Mineralogy of the Iron Mineralizations Associated With Uckapili Granitoid (Nigde Massif)

Tumuklu. A, Altuncu. S, Ozgur.F.Z.

***Abstract*— Nigde Massif is the southest part of the CACC (Central Anatolian Crystalline Complex) which is composed of magmatic and metamorphic rocks. Niğde Massif consist of Gümüşler, Kaleboynu and Aşıgediği formations. Üçkapılı granitoid cuts all these units.**
The iron mineralization is observed in all the units forming an irregular distribution in the Niğde massif. Field studies and the results of mineralogical research on polished sections indicates that the origin of the mineralization is hydrothermal.
The iron ore deposits in the study area have a paragenesis composed of magnetite, hematite and limonite. The mineralization paragenesis is accompanied by chalcopyrite, malachite, covellite, chalcocite, native Cu and native Au.

***Index Terms*— Nigde Massif, Üçkapılı Granitoid, Iron, Hydrothermal**

I. INTRODUCTION

In this study, iron mineralizations associated with Üçkapılı granitoid cutting the Gümüşler, Kaleboynu and Aşıgediği formations in the Niğde massif between Niğde and Çamardı are investigated.

The Nigde Massif is an isolated crystalline dome near the Inner-Tauride suture in Central Turkey and represents the southernmost part of the Central Anatolian Crystalline Complex (CACC, Göncüoğlu et al., 1991), which includes the Kırşehir and Akdağ Massifs in the north. It is bounded on the east by the sinistral Ecemiş Fault (Tertiary) and on the south by the Ulukışla sedimentary basin (Figure 1).

So far, there are many geological based researches in the region. These studies generally can be divided into three groups. The first is the studies carried out to determine the basic geological features of the region (Göncüoğlu, 1981; Göncüoğlu, 1982; Göncüoğlu, 1986; Whitney and Dilek, 1998; Whitney et.al., 2007; Gautier, et al., 2008). The second group especially belongs to the Sb ± Sn ± W ± Hg mineralization in the region (Kuşcu and Erler, 1992;Akçay, 1994; Akçay et. al., 1995; Yalçın, et. Al., 2016;). The third group is related to environmental geochemistry (Tumuklu, 2013; Tumuklu and Yalçın, 2016)).

In this study, iron mineralizations associated with granitoids in the region has been subjected. Investigation of geological and mineralogical features of iron mineralization is aimed. For this purpose, iron ore samples were collected from the quarries and outcrops where the iron mineralizations were seen in the region and host rock relations were investigated. The mineralogical features of the iron ore samples were determined by using about 20 polished sections. XRD analysis was conducted on one sample.

Manuscript received Dec 16, 2016

Tumuklu. A, Omer Halisdemir University, Geological Engineering Department, Nigde, TURKEY
Altuncu. S, Omer Halisdemir University, Geological Engineering Department, Nigde, TURKEY
Ozgur.F.Z., Omer Halisdemir University, Geological Engineering Department, Nigde, TURKEY

II. GEOLOGICAL SETTING

The Niğde massif, located at the southern tip of the CACC, is a structural dome comprised of a core that primarily consists of high-grade metasedimentary rocks (including migmatite) that record upper amphibolite facies metamorphism and, in the deepest structural units, partial melting (Whitney and Dilek, 1998; Whitney et al., 2003). These basement rocks are Gümüşler Formation, Kaleboynu Formation and Aşıgediği Formation in stratigraphic order from old to young. In the study area, the local stratigraphy starts with the Paleozoic Gümüşler Formation which is made of mostly gneiss, amphibolite, marble and quartzite. During pre-Late Cretaceous time, the Sineksizyayla gabbro intruded into the Gümüşler Formation. The unit underwent deformation and metamorphism together with the Niğde Group rocks, probably during the emplacement of the Üçkapılı Granitoid. Kaleboynu Formation is dominated by marble, with alternations of quartzite, gneiss and amphibolite. Aşıgediği Formation which covers almost half of the Niğde Massif consists mainly of marbles with intercalations of gneiss, quartzite and amphibolite. All these units are cut by the crustally derived Late Cretaceous Üçkapılı two-mica granite and its vein rocks with a thickness of 30-100 cm like numerous aplite, micropegmatite and pegmatite dykes which are distributed mainly in the Gümüşler Formation. The dykes are also locally present in the Kaleboynu and Aşıgediği Formations. They are the late associates of the granitic intrusions and intrude all the units of the Niğde Group, including the main granitoid stock around Üçkapılı village. Incesu Ignimbrite covers unconformably all the units of the Niğde Massif and is covered by the Quaternary alluvial deposits (Kurt et al., 2013) (Figure 1-2).

Granitoids are abundant in the Niğde Massif, intruding the high-grade metamorphic series. The main intrusion is the Üçkapılı granite (Göncüoğlu, 1986), exposed from the center of the massif to the northeast. Smaller exposures of granitoid, similar in appearance to the main body, are also widespread further northwest and south. The most common facies is a two-mica granite. Analyses on samples from several small intrusions in the northwest document that the magma was peraluminous, with a high initial Sr ratio (0.7104 ± 0.0009) (Göncüoğlu, 1986; Akman et al., 1993).

U-Pb geochronology on a sample from the main body shows that most zircons include an inherited core (Whitney et al., 2003). These features indicate that Üçkapılı-type magmas originate from partial melting of the continental crust (Göncüoğlu, 1986; Whitney et al., 2003).

Pressure conditions during emplacement were probably around 3–4 kbar (Whitney and Dilek, 1998). The Üçkapılı granite usually shows very weak ductile fabrics. It is locally associated with a dense array of dikes with variable orientations, crosscutting at a high angle the foliation of the metamorphic rocks. These features might suggest that the emplacement of the Üçkapılı granite was post-tectonic. The main body, however, has been identified as a late-kinematic intrusion, recording the same shearing deformation as its host rocks (Gautier et al., 2002).

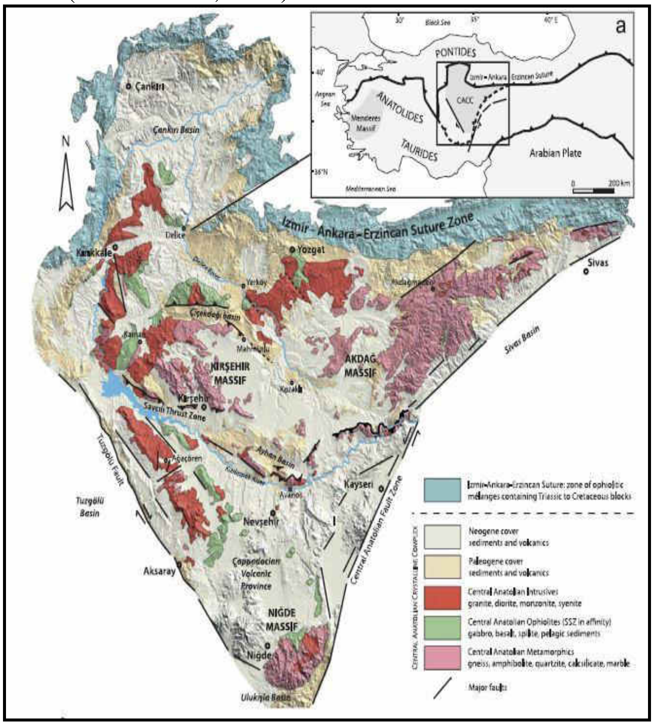

Figure 1. (a) Simplified tectonic map of the Turkish orogenic system. The two gray areas indicate the location of the two largest metamorphic massifs in Turkey: the Menderes Massif and the Central Anatolian Crystalline Complex (CACC). (b)Simplified geological map of the CACC projected on to a Digital Elevation Model (Cˆome Lefebvre et al., 2013).

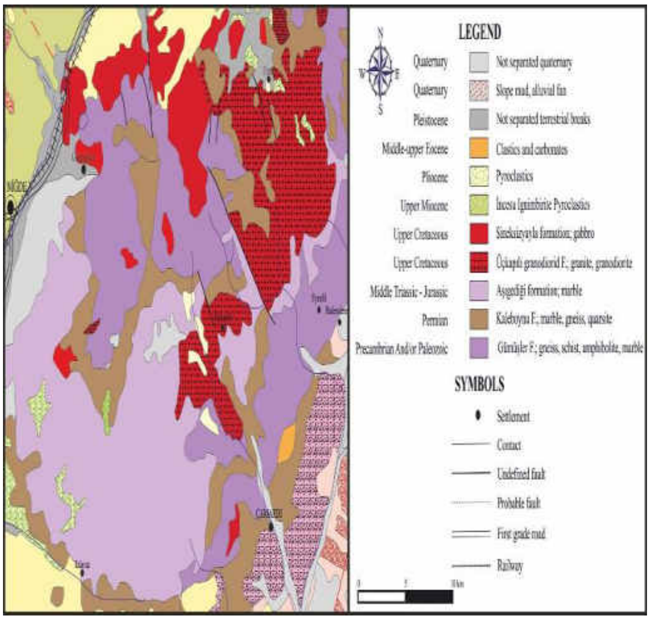

Figure 2. Modified from 1/500.000 scaled geological maps of Turkey series (MTA, 2002)

III. MINERALIZATION

The iron mineralization in the region is located in a wide area between Niğde and Çamardı. During the last 30-40 years, in different periods, Armutbeli, Eynelli, Gümüşler and Elmaderesi quarries have been operated by open pit operation methods. Today, there are no ore mined areas in the region. The mineral deposits in the study area are located in discontinuities in the Gümüşler, Kaleboynu and Aşıgediği formations. The mineralization types in the region (in layer boundaries, fault zones, formation contact zones) are in the shape of breccia, stockwork, veins, veinlets and massive lenses (Figure 3 a,b,c,d). The size of the mineralization can range from 1 cm to 100-150 m. (Figure 3 e).

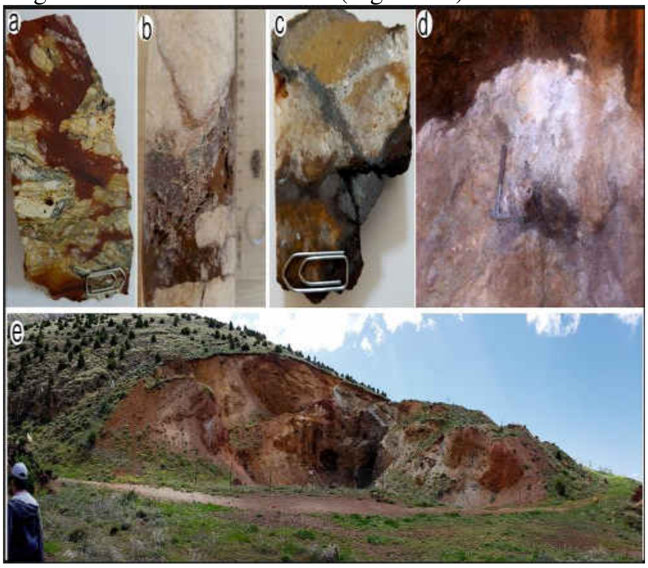

Figure 3. Niğde-Çamardı ore structures and field view. a) Hematite in irregular structure within metamorphic rocks. b) Samples of drilling cores showing hematite, malachite and calcite breccias filling fractures and cracks in marble. c) Hematite and limonite mineralization located along fractures and cracks d) The lens shaped hematite mineralization in marble. e) Eynelli mineralization in the field.

There are barium and calcite veins between the mineralization and the wall rocks. The thickness of the barite mineralization is up to 7 m in the eastern section of the Armutlu quarries. The calcite veins of this area are about 25 cm thick and are approximately steep (Figure 4 a,b). Clay mineral occurences are widespread around mineralizations. The clay occurences are in the form of 3 m thick zones (Figure 5).

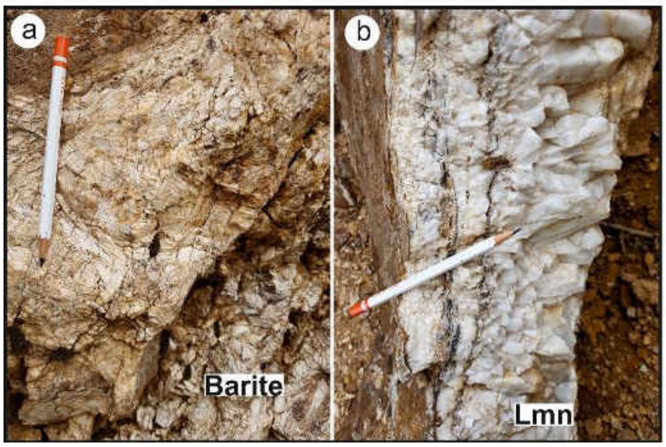

Figure 4. Barite and calcite occurences. a) Barite on the edge of iron mineralization. b) approximately steep calcite vein. (Lmn: Limestone)

IV. Iron Mining Areas

The mineralizations in the study area are located between Niğde-Çamardı and occured in 4 old workings and many outcrops. Old workings areas are Elmaderesi, Armutbeli, Eynelli and Gümüşler fields.

Elmaderesi mineralization is located in Elmaderesi district about 2 km north of Elmaderesi village. The mineralization is irregular in Aşıgediği marbles and it can be 1-3 m in thickness and up to 100 m in length. The mineralization is fractured, pocket filled and lenticular. Steep and approximately steep ores are emplaced in the form of breccia fills. Brecciated materials consists of wall rock marble pieces. The nearly horizontal ore veins are relatively more massive. The main ore mineral is hematite. There is intense limonitization around the mineralization (Figure 5).

Figure 5. Hematite mineralization in the calcite discontinuity zone in the Elmaderesi working area.

Armutbeli mineralization is located in the transition zone of Aşıgediği and overlying Çamardı formation, 3 km west of the Celaller village. It is the most important mineralization in the region. The mineralization is in the form of independent lenses and the long axes of the lenses reach up to 50 m and the short axes to 20 m (Figure 6 a). Common ore minerals are hematite, goethite, limonite and malachite. Goethite minerals, which characterize the superficial environment at the surface or near the surface, are common (Figure 6 b). In particular, limonite is present intensively in the outer zones of the ores. Malachite minerals are common in mineralization. Malachite occurrences are usually not more than 1 cm in size, and in some cases they are also 5 cm in diameter (Figure 6 c). Melting structures occurred at the contacts between the mineralization and the wall rock, and secondary calcite occurrences were deposited in these cavities (Figure 6 d). In some parts of the mineralization, there are melt flow structures similar to the banded structure. This flow structures are generally consistent with the long axis of mineralization (Figure 6 e). This means that the iron oxide ores are formed by magmas (Hou et al. 2009).

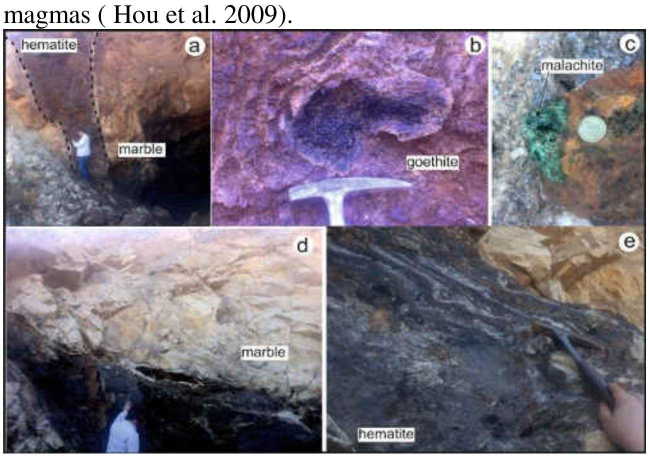

Figure 6. Armutbeli open pit iron deposit. a) Lens shaped iron mineralization. b) Concentric structured goethite developed in spaces. c) Malachite occurences about 5 cm in size within hematite, in fractures and spaces. d) Melting void structure observed

There are many iron ore mineralizations around Eynelli village. These mineralizations are located within the Kaleboynu formation within the marble-granitoid contact zone and in the discontinuous zones of the marbles. In this study, the main quarry located 2 km west of the Eynelli Village is the subject of examination and this lens shaped ore is about 100 m long. There are structures that may be gas holes of 1 m in diameter in the mineralization (Figure 7 a, b). Economic ore minerals are hematite and limonite formed by alteration of them.

Figure 7. Eynelli iron mineralization. a) Iron ore-marble contact. b) Gas voids about 1 m in diameter in the hematites.

About 3 km south of the village of Gümüşler, there are mineralizations containing brecciated structure in gneiss and marble contacts. The dominant ore mineral is hematite. The mineralizations in this area are in conformity with the schistosity planes of the metamorphics belonging to the Gümüşler formation and within the fault planes. The size of the breccia in the mineralization is between a few cm and 25-30 cm. The breccia in the ore is calcite (marble), the edges of which are generally sharp (Figure 8 a,b).

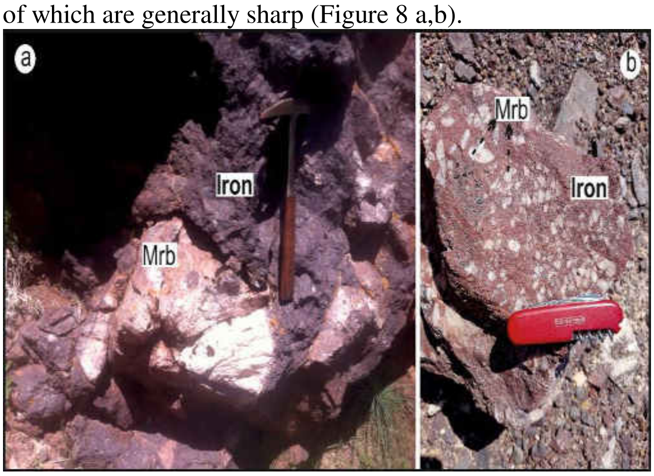

Figure 8. Gümüşler iron mineralization. a-b) Breccic calcite fragments of different sizes within hematites.

V. Mineralogy-Petrography

The following data were obtained as a result of the ore microscope study of the polished sections of the ore samples taken from the old workings and outcrops in the study area. The most important ore mineral in the study area is hematite. To a lesser extent, there are goethite, magnetite, limonite, chalcopyrite, malachite, native Cu, covellite, chalcocite and native Au.

Ore minerals in the mineralizations show modal distribution of 75-80% hematite + specularite, 10-15% goethite, 5% -10% limonite and 1-2% magnetite. Chalcopyrite and other copper minerals are observed at 1% or less. In addition, there is also trace amount of native Au. Hematite in the ore deposits in the region exhibits two different structures. These are primary hematite and secondary hematite occured as a result of martitization.

Primary hematites are common in all mineralization areas. It is often observed in the sticky shapes nested with gangue minerals. The length of the hematite sticks ranges from 200 - 300 μ to 60 - 70 μ. These hematite sticks are arranged in a radial structure. There is no bending, twisting or breaking in these sticks. Magnetite between hematite sticks was not found in other samples except for a few samples. As a result of field observations and microscopic examination, it has been found that these primary hematites are commonly converted to goethite and limonite (Figure 9 a, b, c, d).

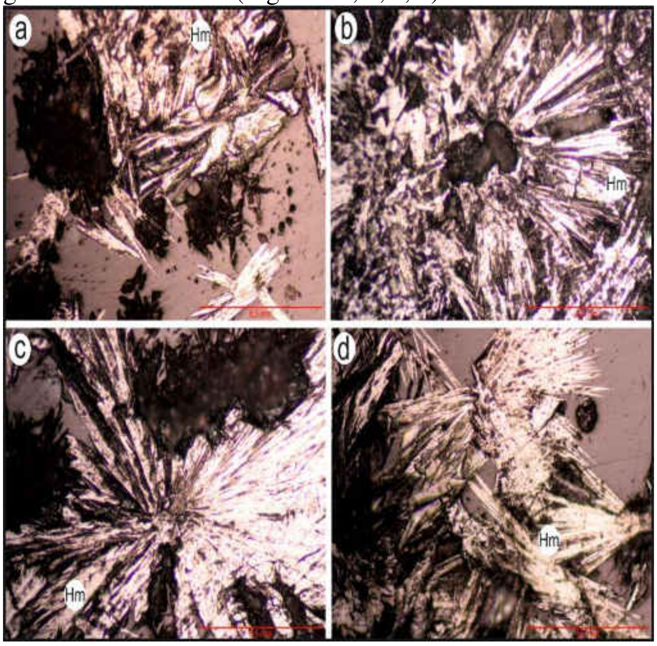

Figure 9. Hematite sticks. a) Hematite sticks in irregular radial structure. b, c, d) Radial hematite sticks in radial structure.

Secondary hematites are the result of martitization of magnetites. This phenomenon developed mainly along the edge and crack planes of the magnetites (Figure 10) and was detected in only a few samples.

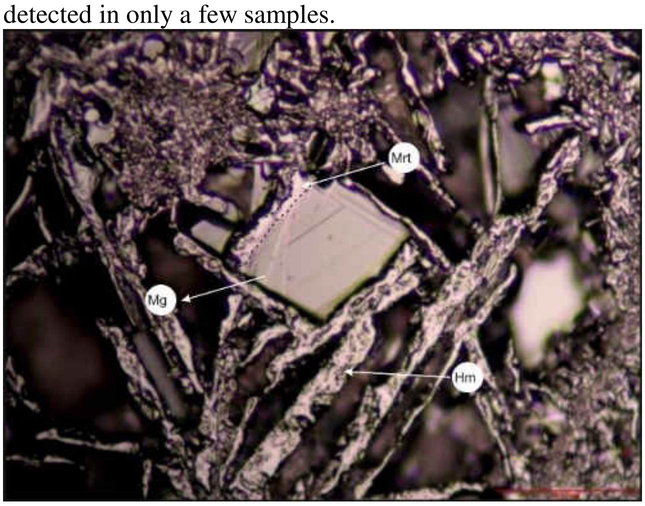

Figure 10. Hematite and magnetite. (Mg: Magnetite; Mrt: Martitization; Hm: Hematite

Limonite is intensely present along the fractured and cracked zones of the minerals it is associated with. In the inner part of the limonites there are some relict grains showing primary minerals that is not decomposited.

Goethite is commonly found in the examined samples especially in Armutbeli field. Goethite ores are seen in the glaskopf structure formed on the outer surfaces from the cavity surfaces of the hematites, which are the main ore minerals in the field. In polished sections of the samples, openings reaching 10-20 μm in width are seen between concentric goethite shells. The outer surfaces of the concentric shells include droplet-like embossments that are observed at diameters ranging from 0.3 mm to 1 cm (Figure 11 a). These embossments reflect the growth directions of the crystals in the shell. Inner sections of the glaskopf structures are colloformed with micro concentric band (sequential growth colloform textures). Crystals grow parallel to the shell surface. The inner structures of these glaskopf structures, which form goethites, are compatible with the edge lines of the shell outer surface. The core, colloform texture and shell morphology are compatible with each other. A bending twisting structure in the outer section continues to affect the interior of the mineral. The concentric bands that make up the internal structure of the goethite have thicknesses ranging from 5 to 15 μm. The central parts of the goethite minerals have two different colors, light and dark (Figure 11 a,b).

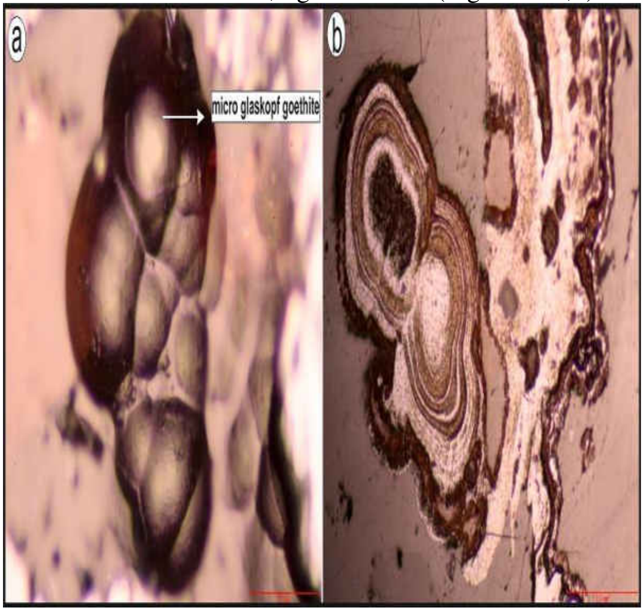

Figure 11. Ore microscope images of goethite minerals. a) Micro-scale goethite mineral. b) Goethite, rhythmic alternating concentric shelled goethite occurrences.

Probably silicates-iron-hydroxides filled between gangue minerals. These solutions exhibit well-formed concentric banding interpreted as colloform banding. These structures include ore minerals of 10-15 μm size and brecciated gangue fragments of 0.1 mm size. Ore minerals in very small scale are probably pyrite. Secondary iron hydroxides substitute and fills anhedral limonites (silicate-iron hydroxide?) There are very small grained pyrites in these secondary occurences (Figure 12 a-b).

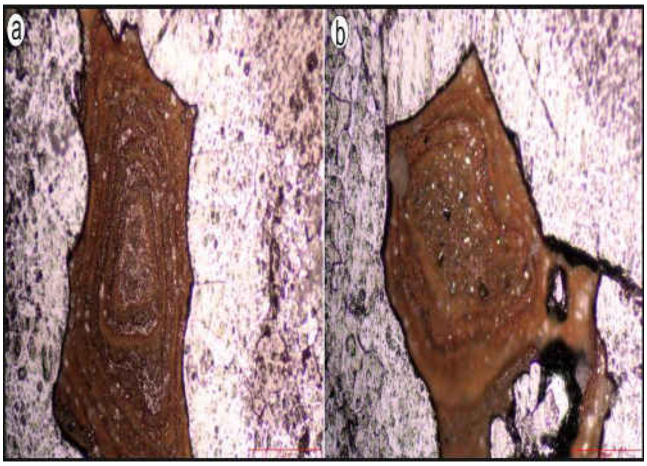

Figure 12. a-b) Colloform banding Secondary iron hydroxides filling the gaps between gangue minerals (silicate-iron hydroxide?)

VI. Copper Minerals

Probably significant amount of copper minerals have been detected in the iron mineralization in the study area. Copper mineralization is located in the outer rims, cracks and fractures of the hematites and secondary calcite veins. The primary copper ore mineral is chalcopyrite. As a result of the investigation of the polished sections, chalcopyrites were detected only in the fracture and cracks of iron oxide and gangue minerals. Chalcopyrite has been transformed into secondary malachite, bornite, covellite, chalcosis (digenite) and native Cu as a result of the alteration (Figure 13).

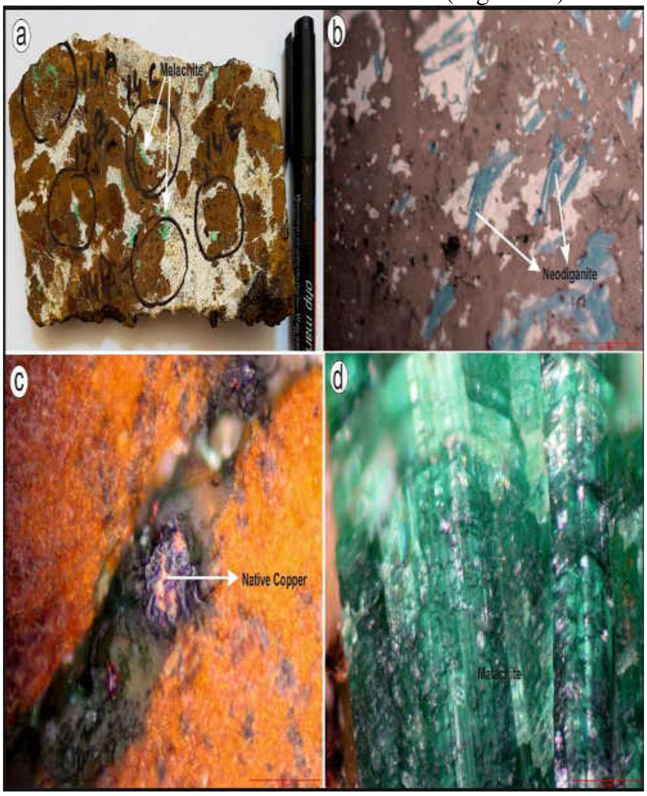

Figure 13. Copper minerals. a) In the sample taken from the mineralization area, malachite, hematite and calcite. b) Chalcopyrite in the primary structure altered to bornite (pink), chalcocite / digenit (blue) and covellite (colors mixed ones). c) Native Cu. d) Micro malachite sticks

VII. Native Gold

In polished section studies, trace amounts of native gold was observed in some samples. Native gold is in fractures and cracks between gangue minerals. The size of the detected native gold grains is up to 100 µm (Figure 14).

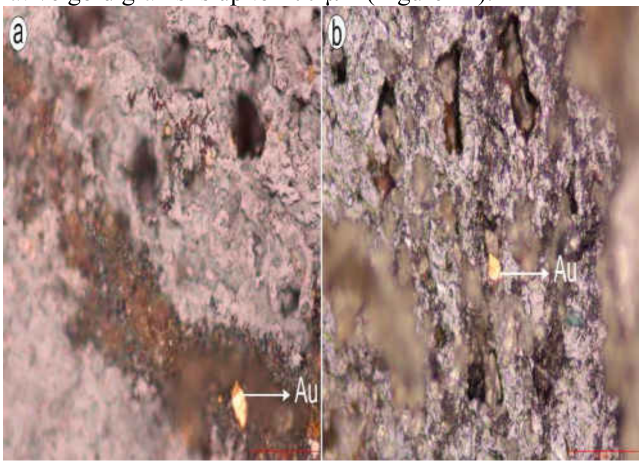

Figure 14.a-b) Native Au in the crack and fracture fillings in Gangue.

VIII. XRD Studies

Sample containing copper and gang minerals with iron ores were taken up for XRD studies, and the diffractogram is shown in Figure 15. According to the XRD diffractograms, only goethite, hematite, calcite and malachite peaks were detected in the sample.

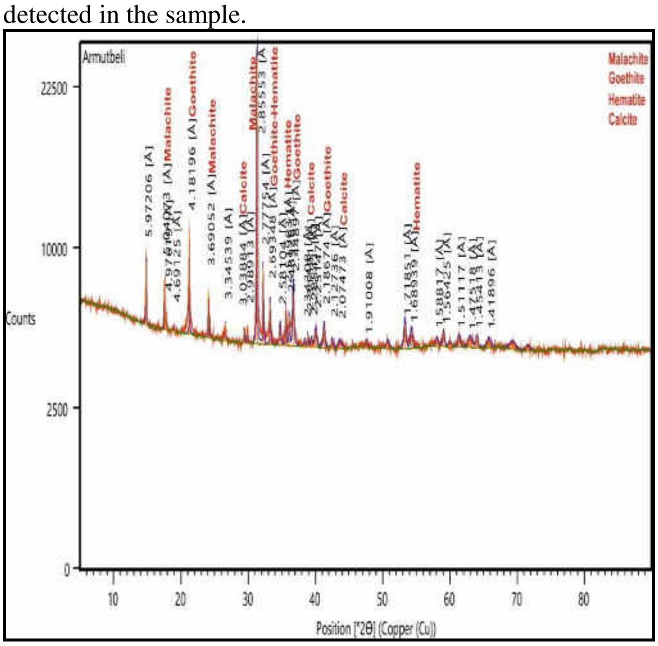

Figure 15. XRD Diffractometer pattern of the Armutbeli iron deposit.

CONCLUSION

The mineralizations with hematite-goethite-limonite paragenesis in Niğde-Çamardı region are located in discontinuity zones of marble and schists belonging to Niğde Massif. The mineralizations are in the form of lenses and breccia fills. It is believed that the mineralization may be closely related to the Üçkapılı granitoid in the region. Kaolinization, which is in contact with the mineralization, indicates the presence of a hydrothermal process in the region.

The gas gaps in the mineralization range from cm to 1 m in size also indicate a hydrothermal process.

The presence of magnetite-hematite-goethite-limonite as a result of the ore microscope study indicates that the mineralization is zoned from moderate to low temperature, ie mesothermal to epithermal phase. The presence of chalcopyrite and native Au also confirms this determination.

The more detailed metallogenic studies to be carried out in the region can reveal the economic potential in terms of iron-copper and gold.

REFERENCES

[1] 1/500.000 scaled geological maps of Turkey series. (MTA, 2002)

[2] Akçay, M., 1994, Mineral Chemistry of Tourmalines from the Gümüşler Sb-Hg-W Deposits (Niğde Massif, Central Turkey): Geosound, 24, 151-161.

[3] Akçay, M., Moon, C. J., and Scott, B. C. 1995. Mineralchemie und Flüssigkeitseinchlüsse der bei der Sb-Hg± W-lagerstatte auftretenden Turmaline im Gebiet Gümüşler (Niğde Massive, Zentral-Türkei). Chem. Erde., 55, 225-236.

[4] Akman, O., A. Erler, M. C. Göncüoğlu, N. Güleç, A. Geven, T. K. Türeli, and Y. K. Kadıoğlu (1993), Geochemical characteristics of granitoids along the western margin of the Central Anatolian Crystalline Complex and their tectonic implications, Geol. J., 28, 371 – 382.

[5] Gautier, P., E. Bozkurt, E. Hallot, and K. Dirik (2002), Dating the exhumation of a metamorphic dome: Geological evidence for pre-Eocene unroofing of the Niğde Massif (Central Anatolia, Turkey), Geol. Mag., 139, 559 – 576.

[6] Gautier, P., Bosse, V., Hallot, E. and Dirik, K. 2008. Coeval extensional shearing and lateral underflow during Late Cretaceous core complex development in the Nigde Massif, Central Anatolia, Turkey. Tectonophysic, 27, 1-27.

[7] Göncüoğlu, M. C. (1986), Geochronological data from the southern part (Niğde area) of the Central Anatolian Massif, Bull. Mineral Res. Explor. Institute Turkey (MTA), 105/106, 83 – 96.

[8] Göncüoğlu, M.C., 1981. The Origin of Viridine –gneiss from Niğde Massif. Bulletion of the Geological Society of Turkey, V. 24, 45-51, February 1981.

[9] Göncüoğlu, M.C., (1982). Zircon U/Pb ages from paragneisses of the Niğde Massif (Central Anatolia). Bulletin of the Geological Society of Turkey, V. 25, 61 - 66, February, 1982.

[10] Göncüoğlu, M.C., (1986). Geochronological data from the southern part (Niğde area) of the Central Anatolian Massif. Bull. Mineral Resarch and Exploration, 105/106: 83-96.

[11] Göncüoğlu, M. C., V. Toprak, I. Kuşçu, A. Erler, and E. Olgun (1991), Orta Anadolu Masifinin batı bölümünün jeolojisi, Bölüm1: Güney Kesim, Turkish Petroleum Corporation (TPAO) Report, 2909, 140 pp.

[12] Hou, T., Zhang, Z., Du, Y and Li, S. (2009). Geology of the Gushan iron oxide deposit associated with dioritic porphyries, eastern Yangtze craton, SE China. International Geology Review. Vol. 51, No. 6, 520–541.

[13] Kuşçu, I, Erler, A., (1992), Geology and Mineralogy of the Madsan Antimony Deposit (Çamardı-Niğde). Geosound, 21, 163-177.

[14] Kurt, H., Koçak, K., Asan, K and Karakaş, M. 2013, “Petrogenesis of the Üçkapılı Granitoid and its Mafic Enclaves in Elmalı Area (Niğde, Central Anatolia, Turkey)”, Acta Geologica Sinica, Vol. 87, No:3, pp. 738-748.

[15] Lefebvre, C., Meijers, M J.M., Kaymakci, N., Peynircioğlu, A., Langereis, C. G. and Hinsbergen, D. J.J. 2013, “Reconstructing the geometry of central Anatolia during the late Cretaceous: Large-scale Cenozoic rotations and deformation between the Pontides and Taurides”, Earth and Planetary Science Letters, 366, p. 83–98

[16] Tumuklu, A., 2013. Investıgatıon of The Source Rocks of Arsenic found in Soil and Water of Gümüşler (Niğde) Area. 2.Tıbbi Jeoloji Çalıştayı, 4-6 Aralık 2013, Akdeniz Üniversitesi, ANTALYA-TURKEY.

[17] Tumuklu, A. And Yalçın, M. G., (2016). Economic And Environmental Effects Of Historical Mining Enterprises İn Gumuşler Village And Çamardı Towns Region (NIGDE, TURKEY). 16th International Multidisciplinary Scientific GeoConference SGEM, Albena, BULGARIA, 28th June - 7th July 2016.

[18] Yalçın, F; Tumuklu, A; Boztas, S. Ilbeyli, N; (2016). Investigation Of Statistical Relationships Between Au, Ag, As, Ba, Cd, Cu, Fe, Pb, S, Sb, And Zn Elements Of Antimony Deposit In NW Camardı–Nıgde (Turkey). 16th International Multidisciplinary Scientific GeoConference SGEM, Albena, BULGARIA, 28th June - 7th July 2016.

[19] Whitney, D. L., and Y. Dilek (1998), Metamorphism during Alpine crustal thickening and extension in Central Anatolia, Turkey: The Niğde metamorphic core complex, J. Petrol., 39, 1385 – 1403.

[20] Whitney, D. L., C. Teyssier, A. K. Fayon, M. A. Hamilton, and M. Heizler (2003), Tectonic controls on metamorphism, partial melting, and intrusion: Timing and duration of regional metamorphism and magmatism in the Niğde Massif, Turkey, Tectonophysics, 376, 37 – 60.

[21] Whitney DL, Teyssier C, Heizler MT (2007). Gneiss domes, metamorphic core complexes, and wrench zones: thermal and structural evolution of the Niğde Massif, central Anatolia. Tectonics 26: TC5002.