GENESIS OF BAUXITE BEARING IRON ORE DEPOSITS FROM PAYAS (HATAY) DISTRICT

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ABSTRACT. - In the study area, a unit composed of dolomite and dolomilic limestone of Lower Triassic-Lower Jurassic age forms the base. This unit up to 400 m. thick is conformably overlain by Lower Cretaceous units represented by limestone and dolomilized limestone. These limestones which also host mineralization arc conformably overlain by Senonian olisloslromal sequence. A sequence consisting of conglomerate, sandstone and limestone, that is of Middle Miocene age conformably overlies the olisloslromal fades. The Upper Pliocene sediments occurring over extensive flatnes areas rest conformably upon all of the units in the study area. Mineralization in the region occurs as lenses between the Lower Crelaccous limestones and Senonian limestones. Ore bodies lie on lop of limestones characterized by common dissolution cavities and brecciated in places and on top of sandstones in other places. Ore microscopic studies reveal that main ore minerals arc maghemite, hematite and goethile. Mineral paragenesis also includes berthierine, diaspore, quartz and calcile. Massive, granular, colloidal and oolitic textures are observed in ores. On the basis of sedimentary petrographic studies, three types of mineralization in which massive, granular and combined massive and granular textures arc dominant could be recognized. Each type is characterized by dissolution cavities and microkarstification features. Geologic, ore microscopic and sedimentary petrographic studies provide evidence that these deposits have originally developed on top of a gentle topography by long-lived atmospheric effects and subsequently washed away and broken up and eventually formed by infilling of regional karstic cavities by transported material.

INTRODUCTION

The workers who have studied in the present area and its surroundings (Fig. 1) report a great number of ferruginous bauxite and bauxite bearing iron occurrences. However, the opinions on the origin of these occurrences in the region are contradictory.

Some workers (Riches, 1913) attribute the formation of ore occurrences to alteration of basalts, while others (Pilz, 1939; Ami, 1941; Romicux, 1942) consider them to be terra rossa type of bauxites. Krupp (1959) concluded from his studies that ore bodies occur in conformable with thick limestone scries and furthermore it is controversial whether influx of metal bearing solutions into the environment and mineralization occurred concurrently with sedimentation or not. Rouzand (1910) and Petrascheck (1965) point out that the solutions which arc enriched in Fe and Al, released by alteration of basic rocks were transported and finally precipitated in hollows of limestones. Some other authors (Brennich, 1956; Akçay and Hasan, 1974) claim that the formation of ores may be explained by transport of residual enrichments that developed over basic and ultrabasic rocks and subsequent precipitation in sedimentary basins. Erten et al. (1971) relate the ore occurrences in the region to a laterilic phase containing high Al_2O_3- Elgin (1975) regards the Payas iron occurrences as sedimentary deposits hosted in the Upper Cretaceous limestones.

Apart from these studies, various general geologic and mining geologic surveys are known to have been conducted in different parts of the Amanos mountains (Wippern, 1964; Hatay, 1967; Alan, 1969; Arda, 1972; Aslaner, 1973; Çoğulu, 1974; Yalçın, 1980; Selçuk, 1981; Tekeli and Erendil, 1986; Aksay et al., 1988).

The main purpose of this paper was to establish the genetic relations of ore forming metallic elements with surrounding rock units and also to propose a model by which geological events that have been effective on the present day setting of ore occurrences may be explained in connection with theserclationships.

The study area is located to the east and southeast of Payas subdistrict of 15 km. north İskenderun town, Hatay province. Along 15 km. north-south direction, 8 km in easj-west direction of the area is located on 1:25 000 scale topographic maps of Antakya O-36 a_3, b_4, c_1, d_2.
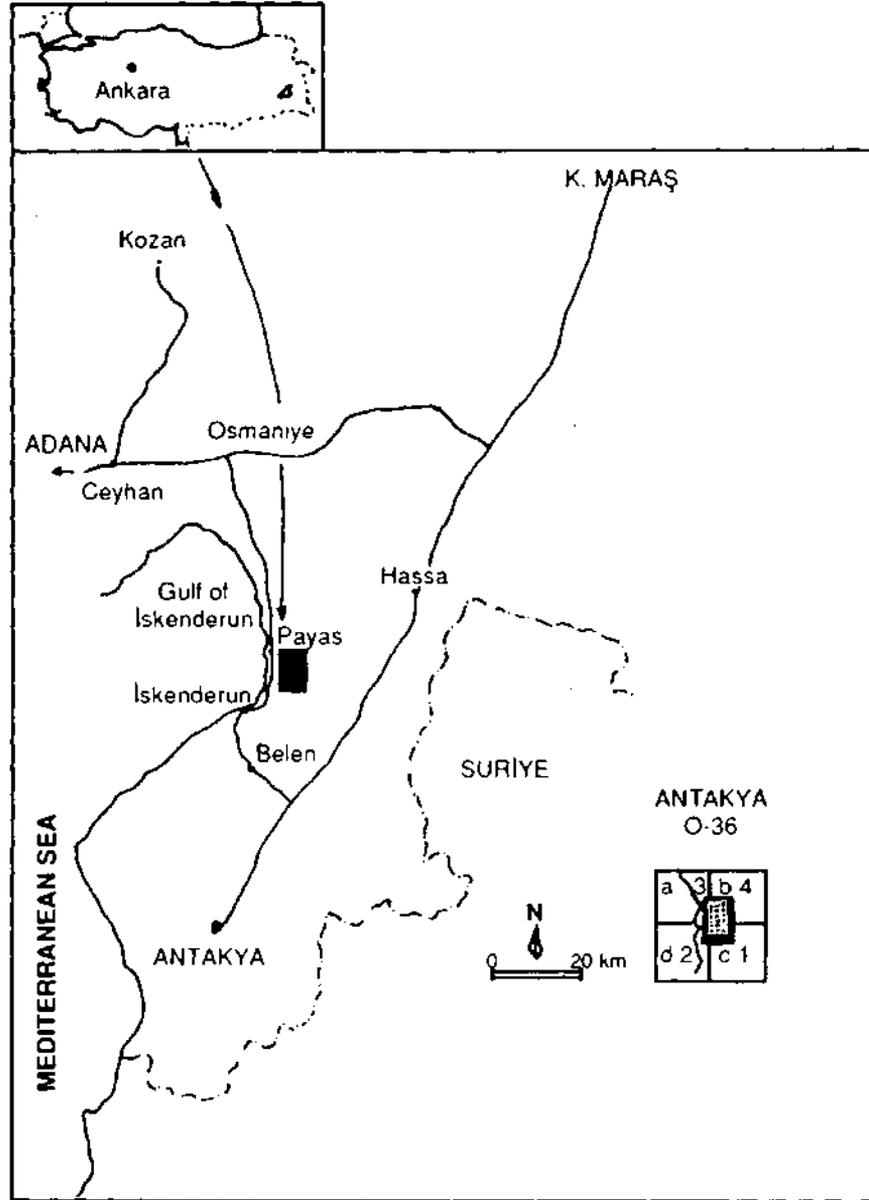
Fig. 1 - Location map

REGIONAL GEOLOGIC SETTING

The regional geologic information was compiled from the studies of Aksay et al. (1988) and Alan (1969). A generalized columnar section from the Amanos mountains is given in Figure 2. According to this section, the Paleozoic formations lie beneath the Amanos mountains range constituting a part of the Arabian platform. The relationships between these units are conformably stated.

The Paleozoic sequences of clastic sediments are conformably overlain by the Mesozic carbonate sequences.

During the Upper Cretaceous the sequencer of the Arabian platform are overlain by the Amanos olistostrome and Kızıldağ ophiolite which was emplaced during early Upper Cretaceous Campanian-Maestrichtian age.

Upper columnar section (Tertiary – Triassic)

SYSTEM	SERIES	STAGE	FORMATION	SYMBOL	LITHOLOGY	PALEONTOLOGY
KUV.	PLIOCENE	UPPER	Karayorun		Alluvium, talus, basalt	
T E R T I A R Y	MIOCENE	Upper Burdigo-lian	Yorik		Unconsolidated Conglomerate, sandstone, claystone	Pecten josslingi Smith.
			Enek		Marl intercalated with sand	Clipeaster altus Klein
	EOCENE	Ypresian-Lutetian	Alimacik		Conglomerate and sandstone	Discocyclina archiaci Schlumb
	PALEO-CENE		Alan Ust.		Sandy, fine pebble Lst.	
C R E T A C E O U S	UPPER	Comp.-Up Ma.	Mesi		Ophiolite pebble conglomerate, sandy, clayey marl, limestone	
		Turonian			Kızıldağ ophiolite	
		Senon			Amanos olistostrome	
	LOWER	Valanginian-Hauterivian	Karadağ		Limestone, dolomitized Lst.	Orbitolina kurdica Henon Cuneolina sp.
JURASSIC	LOWER		Kürecı		Dolomite	Glomospira sinensis Ho
TRIASSIC	LOWER-UPPER	SCYTHIAN-LOWER L.TAS	Arilin		Cross-bedded quartzite and quartzitic sandstone	Involutina minuta Koehn-Zaninetti

Lower columnar section (Devonian – Cambrian)

SYSTEM	SERIES	STAGE	FORMATION	SYMBOL	LITHOLOGY	PALEONTOLOGY
DEVONIAN			Hasanbeyli		Alternation of limestone and shale	Erlandia sp. Spirifer sp.
S I L U R I A N	UPPER		Kızıltaş		Alternation of coarse-pebble and cobble conglomerate, quartzite, sandstone and shale	
	LOWER		Bahçe		Alternation of shale and fine-grained sandstone	
			Akçadağ		Alternation of quartzite sandstone and shale	
			Dedeler		Quartzite, conglomerate, siltstone and sandstone	
O R D O V I C I A N	UPPER	LOWER	Kızıltaş		Shale and sandstone intercalated with siltstone	
			Kardere		Quartzite and quartz sandstone	Cruziana furcifera d'Orbigni
C A M B R I A N	UPPER	LOWER	Tiyek		Nodular Limestone, siltstone and clayey Limestone	Paradailhania cf. barthauxi Mansuy.
	MIDDLE		Karayücce		Dolomite and dolomitic Limestone	
	LOWER		Eğrik		Conglomeratic sandstone, quartzite and arkose	
					Shale, siltstone and quartzitic sandstone	

Fig. 2- Generalized columnar section of the Amanos range (after Aksay et al., 1988).

Following the emplacement of ophiolite, a sedimentary sequence called the Alan limestone was deposited. This sequence begins with ophiolite derived pebble conglomerate of Macstrichtian age and continues upward with abundant fossilliferous sandy limestone, clayey limestone and marl strata. The latter sequence is conformably and transitively overlain by a Paleocene sequence of clayey limestone and limestone stratums.

The Alan limestone is conformably overlain by the Almacık limestone of Lower Middle Eocene age. Following this unit, Miocene age Enek formation consisting of conglomerate sandstone and abundant-fossil-bearing limestone and with the Yazır formation consisting of marl commonly intercalated with sand horizon, are overlain unconformably. The Palcocene sequence called the Sarayburnu formation conformably rests upon all the units below. This unit consists of unconsolidated conglomerate, sandstone and claystone.

The occurrences which indicate the Quaternary units in the region arc, basalts that exposure over a very extensive area, talus and alluvial deposits.

Regional tectonic features were compiled from the studies by Ketin (1959). The Amanos mountains structurally form an anticline. Fold axis trends NNE-SSW and the strata on the limbs strike NE-SW.

In the region, the Cambrian terrain was affected by Caledonian orogeny. Triassic strata were shaped by tectonic movements that occurred during the time interval between Triassic and Albian. The Karadağ limestones of Cretaceous age were affected by the Subhercynian phase of Alpine orogeny. Furthermore, the ophiolite nappes gained their present day setlings by the affects of this phase. Afterwards, they have emerged above the sea level and have been subjected to erosion by the affects of the same phase and as a result, ophiolitc derived pebble conglomerates of Macslrichtian age have been transgrcssively deposited over serpentinites.

Strata of Maestrichtian age emerged above the sea level by folding during the Laramian phase (Upper Cretaceous-Eocene) and were subjected to erosion. As a result of this. Eocene conglomerates were disconformably deposited above the older units.

The majority of the Taurus range emerged above the sea level by the end of Oligocene. As a result of this, the Miocene sequence began with a thick basal conglomerate. Uplifting and folding occurred again at the end of Miocene. Intense deformation and particularly faulting took place during the Upper Miocene and Early Pliocene.

The Amanos range gained its present day morphology by vertical faults. These faults, one of the most prominent structural elements in the region fundamentally trend N-S, N45°-75°E and N4()°-7()°W.

STRATIGRAPHY OF THE STUDY AREA

The stratigraphic features of the mapped area (Fig. 3) are given in Figure 4. The rock units exposed in the vicinity of Kargıcak and called the Küreci limestone (Alan, 1969) are of Lower Triassic Lower Jurassic age (Aksay et al., 1988). This unit, conformably overlying the Anlık quartzite that occurs outside the study area, consists predominantly of dolomite and less amount of dolomitic limestone. This sequence gray to dark gray, thin, medium or thick bedded and locally massive, contains some levels made up of cherty bands, yellow-brown dolomitized limestone, and interbeds of dark gray shale.

Strata are repeated upwards through the Küreci dolomite. Strata of the lowermost section are dolomitic limestones containing ostracoda, pelloid, pyrite and quartz. This section grades upwards into laminated limestone that is more intensely dolomitized, and dolomite. Breccias that are generated by dissolution of evaporiles are common within the dolomites.

This unit, up to 400 m. thick, is unconformably overlain by the Karadağ limestones. This unit, of Lower Cretaceous age (Aksay et al., 1988), known as the most common lithology within the study area, is represented by limestone and dolomitized limestone. It occasionally, contains interbeds of siltstone and shale.

Even though the Karadağ limestone looks as if it overlies conformably the formation below, it is suggested that it rests unconformably upon the same formation on the basis of the fact that bauxite occurrences are found at some horizons between these two units in the vicinity of Islahiye (Gaziantep), outside the mapped area.
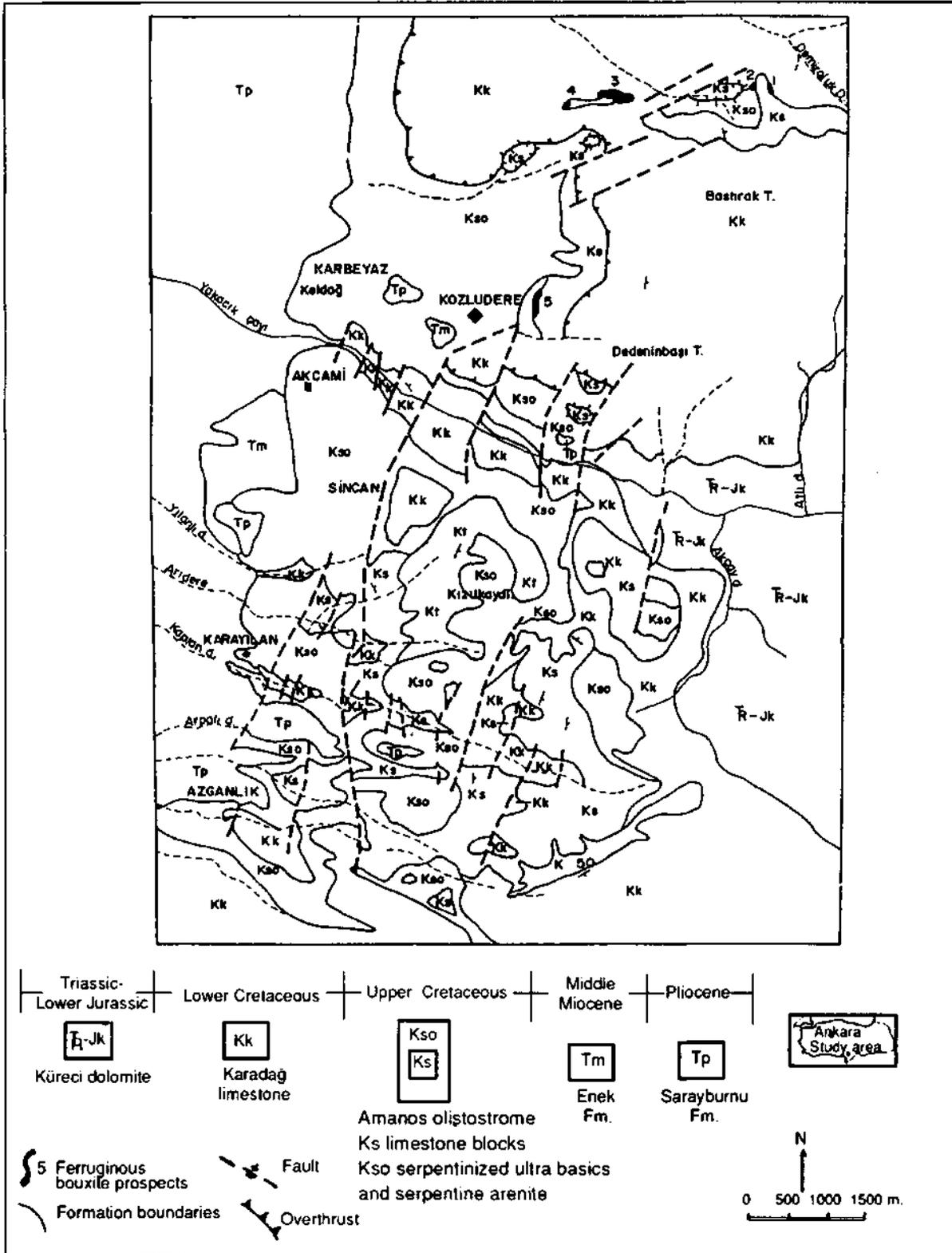
Fig. 3 - Geologic map of the study area and locations of sample groups.

UPPER SYSTEM	SYSTEM	SERIES	STAGE	FORMATION	SYMBOL	EXPLANATION	
						LITHOLOGY	PALEONTOLOGY
CAINOZOIC	TERTIARY	PLIOCENE	Upper	Sarayburnu		Unconsolidated conglomerate Sandstone and claystone	
		MIOCENE	Ypresian-Lutetian	Enek		Limestone cobble and pebble-bearing conglomerate, sandstone and clayey limestone	Pecten josslingi Smith. Clipeaster altus Klein.
MESOZOIC	CRETACEOUS	UPPER	Senonian	Amanos Olistostrome		Limestone blocks, ultrabasic rack fragments and serpentine arenite	
						→ Ore Limestone and dolomitized limestone	Cuneolina sp. Rotalia sp.
		LOWER	Valanginian -Turanian	Karadağ			
	JURASSIC	LOWER	Upper Scythian Lower Lias	Küreci Dolomite		Dolomite	Triasina hantkeni Majzon. Planiinvolutina carinata Leischner.
TRIASSIC	LOWER UPPER						

Fig. 4 - Columnar section of the study area.

The limestone and dolomitic limestone that constitute this unit are thinly to moderately and locally massively bedded and include a variety of karstic features. They are seen as thin channels in some places and as deep hollows in others (Plate I, fig. 2). The limestones that have breccial character immediately below the ore bodies are cemented by calcite.

The Karadağ limestones that host mineralization is unconformably overlain by the Senonian olistostromal sequence.

The olistostromal sequence is composed essentially of limestone blocks of varying size, fragments of serpentinized ullrabasic rocks and serpenlinc arenite.

The serpentine arenite that makes up the groundmass of the sequence is light green to greenish-gray colored, thinly laminated and foliated. The serpentinites have undergone dynamothermal metamorphism as the overlying blocks of limestone have slowly moved over them and as a result, schistose textured lenses that seem to be totally serpentinized ultrabasic rock have formed in the upper levels of the serpentinite (Plate I, fig. 3).

The fragments of serpentinized ultrabasic rocks seen around the An stream are massive in appearance at the base. Microscopic studies reveal that this rock contains serpentine minerals (chrysotile, antigorite) displaying fibrous texture, relics of serpentinized pyroxene and opaque minerals (Plate II, fig. 1).

The limestones belonging to the olistostromal sequence are seen in various forms. The most common ones are those which rest upon the serpentinites. A completely argillized crushed zone about 1 m. thick lies between the serpentinites and these limestones. Folding has occurred within limestones along these horizons by deformation and the lowermost levels of these limestones have gained schistosity by the effects of metamorphism that has been produced during the movement of limestones over serpentinites. The study of thin sections from these gray colored and thinly bedded limestones reveals that the rock consists mostly of calcite and also contains recrystallized calcite and quartz.

In some places, the schislose limestones are also seen above the levels of sandstone, and ankeritic limestone, all of which cover the ore bearing zones. The thickness of the ankeritic limestones ranges from 1 to 3 m. Here, a regular transition from the ore body toward the schistose limestone is observed (Plate II, fig. 2). This limestone that occurs adjacent to all of the ore occurrences with the exception of Fındık Yaylası-I, consists of calcite ranging in size from 0.02 to 0.15 mm., locally displaying pressure twinning and contains minor intergranular quartz and infiltration of iron hydroxide (Plate n, fig. 3).

Some of the limestone blocks belong to gray colored, thickly to massively bedded limestone that overlies both the serpentiniles and schislose limestones. These rocks displaying cataclastic lexture consist of calcite that ranges in size from 0.05 to 0.3 mm., locally displaying pressure twinning, and containing clay minerals in very small amounts and quartz.

A part of limestones belonging to the Amanos olistostrome is seen as lenticular bodies within serpentinites. These rocks arc gray to dark gray, thin bedded and exhibit schistosity. They consisl essentially of calcite and minor quartz.

Besides those mentioned above, recrystallized limestone blocks are found within serpentinites. These dark gray and black limestones are massive and dolomitic in composilion.

On the basis of idenlified fauna such as *Globigerina* sp. and *Globotruncana* sp. from gray colored horizons of these limestoneblocks, that are found above serpentinites, an Upper Crelaceous age is assigned to these limestones.

Another unit which constitutes the olistostromal sequence is sandstone levels overlying and underlying the Findik Yaylası-I ore. These levels that are yellow and 2-3 m. thick consist of quartz grains ranging in size from 0.03 to 0.1 mm. and from 0.4 to 1.0 mm. and contain feldspar, tourmaline, zircon, chloritized biotite, carbonate minerals and minor limonite.

The depositional age of olistostromal sequence has been dated based on the ages of limestone blocks that rest upon and intervene in serpentiniles. These blocks are of Albian-Aptian age in the vicinity of Osmaniye, in the north (Arda, 1972), Coniacian-Campanian age near Kızıldağ (Aslaner, 1973) and Upper Cretaceous age in the study area. On the basis of this evidence, the unit is of Senonian age.

The Enek formation of Middle Miocene age that is exposed in the southwestern part of the study area (Aksay et al., 1988) unconformably overlies the Senonian olistostrome. A conglomeratic level, rich in very coarse and fine pebbles of limestone and serpentinite lies al the base of this sequence. The limestones are of Senonian age and display schislosity. Fine pebbles are rounded, whereas very coarse ones are angular. Grains are cemented by a carbonate mineral. The overlying sandstone are coarse grained arid thin bedded. Abundant altered serpentinite, quartz and iron oxide were identified within these sandstones. The uppermost levels of the sequence are characterized by thin bedded, light, gray limestones.

The porous conglomerate, unconsolidated sandstone and clayslone, all of which arc Upper Pliocene in age (Dubertrct, 1953). arc exposed in extensive flat areas overlying conformably the older units.

TECTONICS

The study area was highly affected by the Subhercynian phase of the Alpine orogeny. Following the emplacement of ophiolite during this period, the olistostromal sequence was emplaced during the Senonian (Ketin, 1959).

The serpentinites gained schistosity under high pressure which has been generated in response to slow movement of limestone blocks that were transported into the environment during the emplacement of olistostrome over the serpentinites. Mcanwhile, the basal parts of detached blocks of Senonian limestone gained schistosity as well. A calaclastic texture was developed in some blocks of limestone above serpentinites.

The major faults in the study area arc N20° - 30°E-trending and N60° - 70"E-trending normal faults with vertical displacements. The older units were exposed due to these faults that developed at the end of Miocene.

MINIM; GEOLOGY

Field observations

The mineral occurrences in the region are found as lenses between the Lower Cretaceous limestones and Senonian limestones. In some places, the ore bodies are underlain by sandstones, whereas in other places, they are underlain by limestones including common dissolution cavities and having a breccia character. On the other hand, they arc overlain by yellow sandstones interbedded with hematite in some places and by yellow ankeritic limestones in other places. These overlying horizons that are found only as 2-3 m. long zones are covered by gray colored limestones of Senonian age whose lowermost parts display schistosity.

Most of the mineral occurrences are found around the Paşanın Eğreği Yaylası. In addition, ore prospects near such localities as Sarıyokuş, Mağarabaşı, Fındık Yaylası, I. Fındık Yaylası - II and Kozludere were also studied (Fig. 3).

The mineral occurrences near the Paşanın Eğreği Yaylası are hosted by brecclated limestones in which widespread dissolution cavities developed. These limestones form the upper levels of dark gray thick bedded limestones of Lower Cretaceous age. Mineralization occurs as massive bodies in some places and as conglomeratic masses in others. Its grain size is up to 20 mm. Massive bodies contain specularite. Ore bodies are overlain by yellow ankeritic cryptocrystalline limestones that grade into gray schistose limestones (Plate II, fig. 2, 3). The Lower Cretaceous limestones are overlain by serpentinites and Senonian limestones 20 m. cast of ore bearing zone (Fig. 5).
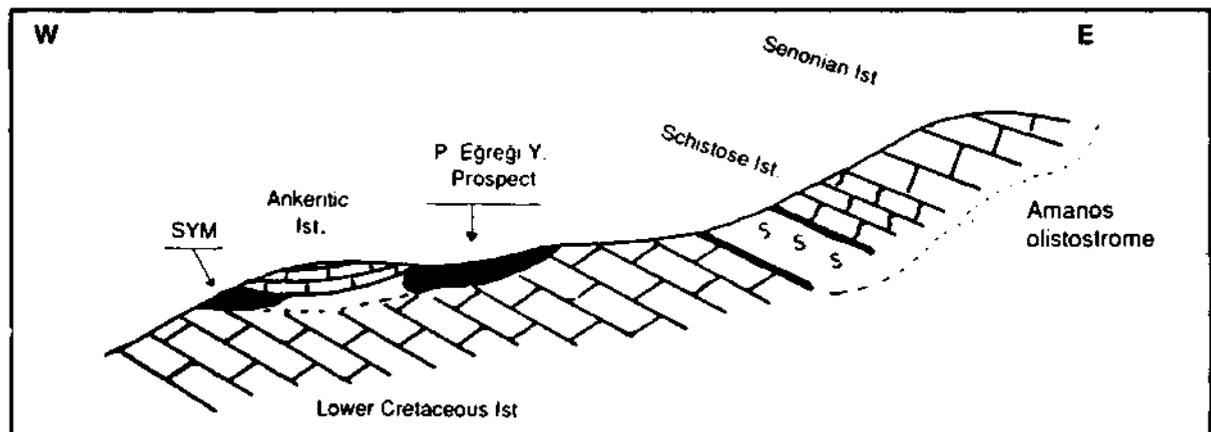
Fig. 5 - Sketch cross section of ore occurrences from Paşanın Eğreği Yaylası and Sarıyokuş Mağarabaşı Mevki (SYM).

The Sarıyokuş Mağarabaşı prospect is in the same position as the above mentioned mineral occurrence (Fig. 5). However, ore from this prospect display schistosity. When broken by hammer, it splits readily into thin sheets. Flaky grains of hematite are macroscopically seen in a pinkish red matrix.

The Fındık Yaylası-I prospect differs from the other ones that is overlain and underlain by sandstones intercalated with hematite. Mineralized body has, locally a massive character and locally conglomeratic and breccial character (Fig. 6; Plate III, fig. 1).
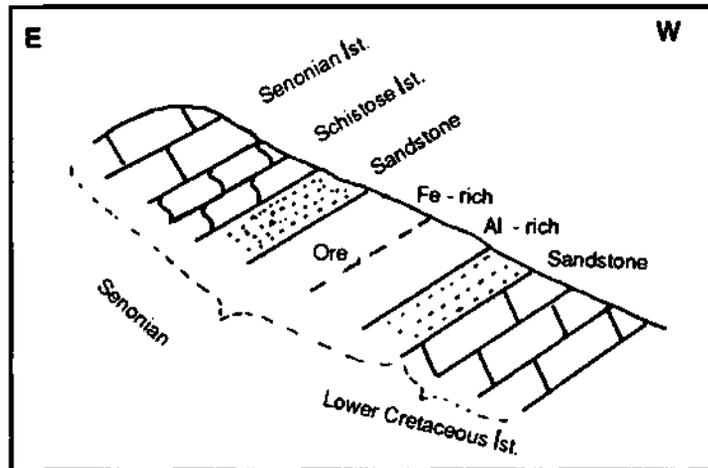
Fig. 6 - Sketch cross section of Fındık Yaylası-I ore occurrence.

The Fındık Yaylası-II prospects consist mostly of limonitized hematite. Mineralization is underlain by the Lower Cretaceous limestones and overlain by a yellow ankeritic zone 2-3 m. thick and gray schistose limestone. The serpentinites arc exposed about 10m. to the south of mineralized bodies (Fig. 7).
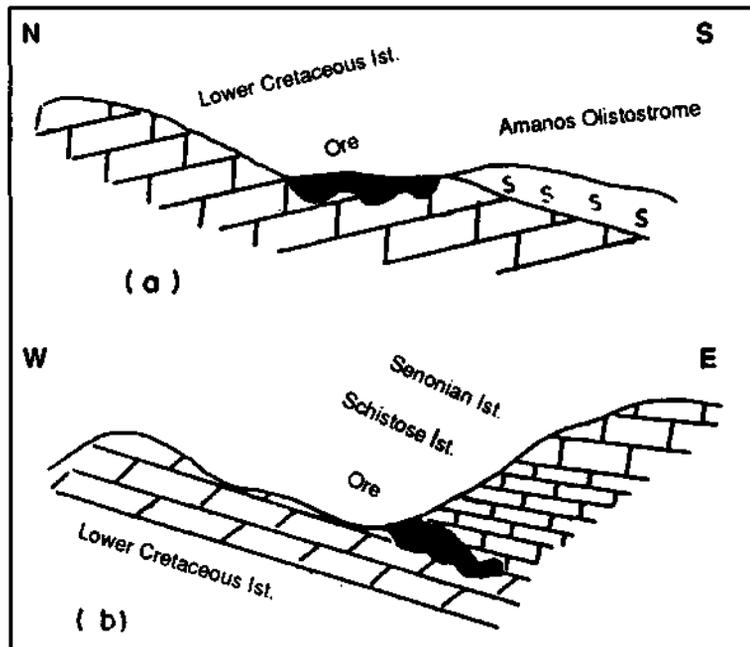
Fig. 7 - Sketch cross section of Fındık Yaylası-II ore occurrence.
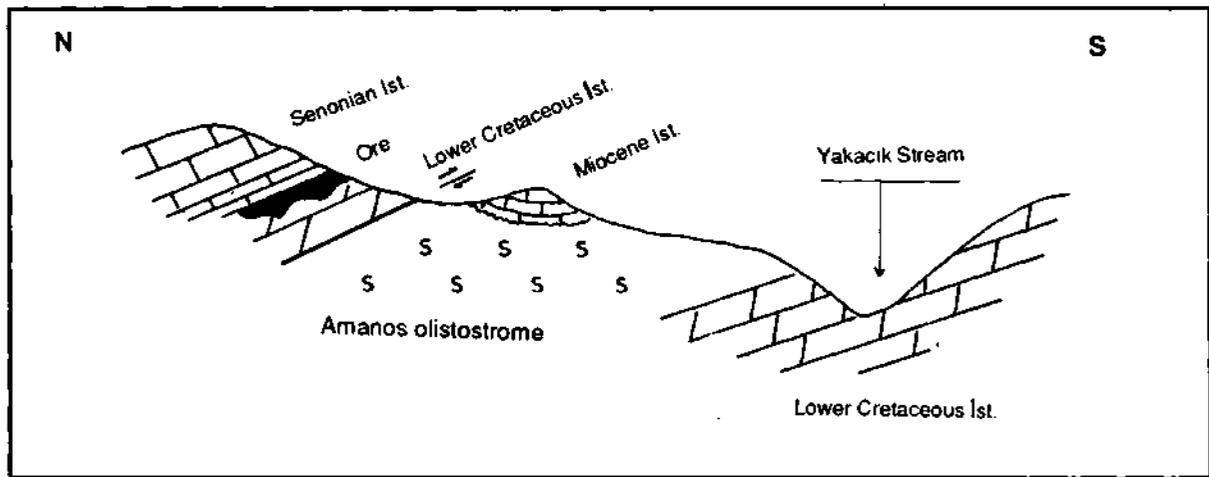
Fig. 8 - Sketch cross section of Kozludere ore occurrence.

The Kozludere occurrences lie as bands between the Lower Cretaceous limestones and Senonian limestones. Here, the same yellow ankeritic zone occurs in transition to the overlying gray limestone.

Ore microscopic studies

The ore microscopic studies of mineral occurrences from the above mentioned five different districts indicate slightly diverse paragenetic, structural and textural relationships among them. X-ray diffractograms of samples from these districts were utilized in addition to ore microscopic studies in establishing these relationships.

Some polished sections of samples that characterize different mineral occurrences were examined under the ore microscope in order to get the mineral paragenesis. On the basis of these studies, maghemite, hematite, specularile, goethite and rutile were determined in paragenesis. Non opaque minerals were examined through the thin sections of ore samples and X-ray diffractograms. They include carbonate, quartz, berthierine, diaspore and rock fragments (serpentinite). Furthermore, some studies concerning the textural features of mineral occurrences have been done in order to provide evidence that may expose the origin of mineralization. Granular and colloidal textures arc observed in all mineral occurrences except those found around the Fındık Yaylası where oolitic texture is dominant.

Hematite -Hematite is the dominant mineral of samples and mainly displays colloidal texture (Plate III, fig. 2). Colloidal texture is formed by infilling of voids from the rims of mineral or observed as being of cocarde type. Hematite is found as single crystals or aggregates surrounding rounded or angular grains (Plate III, fig. 3).

Nucleus is composed of either rock fragments or fossil remnants. Colloidal precipitates that have occurred in small vugs form radiating aggregates in larger vugs that have originated from coalescense of smaller ones. Ferruginous clay or goethite bands are seen as parallel to the rims of minerals in ores displaying radial texture. A clayey matrix composed mainly of berthierine occurs between hematite grains found as space filling or cocarde.

Apart from colloidal forms, hematite is also found as grains or oolitic bands. Hematite grains range in size from 540-770 to 40-80 m.m. or may be even smaller. Hematite which is mostly converted into goethite displays relict texture (Plate IV, fig. 1,2).

That hematite is observed in variable tonality of color and younger hematite crystals appear as cutting older ones may provide evidence that hematite formed at least in two stages in that environment.

Hematite that envelopes ooliths displays indistinct anisotropy in grayish tints.

Hematite is abundant in ferruginous bauxitic clays which arc commonly seen as matrix material. These minerals which arc readily identifiable by its reflection colors and anisotropic features are found as very tiny (2.50 to 4.0 mm.) acicular

crystals (Plate IV, fig. 3) or grains having irregular shape (8-16 mm). Unsorted xenomorphic grains of hematite are relict minerals (relict texture) of goethitization. Most of the grains are converted into goelhite along their rims (Plate V, fig. 1).

Although in hand specimens, hematite is seen as rounded pebbles of varying size, embedded in a brownish red matrix, the ore microscopic studies clearly indicate that it also constitutes the matrix of smaller pebbles which display granular texture. These pebbles are made up of lithic fragments, ferruginous bauxitic clays, goelhite, hematite and fossil particles. The vast majority of hematitic matrix is converted into goethite in varying degree and a zoned texture develops in sections where this conversion occurs from the rims inward. In contrast, a mottled (spotted) texture (white and gray) develops in sections where it occurs from the interior parts outward. One can see that matrix composed of hematite locally includes vugs and they are filled with ferruginous clays.

Maghemite. _ It is found in varying amount in all samples and observed particularly in ores displaying oolitic texture (Plate V, fig. 2). Maghemite which is lighter gray than goethite and somewhat darker gray than hematite and seen as euhedral crystals (triangular, quadrangular) is found as very tiny grains (24-80 microns). Very minute maghemite crystals are more readily distinguished from co-existing ferruginous clay minerals and goethite which display yellow, yellowish red and brownish red colored internal reflections by their isotropic appearance between crossed nicols. Maghemite from the samples displaying granular texture is found as disseminated throughout the matrix (Plate V, fig. 3). In contrast, maghemite from the samples displaying oolitic texture occurs both as surrounding the ooliths and as arranged parallel to the exterior surfaces of them within the zones of ooliths and between them. It is also shown that some ooliths are fractured and maghemite grains form along these fractures. Besides, some ooliths that don't include any maghemite are present in some portions of the samples. (Plate VI, fig. 1).

Goelhite. _ Goethite, present in all the samples, is found in two different forms. Grains composed wholly of goethite and those displaying relict texture is formed by partial conversion of other minerals (Plate VI, fig. 2). Although some goethite minerals from the samples displaying granular texture are larger in size (385 to 700 microns) than hematite and maghemite, they may also occur as smaller and larger grains. These larger goethite crystals, that are readily identifiable by their yellow, brownish internal reflections, are replaced by a matrix which has given rise to break up of them. Smaller goethite grains that resulted from this break up as well as maghemite grains are dispersed through the matrix at random.

The reflection colors of goethite which formed by conversion of hematite show varying tints of gray, depending on the degree of conversion. This case may be accentuated by the fact that hematite shows bluish gray-white anisotropy and goethite has brownish red internal reflection between crossed nicols.

Particularly, the grains which do not comprise any maghemite were completely converted into goethite in the samples displaying oolitic texture.

The samples contain specularite in minor amount and very scarce rutile other than these main ore minerals.

Matrix. _ The matrix of ores displaying granular texture is composed of berthierine, a kind of chamosite having a clay structure. Moreover, a sample from Fındık Yaylası-I contains diaspore in addition to berthierinc in the matrix. Most of the conglomeratic pebbles forming granular texture arc cemented by hematite. The matrix is composed of quartz, ankerite, chlorite and carbonates in addition to these main constituents. Besides, abundant fossil is also present in the matrix as seen in the mineral occurrences.

X-Ray analyses:

Hematite, goelhite, maghemite, berthierine and diaspore were identified by X-ray analyses in the laboratories of Union of Turkish Cement Manufacturers.

Sedimentary petrography:

Microscopic studies reveal thai three types of ore can be pelrographically recognized. These are granular, massive and combined granular and massive ores.

Granular ore comprises well rounded grains of hematite, and limonite. Some of these grains are found as intergrown Zones. They have fairly massive internal structure. Angular ore grains accompanying these grains locally show internal structure even if weakly developed (Plate VI, fig. 3; Plate VII, fig. 1). Some of these grains arc derived from highly altered serpentine (Plate VII, fig. 2).

Massive parts of massive ores or massive granular ores appear to be intcrgranular matrix. Numerous fissures developed throughout these parts (Plate VII. fig. 3). In places, they are found as parallel and oblique to one another. They are filled with calcite, microcrystalline quartz (Plate VIII, fig. 1) and even calcite mixed with bauxite minerals (diasporc) (Plate VIII, fig. 2). In addition, these massive parts include dissolution cavities and microkarst features (Plate VIII, fig. 3). Most of microkarst features are preserved as dismembered masses. Several massive ores contain quartz, sand up to 20-30 % in proportion. Quartz sand is arranged as weak bright alignments within the ores or dispersed throughout them.

CONCLUSIONS AND DISCUSSION

1. Maghcmite, hematite and goethite as iron ore minerals, berthierine and diaspore as bauxite mineral were identified from the samples collected.

- Maghcmite found as cuhedral crystals is dispersed throughout the matrix and contained within the ooliths.

- As a matrix hematite found in large amound and also observed as granular.

- Gocthite, formed as a weathering mineral, is mostly found as single grains together with hematite.

- Berthicrine is found both as a matrix material and also observed in the ooliths, body.

2. Oolitic, granular (conglomeratic) and colloidal textures were recognized through the textural studies.

- In the case of oolitic texture, ooliths show an orientation with respect to long axes. Some oolitic grains have broken up and new zones of ooliths have developed around the old oolitic fragments. Some ooliths consist of maghemite and hematite, while the others are completely converted into goethite. The matrix is very scarce around the oolitic grains and these grains arc found as one on top of the other. Maghemite grains are not only arranged within the envelopes of ooliths, but also aligned in conformance with the slopes of the outer surfaces of the ooliths.

- Two types of conglomeratic ore can be recognized from the samples displaying granular texture. The primary ore later made up the grains of the secondary ore. The primary ore in which hematilic malrix is dominant consists of well rounded grains.

- Colloidal texture is developed by hematite and goethite. Colloidal tcxture which develops as open space filling from the rims also formed as being of cocarde type that resulted from deposition around a nucleus.

3. Abundant transported fragments of Miliolidae were identified from all the samples.

The ore microscopic sludies and lypes of texture idenlified suggest that mineralization occurred in shallow sea environments or karstic vugs. It is known that ooliths are shallow sea formations formed in environments devoid of cool currents in part depending on wave and current actions and may also develop in karstic vugs. On the other hand, both granular and colloidal textures which arc common may shed light on transportation of iron into sedimentary environment. The fact that maghemite grains are found as angular fragments indicates that transportation occurred for a short distance. In contrast, colloidal textures document that some iron was transported as colloids. Intergrown conglomerate textures seen from some samples indicate the presence of two types of mineralization. A pre exisling conglomeratic ore makes up the grains of a late stage conglomeratic ore. This evidence may indicate two different depositional environment. The fact that some oolitic fragments make up the nucleus of late stage ooliths may reflect that a pre existing oolith has broken up during the transportation and been involved in the formation of oolith as nucleus in new environment. However, having regard to the fact that this type of ores displaying granular texture can develop in karstic hollows and other available geological data, the mechanism of formation may be clearly understood.

PLATES

PLATE -I

Fig.   1- Karadağ limestones including karst features.

Fig. 2- Calcite grains displaying pressure twins from Karadağ limestones.

Fig. 3- Serpentinites displaying schistosity.
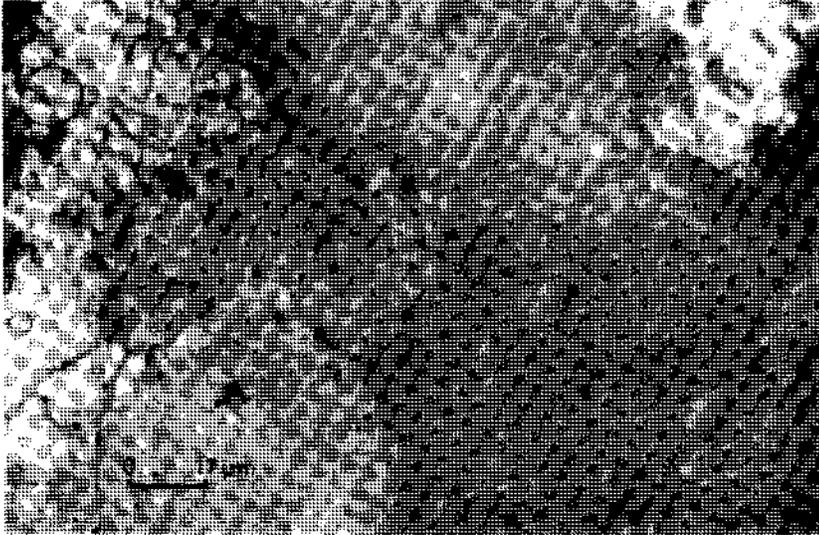
PLATE - II

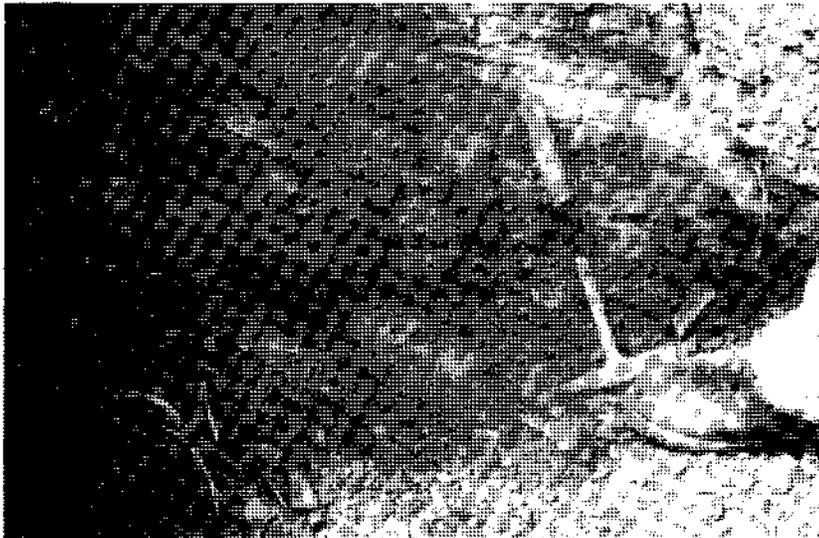Fig. 1- Pyroxene and serpentine minerals of serpentinized ultrabasics.

Fig. 2- Ankeritic limestone overlying ore horizons.
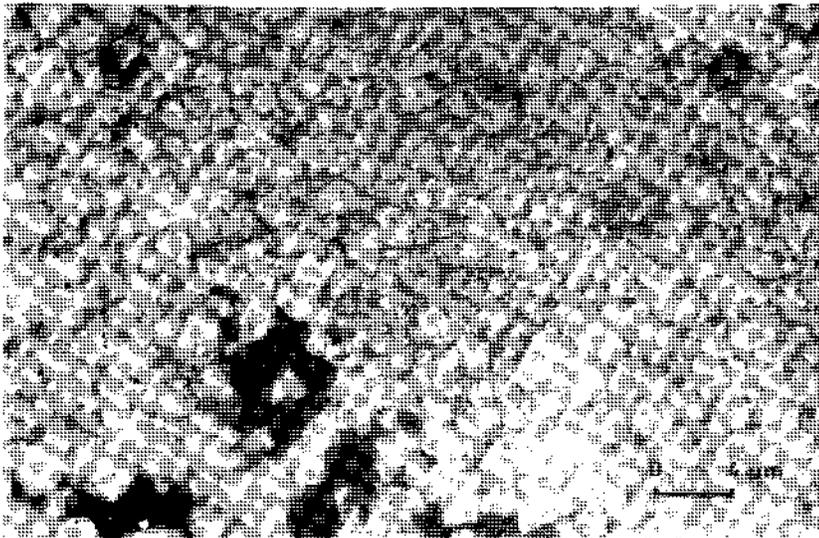
Fig. 3- Ankeritic limestone.

PLATE - III

Fig. 1- Ferruginous conglomerate from Fındık Yaylası.

Fig. 2- Colloidal texture within ore minerals.

Fig. 3- Hematite grains surrounding rounded and angular grains.
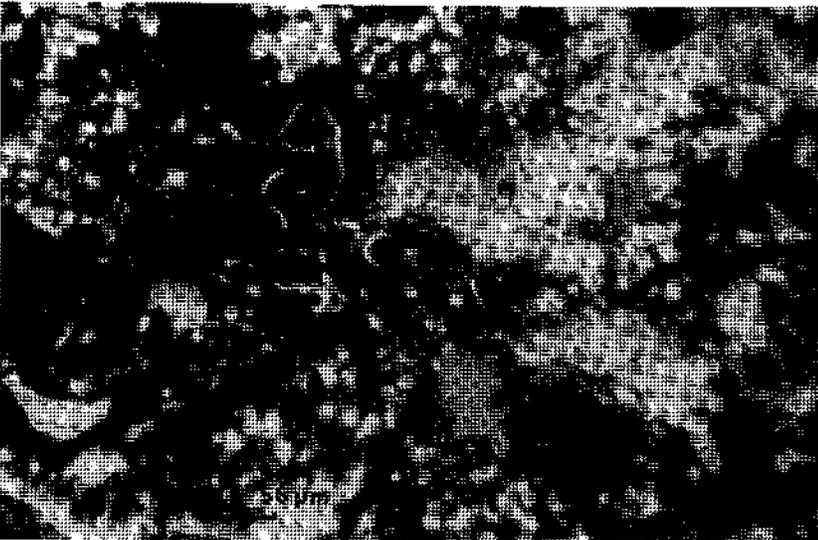
PLATE -IV

Fig. 1- Hematite displaying relict texture (white: hematite, gray: goethite).

Fig. 2- Goethitized hematite grains.

Fig. 3- Hematite grains shown as acicular crystals.
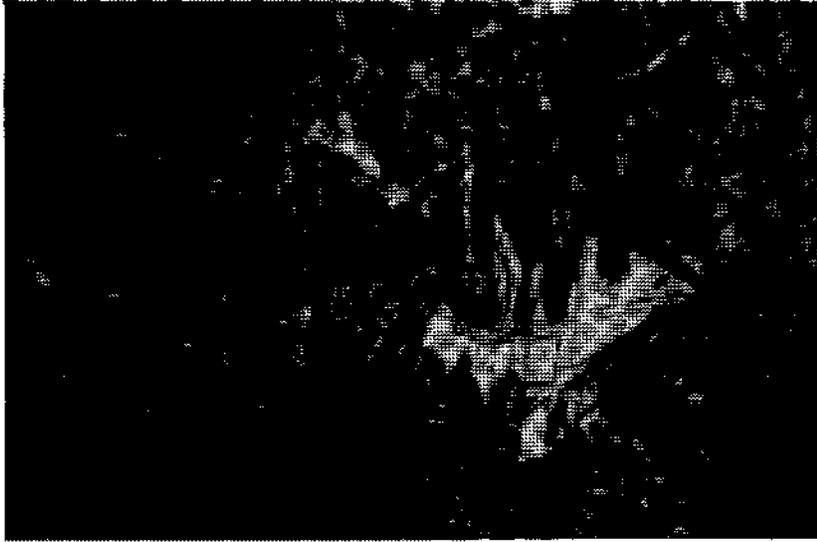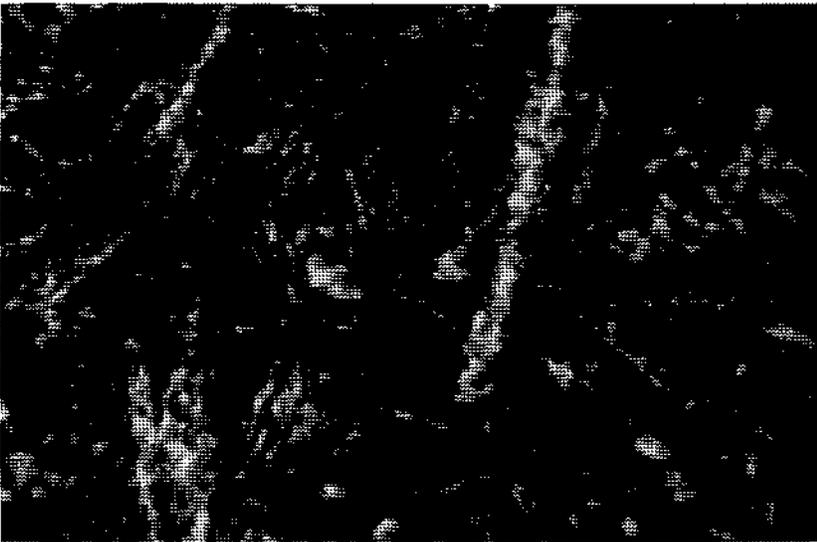
PLATE - V

Fig. 1 - Hematite goethitized along its rims.

Fig. 2- Maghemite grains (while) surrounding and within ooliths.

Fig. 3- Maghemite grains within matrix.

1
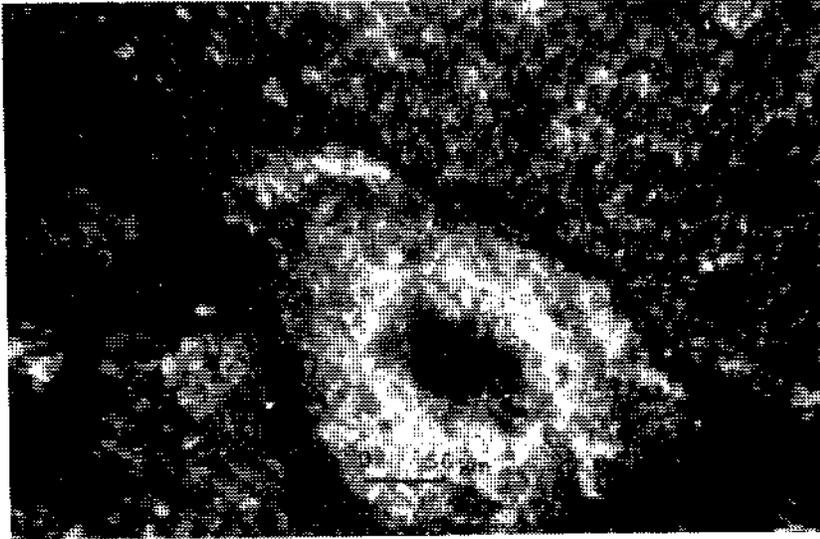
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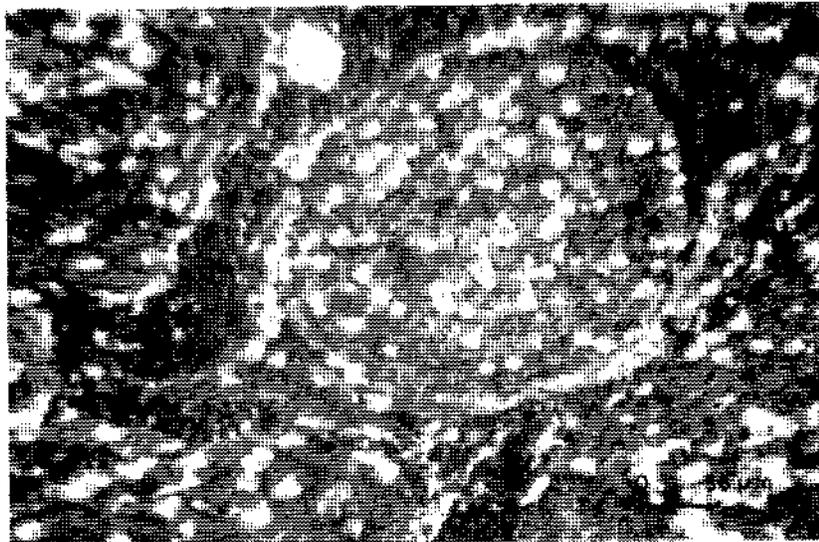
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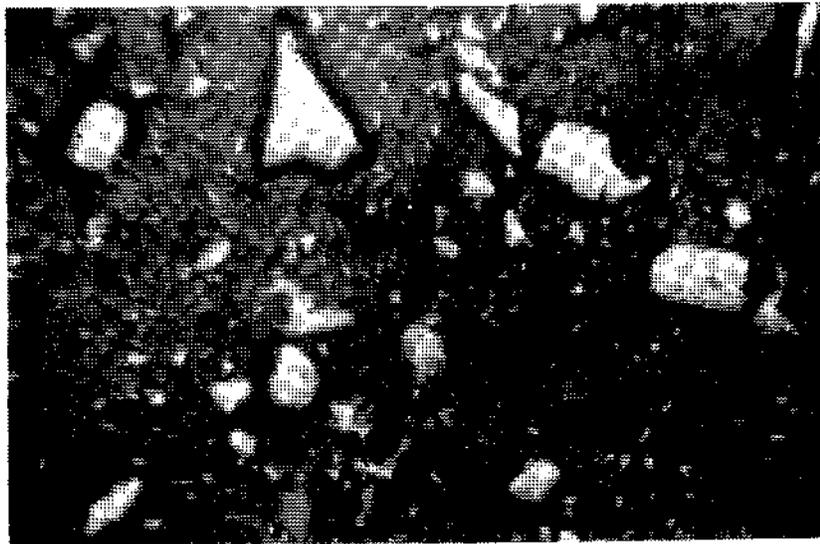
PLATE - VI

Fig. 1- Goethilized ooliths without maghemite.

Fig. 2- Goethite minerals (gray) displaying relict texture and Lath-shape hematite grains (white).

Fig. 3- Well-rounded hematite grain.
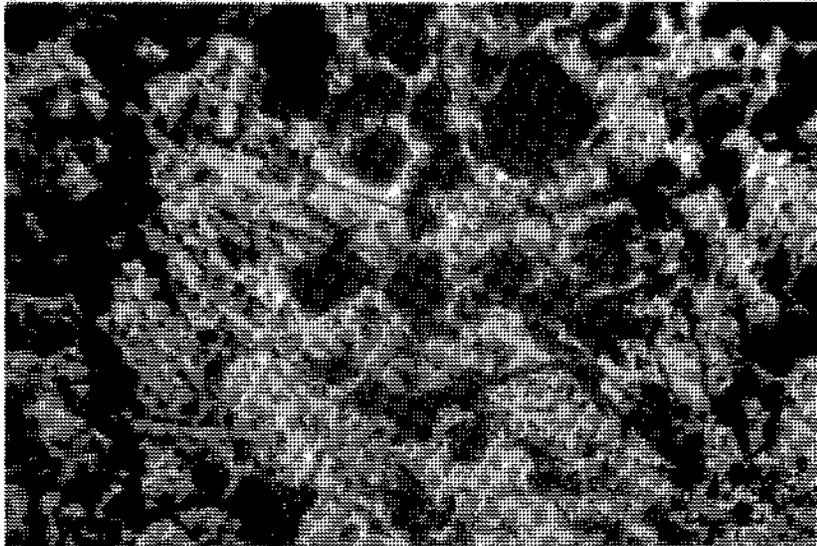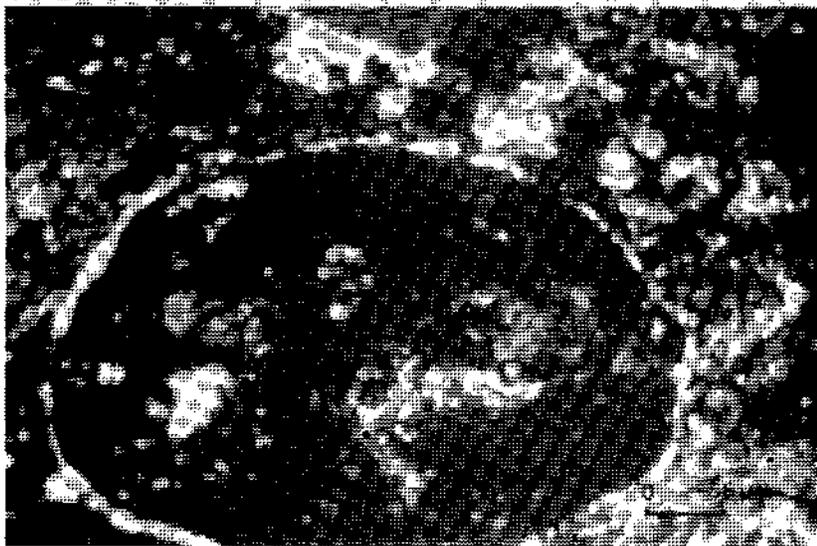
PLATE - VII

Fig. 1- Angular hematite grain.

Fig. 2- Altered serpentine fragment (light).

Fig. 3- Fissures through hematite matrix (black).

1
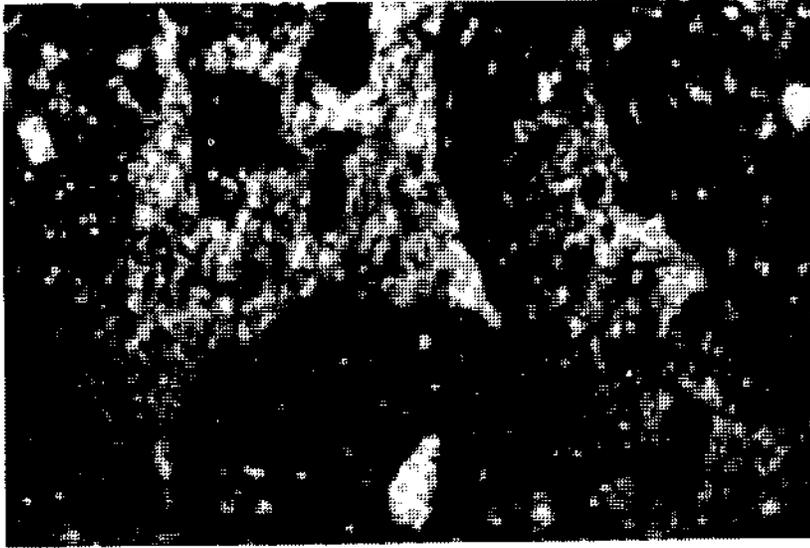
2

3
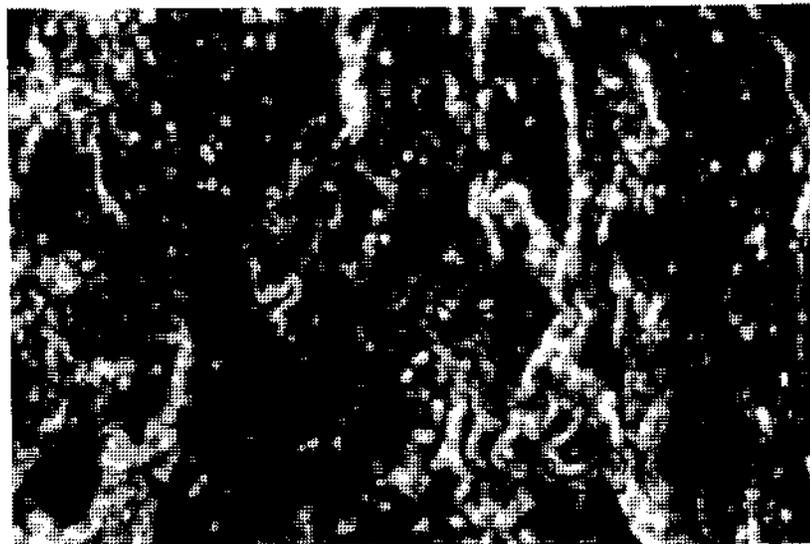
PLATE - VIII

Fig. 1- Limonilized grains within hematite matrix (black) and microcrystalline quartz grains surrounding them.

Fig. 2- Diaspore minerals as aggregates within hematite matrix (black).

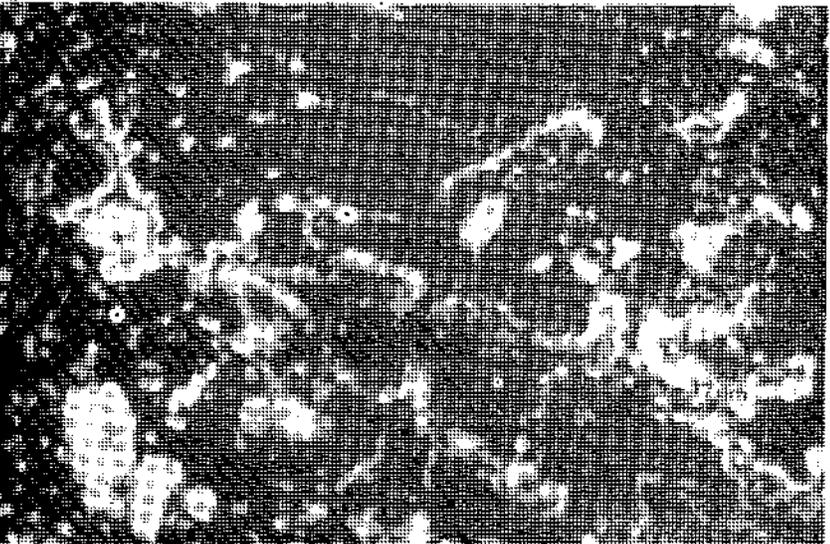Fig. 3- Black grain including karst features within hematite matrix.

1

2

3
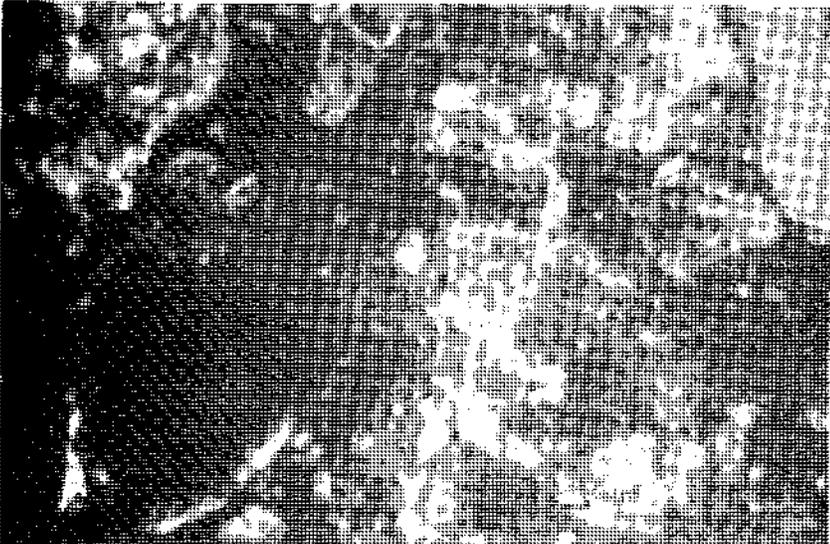
Sedimentary pctrographic features support that mineral occurrences were formed as a result of transportation. Roundness is possibly a result of this transportation process. Some ore material has probably become colloids in a transporting agent by break up of grains during the transportation. This resulted in the formation of matrix forming massive ore. A great number of microfissure systems and microkarst features seen throughout the ores reflect that these ores were probably subjected to atmospheric effects after their secondary emplacement. These fissures that arose as a result of drying under atmospheric conditions were later filled with CaCO3 of meteoric waters and gave rise to the formation of carbonate matrix. Diaspore and possibly oder bauxite minerals probably formed in this stage. Furthermore, quartz sand and sandstones cemented by hematite reflect the uplifting and subsequent erosion of the source area by faulting tectonics during the emplacement of ore.

All these observations support that mineral occurrences have a deposilional character, subjected to atmospheric effects. This may be regarded as karstic deposition. These deposits which developed on top of a gentle topography by long lived atmospheric effects were washed away or broke up and eventually filled the regional karstic hollows during some probable interruptive periods (waning of precipitation depending on climatic changes, etc).

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