here is NW-SE, dipping SW about 60°. The pods are located in highly sheared, brecciated and serpentinized harzburgite. They all have mechanical contact relations with the host rock but in places the remains of dunite cover around some pods can still be seen.

Serpentinized harzburgite in which the Kapin deposit is located is separated from the relatively fresh harzburgite in the southwest by a NW-SE running fault (Fig. 2). Around Kapin mine the harzburgite is rather poor in displaying the internal structural features. Layering and foliation observed locally appears parallel to the layering measured in the fresh harzburgite to the southwest, running NE-SW, dipping SE about 50°. This trend is in accord with the trend established in the Kefdağ-Kapin section.

The lowest chromite outcrop here appears in the Bahru Çayı creek at 1070 m elevation. From here northwestwards the outcrops can be followed up to a ridge. The highest outcrop is located at 1176 m elevation. Following the open pit mining operations the ore is produced now by underground mining methods. At present large scale underground mining operations are being conducted here.

Etibank's production figures show that Kapin mine opened in 1951 and produced 5850 tons of ore in that year. From 1951 to 1981 about 250,000 tons of massive ore were produced. The elevaticn of the deepest level of production is at present 1042 m. This level is about 30 m below the stream beds of Bahru çayı and Derikendere creeks which bound the area from NE and SE. The water penetrating into the production levels cause some difficulty for the mining operations.

There are three rows of outcrops on the surface but four rows can be seen underground. Chromite bodies all have mechanical contact relations with the sheared and serpentinized harzburgite underground. Their orientations and dip angles are similar to the surface outcrops. The dimensions of the underground chromite bodies are much larger than the outcrops seen on the surface. The maximum length and width of the chromite bodies measured underground are 115 m and 26 m respectively. Drilling made in Kapin to control the dip down extension of the ore body, intercepted 7 m thick massive ore at 960 m elevation. Based on these data taking the 60° dip angle of the chromite pods the dip down extension of the ore body between the highest outcrop and the 960 m elevation can be estimated to be about 250 m. When same calculation is made for the lowest lying outcrop the extensions found to be 125 m. So far the average dip down continuation of Kapin chromite deposit can be estimated to be about 190 m.

The type of ore present in Kapin is massive, brecciated and friable. From the commercial point of view, most of the Kapin ore is refractory grade, only the most southwesterly row of chromite pods known as the 3rd zone is of metallurgical grade. Commercially analysed 60 chromite specimen from Kapin showed variations between 43.31-47.01 % Cr_2O_3.

Şabate Chromite Deposit. — Şabate chromite deposit is situated to the southeast of Kapin and on the northwestern slopes of Şabate Tepe (1370 m). A big fault zone extending in a NW-SE direction along the Bahru Çay creek separates Kapin and §abate deposits (Fig. 2). The open pit which includes 8 chromite bodies is about 70 m long and 35 m wide. The maximum length and width of these bodies is 30 m and 2.5 m respectively. They are oriented parallel to the NW-SE direction, dipping SW about 60°. The elevation of the outcrops varies from 1101 m to 1126 m. The ore was intercepted at 1089 m level addit.

The host rock here is also harzburgite. Dunite is peresent in the form of 0.5 m- 1 m thick bands and lenses. The chromite bodies have mechanical contact relations with harzburgite. But the remains of dunijte cover around the pods can again still be seen in places.

The harzburgite around Şabate is rather brecciated and poor in exhibiting internal structure. The information gathered on the internal structure was mostly from the thin chromite bands in the dunitic parts. The layering measured from these chromite bands appears parallel to the orientation of the chromite pods, striking NW-SE, dipping SW.

As can be seen in Fig. 2 Şabate chromite occurrences are located at the southeastern extension of the Kapin deposit. Although the orientation of chromite pods in Kapin have oblique relations with the layering of the host rock harzburgite, their position is similar to the pods in Şabate. On the other hand the fault zone which is running alongthe Bahru Çay creek and separating the Şabate and Kapin deposits appears to have caused about 300 m separation on the Kef dunites along the Bahru Çay creek (Fig. 2). This may suggest that Şabate is not the continuation of Kapin.

The ore type in Şabate is mainly massive with some nodular chromites. Etibank's production records show that in 1958, 2053 ton ore was produced from Şabate but at present there is no mining activity there.

DISCUSSION

The development of alpine chromite deposits is a subject of great controversy. Conflicting theoretical considerations and field data relating to their origin is commonly found. The presence of authigenic chromite deposits in harzburgite can not satisfactorily be explained by existing theories, therefore the authigenic nature of some of the chromite deposits has tended to be overlooked. The kind of deformation which alpine chromites and peridotites were subjected to has destroyed or concealed some of the vital field data in many parts, also causing formidable difficulties in the exploration and mining of these deposits.

Apart from their relatively large size and some structural characteristics Guleman deposits exhibit the features of alpine type chromites (Thayer, 1960; 1964; 1969a; Borchert, 1964; Engin and Hirst, 1970). They are located either in dunite or in harzburgite with a thin dunite shell around them at various structural positions. Although it has a mechanical contact at its base with the surrounding rocks the known thickness of the Guleman peridotite unit is estimated to be about 10 km. Chromite deposits mentioned here represent different structural and stratigraphical positions in this unit.

Discussion on Gölalan and Pütyan Sections

Studying the geological setting of chromites in the Gölalan section Wijkerslooth (1947); Hiessleitner (1951, 1954); Petrascheck (1958); Helke (1962) concluded that the massive nature of the deposits, large size of individual chromite agregates and their high Cr_2O_3 content indicate that the deposits were either the upthrusted pieces of the dip down continuation of the known deposits of the Rut-Taşlıtepe section or that they were parts of yet unknown deposits which could be stratigraphically below and not cropping out.

In accordance with these suggestions it is proposed that the dip down continuations of the ore zones in the Rut-Taşlıtepe section were broken up and upthrusted along the various thrust planes which were probably developed during the emplacement of the peridotite. Chromite deposits probably moved to their present setting during or at a later stage of the peridotite emplacement.

As explained before the field relations here are rather complicated. Chromite bodies and the rock units all have mechanical contacts with each other. On the other hand close field relations of the ore bodies with cumulate rocks which are the dominant rock type in this section may suggest that the ore bodies might belong to the upper section of the peridotite near to the cumulates.

It is a well known concept that cumulate rocks develop from the partial fusion of the mantle material. In an ophiolite assemblage cumulate rocks form the stratigraphically upper levels relative to tectonites. While expressing his views on the Gölalan chromite deposits Thayer (1964) draws attention to the gabbroic rocks in the neighbourhood.

When the theoretical aspects of chromite crystallization is considered it seems reasonable to expect chromite deposits with large crystals rich in Cr_2O_3 to settle in the lower levels of the crystallizing magma. It can also be supposed that the chromite deposits in the upper levels would be relatively poorer in Cr_2O_3 and richer in Al_2O_3 and FeO than the lower level deposits (Valt, 1942;

Hiessleitner 1951; Kaaden 1959; Borchert and Uzkut, 1967). Bearing this approach in mind it is possible that the chromite deposits in the Gölalan section may represent the lower level deposits in the peridotite as was suggested.

When the complex nature of the crystallization process is taken into consideration it is common to find deviations from the expected compositional trends. Compositional trends seen in the Stillwater chromites, Montana, U.S.A. one of the best known examples of the stratiform chromites may well reflect deviations from the expected trends (Jackson, 1961, 1969; Page, 1977; Coleman, 1977).

On the basis of some experimental studies Irvine (1965, 1966) claims that the chromites crystallizing under high pressure conditions in the lower levels of the mantle, which have been subjected to partial fusion should be relatively richer in Al_2O_3 and poorer in Cr_2O_3 than the chromites crystallizing under relatively lower pressure conditions near the tectonite cumulate boundary zone.

Although many of the high grade massive chromite deposits are known to be located in the harzburgite or along the boundary zone between tectonite and cumulate. The presence of massive deposits is also known in the cumulates. An example of this may be the massive chromite deposit in dunite alternating with wehrlite which is found in the Batı Kop area, Erzincan, Eastern Turkey (Engin, 1979). All these data may indicate that the structural positions of chromites can not be definately established by studying the chemical composition alone.

Complicated but close field relations of the chromite deposits with the cumulate group of rocks in the Gölalan section suggest that the chromite deposits might have developed in the upper part of the tectonite, close to the tectonite cumulate boundary zone. As was mentioned previously chromite deposits and their geological setting in the Pütyan section are similar to the deposits in Gölalan. Observed parallelism of chromite occurrences with the alternation of dunite and wehrlite bands may be used to support the above conclusion by drawing attention to the primary relations which existed prior to deformation.

Discussion on the Rut-Taşlıtepe Section

Chromite deposits in this section are located in harzburgite with a thin dunite shell around them. From the theoritical point of view the development of large chromite pods and bands in harzburgite through partial fusion process does not seem possible (Thayer 1969b). Dickey et al. (1971) say that partial fusion of mantle (Iherzolite) could produce liquid-residual dunite or harzburgite with disseminated chromite. According to these workers incongruent partial fusion may bear upon the origin of podiform chromite deposits. By incongruent partial fusion it would be possible to relaese Cr from the silicate minerals (chromium diopside, Cr rich clinopyroxene) of mantle peridotite and yet physically restrain the Cr from escaping in the newly formed liquids. They also say that although incongruent partial fusion can account for the retention of chromium in residual dunite and harzburgite but it fails to explain the concentration of the ore. On the other hand Thayer (1980, personal communication) says that a 100 m thick harzburgite containing 1 % chromite should be fully fused to produce a 1m thick chromiteband.

Again from the theoretical considerations Dickey (1975) claims that chromite deposits may have developed in dunites in the magma segregation zone along the tectonite cumulate boundary. With this concept in mind the presence of chromite bodies in the underlying harzburgite is explained by the sinking of chromite pods from the magma segregation zone above into deeper levels of harzburgite. Due to the difference in specific gravity between chromite and the host rock peridotite Dickey (1975) assumes that a chromite-dunite body with 50 m dimensions and with 3.8 gr/cm^3 specific gravity would sink about 600 m, into the harzburgite during the first 1 million year and afterwards about 20 m in each subsequent 1 million year.

From a different point of view considering that all dunites are cumulate Greenbaum (1977) explains the presence of dunite bands, lenses and associated chromite deposits in harzburgite by infolding from the above lying cumulate section.

Advancing Dickey's theory further Lago et al. (1981) attempt to explain the origin of alpine chromite deposits and the presence of chromite bodies in harzburgite. They say that the basaltic liquid feeding the magma chamber is produced by partial melting of the rising asthenosphere at some tens of kilometers beneath the spreading centre. By mechanism of hydrolic fracturing, ascending liquid is injected through the uppermost peridotites towards the crust. Due to rapid cooling of the liquid at 1 or 2 km beneath the magma chamber chromite and olivine are precipitated and can locally settle in the conduits. During their subsequent drifting beneath the magma chamber they are deformed and melted which results in a nearly complete migration of trapped magma out of the dunite veins. According to Lago et al. (1981) the chromite pods with their dunite walls were originally the former conduits for the basaltic liquid.

The presence of cumulate pockets in tectonites, infolding and sinking processes may to a certain extent explain some of the chromite bodies particularly the isolated pods in harzburgite. The validity of these theories for all alpine type deposits in harzburgite particularly for the Rut-Taşlıtepe deposits is quite doubtfull.

In the light of these suggestions some important features of the chromite deposits in this section may be summarized as follows;

a. There are 6 major parallel ore zones situated in an approximately 3 km thick section of the harzburgite;

b. Chromites have primary relations with the host rock harzburgite with a thin dunite envelope around them;

c. Chromite zones are parallel to the internal structure of the peridotite;

d. Remains of some of the settled textures can be identified in chromites as well as in harzburgites;

e. Ore zones have an almost uninterrupted continuation up to 1600 m along the strike and 475 m along the dip directions;

f. Deposits do not show grading, size or composition wise, to suggest sinking;

g. No evidence of large scale folding has been identified to suggest infolding.

Evidently all these features show that the chromite deposits here may have developed primarily in the harzburgite and were both subsequently subjected to deformation. The features also suggest that the degree of deformation which the Rut-Taşlıtepe section was subjected to could not have been very great.

Discussion on Kefdağ-Kapin-Şabate Section

In this section there are mainly two types of chromite deposits according to their geological setting; (a) Chromite deposit in dunite; (b) Chromite deposits in harzburgite.

Batı Kef deposits comprise the chromites in dunites. The dunites in which the chromite deposits are located have transitional contact relations with the underlying harzburgites. The dunite here is estimated to be about 2500 m thick and the deposits are located at its base about 5-10 m above the harzburgite.

About 1 km to the south of dunite-harzburgite contact zone, cumulate dunites appear alternating with 5-10 m thick wehrlite-troctolite bands. Kef dunites have steeply dipping faulted contact relations with those cumulates. The fault zone mainly follows the Bahru Çay creek. Although faulted, the cumulates appear overlying the Kef dunites.

As previously mentioned some of the textural features of the Kef dunites such as the straight boundary relations of olivines, chromite grains occupying the area betweeen olivine grains etc. have been interpreted as cumulate textures. On the other hand the presence of deformation lamellae in olivines and the elongated (foliated) nature of some chromite grains have been interpreted as tectonite textures. It may be true to say that Kef dunites exhibit cumulate as well as tectonite textures. The Kef dunites may be classified as a transition zone between tectonites and cumulates.

Jackson et al. (1975); Coleman (1977); George (1978); Nicolas et al. (1980) also talk about the presence of a transition zone in some peridotites between tectonites and cumulates. Some of the tectonite textures observed in the cumulates namely foliation and lineation are seen as the result of high temperature deformation after their deposition. However some of the descriptions of the transition zones given in the above mentioned studies differ in some way from the Kef dunite.

From the theoretical point of view the chromite deposit in Batı Kef is located where it is expected to be, at the base of a thick dunite unit in the transition zone overlying harzburgite. Some important features of the Batı Kef deposit can be summarized as follows;

(a) The ore body has long continuation along its strike and dip directions;

(b) It has primary relations with the host rock dunite;

(c) The ore body is parallel to the internal structure of the peridotite.

These features indicate that the deposit was primarily developed in its present position in the peridotite and has not been subjected to any major deformation.

Doğu Kef, Altındağ, Kapin and Şabate deposits are all located in the harzburgite. In Doğu Kef they follow the fault zone between dunite and harzburgite but they are located on the harzburgite side of the fault zone. In Altındağ the outcrop is only 15-20 m away from the fault zone. On the other hand Beneklidamar, Kapin and Şabate deposits are located well in the harzburgite. They have mechanical contact relations with the host rock peridotite and have oblique angular relations with the internal structure of the peridotite. This angular relation is almost at right angles in Kapin . These features clearly point out that these deposits are different from that of Batı Kef Deposits. The difference in ore grade and type is an additional feature.

The problem is far from being clear whether Doğu Kef, Altındağ, Beneklidamar, Kapin and Şabate occurrences are fragments from one big chromite deposit or of more than one deposit of similar setting.

The Altındağ deposit appears to be transitional between Doğu Kef and Beneklidamar-Kapin. It is situated at the eastern continuation of Doğu Kef and northwestern continuation of Kapin-Beneklidamar occurrences. It resembles Doğu Kef by being very close to the harzburgite-dunite mechanical contact but differs from it with its strike and dip directions. On the other hand Altındağ resembles Kapin and Beneklidamar with its strike and dip directions but differs from them with its location, in the harzburgite.

Accepting the argument that the harzburgite in the Kapin area is not the same as the harzburgite which is underlying the Kef dunite in Batı Kef area then Altındağ-Beneklidamar and Kapin occurrences may be said to be different from the Doğu Kef occurrences.

Doğu Kef occurrences may be large fragments of a chromite deposit primarily developed in harzburgite near to the dunite -harzburgite contact, but then disturbed and dragged by a fault closely following this contact.

By looking at the disposition of the outcrops on both sides of the Bahru Çay creek the Şabate deposit appears to be the southeastern extension of Kapin across the Bahru Çay. But the structural features, particularly the position of the dunite-harzburgite contact on both sides of the creek suggest that the Şabate deposit may not necessarily be the continuation of Kapin but a fragment of a different deposit brought to its present position probably by a fault.

Doğu Kef, Altındağ, Kapin, Şabate chromite occurrences all have mechanical contact relations with the host rock peridotite. Their structural position suggests that if the main part (s) of these deposits have not eroded away they are yet to be discovered. Further mining operations will help in the better understanding of the structural positions of these, deposits.

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