The Mineralogy and Chemistry of the Chromite Deposits of Southern (Kızıldağ, Hatay and Islahiye, Antep) and Tauric Ophiolite Belt (Pozantı-Karsantı, Adana), Turkey

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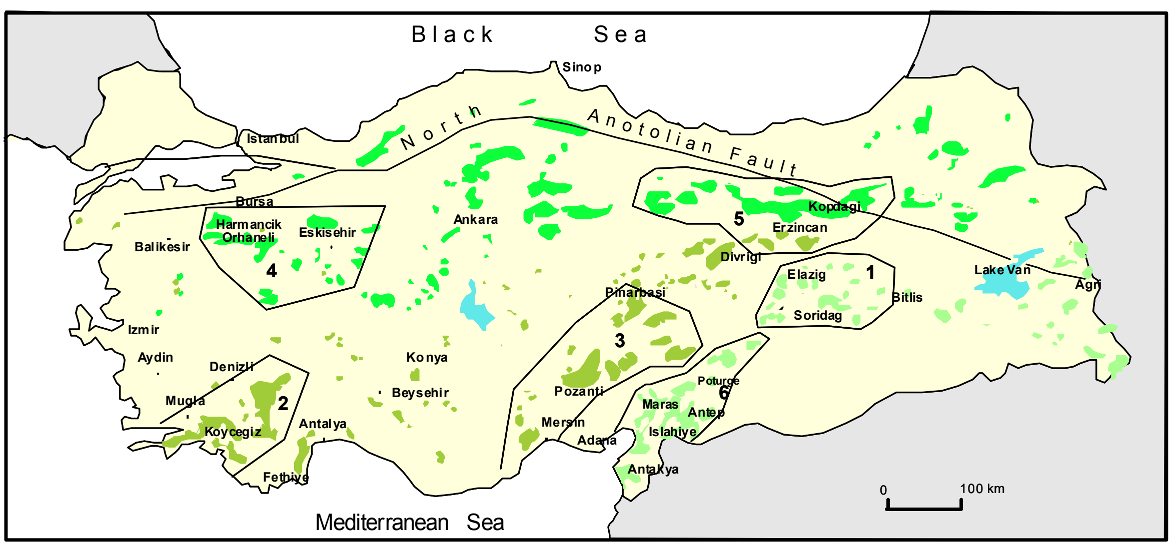
Introduction

The Tethyan ophiolite belt is one of the longest ophiolite belts in the world, extending from Spain to the Himalayas. The geochemistry, genesis and geological time scale of the ophiolite belt varies from west to east. It shows its maximum development in Turkey. The tectonic setting of the Turkish ophiolite belt is a direct result of the closure of the Tethyan Sea.

Ophiolites in Turkey are widespread from west to east and show tectonically complex structures and relationships with other formations and geological units. The three ophiolite belts recognized in Turkey are: a) the southern (peri-Arabic) ophiolite belt, b) the Tauric (median) ophiolite belt, and c) the northern ophiolite belt.

In this study, chromite deposits from the southern and Tauric ophiolite belts have been studied. In the study area, the Southern and Tauric ophiolites have more than 2000 individual chromite deposits throughout the ophiolite; geographically, the chromite pods are clustered in four locations: the Karsantı and Gerdibi-Cataltepe districts in the Tauric ophiolite belt and the Hatay and Islahiye area in southern ophiolite belt.



The three main ophiolite belts in Turkey are:

- The norhern ophiolitic belt (Izmir-Bursa-Ankara-Erzincan-Erzurum)
- The median (Tauric) ophiolite belt (Mugla-Antalya-Beysehir-Mersin-Pozanti-Pinarbasi-Erzincan
- The southern (peri-Arabic) ophiolitic belt (Antalya-Elazig-Soridag-South of Lake of Van)

Location of some Chromite areas:

1 Guleman-Elazig region
2 Fethiye and Koycegiz Areas
3 Pozanti-Karsanti Area
4 Bursa and Eskisehir Areas
5 Kopdagi Area
6 Antakya, Islahiye and Maras areas

Figure 1. *Distribution of ophiolites and main chromite ore districts in Turkey (Modified from Engin et al., 1986).*

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Podiform chromite ore bodies in different shapes and sizes (potato, pipe, pod, tabular, folded etc.) can be seen at different stratigraphic levels of the harzburgites of the ophiolite. Podiform ore bodies are affected by plastic deformation during forming of pods and also by different degrees of tectonic deformation during and after emplacement.

The chemistry of the chromite grains was determined using a wavelength dispersive microprobe. Mineral and metal standards were used to analyze the following elements Cr, Al, Fe (total), Mn, Mg, Ni, Co, V, Ti, Si. Fe^{2+}, Fe^{3+} have been calculated based on 24 cations using spinel stoichiometry

Hatay and Islahiye area (Southern ophiolite belt)

The southern belt, geographically enters Turkey from the north of Syria (Baer-Bassit area) and extends from Antakya to Elazığ Soridağ. It enters Iran (Zagros range) through Oman (Oman ophiolite). It incorporates some of the most well known ophiolite complexes, such as the Troodos (Cyprus), Kızıldağ (Turkey), and Semail Nappes (Oman). The allochthonous Kızıldağ ophiolite exposes the complete ophiolite sequence.

Aproximately 200 economic scale individual podiform chromite ore bodies are observed on Kızıldağ Mountain (Kızıldağ ophiolite) and Balıkalan, Türkoğlu Village (Islahiye ophiolite). Generally the podiform chromite bodies are clustered near the cumulate/harzburgite boundary.

The pods are composed of chromium spinel and olivine. The chromite mineralization has different textures which reflect depositional conditions. The textures are nodular, banded, disseminated (coarse and fine grained) and massive. Electron microprobe analyses have been carried out on chromites from the Kızıldağ and Islahiye areas.

The chromites from the Kızıldağ and Islahiye ophiolites exhibit a wide compositional range of Cr_2O_3, Al_2O_3, Fe_2O_3, FeO, MnO. The chromites from the Kızıldağ ophiolite have higher Cr_2O_3 and lower Al_2O_3 than the Islahiye chromites. The results of geochemical analyses of the Kızıldağ and Islahiye chromites have been projected in the spinel prism to show the variation and the changes of chemical composition which is typical for podiform chromites.

The chromites from the Kızıldağ and Islahiye ophiolites show similar chemical characteristics to the chromites from the Troodos ophiolite but some data from the Islahiye chromites plot outside of the Troodos field due to the high Cr/Fe ratio.

During the detailed microscopic study of the chromite samples Laurite (PGM), copper and nickel sulphides were also observed.

Pozantı-Karsantı area (Tauric ophiolite belt)

The Mesozoic age Pozantı-Karsantı ophiolite is located 60 km north of Adana. The ophiolite extends in a northeasterly direction for more than 100 km with an average width 20 km between the towns of Pozantı and Faraşa.

The autochthonous Mesozoic platform carbonates, belonging to the "Tauric limestone axis" have a tectonic contact with the Pozantı-Karsantı ophiolite. The ophiolite sequence consists of tectonites and cumulates. The harzburgite has been affected by asthenospheric plastic flow during spreading. Non-deformed layered cumulates are represented by dunite, clinopyroxenite, layered gabbros and quartz diorites

The Pozantı-Karsantı ophiolites contain about 1000 individual chromite deposits. The chromite pods are clustered in two locations: a) the Karsantı district to the north east, and b) the Gerdibi-Cataltepe district in the south west. The chromite ore bodies occur in both the harzburgite cumulate parts of the ophiolite.

Two types of chromite mineralization have been determined: a) Podiform chromite bodies (in dunitic pockets) inside the harzburgite and b) stratiform chromite deposit in non-deformed cumulate zones above the transition zone and within the gabbro-peridotite sequences. This latter deposit (Kızilyüksek) occurs as rhythmic interlayering of chromite and dunite layers and it is economically important.

The different sizes of the dunitic pockets and chromite pods seen in the transition zone are concordant or sub concordant to the foliation.

The upper part of the transition zone of the Pozantı-Karsantı ophiolite is rich in dunite (300-500 m.). The dunitic part of the transition zone is the most affected part and records strong high temperature plastic deformation. This section exhibits layering parallel to the foliation of the harzburgites due to the deformation. This is the main factor which differentiates the dunite of the transition zone from the dunite of the cumulate unit. The wehrlite layers and pyroxenite dikes (1-10 cm width up to 10 m. long.) are observed infrequently within the dunitic parts and granoblastic harzburgites, respectively.

Electron microprobe analyses have been carried out on chromites from the Pozantı- Karsantı areas. The plot for the Pozantı-Karsantı shows that most of the data lie in two main fields (Cr# between 77-81 and 72-75). The compositional variations between single pods are mainly in Mg# rather than Cr#, which can be explained by increases of fO_2 and temperature, resulting in an increase of Mg# in chromite.

In the plots of Mg# vs Fe^{+3}#, the Fe^{3+}# indicates very limited variation and data are placed within the podiform range. The data from the Karsantı and Pozantı areas remain in the podiform field and areas do not show any distinct chemical trend. The chromite mineral composition of the stratiform deposits of Kızilyüksek shows the same pattern as podiform deposits.

The Pozantı and Karsantı chromite analyses have low TiO_2 contents (0.21 wt.%), which is characteristic for podiform chromite. Chromites from the study areas are clustered mainly within the Troodos compositional field.

Chromite Mineralisation and Relation of the Tectonic Setting of the Ophiolites

Pearce at al., (1984) analyzed the tectonic settling of Tethyan ophiolites based on the geochemical data from the ophiolites and concluded that Eastern Mediterranean and Middle East ophiolites are rich in ionic lithophile elements as a direct result of a different tectonic setting which was named as a Supra-Subduction Zone (SSZ). They concluded that these ophiolites are a result of immature island arc magmatism. SSZ ophiolite is characterized by depleted mantle sequence. Therefore, the chemical compositions of chromite display variable degrees of the partial melting of host peridotites (Zhou and Robinson, 1997). Magma mixing plays important role of forming podiform chromite (Ballhaus, 1998).

Pearce et al. (1984) demonstrated that the ophiolites in the Troodos massif, Hatay and Oman are SSZ type, and Parlak (1999) reported that the ophiolites in Mersin and Pozantı-Karsantı areas are also SSZ origin.

During the formation of chromites, the following factors are involved in SSZ ophiolites: the degree of partial melting, the hydrous nature of the SSZ magma and magma mixing changes in P and their affect on the partial pressures. The presence of subduction-derived water (hydrous nature) in the melt could expand the olivine and spinel phase volume and so lead to extensive crystallization of olivine and chromite during the formation of the ophiolite.

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