Mineral Res. Expl. Bull., 118, 25-50, 1996

DISCUSSION ON THE ORIGIN OF OTLUKİLİSE IRON DEPOSIT GÜRÜN-SİVAS

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ABSTRACT.- In this study, the geological aspects of Otlukilise iron deposit near Gürün (Sivas, Turkey) is investigated and possible mechanicms responsible for the formation of that deposit are discussed.

Otlukilise iron occurrences are located in volcanosedimentary levels in Yanıktepe and Akdere formations which are age of Upper Cretaceous and Paleocene, respectively.

The occurrence of Otlukilise iron formations is belived to have taken place as enrichments by secondary processes from siderite ores volcanosedimentary origin in relation with volcanic intercalations. Studies carried out on iron rich massive ores indicate an old formation in a sedimentary basin that represented by cumulative supplements of iron and associated elements which are directly on indirectly leached from serpentinites by submarine volcanites spreading out into an environment of carbonate deposition and hydrothermal exhalative fluxes and associated silicate phases formed by intensive silica rich fluids of hydrothermal origin and sulphide phases resulted from reactions of seewater and the same submarine volcanites.

Sequential conjugateness observed especially among quartz and siderite, clay and/or clay bearing siderite layers in iron poor conglomerate breccia ore samples and estimations realized by certain mathematical rules indicate a sedimentary relationship prior to deformation. Both massive ores and fragments are deposited by the processes during formation of an ore horizon intercalated by clay and quartz rich levels and/or just after the movements at the bottom of the basin. Thus, Otlukilise iron deposits represent an other sample of Lahn-Dill type syn-sedimentary volcanogenic or exhalative-sedimentary type ore formation as Deveci Iron Deposits (Hekimhan-Malatya, Turkey) do.

INTRODUCTION

Otlukilise iron deposit located near Gökçeyazı village of Konakpınar country of Gürün town of Sivas, which takes place in Elbistan K38 b4 sheet, will be evaluated in this study.

Lithological units of the studied area and its vicinity belong to Geyikdağ unit (Özgül, 1976) in Eastern Tauride Platform consisting of sedimentary rocks of Gürün autoctone and young sediments and volcanites of Pliocene - Quaternary age (Atabey, 1993 *b).*

The main regional geological studies are carried out by Akkuş, 1971, Kurtman, 1978; Aziz et al. 1981; Özer et al. 1984; Alkan and Turkmen, 1987; Kozlu et al. 1990 and Atabey, 1993 a, b, c. Stratigraphic correlation columns, created by the studies of various authors in the investigated area is illustrated in Fig. 1. The names of the formations are different according to different authors. Çiftçi, (1994) is referred to more detailed information.

Mining geological studies are carried out since 1960 at Otlukilise Iron Deposit and its surrounding. In all these studies, it has been announced that the deposits and mineralizations are located at the cracks and open spaces of limestones but the genesis of ore has not been well established (Gülibrahimoğlu, 1979).

Although no available data is present for the genetical interpretations in the given studies, due to relationship of mineralizations in the region, all authors has come to the consequence of a metasomatic type of formation. However, discussions of various opinions have raised different syntheses about the sources of ore - bearing rock. Some authors suppose submarine volcanics as host rocks of ores (Gümüş, 1962, 1964), while others advocate epigenetic character of ore formation occurred by the effect between plutonic rocks and the same volcanites which include ore solutions and limestones (Kormalı, 1972). Other authors suppose that iron is derived from leaching of iron bearing sedimentary rocks (Barosh, 1971).

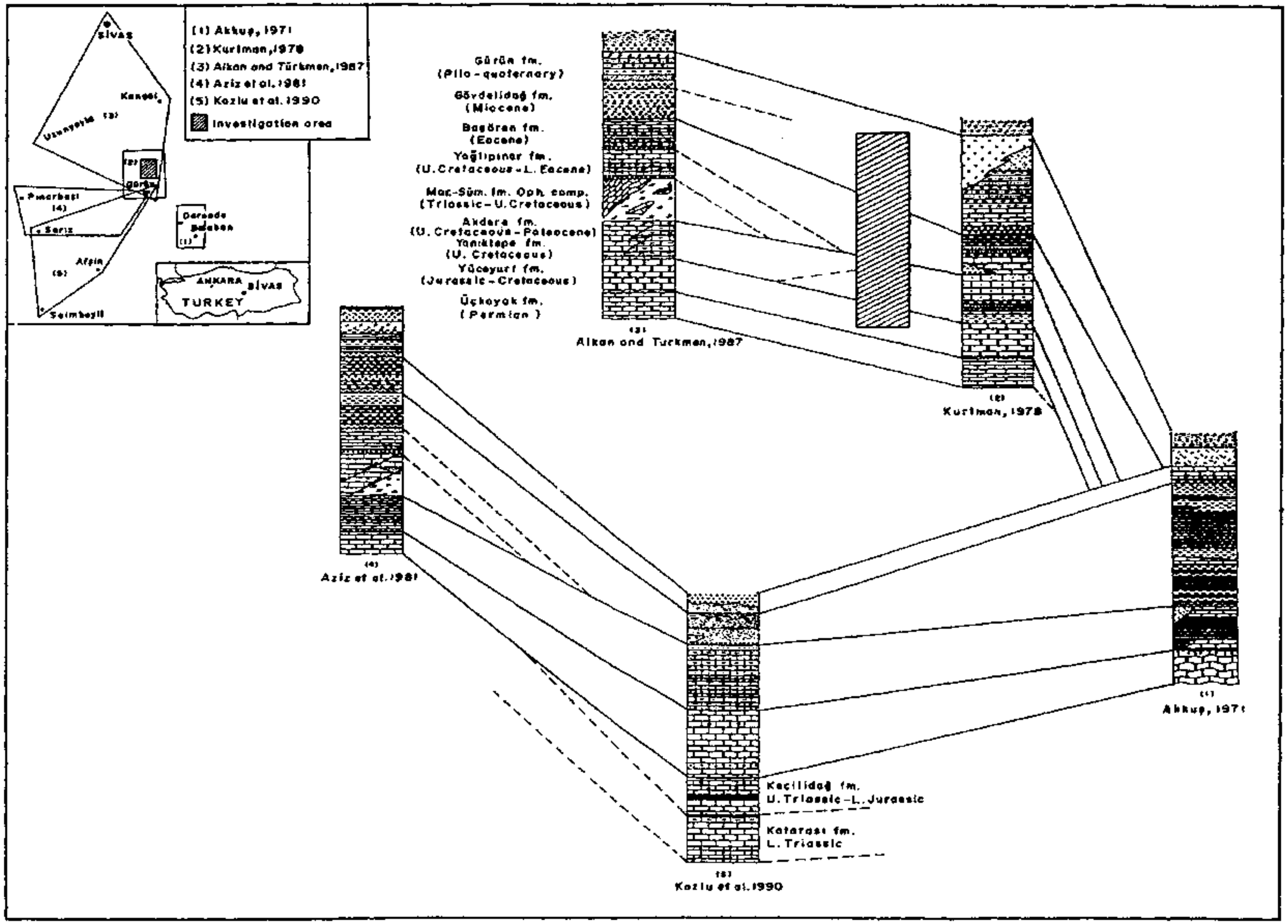

Fig. 1- Nonscaled stratigraphic sequences (investigated area is shown by striped lines). Ophiolitic overlying at NE-Se direction and unconformity between Yüceyurt and Akdere formations out of Gürün vicinity (Kurtman, 1978) is supported by these correlations.

Epigenesis or syngenesis of Otlukilise Iron Deposit creates the focus of genetical discussions of the mineralizations. This study aims to bring a new aspect for genetical discussions by means of mineralogical, petrographical and geochemical studies carried out mainly on massive and conglomeratic - breccious ore samples.

GEOLOGY OF STUDY AREA

Units cropping out in the studied area and its vicinity are represented by Yüceyurt formation, Yanıktepe formation, Akdere formation, Başören formation, Gövdelidağ formation, Gürün formation and young volcanites from older to younger, respectively (Fig. 2).

200 hand specimens collected from the lithologies of above mentioned formations are mineralogically and petrographically investigated. The details of these studies are presented below.

Yüceyurt Formation (Jky)

This formation consists of completely recrystallized and spatially dolomitized limestones while they are platy at the bottom becoming more and more massive to the top and at the uppermost part fossil shells bearing highly fractured and brecciated. Two types of limestones with micritic and sparitic matrix are recognized.

Micritic limestones consist of fine grained, equigranular calcites and some dolomite crystals in addition to recrystallized fossil shells, cherts and rarely opaque minerals. Larger calcites and iron oxide and hydroxide stainings are observed at the calcites. All of these data suppose that carbonates are transported in the some basin and are cemented partly by own components and partly by the material into which they are transported.

Sparry limestones are sligthly rounded and generally formed by angular micritic and sparry limestones fragments which are cemented by sparry matrix. Calcite fragments are associated by some dolomites and rarely chalcedony and opaque minerals. Two different deformation have been determined at the fragments of rocks. First deformation is caused brecciation and the second one another brecciation and penetration of ironoxide and hydroxide bearing fluids into the fractures and cracks of others.

Basing on the paleontological studies carried out on the collected samples from the investigated area (Çiftçi, 1994), the age of Yüceyurt formation is determined as early Upper Cretaceous (Coniacian - Santonian). Depending on the previous studies (Aziz and Erakman, 1980; Aziz et al. 1981; Alkan and Turkmen, 1987; Kozlu et al. 1990), the age of formation is Jurassic-Cretaceous.

Although the bottom of Yüceyurt formation can not be observed in the studied area, this formation uncomformably overlies the limestones of the formations of Keçilidağ (Kozlu et al. 1990) of Upper Triassic - Lower Jurassic age at the east of Saimbeyli, Katarası (Aziz et al. 1981) of lower Triassic age at the east of the Tufanbeyli and Üçoyak (Kurtman, 1978; Alkan and Türkmen, 1987) of Permian age at the nortwest of Gürün. Yüceyurt formation is uncomformably overlained by Yanıktepe formation which can be clearly seen at the investigated area.

Jurassic - Cretaceous limestones with similar characteristic are named as Köroğlu Tepe formation due to previous studies (Demirtaşlı, 1967; Metin, 1982; Metin et al. 1987; Alkan and Turkmen, 1987). But above mentioned formation does not crop out typically at the region of Köroğlu Tepe. Afterwards, Yüceyurt Tepe and its vicinity located norteast of Sarız, is accepted as typical location and so mentioned formation name has been changed as Yüceyurt formation (Kozlu et al. 1990).

Yanıktepe Formation (Ky)

Yanıktepe formation begins with rudist bearing limestones and continuies with shale, marl and sandstone alternations.

Volcanic rock fragments are also abundant in the alternating rocks of this formation.

Rudist bearing limestones appear to be as conglomerates and consist of spatially dolomitized limestone fragments of sparrite and micrite character, fina grained quartz and chert particles, fossil

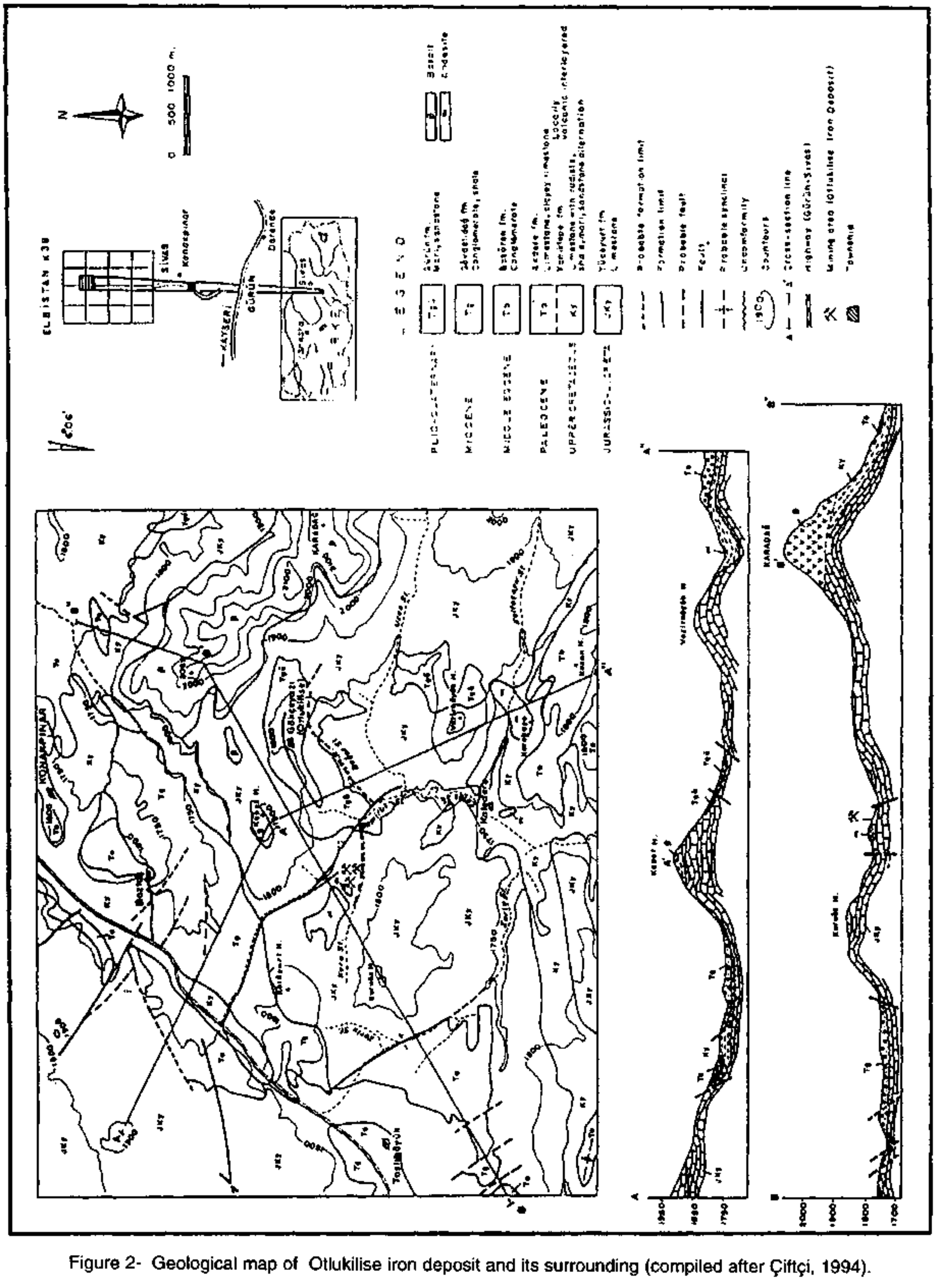

Figure 2- Geological map of Otlukilise iron deposit and its surrounding (compiled after Çiftçi, 1994).

fragments (algs and rudist shells) and micritic and sparritic cemented some volcanic rock fragments. Strongly deformed parts of these limestones grained breccia character. Secondary calcite fillings, siderite occurrences and dolomitized parts and stainings by ironoxide and hydroxides are observed at the cracks and fractures.

The sizes of volcanic rock fragments reach up to 1.5 mm and above. Fragments are usually rounded though some angular. Recognizable minerals which are plagioclase laths and altered mafic minerals which are partially replaced by opaque minerals (Plate 1, Figure 1). In addition, some serpentinite type rock fragments are also observed in some samples. Chromite particles exhibit locally streched an torn apart structures.

Sandstones of shale, marl, sandstone alternations include micritic and sparitic rock fragments, intensively packed fossil shell fragments, chalcedony, quartize, opaque minerals and abundant volcanic rock fragments. On the other hand, volcanic rock fragments consist of quartz, some chert and opaque minerals.

Based on planctonic studies carried out on shales and marls (Çiftçi, 1994) and fossil findings, the age of Yanıktepe formation, representing a shallow marine character, is Late Cretaceous (Campanian - Maastrichtian).

Yanıktepe formation overlies unconformably Yüceyurt formation and is conformably overlained by Akdere formation in the studied area.

Yanıktepe formation is originally named after Özgül et al. (1973) at south of Gürün out of investigated area where its thickness up to 300 m, and aged as Upper Cretaceous by same authors.

Akdere Formation

Gray, light gray, cream and spatially yellowish, reddish colored limestones with are amount of volcanic rock fragments, marly limestones and breccious limestones form the rock of Akdere formation, which is observed in some localities of the studied area.

Limestones and marly limestones consist of especially micritic rock fragments which grade into coarser grains by recrystallization. These rock include small amount of dolomite, fossil shells and fragments, quartz, chalcedony and rarely volcanic rock particles.

Coarse grained, angular rock fragments scattered within a fine grained micritic carbonate matrix are observed in the samples of breccious apperance. Secondary calcites and locally dolomit and siderite and stainings of ironoxide and hydroxide are the main components in the cracks and fractures. In addition, rounded and locally coarser volcanic rock fragments are abundant in the investigated samples (Plate I; Fig. 2). Plagioclase laths, mafic minerals replaced by opaque minerals, spatially chloritizations and carbonatizations are the main characteristics of volcanic rock fragments.

According to the fossil findings (Çiftçi, 1994), the age of Akdere formation is supposed to be younger than Maastrichtian.

Lower contact of Akdere formation is transitional to by Yanıktepe, but upper contact shows unconformatable relations to Başören formation of Mid Eocene age and Gövdelidağ formation of Miocene age.

Outside of the investigated area, around Sarız, the age of the succession reach up to Early Eocene represented by calcarenite, brecciated limestone, marly limestone and locally micritic limestone lying over rudist bearing limestones of Mesozoic carbonate platform (Kozlu et al. 1990). Sequence of deep basin sediments with the thickness of 100 m. (Atabey, 1993a, 1993b), cropping out related with rudist bearing limestones in the region and studied area is called as Akdere Formation (Aziz et al. 1981).

Başören Formation (Tb)

Sequence commencing with red cream colored, rounded basal conglomerate in the study area continuies up to upper levels of the sequence with light gray colored shale, marl, marly limestones and limestone with abundant nummulites at the outside of investigated area.

Conglomerates are formed by micritic and sparitic rock fragments, dolomitic and at the same time ironoxide stained rock fragments, quartz, chalcedony and volcanic rock fragments which all are cemented by generally sparitic and locally, micritic material. These conglomerates also include rock fragments of Yüceyurt, Yanıktepe and Akdere formations.

The age of this formation is supposed to be Mid Eocene (Upper Lutetian) due to previous studies (Aziz et al. 1981; Alkan and Türkmen, 1987). The name of the formation comes from Başören village (Azizetal. 1981).

Başören formation overlies unconformably Akdere formation and is again unconformably overlained by Gürün formation.

Gövdelidağ Formation (Tg)

The formation commences by conglomerates at the bottom and continuies with sandstone and marl alternations which exhibit lateral transitions with conglomerates to the top. Clay rich levels increase in conglomerates so they gradually amount of the rock fragments of ophiolites. Lithologies of this formation have limestones, cherts and small amount of the rock fragments of ophiolites. Lithologies of this formation have light yellow, greenish yellow and reddish colors and very soft character and are rich in clay. Gövdelidağ formation exhibits lateral and vertical fades changes with repetition short intervals.

The matrix of coglomerates are in sparitic and their gravels consist of iron rich ring like textured carbonates, fossils shells and particles in which sparries are penetrated, locally brecciated, micritic and sparitic carbonate particles and fein grained quartz, chert and very small amount of volcanic rock fragments.

Because matrix of any accurate fossil findings could not been found in the investigated lithologies, no age could be evaluated for Gövdelidağ formation. Only conclusion for it is that its deposition indicate a very shallow marinal with high energy or continental environment. The age of formation is Miocene due to Aziz et al. (1981) which is an accepted age in this study or Upper Miocene according to Alkan and Turkmen, (1987).

Gövdelidağ formation overlies unconformably Yücetepe, Yanıktepe and Akdere formations.

Gürün Formation (Tgü)

Light yellow, greenish yellow colored thin layered fresh water limestone, shale, marl and locally tuffs levels of this formation crop out outside of the study area, while it is represented by marl-sandstone alternation in the investigated area. Rock fragments of older lithologies are observed in sandstones.

No paleontological data has been found in Gürün formation. Due to the stratigraphic level and using the data previous authors (Kurtman, 1978; Alkan and Türkmen, 1987) the age has been accepted Plio - Quaternary.

This formation cover unconformably Yüceyurt and Yanıktepe formations in the studied area.

The name of the formation is given after the vicinity of Gürün by Kurtman, (1978), where it is most clearly and widespread observed.

Volcanites

Volcanites of the studied area represented by Karakaya andesites and Karadağ basalts.

Karakaya andesites (a)

The andesites are grayish white colored and fractured.

Phenocrystals of andesites consist of coarse grains of plagioclase and greenish brown amphiboles and locally partly martitized magnetites, ilmenomagnetites and limenites. These minerals are surrounded by a matrix of fine grained plagioclase and amphibole microlits opaque minerals and volcanic glass. This matrix is partly kaolinized and stained by iron oxides and hydroxides. Hyalopilitic texture is very clear in the rocks.

Besides andesites, often agglomerates, tuffs and volcanic breccia are the other rock types. With increasing amount of volcanic glass, tuffs are evolved from andesites. Andesites and tuffs gain an apperance of breccia where strongly fractured. These fragments are healed by ironoxide and hydroxide fillings.

The age of volcanites, depending upon filed relations and previous studies (Kurtman, 1978; Alkan and Türkmen, 1987) is supposed to be Pliocene.

Karadağ Basalt (B)

The basalts are brown, gray and black colored and furnished by cracks.

Phenocrystals of basalts consist of labradoriteite type of the plagioclase, pyroxenes with euhedral to subhedral crystalls which are amphibolized and partly replaced by opaque minerals, iddignsitized olivines and thin long ilmenite crystals. Matrix is mostly made up of plagioclase microlites, besides volcanic glass. Flow, hyalopilitic and pilotaxitic texture are clearly observed in basalts.

BASIN EVOLUTION MODEL

Basing on the lithologies presented above, the following basin evolution model can be suggested (Fig. 3).

First depositions, opened over the basement, Yüceyurt formation (I) consist of shale, marl, sandstone alternation (II). This sequence associated with marinal and continental (?) volcanic activity is called as Yanıktepe formation. Pelagic sediments of Akdere formation (III) indicating the sinking of the basin, include volcanic intercalations. This sequence of transgressive character, described in II. And III. Stages, evolved to a presumably subaerial environment at Lower Eocene changing later marinal environment and so the sediments of Başören formation deposited (IV). It is assumed that folding and fracture dynamic probably prevailed at subaerial environment stage. Gövdelidağ formation of aerial character unconformably overlies the previous units and Gürün formation again unconformably covers the underlying units.

MINING GEOLOGY

The access to the Otlukilise iron Deposit is by means of mine road of 3.5 km long seperated to east from the 25 km of Gürün - Sivas main road.

Otlukilise iron Deposit located in the study area has been mined with concession number of 55/334 by Demir Export Ltd. company since 1961. Five occurrences in concession area and one outside are located in the region (Fig. 4). Except occurrence Nr. 2 called a main ore deposit (Otlukilise iron Deposit), Taşlıhöyük Occurrence (Nr. 5) with economic resource, operated earlier and currently abandoned.

Two types mineralization occur at Otlukilise iron deposit. First type is represented by massive ore which consist of mainly hematite and some goethite. Extention of this type is limited by limestones at east, west and south, and by conglomeratic breccia ore at north. Second type is formed by low grade conglomeratic breccia ores comprised from ore fragments of predominantly hematite components, sand or coarse sized geothite fragments, iron bearing sandstone fragments, ophiolitic rock fragments, siderite gravels, detritic grains in clay size. This type of one in the field is surrounded by limestones at east and west. Ore deposit cut by NE-SW trending faults and ore is also controlled by these faults. Evidences are abundant about the development of faults during and/or after mineralization. Faults mentioned above caused for ores to crop out.

Because of mineable feature and similarities with probable other occurrences, Otlukilise iron deposit will be investigated detail and the results obtained from this deposit will eventually help for evaluation of other occurrences.

PETROGRAPHY OF DRILL - CORE SAMPLES

200 core samples, compiled systematically from five drills at Otlukilise iron Deposit opened during 1977 - 1978 period by MTA General Directorate have been petrographically investigated. They show that there are different between the first 70 metres and the rest of the drill.

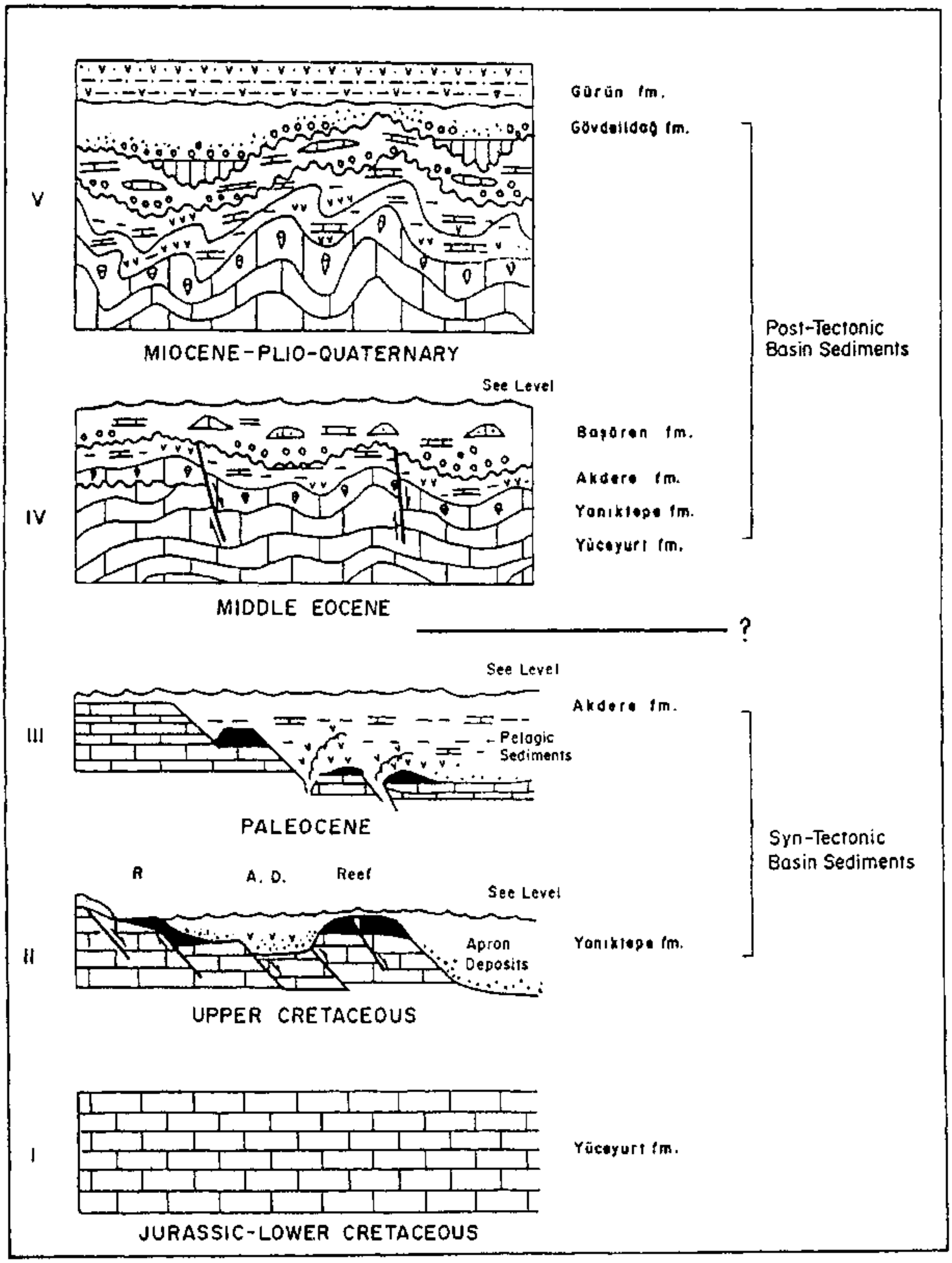

Figure 3- Generalized basin evolution model of the investigated area.

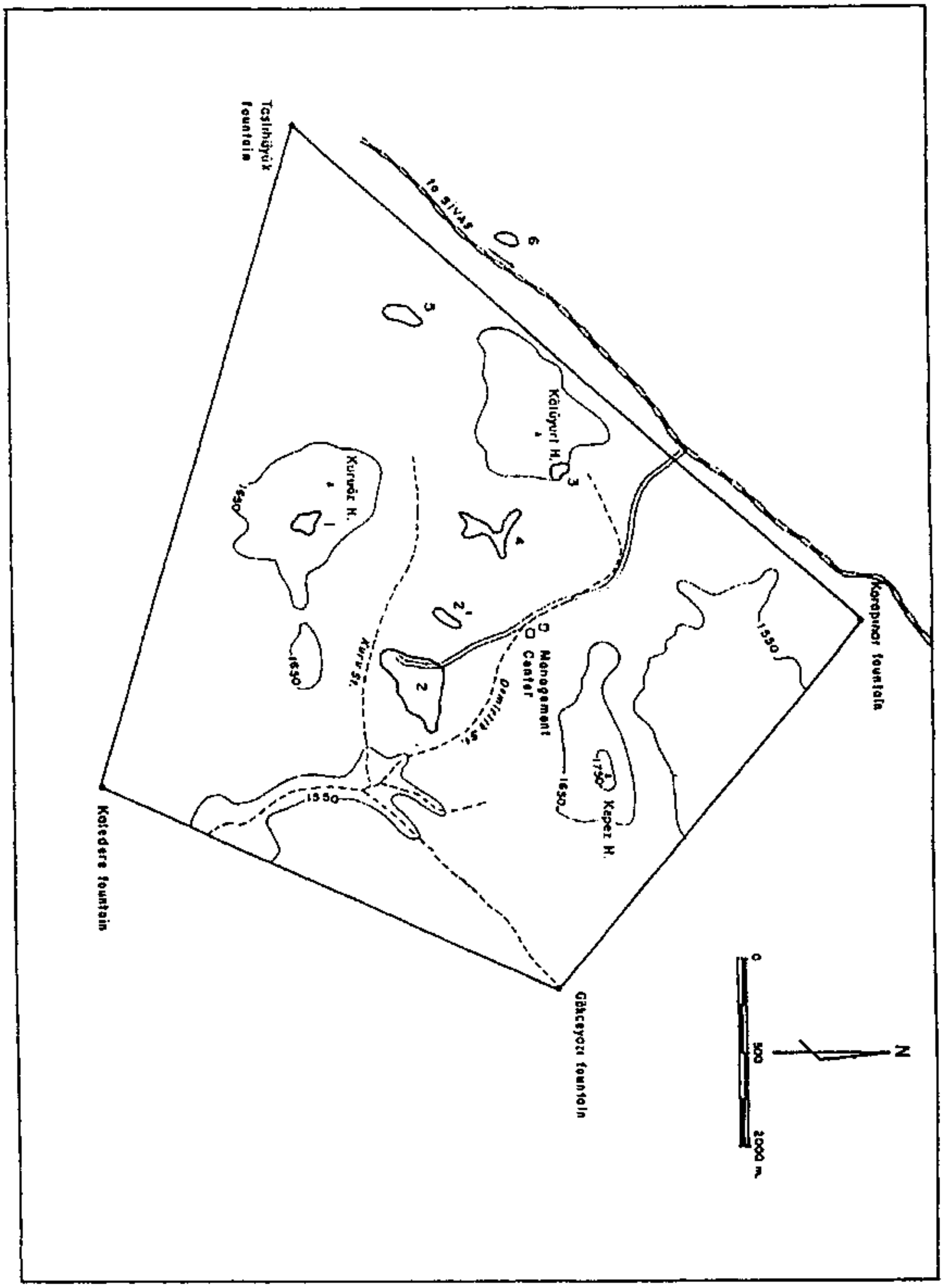

Figure 4- Map showing occurrences of in development area with 55/334 concession number of Gökçeyazı (Otlukilise) county of Gürün town is Sivas. Modified from Gümüş, 1964 (occurrence are numbered 1,2,... 6 and occurrence number 2 indicate "Main Deposit".

Section of volcanic rocks

Andesites, andesitic tuffs and pyroclastic and locally thin carbonate fragments cemented by ironoxides are observed at the core samples from surface to 70 metres. Light yellowish rocks, stained by ironoxides and hydroxides are cemented toughly.

Sizes of rock fragments reach up to 2 cm. Rounded locally angular grains are surrounded by ironoxides and hydroxides. Plagioclases with magnetite inclusions, brown hornblende and trace amount of opaque minerals form phenocrystals of volcanic rock fragments. Matrix consist of volcanic glass in which some plagioclase microlites and fine grained magnetites occur. Angular carbonate rock fragments are also found this section.

Section of ore

Ore rich zone with conglomeratic - breccious appearence commence from 70 metres onwards. Red, localy green colored rock fragments are cemented by reddish clays in hand specimens. Magnetism is emphasized at greenish samples.

Polygenic rock fragments are cemented by limonite - goethite, clay and siderite according to petrographical investigations of compiled core samples. Features of rock fragments and matrix are presented below.

Sandstone fragments: Three kinds of quartz bearing sandstone are determined in the samples. First type contains rounded, locally angular quartz, chlorite, plagioclase, opaque minerals and trace amounts zirkon and turmaline. Small amount of chlorite as matrix can be observed in these grain supported sandstones. Opaque minerals fills cracks and fractures. Lineation of blurred character is sometimes seen at rock fragments.

Second type rounded, locally angular sandstone fragment consist of quartz opaque minerals, chloritized plagioclase and again trace amounts of zirkon and turmaline. These constituents are cemented by chlorite and clay. The most important features of this type which distinguish it from the others are intensive clay matrix and no lineation at the grains. In addition, various grain sized siderites in matrix and as fracture fillings in semirounded sandstones are observed (Plate I, Fig. 3).

On the other hand, third type sandstones are "cemented by very fine grained quartzs and ironoxide and hydroxides (Plate I; Fig. 4). Distinguishing feature at this type sandstones is intergrown textures of iron minerals and quartzs.

Metamorphic rock fragments: Transported and locally rounded various rock fragments such as slate and phyllites which are effected from low grade metamorphism contain very good schistosity and elongation along one axeis. The schistosity of the rock formed from these metamorphic rock fragments which are made up of fine grained quartz, chlorite, muscovite, graphite, coal like material and filled cracks and fractures and locally at matrix by siderite is weak.

Basic rock fragments: Basic rock fragments totally chloritized, silicified and kaolinized hornblend and biotite phenocrystals of angular rounded basic rocks are intensively altered. Rock fragments are rich in opaque minerals. Due to original rock textures, these rocks are considered as spitilized basalts and/or diabases (Plate I; Fig. 5).

Siderite Fragments: Grain sizes of siderite particles vary between very fine grained and up to 2.5 mm. Fine and medium grained siderites are euhedral to subhedral and contain opaque mineral inclusions. This appearance look like graphic texture (Plate I; Fig. 6). Colloform textured siderites are observed at the cracks and open spaces associated with quartz, chalcedony and locally euhedral zoned dolomites.

Fragments rich in opaque minerals: Local network like openspaces, observed in generally angular and rarely rounded opaque rich rock fragments, are filled by chlorite, quartz and siderite. Furthermore, euhedral to subhedral opaque minerals together with siderites do also exist.

Three types of matrix are seen from surface to deeper parts of ore dominant sections.

Ironoxide - hydroxide matrix: Quartz bearing sandstone of conglomerate apperance, slate, phylltes, basic volcanic rock fragments rich in siderite and opaque minerals and locally individual minerals are cemented by limonite and goethite. This rock is again fractured and cemented again as angular rounded particles.

Green colored clay matrix: Mixed with ironoxide and hydroxide clay cement fillings of various kinds of rock fragments is colored to red. In addition, opaque minerals bearing clay cement occur in openspaces of quartzs in sandstones.

Siderite matrix: Fine to medium grained siderite cement among rock fragments and network like siderite veinlets again in cracks and fractures on the same are observed. Such particles are transported and cemented again by siderite.

In drill cores, green clay matrix gradually vertically and laterally pass to limonitized siderite rich matrix.

ORE MINERALOGY

36 polished section are prepared from surface, open pit and drill core samples of Otlukilise iron deposit and investigated by ore microscope. Gangue minerals are determined by means of polarizan microscope.

Surface samples: Some of the samples from Yanıktepe formation contain sandstone with quartz, carbonate and locally volcanic and metamorphic rock fragments. The features of these components are presented below.

Basic rock fragments: Subhedral to euhedral, fein grained cataclastic chromite crystalls are observed in silicified and carbonatized rock fragment with indications of ophitic texture. In addition, rutile, leucoxene, apatite, grains up to 280 micron and pyrite and hematite much smaller than those are found in these rock fragments.

Graphite bearing schist fragments: Transported graphite bearing schist fragments contain graphite, coal particles and locally rutile grains generally in accordance with schistosity.

Quartz fragments: Angular, locally euhedrat quartz up to 4 mm include transported hornblend grains.

All of above mentioned rock fragments are cemented by calcite and/or dolomite and sometimes by siderite.

The features of chromite and magnetite observed in highly serpentinized, silicified and carbonatized and locally aspestos bearing ultramafic rock fragments of Yanıktepe formation are as follows:

Euhedral to subhedral cataclastic chromites are replaced by chromspinell and magnetite at their edges and fractures (Plate II, Figure 1).

Magnetites reveal three types of formation. These are respectively; replacement production of chromites from it edges, skeletal shaped magnetites at the serpantinization and magnetites of euhedral shaped and in veinlets occurred hydrothermal emanations. All of these magnetites locally and sometimes completely replaced by hematite as result of martitization process.

Furthermore, small amount of heazlewoodite, millerite, pyrite, chalcopyrite are located in serpantinized, silicified and carbonatized ultramafic rock samples.

Open Pit Samples

Ore samples collected from open pit area are characterized by siderite, goethite, magnetite, quart, calcite, and/or dolomite, gypsum (?) and small amount of pyrolusite and psilomelane.

Siderite vary from generally anhedral fine grained to rarely subhedral medium grained crystalls at siderite dominat samples. Geothite replacements can be observed at fine grained, clamped siderites (Plate II; Figure 2). In addition, subhedral to euheral hydrothermal quartz and locally zoned magnetites replaced by siderites occur together with siderites.

These samples revealing party transportation features and conglomeratic apperance are cemented by calcite and/or dolomite, siderite, chalcedony and small amount of gypsum.

Drill Core Samples

Following rock fragments are observed in drill core samples:

Altered basic rock fragments: Highly chloritized, silicified and kaolinized basic rock fragments (Plate II; Fig. 3) contain chromite, siderite, magnetite, hematite and pyrite. Subhedral, fine to medium grained chromites are observed both within the basic rocks and at the matrix among basic rock fragments. Magnetites are generally fine grained, sub- to euhedral and partly replaced by hematite as result of martitization. Furthermore, lath like hematite occurrences of primary origin can also be seen.

Siderite fragments: Siderite fragments show anhedral very fine grained to euhedral fine grained features and concentric, zoned growth textures, in which magnetite, hematite, arsenopyrite, pyrite, chalcopyrite, fahlore (tetraedrite-tennantite) and enargite occur. Chalcopyrites are replaced by chalcosine an covellite, siderites by goethite, enargite and fahlores by Sb-As ochers. Five different type of magnetite formation are distinguished at siderites. First type is euhedral to subhedral, partly replaced by siderite and locally or totaly hematitized by martization (Plate II, Fig. 4-5). Second type magnetite reveals myrmekite like textures in siderites (Plate III; Fig. 1-2). Forth type magnetites are associated by lath like musketofite occurrences. Finally, the last one exhibit intergrown textures together with siderites (Plate III; Fig. 3). Arsenopyrites are fine- to medium grained, euhedral to subhedral and form twinnings of two and/or multiple inviduals. Melnikovite pyrites (Plate III, Fig. 4) and hematites are also observed as intergrown products with siderites. Fine grained siderites are replaced by goethite beginning from their edges. Small amount of chalcopyrite, covellite and goethite occur in siderite fragments.

Rock fragments: These are characterized by shale and sandstones. These rocks reveal well developed schistosity and consist of graphite, coal particles, hematite, siderite veinlets and pyrite framboides or pyrite bacteria stained by iron oxide and hydroxides. Rounded and partly grown together with hematite. Concentric chamosite particles (?) and chalcedoy grown with siderite are also observed.

Two kinds of matrix cenient all rock particles. One is very fine grained matrix colored by ironoxide and hydroxides. These colored matrix composed of day minerals and different mineral (Plate III; Fig. 5-6) and rock fragments fill the open spaces between the coarse rock fragments of conglomerates. Second matrix is made up of fine grained siderite. All of these rock fragments are fractured by secondary processes and are cemented by calcite, dolomite, siderite and gypsum (?).

GEOCHEMISTRY

Sampling and Analytical Method

Mainly iron rich massive ore samples were compiled by second author of this paper from the operating time of mine of Otlukilise iron deposit in previous years. 13 samples are selected from these ores and detailed chemical analyses were carried out at Copenhagen University. Statistical data about these samples are presented by Ünlü and Stendal (1986). Because of expansiveness of such kind of chemical analyses, accuracy and to avoid from repetitation, the above mention data source will be used and so detailed interpretations and evaluations will be made.

Ten major and thirtyone trace element analyses had been conducted on 13 samples. W, B, Be, Mo, Li, Ag, As, Sb, Bi, Sn analyses were realized by Emmission Spectral Analyses (ESA) method. All other element analyses except Na and Mg been made by X-Ray Flourescence method.

Glass discette prepared by solvent of sodiumtetraborate were for major element analyses. Loss on ignition had been calculated by loss of other elements. Na and Mg analyses had been carried out by Atomic Absorbtion Spectrofotometer Analysis (AAS).

Trace element analyses have been conducted by X-Ray Flourescence method on powder pellets at PW 1400 Philips instrument using Norrish And Chappel (1977) technique. Interference of tube and sample spectral lines and major element percentages for matrix changes were used for some corrections on results. USGS standarts (G-2, GSP-1, AGV-1, W-1, BCR-1, PCC-1) were used for corrections (Gladney et al. 1983).

Results of Chemical Analyses

Chemical analyses of some samples collected from Otlukilise iron deposit are presented at Table 1. Maximum and minimum values, standart deviations and means for all samples will here only be referred since they are previously given by Ünlü and Stendal (1986).

40-90% Fe_2O_3, 1-35% SiO_2, up to 10% Al_2O_3 and up to 2.5% K_2O contents of massive ore samples of Otlukilise iron deposit indicate an iron-claystone formation at first galance. Reaching up to 3% MnO values derive from similar physicochemical behavior of Fe and Mn, MgO and CaO contents varying around 1% point out a small percentage of carbonate phase. Other associated oxides of ore are characterized by less than 5% Na_2O, TiO_2 and P_2O_5. Trend of major element values indicate an iron environment characterized by the dominance of carbonate, quartz and clay minerals (possibly clayey carbonate). The mean less than 10% varying within the limits of 5-20% of loss on ignition reflects that the recent character of ore is represented by oxide phase rather than carbonate phase.

Trace element values of Ba vary between 200-1800 ppm, Co, Cu and Zn between 2 -1225 ppm, Ni between 2 -50 ppm, S, Cl and As between 10 - 7000 ppm and all of these values suppose hydrothermal solutions. On the contrary, Pb contents are very low changing within 1 - 20 ppm values.

Ga contents vary between 20 - 30 ppm and Cr between 150 - 250 ppm which emphasize the role of ultramafic and mafic roks at ore formation. V values are relatively low varying from 10 to 125 ppm.

Rb, Zr, Sr with approximately 250 ppm, Ce with 150 ppm and La, Nd, Y, Nb, Sc with 50 ppm values probably indicate granitic effects on ore formation system. On the other hand, Th contents are less than 1%.

All of these geochemical values point out that a formation processed at a carbonate associated with clays deposition environment and ultramafic - mafic rocks are affected by hydrothermal solutions. Effects of granitic rocks to the system can also be slightly recognizable.

Geostatistics

Although sample number is relatively low, cluster and factor analyses are tired on linear regressions among elements pairs of 30 elements chemically analysed from 13 samples.

Correlation coefficients are determined on "In" base of element contents using computer programs. On the other hand, computer programs are not used to realize cluster and factor analyses. Results are obtained by trial and error method (Table 2). 435 correlation coefficients are grouped statistically and element associations are created taking into consideration of possive and negative relationships (for more detailed information see Çiftçi, 1994).

Three groups are determined with very high positive correlations ($r > + 0.85$) (Table 2). First group is represented by Fe, Zn, Cr and Co elements. In this element association, four element behave positively to each other. Second group can be classified into three subgroups namely a, b and c. Subgroup a consist of Ni, Cu, Cl and S, b of K, Al, Si, Na, and ti and c of Zr, Rb, Nd, ce, y, Nb and Sc. The elements of subgroup exhibit positive relationship to each other. When considering the statistical behaviors of these three subgroups, they also show relatively positive relationship. Because of only the relationship of subgroup c to other subgroups are relatively questionable the values at Table 2 are written in parenthesis. The group include P and V elements, therefore it is a relatively small group.

Two groups with high positive correlation coefficients ($+0.85 > r > +0.70$) are clearly to be seen in Table -2, First group is represented by Fe, Zn, Cr, Co and Mn elements. The only difference from the first group of very high positive correlation is presence of Mn. On the other hand second group is characterized by four subgroups a, b, c, d. First subgroup very high positive correlation. Second

Table 1- Result of chemical analyses of Otlukilise iron depôsit. Areas without results mean any analyses performed. Total iron is given Fe_2O_3.

Sample Nr.	2	4	7	9	11	14	17	20	25	26	29	31	32
Main Element (%)													
SiO_2	0.84	1.14	1.57	4.99	56.04	33.84	3.61	4.14	2.16	36.45	26.74	25.83	13.15
TiO_2	0.00	0.00	0.01	0.02	0.63	0.58	0.04	0.00	0.00	0.60	0.42	0.41	0.17
Al_2O_3	0.00	0.01	0.47	0.56	9.47	8.97	0.83	0.17	0.00	9.28	7.04	6.60	2.83
Fe_2O_3	88.09	87.13	75.43	81.53	38.51	42.46	89.56	79.71	86.86	44.86	45.28	52.04	71.98
MnO	2.73	2.49	0.87	0.91	0.03	0.04	0.13	0.87	1.56	0.03	0.19	0.06	0.20
MgO	0.62	0.57	0.75	0.52	0.70	0.75	0.64	0.44	0.70	0.82	0.88	1.13	0.93
CaO	0.26	0.24	0.44	0.05	0.31	0.40	0.07	0.04	0.30	0.33	0.91	0.62	0.59
Na_2O	0.00	0.00	0.02	0.02	0.29	0.19	0.00	0.01	0.00	0.25	0.19	0.11	0.07
K_2O	0.00	0.00	0.09	0.11	2.53	2.23	0.09	0.00	0.00	2.54	1.78	2.06	0.65
P_2O_5	0.17	0.18	0.02	0.03	0.14	0.14	0.03	0.01	0.05	0.13	0.11	0.11	0.00
Loss on ignition	7.29	8.24	20.33	11.27	11.35	10.39	5.00	14.91	8.35	5.89	16.46	11.01	9.38
Trace Element (ppm)													
S	390	60	1190	780	6620	5820	720	490	210	3150	3730	2470	1020
Cl	30	10	340	30	950	830	170	30	10	1780	320	1890	1660
Rb	< 0.5	1.0	5.9	12.0	171.0	172.0	20.0	5.6	< 0.5	214.0	142.0	267.0	101.0
Ba	2624	2930	2649	2985	17710	16173	1904	1163	2343	6362	6515	218	981
Pb	< 1	< 1	< 1	< 1	14	14	< 1	< 1	< 1	9	7	20	< 1
Sr	36.0	26.0	8.2	31.0	182.0	141.0	11.0	10.0	49.0	64.0	71.0	21.0	13.0
La	< 1	< 1	3	8	15	14	< 1	< 1	3	16	19	16	2
Ce	< 2	< 2	11	< 2	50	68	23	< 2	12	68	41	155	57
Nd	6	6	18	15	48	46	20	13	15	32	30	18	15
Y	< 1	< 1	7.4	5.4	27.0	26.0	13.0	2.2	4.6	25.0	18.0	18.0	11.0
Th	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Zr	15	16	16	28	248	265	34	15	13	219	152	158	72
Nb	3.2	3.4	2.3	3.8	14.0	13.0	3.2	3.4	2.7	14.0	10.0	12.0	7.8
Zn	190	224	365	246	3	41	129	150	367	25	53	47	265
Cu	< 2	5	84	46	966	1216	436	< 2	< 2	836	1063	1225	617
Co	386	395	346	420	100	124	490	408	408	160	174	208	324
Ni	< 2	< 2	< 2	< 2	23	32	< 2	< 2	< 2	33	27	48	7
Sc	< 1	1	3	2	15	12	6	< 1	< 1	14	9	10	7
V	47	123	19	21	82	83	26	13	17	86	71	69	40
Cr	256	259	207	231	157	154	253	225	247	176	162	164	198
Ga	30	34	25	31	19	21	23	23	21	27	22	21	24
W	<30	136	125			66		163	215		170		300
B	<10	<10	90			180		<10	<10		180		175
Be	< 5	< 5	< 5			< 5		< 5	< 5		< 5		< 5
Mo	<10	<10	<10			<10		<10	<10		<10		<10
Li	0.1	0.1	3			18		0.1	0.1		14		5
Ag	5	10	11			76		8	2		11		11
As	62	76	790			1760		76	1850		650		4000
Sb	< 1	< 1	< 1			< 1		< 1	< 1		< 1		< 1
Bi	4.2	1.3	18			9.5		1.0	2.5		9.5		35
Sn	< 0.5	< 0.5	0.5			0.7		< 0.5	< 0.5		0.6		< 0.5

subgroup b is represented by K, Al, Si, Na and Ti elements which is also the same element association of subgroup b of second of very high positive correlation. Third subgroup c also exhibit similar features like a and b to very high positive correlation and include Zn, Rb, Nd, Ce, Y, Nb, Sc and La. The difference is existance of La in this subgroup. The last subgroup d, which does notexist very high positive correlation group, consist of Ca, Mg, Sr, Ba element association. Every element of each subgroup reveals high positive correlation coefficients among each other and each subgroup also is characterized by again same type of correlation coefficients as pairs with each other. Y, Nb, Sc and La elements of second group are shown by dashes on top of them. The reason why is that their minimum and maximum values vary within very close limits that is for Y: < 1-27 ppm, for Nb: < 2.3-14 ppm, for Sc: <1-15 ppm and for La :< 1-19 ppm, which can inevitably increase the correlation coefficients and this should be carefully taken into account during interpretation. It would be better if the results of

Neutron Activation Analyses (NAA) were used instead data could give more accurate values and so better correlation coefficients. Elements of subgroup c of second group are displayed within parenthesis, because three elements are relatively weak relationships when compared with elements of other group.

Two main group occur with very high negative coefficients (r < -0.83) at Table - 2. First group are represented by Fe, Zn, Cr, Co, while second group by three subgroups (a, b and c). The subgroup a consists of Ni, Cu, Cl, S and b of K, Al, Si, Na, Ti and c of Zr, Rb, Nd Y, Nb, Sc and La. The most important point is that elements of first and second group exhibit positive correlations to each other but as a group they represent very high negative correlations. It means that while the value of an element of first group is increasing, the value of an element of second group can decrease or vice versa.

High negative correlations (-0.65 > r > -0.83) are shown at the last row of Table -2. First group of the high negative correlations differ from very high negative correlations only with the presence of Mn and Ga. Subgroup a and b consist from the same elements when compared with again very high negative correlation subgroups. Subgroup c differ from those by the addition with Ca, Mg, Sr and Ba elements subgroup d with high negative correlations appear hear with Ca, Mg, Sr and Ba elements which do not exist in subgroups of very high negative correlations. Dash lines on top of some elements and paranthesis are put because of the same reasons mentioned above.

Table 2- Element groups and associations determined from Cluster and Factor analyses.

Very High Positive Correlation (r>+0.85)				
Group 1 : Fe,Zn,Cr,Co				
Group 2 :	Ni,Cu,Cl,S (a)	K,Al,Si,Na,Ti (b)	(Zr,Rb,Nd,Ce,Y,Nb,Sc) (c)	
Group 3 : P,V				
High Positive Correlation (+0.85>r>+0.70)				
Group 1 : Fe,Zn,Cr,Co,Mn				
Group 2 :	Ni,Cu,Cl,S (a)	K,Al,Si,Na,Ti (b)	(Zr,Rb,Nd,Ce,Y,Nb,Sc,La) (c)	Ca,Mg,Sr,Ba (d)
Very High Negative Correlation (r<-0.83)				
Group 1: Fe,Zn,Cr,Co	Group 2: Ni,Cu,Cl,S (a)	K,Al,Si,Na,Ti (b)	(Zr,Rb,Nd,Y,Nb,Sc,La) (c)	
High Negative Correlation (-0.65>r>-0.83)				
Group 1: Fe,Zn,Cr,Co,Mn,Ga	Group 2: Ni,Cu,Cl,S (a)	K,Al,Si,Na,Ti (b)	(Zr,Rb,V,P,Nd,Y,Nb,Sc,La,Ce) (c)	Ca,Mg,Sr,Ba (d)

Element behaviors of each subgroups, groups and behaviors among groups are clarified by using cluster and factor analyses. Thus, element mobilities are statistically set from the geochemical point of view.

Interpretation of Geostatistical Results

Element groups and associations of Table -2 will be tried to be interpreted as follows:

Discussion of especially last associations creates the base of genetic evaluation. Group 1: Fe, Zn, Cr, Co, Mn, Ga elements (oxidic phase), Group 2: a) Ni, Cu, Cl, S (sulphidic phase), b) K, Al, Si, Na, Ti (silicate phase), c) Zr, Rb, V, P, Nd, Y, Nb, Sc, La, Ce (effects of granitic rocks(?) and d) Ca, Mg, Sr, Ba (carbonate phase) are represented by subgroups and element associations. Subgroup d that is Ca, Mg, Sr, Ba element association characterize carbonate depositions while subgroup a (Ni, Cu, Cl, S) sulphide phase resulted from the reactions between seewater and submarine volcanic rocks. On the other hand, subgroup b (K, Al, Si, Na, Ti) represents silicate phase (clay minerals and quartz). These subgroup is represented by clay constituents (clay minerals and quartz). But positive correlation relationship between the elements of this subgroup and subgroup d which consist of Ca, Mg, Sr, Ba elements, indicate same kind of mobility of these two groups. That is when carbonate phase increase, increase also the silicate phase. Geochemical studies carried out on common sedimentation environments characterized by carbonate and clayey level alternations reveal high negative correlation relationship between these constituents and while one is accumulating the other one is waiting to be deposited. As shown at Table -2, positive relationship between clay and carbonate components reveal at least that clay minerals transported to carbonate deposition environment are not deposited alternately as supposed above or silicate are derived from another soures and transported to the environment. This different source can be hydrothermal solutions associated submarine volcanism and penetraped using fractures at the bottom of the basin. These solutions following different processes and channels transported elements of silicate phase to the environment and represent positive correlation relationship between carbonate and silicate phase which are participated to carbonate environment during ore formation instead of negative correlation relationship which indicate a mathematical expression of "deposition of clay carbonate alternations is such in common deposition environments.

So, the positively related a, b and d subgroups, in other words carbonate, silicate and sulphide phases altogether characterize sulphide phase resulted from the reaction between seewater and submarine volcanites spreading out on a carbonate deposition environment and at the same time silicate formations mostly related with hydrothermal fluids associating the same volcanites. High positive correlation coefficients among these three shows this relationship extremely well.

Group 1, as earlier mentioned, forms from Fe, Zn, Cr, Co, Mn and Ga elements. This association symbolize most probably ultramafic and partly mafic rocks. The existence of iron in this group directly indicate that the source of iron of this ore deposit should be searched at this kind of rocks. However, very high negative correlation coefficients between Group 1 and Group 2 elements can be interpreted as that the source of Group 2 elements are more different that the ones Group 1. The mineral associations of Group 1 and 2 exhibit clearly sequential conjugateness. The interpretation of this statement point out an hypothesis that iron and associated elements are extracted from the country rocks by means of fluids heated by submarine volcanites and/or their porphyries (of granitic rocks ?). These fluids are transported into the deposition environment of submarine volcanism. Various iron mineral are formed due to the changes at Eh, pH and temperature factors controlled by physicochemical conditions created by basinal changes at the bottom. It should not be also ignored that the changes at unstable minerals and new stable minerals could also occur. This synthesis brings an explanation for the iron occur. This synthesis brings an explanation for the iron element source of exhalative sedimentary or synsedimentary volcanogenetic type of formation.

Geochemical interpretation represented until now, reflects a sedimentation basin in which iron and associated elements, which are leached from serpentinites by direct or indirect effects of submarine volcanics spred on a carbonate deposition environment, are transported by hydrothermal exhalites which are associated with silicate phases of hydrothermal origin, associated sulphide phase resulted from same submarine volcanics and sea water reactions.

The most critical point at this model is that the questions of how, when and with kind of rocks are associated Zr, Rb, V, P, Nd, Y, Nb, Sc, La and Ce elements of subgroup c of second group. As mentioned above, there are some uncertanties at their interpretation because of their narrow variation limits. But some diagrams from Ünlü and Stendal (1989) are carried in order to discussion properly.

Sample number 14 at Figure 5 represents an ore sample comprised from quartz, hematite and magnetic characterizing the matrix of conglomeratic ore of Otlukilise iron deposit. On the other hand conglomeratic ore itself is represented by sample number 20 and goethite mineral. Sample number 32 is an ore sample consisted of siderite and ore sample consisted of siderite and magnetite in serpentinized ultramafic rocks around Divriği A- and B-Kafa is characterized by sample CS 1-10 and contains intensively serpentine and magnetite. Biotite-hornblend diorites of Divriği A- and B-Kafa are represented by CA-10 sample and biotite-hornblende (quartz) monzonites of Divriği A- and B-Kafa by AA-20 sample (for more information see Unlu ve Stendal, 1988).

The result from the distribution of rare earth elements Figure 5 is that goethite and magnetite with siderite bearing ores of sample 20 and 32 respectively, exhibit close similar characteristics with serpentinites of Divriği A- and B-Kafa. On the contrary, ore formed from quartz, hematite and magnetite constituents with sample number 14 is in accordance with diorites and monzonites of Divriği A- and B-Kafa region, when are element contents and distribution features are taken into consideration. Sample number 14 of Otlukilise iron deposit reveals a relationship and/or an effect from for example granitic rocks. With the careness of only. one sample used for the interpretation, it is avoided to generalize for granitic effects.

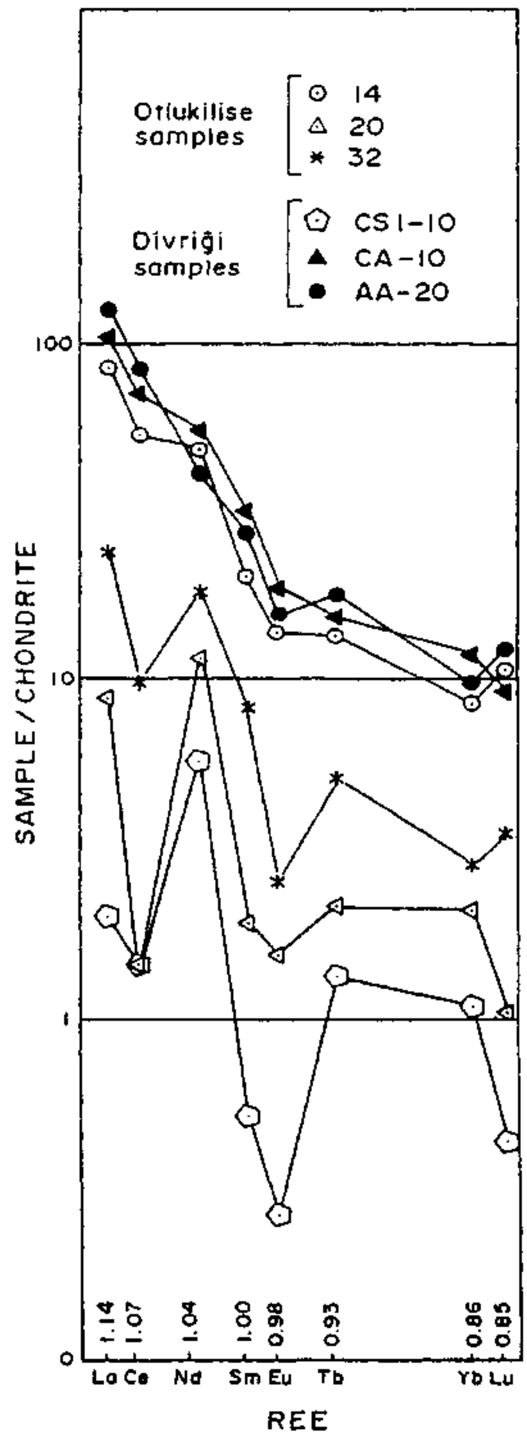

Fig. 5- Correlative REE distribution diagrammes between ore samples of Otlukilise iron deposit and the ones of Divriği A-B Kafa Iron Deposit.

Schematized model of Otlukilise iron deposit prepared from the geochemical data and basin evolution model is presented at Fig. 6. Syntectonic sediments of fault controlled basin which forms the basement under ophiolitic nappe overlying the limestones of Yüceyurt formations are rudist bearing limestone, shale, marl and sandstone alternation and limestone, clayey limestones of Yanıktepe and Akdere formations are subaerial to marine as well as submarine volcanics. Primary iron deposit exhibit concordance with contem-poraneous volcano-sedimentary sequence and is formed by metal mobilizaton created by hydrothermal convective systems of submarine volcanics.

XRD Studies

Sampling and Analytical Method

X-ray difractograms of whole rock are taken using XRD instrument and mineral associations are determined from 31 ore samples collected from O-42 drill hole (drilled by Gülibrahimoğlu, 1979) of Otlukilise iron deposit. XRD studies are carried out on samples conglomerate - breccia comprised from different rock particles which are cemented by siderite, clay, and/or clayey siderite, compiled between 80 and 290 metres, below weathering zone. These studies have been realized by Philips PW 3710 difractometer of MTA General Directorate at the conditions of 30 mA, 40 kv, 29 = 3°/dak. and 2°-70° and with Cu filter.

XRD Results

Sample numbers, depths of samples, minerals determined from difractograms and microscopic descriptions of samples are given at Çiftçi, (1994) in detail.

Determined minerals from all difragtograms are siderite, quartz, illite, magnetite, hematite and small amounts of albite, K-feldispar, amphibole, pyroxene, ankerite, baryt, sphene and opal (?). No zonal distribution of mineral associations with the depth have been found.

Percentage contents of quartz, siderite, clay, magnetite and hematite mineral constituents as major minerals are estimated from the intensities of each peak at XRD studies (Table - 3). From this table, it is clearly to see that first three samples (Z-35, 53 and 61) are quartz rich and poor in siderite, following nine samples (from Z-72 to Z-109) are generally rich in both quartz rich and siderite and fourteen samples from Z-110 to Z-131 except Z-112 without any quartz but rich in siderite (for example sample Z-131 is formed completely from siderite) and the last five samples contain partly quartz and partly siderite rich samples (from Z-132 to Z-138). It should be emphasized that a relative reverse relationship between siderite and quartz components is to take into consideration. Clay component at all samples vary between 1.12% and 40.29%. Theoritically siderite increase is paralell to clay increase but is reverse with quartz increase. Magnetite ratio vary from 2.56% to 27.99% and quartz and clay increase together. Hematite contents change between 2.05% and 13.25% and exhibit a slight parallelism with magnetite increase.

Quantitative vertical distribution graphic of 31 samples as a result of XRD studies are presented at Fig. 7. Quartz content vary between 40% and 85% from 81 to 170 metres of drill cores, siderite vary between 5% to 35% and increase with depth. Clay contents change from 2% to 9%. Hematite and magnetite reveal a parallel distribution though in various ratios. Quartz and siderite contents reflects an alternating sequence between 170 and 290 metres with approximately 90% for quartz and 100% for siderite. At least four levels for quartz and siderite repeat by clay contents of up to 40% at siderite levels. Magnetite together with hematite represented a parallel vertical distribution pattern with siderite.

Correlation coefficients of these constituent pairs are presented at Table - 4. High negative correlation relationship (r = 0.88) observed between quartz and siderite at this table is significant. A relatively high negative coefficient (r = -0.62) between quartz and clay components, a moderate negative coefficient (r = -0,45) between quartz and magnetite and a low negative coefficient (r = - 0.22) between quartz and hematite are clearly to observe. At the same table, a low positive correlation coefficient (r = 0.01) between siderite and clay, a very low (r = 0.12) between siderite and magnetite and noncorrelation (r = 0.30) between

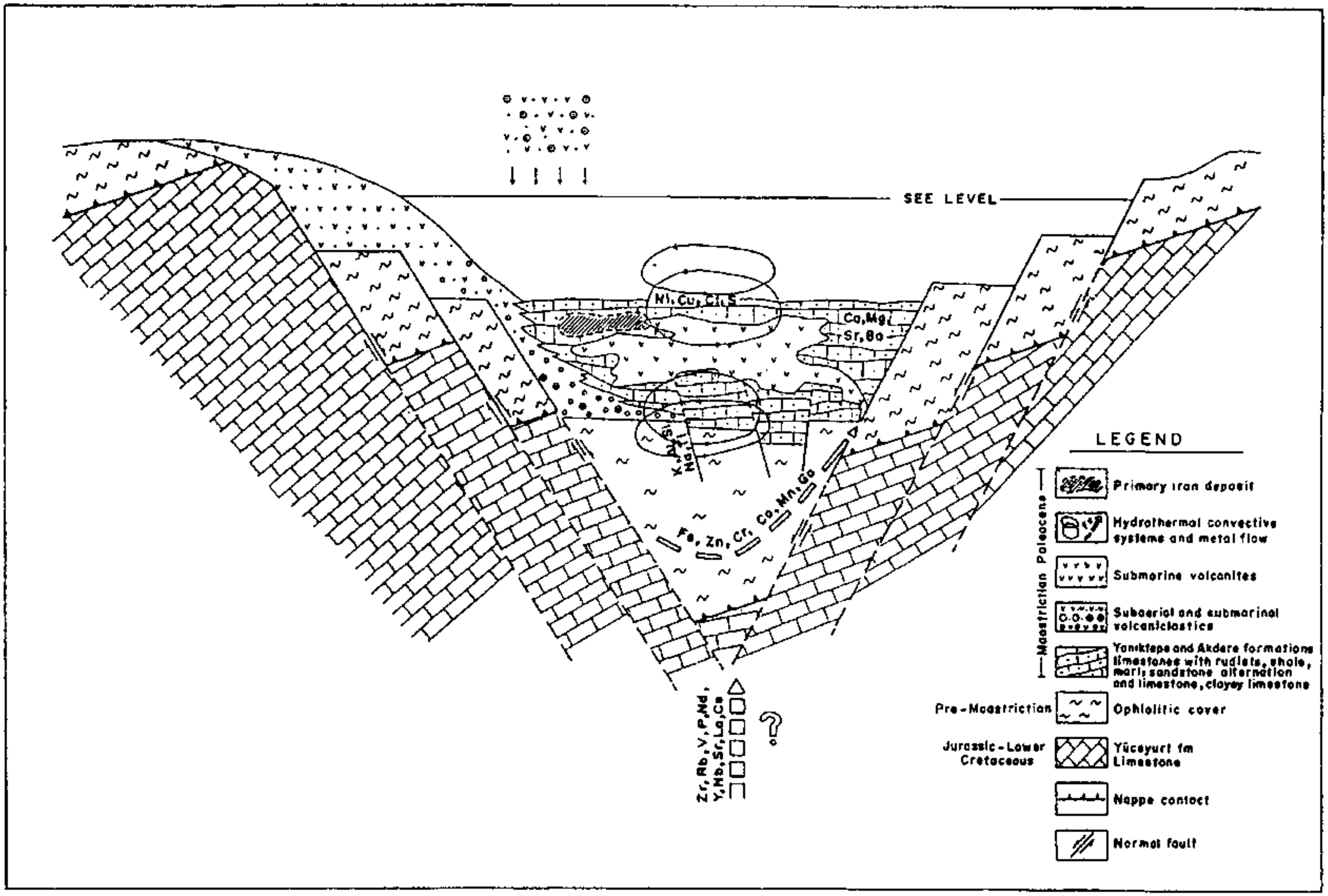

Figure 6- Schematized hypotetical generation model of Otlukilise Iron Deposit.

Sample Nr.	Z-35	Z-53	Z-61	Z-72	Z-81	Z-85	Z-89	Z-104	Z-105	Z-106	Z-107	Z-109
Components(%)												
Quartz	54.51	80.31	85.33	39.66	55.48	-	65.27	41.70	54.82	-	53,56	47.46
Siderite	10.28	9.28	7.56	25.78	36.41	80.94	26.62	50.88	44.06	68.24	44.70	41.31
Clay	4.82	2.25	2.30	9.25	2.13	11.10	3.29	2.56	1.12	19.39	1.74	5.32
Magnetite	17.14	5.59	2.65	12.25	-	-	-	2.56	-	-	-	3.07
Hematite	13.25	2.57	2.16	13.06	5.98	7.96	4.82	2.30	-	12.37	-	2.84
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Sample Nr.	Z-110	Z-111	Z-112	Z-113	Z-115	Z-117	Z-118	Z-119	Z-120	Z-121	Z-122	Z-126
Components(%)												
Quartz	-	-	52.41	-	-	-	-	-	-	-	-	-
Siderite	73.06	83.36	37.06	56.33	70.37	56.97	91.75	53.18	54.33	68.85	43.94	61.09
Clay	15.19	10.97	5.11	12.14	6.83	7.05	4.56	23.18	30.63	18.86	38.77	23.34
Magnetite	6.62	-	3.37	27.99	22.80	22.73	3.69	20.00	12.35	12.28	14.55	10.52
Hematite	5.13	5.67	2.05	3.54	-	13.25	-	3.64	2.69	-	2.74	5.05
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Sample Nr.	Z-129	Z-131	Z-132	Z-133	Z-134	Z-136	Z-138
Components(%)							
Quartz	-	-	92.03	89.39	-	-	94.54
Siderite	75.27	100.00	5.68	9.07	59.71	56.30	3.88
Clay	9.32	-	2.59	1.54	40.29	21.84	1.58
Magnetite	11.89	-	-	-	-	13.67	-
Hematite	3.52	-	-	-	-	8.18	-
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 3- Percentages of mineral componenets of O-42 drill cores samples.

siderite and hematite are also visible at the second vertical colomn. On the other hand, a low positive correlation coefficient (r = 0.32) between clay and magnetite, a very low (r = 0.09) between clay and hematite can easily be seen at the third vertical colomn. The last colomn points out a low positive correlation coefficient (r = 0.30) between magnetite and hematite.

Interpretation of XRD Results

Siderite, clay and quartz assemblage observed usually at particular sample difratograms suppose either intergrown textures developed among siderite and/or clayey siderite an quartz minerals or cementation of these minerals or rock fragments consisted from these minerals.

Siderite, clay and magnetite amounts decrease at the environment characterized by quartz in a wide ore horizon, but increase where clay exists at the environment. Furthermore, magnetite, hematite and siderite exhibit though weak but similar behavior features.

Quantitative distribution relationship of components of samples to the depth show an alternating association between quartz and siderite, clay and/or clayey siderite, magnetite and hematite. In other words, when one is decreasing the other increase. This event also points out an alternating deposition environment prior to deformation.

Amort silica observed in almost all the samples of conglomerate-breccia which consist of various kinds of rock fragments and siderite, clay and/or

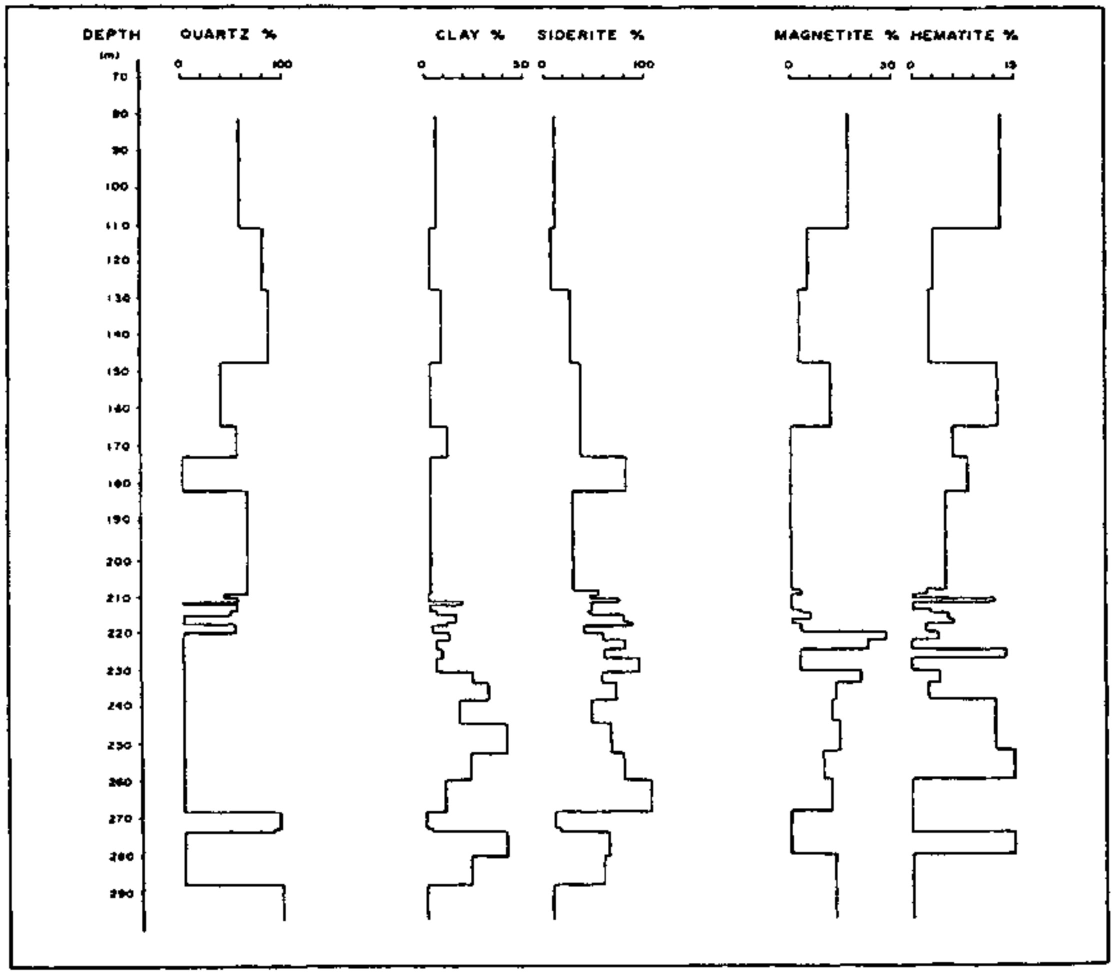

Figure 7- Quantitative vertical distribution graphic of constituents of samples.

clayey matrix and are called as "accumulated ore" according in previous studies (Gülibrahimoğlu, 1979) associates to ore as a significant component.

Positive correlation relationship among (K, Al, Si, Na, Ti group of massive ore samples were mentioned above (Table -2). In addition, a very high positive correlation coefficient (r = 0.99) was determined between Si and K and between Si and Al in massive ore samples (Çiftçi, 1994). So the mentioned elements could generally be symbolized as K-Al silicates. Under these circumstances, a

	Quartz	Siderite	Clay	Magnetite	Hematite
Quartz	1.00				
Siderite	-0.88	1.00			
Clay	-0.62	0.30	1.00		
Magnetite	-0.46	0.12	0.31	1.00	
Hematite	-0.22	0.01	0.09	0.30	1.00

Table 4- Correlation coefficients of componenet pairs of O-42 drill cores samples.

negative correlation relationship with r = -0.62 (Table - 4) observed between quartz and clay determined from XRD studies on conglomeratic-breccia samples gain importance. So, determined Si values from XRD studies indicate quartz besides clay. Conglomeratic-breccia samples are rich in quartz when compared with massive ore samples.

High negative correlation coefficient (r = -0.88) estimated between quartz and siderites of conglomeratic breccia samples point out that Si element associate ore as free quartz minerals besides as a clay component. This statement is meaningfull at genesis of ore formation.

Massive ore samples include 1-35% SiO_2 (Table - 1) and conglomeratic-breccia ore samples 1-95% SiO_2 (Table - 3). Massive ore samples are rich of these features, massive ore samples exhibit plastic behavior but conglomeratic breccia ore samples a brittle one. From all those characteristics, it can be concluded that partly fractured ores can occur at or during formation of an ore horizon which contains clay and quartz by the movements of the bottom of basin. This special result indicate the presence of massive and conglomeratic-breccia ores together at the same basin.

CONCLUSIONS

1- Jurassic - Lower Cretaceous aged limestones of Yüceyurt formation from the basement of the study area. Early sediments of a basin developed in relation to ophiolite emplacement and opened over a fault controlled basement in the region consist of reefal limestones of Upper Cretaceous age and shale, marl and sandstone alternation and locally volcanic rocks of both subaerial and marigin origin. All these units are called as Yanıktepe formation. Paleocene aged Akdere formation made up of pelagic sediments and volcanic intercalations reflects deeper parts of the basin. After the sedimentation of Akdere formation, basin is evolved to subaerial period and marinal Gövdelidağ and Plio-Quaternary aged Gürün formations and volcanites of subaerial character cover all other units.

2- The oldest volcanic rocks in the studied area are observed as chloritized, carbonatized volcanic rock fragments in Yanıktepe and Akdere formations. Hihgly altered chloritized, silicified and argillized angular and rounded basic rock fragments are called as spititicbasalts and/or diabases found in drill core samples accompanying to mineralization. These are accepted as contemporaneous volcanites in the above mentoned formations.

3- Main ore minerals are siderite, magnetite, hematite and minor amounts of pyrite, chalcopyrite and arsenopyrite. Secondary ore minerals are represented by goethite in addition to pyrolusite and psilomelane. Other associate minerals are dolomite/calcite, ankerite, ankeritized dolomite, graphite, gypsum, chamosite and chert. In addition to pyrite framboids, observation of existence of gell-colloform textures (colloform siderite, kidney-like siderite, gell magnetite, melnikovite pyrite and colloform quarz) and very fine grained textures (very fine grained siderite, hematite, quartz and chalcedony) and myrmekitic cloud like, skeletal megnetite bearing siderite, musketofite occurrences, zoned siderite and magnetite assemblage all represent ore characteristics.

4- Geochemical studies carried out on iron rich massive ore samples suppose a synsedimentary-volcanogenic mineralization past. Iron and associated elements are directly of indirectly derived from serpentinites by submarine volcanites extrude into carbonate depositions.

5- Mineralogical studies carried out on especially between quartz and siderite, and clay and/or clayey siderite levels in iron poor conglomerate-breccia ore samples indicate a sedimentary relationship prior to deformation. Thus, an ore horizon characterized by interference of clay and quartz rich sediments can form during the formation processes of locally massive and fragmented ores in the same basin even in small distances by the movements at the basement during or just after the ore formation.

6- Karst evolution and sedimentation controlled by fracture systems can run with ore development mechanism and retransport and redeposit it in proper places. These places can be the basement limestones like Otlukilise iron deposit. The last period of ore deposit evolution is the oxidation under surfical conditions and thus enrichment of ore by

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PLATES

PLATE-I

Fig. 1. Volcanic rock fragment (upper left) in rudist bearing limestone. Crossed polar (XPL), magnification x16.

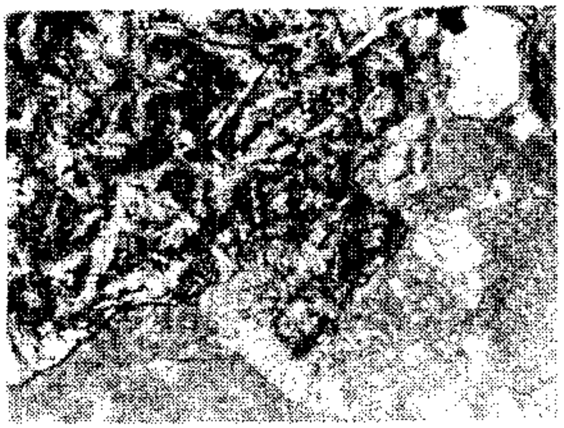
Fig. 2. Volcanic rock fragment showing flow texture cemented by micritic and locally sparitic matrix (in the middle) surrounded by micritic and sparitic rock fragments and some quartz grains (at upper, lower and right edges). XPL, magnification x16.

Fig. 3. Coarse grained (gray - dark gray) siderites (at right side) and fine grained (gray) siderites in rounded sandstone. XPL, magnification x16.

Fig. 4. Very fine grained quartzs cemented by iron oxides. Plane polarized light (PPL), magnification x16.

Fig. 5. Rounded basic volcanic rock fragment (from mid lower to upper part) filled by siderites at amygdules (light gray - white in the middle). XPL, x40.

Fig. 6. Siderite rock fragment including euhedral to subhedral opague minerals (black) and subhedral zoned dolomites (white - light gray). PPL, x16.



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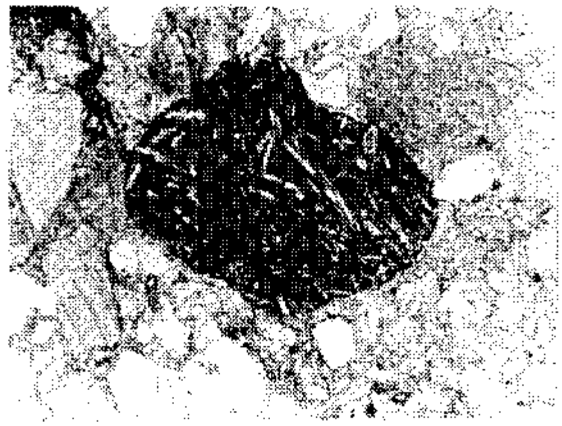

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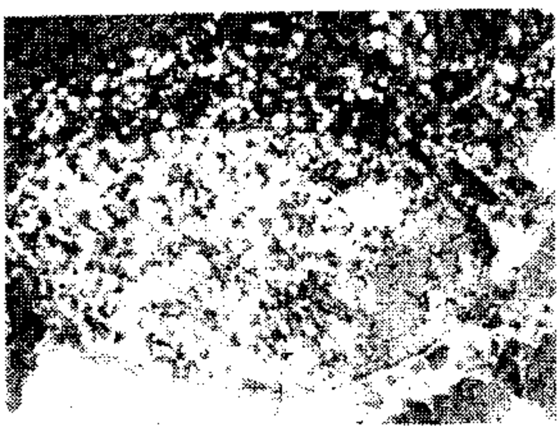

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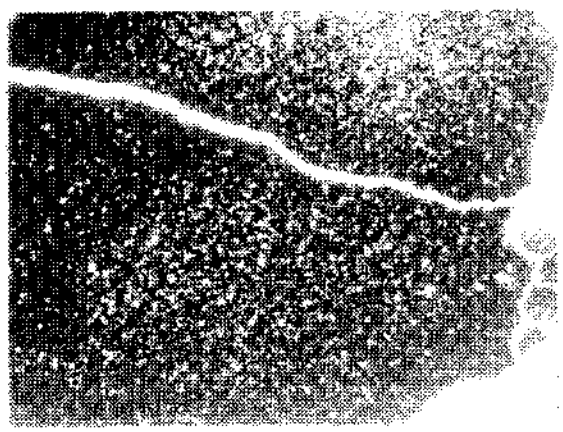

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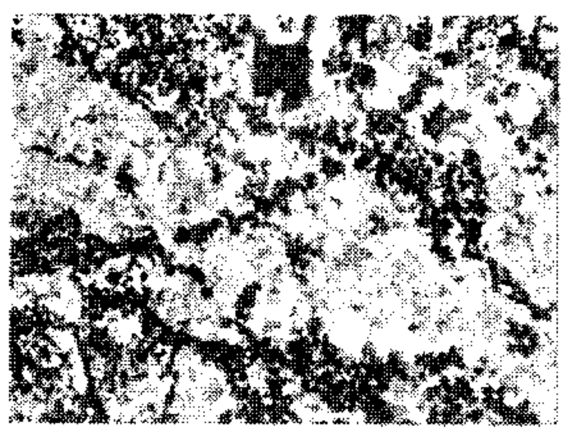

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PLATE-II

Figure 1. Chromite (dark gray) replaced by chromspinel (gray) and magnetite (light gray). In Oil, x200.

Figure 2. Very fine grained siderites (dark gray) replaced by goethite (light gray) from their edges. in oil, x200.

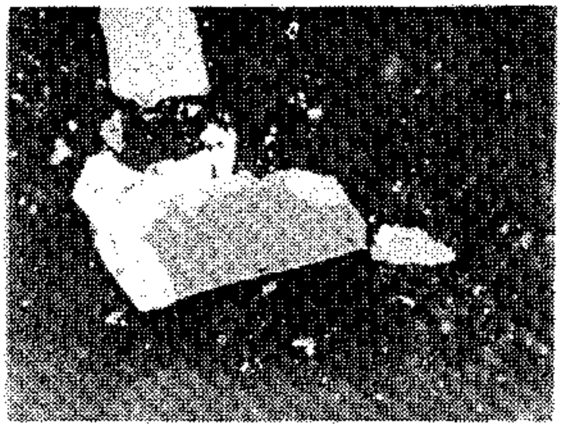
Figure 3. Volcanic rock fragments (midright and midleft, light gray) cemented by siderite (gray - light gray) and small amount of hematite laths (white). In oil, x200.

Figure 4. Partly martitized, zoned magnetite (white - light gray) replaced by siderite (dark gray). In oil, x200.

Figure 5. Limonitized and chloritized basic volcanic rock fragment (at left edge, dark gray) and magnetite (in the middle, gray) and chalcopyrite (to right side, light gray) in concentric siderite (in the middle and lower part, pale gray). In oil, x200.

Figure 6. Siderite (dark gray) and magnetite (gray) association exhibiting myrmekitic like textures. In oil, x200.

Dönmez ÇİFTÇİ; Taner ÜNLÜ and İ. Sönmez SAYILI PLATE-II



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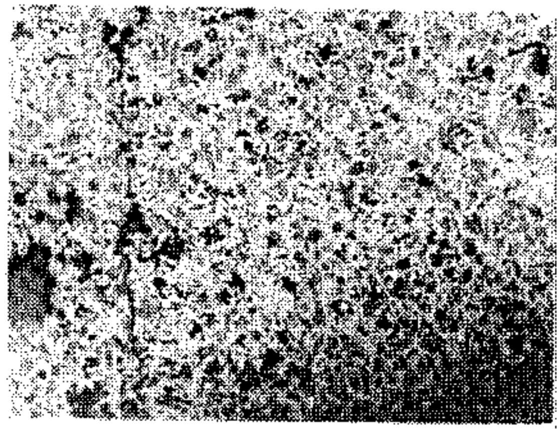

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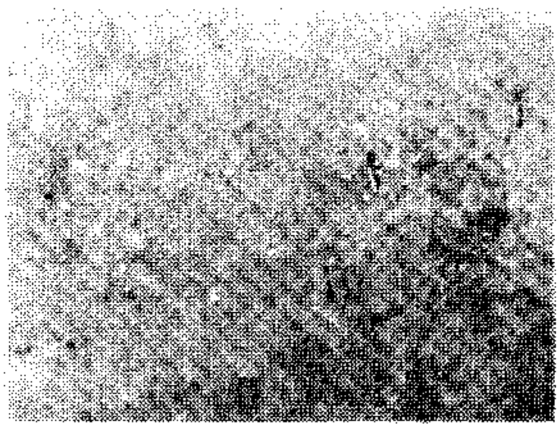

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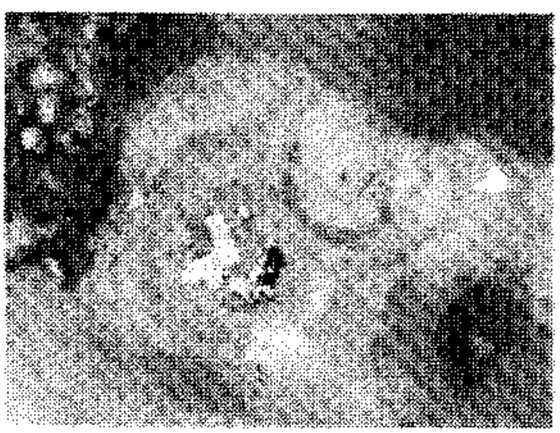

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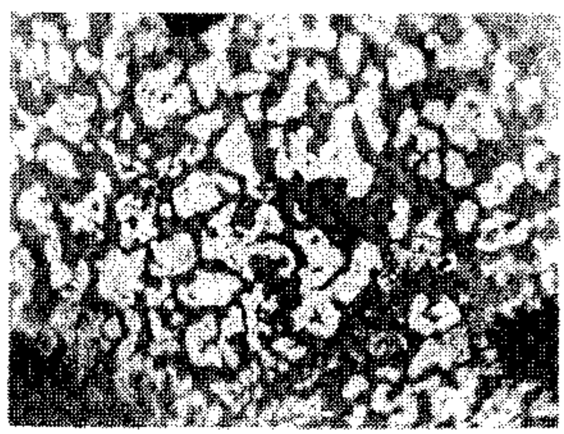

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PLATE-III

Figure 1. Cloud like magnetites (in the middle and to lower and right sides, light gray fine spots) and hematite laths white and chalcopyrite grains (midright and lower side, rounded and white) in siderites (light gray, gray). In oil, x200.

Figure 2. Magnetites (light gray fine spots) in euhedral siderites (gray). In oil, x200.

Figure 3. Euhedral to subhedral magnetites (gray) grown together with siderites (dark gray). In oil, x200.

Figure 4. Gell textured melnipovite pyrites (light gray) intergrown with siderites (dark gray). In oil, x200.

Figure 5. Transported chromite (triangles, gray) in clay matrix, fractured siderite vein (midupper and right side, gray), gell textured magnetite (in the middle and lower parts, pale white) and arsenopyrite grains (shiny white). In oil, x200.

Figure 6. Completely martitized magnetites grains (white) and limonitized pyrite framboid (midlower and lower left sides, rounded, pale white) in clay matrix stained by lirhonite. In oil, X200.

iron element. This represents the actual ores of Otlukilise iron deposit.

DISCUSSION AND CONCLUSION

Genetical discussions of Lahn-Dill type deposits focus on syngenetical or epigenitical type of formations (Quade, 1976). These two types exhibit differences both for their relationships to wall rocks and deposition characteristics.

According to some authors, Otlukilise iron deposit has been interpreted as an epigenetic type of formation being formed as open space fillings in limestones of the basement and metasomatic replacements in them by ore fluids.

Most of karstification events observed often in the region, developed upon fracture systems after mineralizations make the ore minerals unstable and alter also the other components of ore deposit. Thus, the interpretation of the events becomes more difficult. As complementary supplements to the offered, model, fracture zones being served as ore bringing channels and the ones occurred by new tectonic movements helping the ores to reach the actuel surface are filled by silicious ore bearing hydrothermal fluids. The movements at these fractures after all these events can cause to some of conglomerate-breccia ores. On the other hand, in some stable areas in the basin, clay rich and quartz poor massive ores (rich in siderite component) can form. However, remembering that the basin is opened over a basement, new views can be added to the synthesis of ore genesis. Mineralizations can not be limited by ore bringing channels (i.e. fractures) but ore formations with synsedimentary characters in sedimentary basin may reach up to huge sizes and losing their original positions by later on tectonic events, they can evolve actuel sites. Some characteristics of these secondary appearances present some clues on the primary position of ores.

Otlukilise iron deposit exhibits similar features to Hekimhan-Deveci Siderite Deposit by geographical positions, wall rock relations and age of formations. Deveci Siderite Deposit represent a typical case for synsedimentary-volcanogenic of exhalative-sedimentary type of formation in Turkey (Ünlü, 1983). This deposit is indicated as an example of Lahn-Dill type ore deposit (Lehmann, 1972) in Turkey by the same author. Although main ore mineral of Lahn-Dill Deposit is hematite with a small amount of siderite, principal ore mineral in Deveci and Otlukilise Deposits is siderite. MnO contents of Deveci and Lahn-Dill Deposits reach up to 5%. Nonexistance of manganese in Otlukilise iron deposit can be explained by mobile character of Mn during the replacement of siderite to goethite. While silica component of Deveci Siderite Deposit is lower than 8% (see in Ünlü, 1983), this ratio is much greater in Otlukilise and Lahn-Dill deposits. Lahn-Dill deposit is characterized by silica centers where many submarine volcanic piles present. Deveci Siderite Deposit is accepted as a similar occurrence of Vares (Crotia) Iron Deposit where siderite orebody is described (Quade, 1970) by Unlu (1983).

Otlukilise iron deposit involves chromite bearing highly altered basic volcanic rocks. The typical observed in the deposit are gell colloform textures indicating rapid cooling, very fine grained, myrmekitic and contemporaneous growing textures siderite (together with clay) and quartz. This deposit is also characterized by silica rich fluids like Lahn-Dill Deposit. Magnetite and hematite are often replaced by siderite. In addition to these replacement textures, contemporaneous growing of magnetite and siderite are often observed. Fe^{+3} ions are depleted by the minerals formed earlier and so relative Fe^{+2} enrichment of the environment is occurred. Silica and iron elements are the components brought out to the environment from the deeper parts of basin being understood from textural relationships. Due to the Eh and pH conditions of the environment, these components are stabilized as iron and silica bearing minerals. Under these circumstances, it is impossible from the physiochemical point of view that iron has been transported circumstances, it is impossible from the physiochemical point of view that iron has been transported from the continent. Because during the transportation from continent resembling an oxygen rich environment to the basin. $Fe+^{2}$ would be oxidized and precipitated as Fe^{+3} and so no siderite would have been occurred in the basin.

Within the limitations of the data and observations in this study, this paper tries to give the message that whether a source of oceanic lithosphere or ophiolitic rocks lying on the basement can be supposed for iron element origin of exhalative-sedimentary or synsedimentary-volcanogenic iron deposits (Stendal et al. 1995) developed in volcanosedimentary sequences of basins opened over a platform characterized by a geotectonic environment of ophiolitic cover on the basement.

ACKNOWLEDGEMENT

This paper is prepared basing on Master's Thesis of first author at the Department of Geological Engineering of Faculty of Science at Ankara University under supervision of second and third authors. We want thank Prof. Dr. Ayhan Erler, Prof. Dr. Baki Varol, Assoc. Prof. Dr. Okan Tekeli and Dr. Ahmet Çağatay for their constructive critism. We also express our thanks to University af Kopenhagen for laboratory facilities at geochemical studies. Rock samples, thin sections and whole representative material with this paper have been saving at the Department of Geological Engineering of Ankara University.

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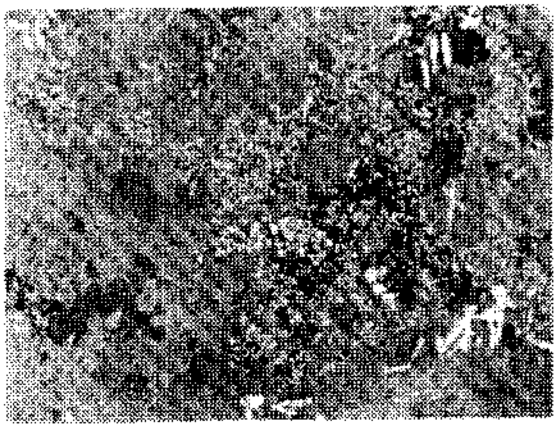

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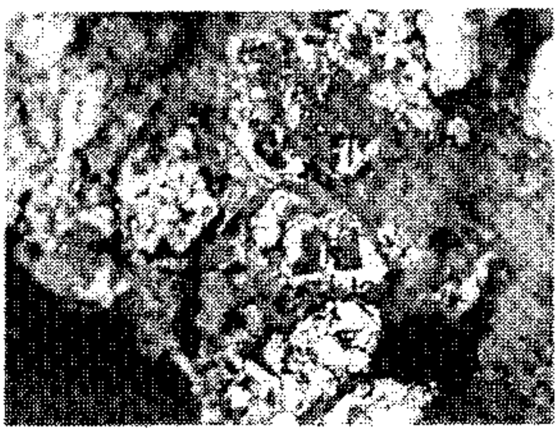

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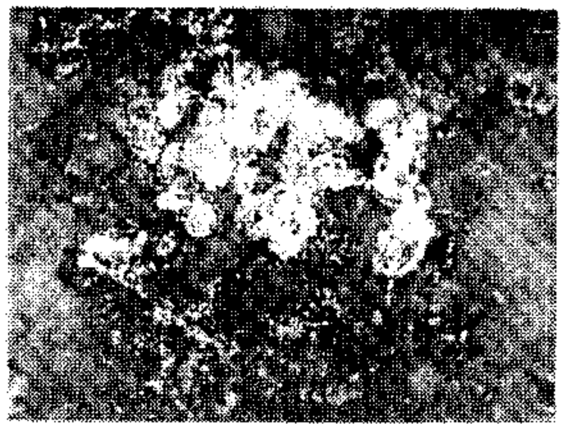

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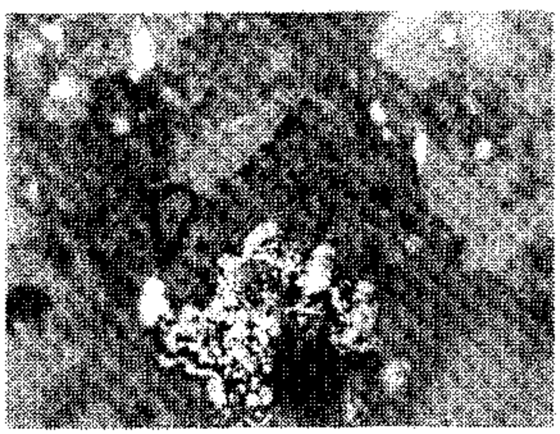

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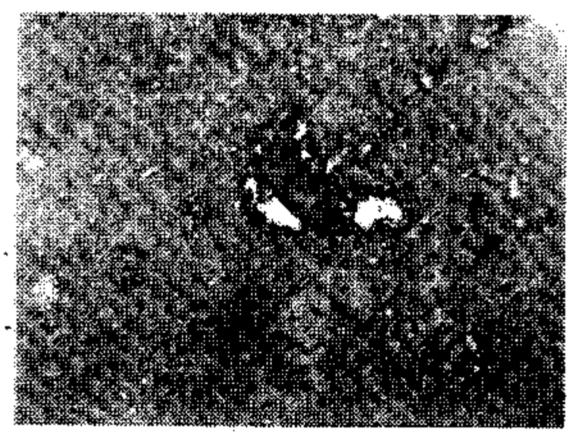

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