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Mineralogical And Gemological Characteristics Of Metaophiolite Hosted Corundum (Malatya-Türkiye)

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Abstract

The corundum is found in the rocks of the Berit metaophiolite in Eastern Anatolia, near Doğanşehir a province of Malatya. Metaophiolitic rocks consist mainly of garnet metagabbro, granulite, amphibolite, mylonitic amphibolite, garnet amphibolite, amphibole schist, pyroxenite, mylonitic pyroxenite, orthopyroxenite, harzburgite, serpentinized dunite and diorite units. Corundum occurrences are mostly found in pyroxenites, amphibolites, peridotites and granulites. Their colors change in range between reddish pink, pink and light pink. They are usually in structure of translucent, vitreous and sometimes cracked. They are seen scattered or clustered together inside the rocks in which they are found. The size of their crystals ranges from 0.5 cm to 10 cm and their euhedral crystals are observed in pseudohexagonal form. As a result of the petrographic examinations, it was observed that pyroxene, amphibole, garnet and plagioclase minerals accompanied with the corundum. The samples of the rocks containing the corundum has qualifications which will be as an object of gemstone and ornament by means of cutting and shining. Large specimens of corundum can be processed alone. Samples, being as scattered and small granules inside the rock can be processed together with the host rock. In the processed samples, it was obtained patterns like the samples of corundum with zoisite which were in great demand in the world gemstone market.

Keywords: mineralogy, gemology, corundum, gemstone, Malatya

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1. INTRODUCTION

The jewellery and tools made from gemstones [1, 2] have been important place in human life since centuries. Today, the demand for the jewellery and decoration stuff, made from natural minerals and rocks in different colors and transparency, which are resistant to atmospheric conditions, continues incremantally. The chemical formula of the corundum is Al_2O_3 and may contain impurities like iron, chromium, etc. [3, 4, 5, 6]. The corundum group is formed with ruby and sapphire [7, 8, 9, 10]. The chemical and physical properties of these two gem varieties belonging to the corundum group, which are defined in different colors, are similar; solely, the amount and variety the elements in which they contain have difference. The pure corundum is colorless and possess the high hardness (9) and specific weight (3,94 - 4,02) due to tight packing and strong bonding of the atoms, despite the presence of two light elements like aluminum and oxygen in its composition [7, 11]. When corundum has rutile inclusions, if they are cut and polished they show the asterism feature (star appearance). The high hardness makes this mineral usable as an abrasive. The reason of red color of the ruby is that the small amount of chromium substitute the aluminum, which is in its crystalline structure. The small amount of iron together with chromium gives brownish red color. The color of blue sapphire depends on the presence of a small amount of iron and titanium [12,13]. Foreign materials can sometimes be found at a rate of 10% or more, in which case a stone becomes cloudish color and loses its aesthetic value [14,15]. Corundum is a secondary mineral found commonly in some metamorphic rocks such as marble, mica-schist, and gneiss [16]. It occurs in regional and thermal metamorphosed bauxite deposits. The corundum in large-size occur in the pegmatites found together with nepheline syenites. In the world, it has been found in Myanmar (Burma), Cambodia, Thailand, Sri Lanka (Ceylon), India (Kashmir) and Australia. Ordinary corundum was found in South Africa and USA [17].

The extracting of valuable gemstone formations in Turkey and putting forth whether they are economical by determining mineralogical-petrographic and gemological features of them are important for contributing to regional economy. The corundum in the study area is pinkish mauve colored and multi-fractured and cracked [18]. For this reason, while the corundum crystals are not transparent, but the color tone in the processed samples and the pattern beauty created by the side rocks indicate that they can be used in jewellery production.

2. GEOLOGY

There are units having different age, tectonic location and rock types in the Southeastern Anatolia Region and its surroundings which are included in the study area. Southeastern Anatolian orogenic belt consists of three sections from south to north which are Arabic Platform, Accretionary Prism Zone and Nap zone [19, 20, 21] (Figure 1). The Arabic Platform consists of sedimentary units most of which have been deposited from the Early Cambrian to Mid-Miocene and are marine sediments [19, 20]. The accretionary prism zone is bounded by Arabic platform from the south and nap zone from the north and consists of tectonic slices containing various rock units in the range of Late Cretaceous-Mid-Miocene period [19, 20]. In the Nap zone consisting of two large tectonic units, sub-nap consists of ophiolitic rock assemblages underwent metamorphism and the mineral group which is exposed in the southern boundary of the study area, and the upper nap consists of the Southeast Anatolian metamorphic massifs [19, 20].

The oldest unit in the study area is the Malatya Metamorphics which is composed of various schists with Paleozoic-Mesozoic ages, recrystallized limestone and marbles (Figure 2). The Malatya Metamorphics overlay all of the Early-Middle Eocene aged units in the study area with tectonic contact. The Berite metaophiolite, which contains the ultramafic garnet, mafic cumulates, gabbro, amphibolite and volcanics, and cut by acidic intrusions, belonging to Early-Middle Eocene aged Doğanşehir Granitoid, overlays the Middle Eocene aged mine complex, which contains diabase, andesite and dacite

dykes, micritic, nummulitic limestone blocks and basic volcanics, with tectonic contact [19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30]

The Middle Eocene aged Suludere Formation unconformably overlies the Granitoid of Doğanşehir and the Berite Metaophiolite. All these units are overlaid unconformably by the Plio-Quaternary aged Beylerderesi formation and the Quaternary alluviums. The corundum formations are in the pyroxenites, amphibolites, peridotites and granulites belonging to the Berite Metaophiolite.

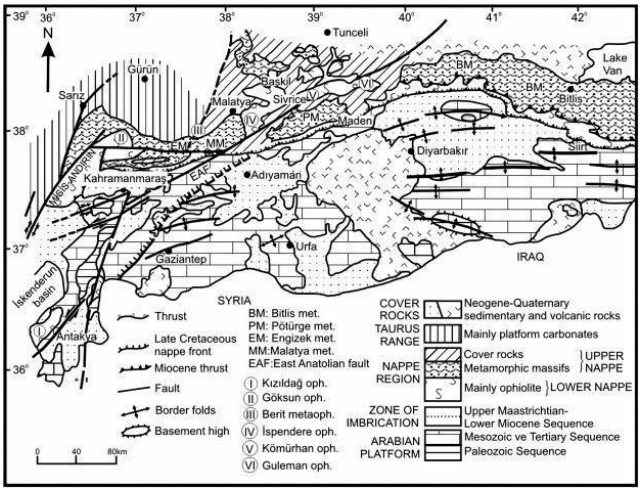

Figure 1 Regional geological map of the study area [19, 20, 21]

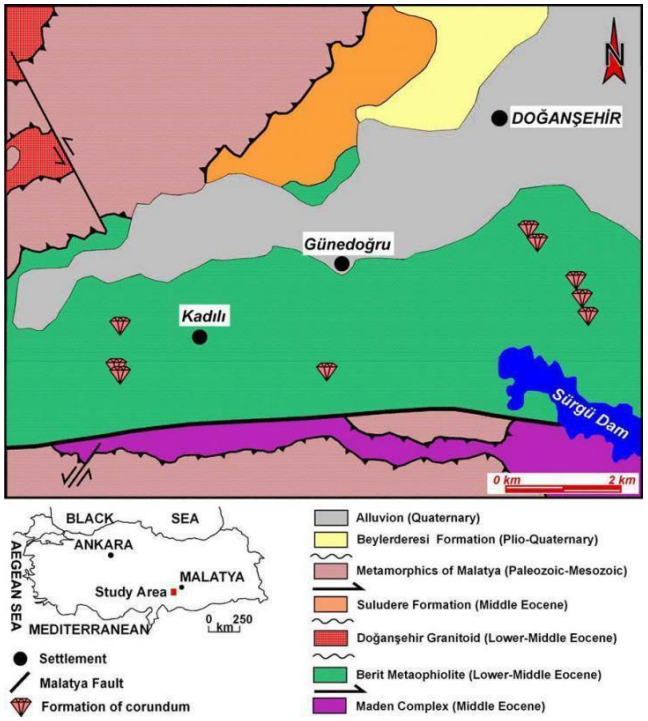

Figure 2 Geological map of the study area [24, 30]

3. METHOD

Eighty samples were taken with the purpose of determining the corundum distribution and its paragenetic relations and also its, geological, geochemical and mineralogical characteristics, in study area. XRD analyzes were performed in the Rigaku RadB-DMAX II Computer Controlled X-Ray Diffractometer at the XRD Analysis Laboratory of Mersin University in order to determine the mineralogical compositions of the samples. In the thin section laboratory of the Çukurova University Geological Engineering Department, thin sections were prepared from the corundum and side rock samples taken from the area and mineralogical determinations were made by examining them under polarizing microscope. Thin sections were prepared from the samples taken from the area and electron microprobe (EPMA) analyzes were carried out at Hacettepe University Geological Engineering. In addition, cabochon (curved) cutting techniques were applied to the corundum samples, which were taken from the area by using diamond coating saws, sinter diamond abrasive discs and polishing machine, and the gemstone workings were carried out with the aim of being used for the jewellery.

4. RESULTS

4.1. Macroscopic Examinations

The corundum, bearing gemstone features, is seen together with the pyroxenites, amphibolites, granulites and peridotites, which belong to Berite Metaophiolite in the study area [31, 32, 33, 34]. The rocks containing corundum in the area were observed as protrusions due to their hardness. However, these rocks are over-altered and have a very fragile structure. The colors of the corundum change in range between reddish pink, pink and light pink (Figure 3a). They are usually translucent, vitreous and sometimes cracked. They are seen scattered or clustered together

inside the rocks in which they are found. (Figure 3b). The size of their crystals ranges from 0.5 cm to 10 cm and their euhedral crystals are observed in pseudohexagonal form (Figure 3b). The extend of the metaophiolite containing corundum in the study area is more than 10 square kilometer. The corundum content in the metaophiolite is also very rich so as to be operated economically. The region was licensed for corundum, and will go into production in an early date.

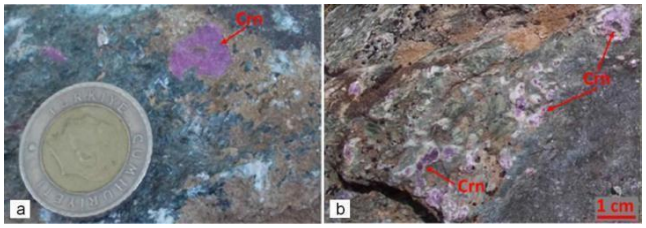

Figure 3 Reddish pink colored corundum mineral in amphibolites (a) and pyroxenites (b) belonging to Berit Metaophiolite

The Berite metaophiolite was metamorphosed at the lower limit of the granulite facies and the eclogite facies at pressures of 3.2-17.5 kbar and temperature range of 690-941°C [30]. This temperature and pressure overlap with the pressure and temperature values required for ruby crystallization [35, 36, 37, 38, 39, 40]. The corundum minerals in the study area are thought to have formed by having been exposed to high temperature high pressure metamorphism in the subduction zone of aluminium rich minerals as omphacite, plagioclase.

4.2. Mineralogy

XRD (Figure 4), thin section and electron microprobe analyses were performed on the corundum that is found in the study area. In the thin section, corundum is usually observed as anhedral and large granules reaching 5 millimeters. They are distinguished from other minerals by their high reliefs and refractive index. They have a very cracked structure and contain weak cleavages, mutually intersecting in partly (Figure 5). It shows a colorless and pinkish pleocroism in single nicol while, it has gray and yellow greyish in color in crossed polarized light (Figure 6). In the electron microprobe image, it was observed that the corundum minerals contain a bi-directional cleavage which is not apparent (Figure 7).

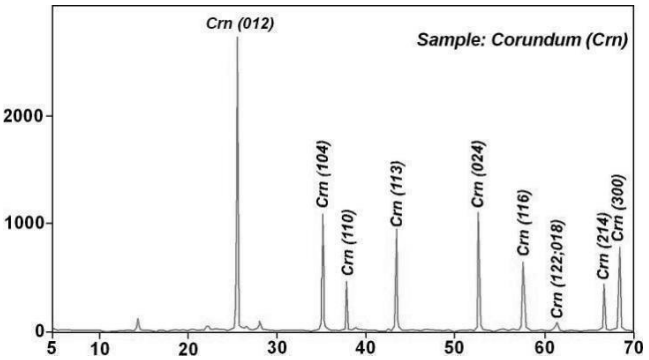

Figure 4 Result of XRD analys of corundum.

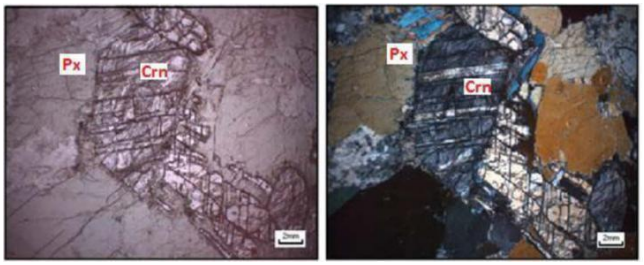

Figure 5 Bi-directional weak cleavage in the corundum in the pyroxenites (Px: Pyroxene, Crn: Corundum, a: Single nichol, b: Double nichol).

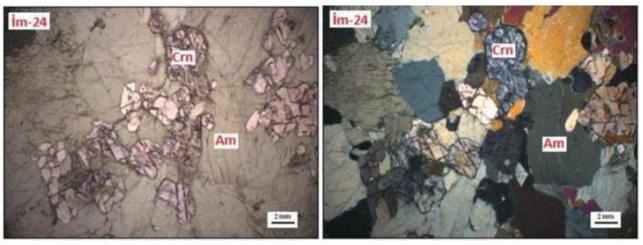

Figure 6 Abundantly cracked fine-grained pinkish-colored corundum minerals in amphibolites (Am: Amphibole, Crn: Corundum, a: Single nichole, b: Double nichole).

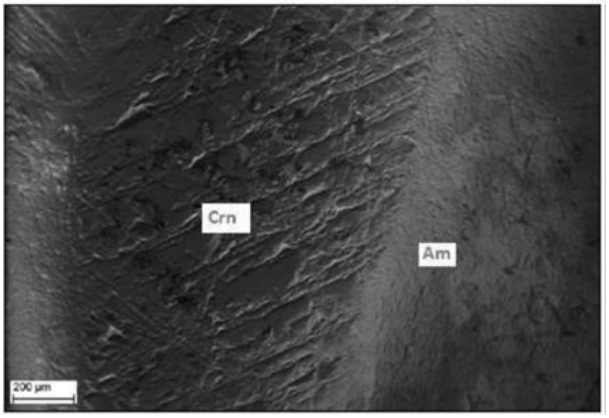

Figure 7 Electron microprobe image of the bi-directional weak cleavages observed in the corundum mineral of Kl-1 no. (Crn: Corundum, Am: Amphibole)

4.3. Geochemistry

As a result of the electron microprobe analysis of the corundum minerals in the amphibolite and pyroxenites in the study area it was determined that the corundum samples in the amphibolite contain 98.17% of Al_2O_3 and the corundum samples in the pyroxenit contain 97.13%of Al_2O_3. There are a few quantity of SiO_2, Na_2O, MgO, MnO and FeO as impurities in the corundum (Table 1). However, unlike pyroxenites, impurity of MnO were determined instead of FeO impurity in the corundum inside amphibolites.

Table 1
Chemical composition of corundum

	IM-24 (Amphiolite)	KL-1 (Pyroxenite)
SiO_2	0.818	1.856
Al_2O_3	98.169	97.133
FeO	0.003	0.106
Na_2O	0.513	0.570
MgO	0.276	0.333
K_2O	0.058	0.001
CaO	0.001	0.001
TiO_2	0.001	0.001
MnO	0.162	0.001

4.4. Gemology

The reddish pink, pink, and light pink corundum (Figure 8a) in the study area are often observed as anhedral scattered clusters and locally pseudohexagonal crystals. Examples of corundum are usually translucent, vitreous and sometimes cracked. The size of the crystals varies from 0.5 cm to 10 cm (Figure 8a-b). Because of their high hardness, it was encountered the corundum about 3 cm in diameter in separated way from other minerals in the area. Some of the samples containing corundum mineral were cut and polished to be used for gemstone and gemstone objects (Figure 8c-d). Large-size corundum samples were processed individually, while small-grain and scattered samples containing corundum mineral were processed with the side rock (Figure 8c-d). In this way, images similar to the samples of corundum with zoisite (Game, 1955), (Figure 8c-d).

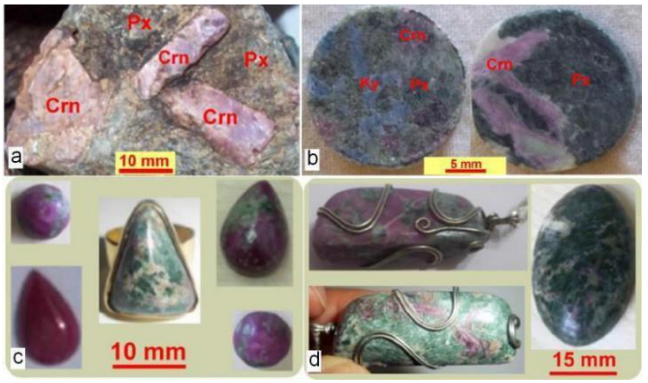

Figure 8 a: Pink colored prismatic corundum; b: Blue colored kyanite and pink colored corundum observed with green colored pyroxenes; c-d: Pyroxenes and corundum as gemstones (Crn: Corundum, Px: Pyroxene, Ky: Kyanite).

In the examination area, kyanite which is blue, transparent and glassy shine, accompany the corundum minerals, in places. The kyanite, in length of up to 1 cm and width of up to 0.5 cm are found as scattered in the pyroxenites. (Figure 9b).

5. CONCLUSION

The corundum, bearing gemstone features, is found within the pyroxenites, amphibolites, granulites and peridotites, which belong to Berite Metaophiolite in the study area [32]. The corundum is observed in reddish pink, pink

and light pink colors, glassy or cloudy shine, cracked and translucent. The dimensions of the crystals range from 0.5 cm to 10 cm, and the euhedal crystals are observed in pseudohexagonal form. In the thin-cut, the corundum usually have an anhedral and very cracked structure and contain weak cleavages intersecting bi-directional with each other, in partly. The reason for this fractured texture in corundum is thought to be due to the tectonism in the region.

As a result of the electron microprobe analysis of the corundum minerals it was determined that 98.17% of the corundum sample in the amphibolite and 97.13% of the corundum sample in the pyroxenit contain Al_2O_3. There are a few quantity of SiO_2, Na_2O, MgO, MnO and FeO as impurities in the corundum minerals, and unlike pyroxenites, impurity of MnO were determined instead of FeO impurity in the corundum mineral inside amphibolites.

Large-size corundum samples were processed individually, while small-grain and scattered samples containing corundum were processed with the wall rock, in the area. In the samples, machined at the result of flat cutting, images similar to the samples of corundum with zoisite [41], which have great demand in the World Gemstone Market, appeared.

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The Declaration of Conflict of Interest/ Common Interest

No conflict of interest or common interest has been declared by the authors.

Authors' Contribution

This study is the part of PhD thesis of İlkay KAYDU. Fikret İŞLER, Ayten ÖZTÜFEKÇİ ÖNAL, Meltem GÜRBÜZ, Zeynel BAŞIBÜYÜK and Murat HATİPOĞLU had a great contribution in providing support for the study, field studies, analyzing the rocks and minerals, interpreting the findings.

The Declaration of Ethics Committee Approval

The authors declare that this document does not require an ethics committee approval or any special permission.

The Declaration of Research and Publication Ethics

The authors of the paper declare that they comply with the scientific, ethical and quotation rules of SAUJS in all processes of the article and that they do not make any falsification on the data collected. In addition, they declare that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

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