

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Mineralogical-Petrographical Investigation and Usability as the Gemstone of the North Anatolian Kammererite, Tokat, Turkey

*İlkyay Kaydu Akbudak, Zeynel Başibüyük
and Gökhan Ekincioglu*

Abstract

Kammererite formations were observed in the region of Tokat province in the north of Anatolia. Kammererite (purple, reddish, pink color) is present in the form of nodules or veins in chromium levels found in Mesozoic basic-ultrabasic rocks. In the surveys, it was found that kammererite minerals do not show a widespread distribution and have different shades of pink and color and glassy brightness. Thin-section analyses were performed from kammererite samples. In the investigations, kammererite mineral showed brownish or pinkish pleochroism in plane-polarized light. In crossed polars, it was observed that they had interference color in grayish tones. Due to its low hardness, kammererite was treated with epoxy to increase its durability. In addition, it has been determined that they can be used in both jewelry and ornamental objects with the applied cabochon cutting styles.

Keywords: kammererite, gemstone, mineralogy, gemology, North Anatolia

1. Introduction

Kammererite mineral, which is rarely found in the world, is found in chromite deposits as reddish pink or purple-violet [1] colors as transparent or semitransparent. Its hardness is around 2.5, and its specific weight is 2.645 g/cm³ [2, 3].

Kammererite mineral is one of the clinochlorine members of chlorite group in phyllosilicates. Clinochlore, which is one of the most common members of the chlorite group minerals [4], can be divided into three subvarieties according to body colors and implicative abundance of the main cations [5–11]. These are blackish-green or bluish-green colored clinochlore (ferroan clinochlore) [12], yellowish-green or green colored clinochlore (magnesian clinochlore) [13, 14], and magenta colored clinochlore (chromian clinochlore) [5, 11, 15–17]. In fact, it is well-known that the name clinochlore derived from “clino,” which refers to the inclined optical axes and the Greek “chloros,” for “green,” its most typical color [4, 11, 18, 19].

Chromian clinochlore (kammererite) represented by the formula $[\text{Mg}_5(\text{Al,Cr,Fe})_2\text{Si}_3\text{O}_{10}(\text{OH})_8]$ [8, 9] is a hydrous silicate with a monoclinic I1b-2 polytype, with symmetry $C^2 = m$, and is extremely rare and of high interest for mineral collectors [20].

Worldwide occurrences of chromian clinocllore (kammererite) in addition to Turkey are as follows: Australia (Coobina chromite mine, Sylvania Station, Meekatharra Shire, Western Australia), Austria (Gulsen, Sommergraben, Lobminggraben, Leoben, Styria), Ethiopia (Tumut River, Sosua Region, Benishangul-Gumaz Province), Finland (Elijarvi Cr Mine, Kemi, Lapland Region), Greece (Nea Roda, Chalkidiki Prefecture Macedonia), Italy (Locana, Orco Valley, Torino Province, Piedmont), Japan (Akaishi Mine, Ehime Prefecture, Shikoku Island), Russia (Poldnevaya village, Sverdlovsk Oblast, Middle Urals), and the United States, (Dunsmuir, Siskiyou Co., California; Cecil Co., Maryland; Green Mountain Mine, Day Book, Yancey Co., NC; Jackson Co., Oregon; Woods Chrome Mine, Texas, Little Britain Township, Lancaster Co., PA) [20].

2. Material and methods

Samples were taken from the study area in order to determine the distribution, the paragenetic relationships, and the mineralogical, geochemical, and gemological characteristics of kammererite. It has been engraved on 1/25000 map. Thin sections were prepared from kammererite and side rock samples taken from the field in thin-section laboratory of Kırşehir Ahi Evran University Geological Engineering Department. Mineralogical determinations (mineral paragenesis) were carried out by examining these samples under a polarizing microscope in Kırşehir Ahi Evran University Geological Engineering Mineralogy-Petrography Laboratory.

In addition, gem-cutting techniques were applied to the kammererite samples taken from the field by using diamond coating saw, sinter diamond abrasive discs and polishing machine, and the usability of kammererites as a gemstone was present.

Kammererite samples taken from the study area applied gem-cutting techniques in the Gemology Laboratory of Mersin University, School of Jewelry Technology and Design.

First, slices of coarse material were taken on the large cutting machine, and different shapes were marked. Edge trimming was done on the small cutting machine, and curves were made on the cabochon machine. Finally, abrasive and polishing processes were carried out to form cabochon stones. Because kammererite are fine grains and fine veins, it cannot be processed alone. For this reason, it was worked together with the side rock. The obtained gems can be used in jewelry as necklaces, rings, earrings, bracelets, brooches, and functional goods such as keychains.

Treatment studies of kammererite samples were carried out in the natural stone analysis laboratory of Kaman Vocational School of Kırşehir Ahi Evran University. First, the samples were kept in the oven at 75°C for one day to allow them to completely exhale. Then, the hot samples were kept in the mixture of epoxy and hardener for 1 day. As a result, the epoxy penetrated the capillary cavities of the samples, and the samples had a solid structure. Epoxy-treated specimens were processed using cabochon and simple step cutting methods.

3. Geology

The study area is located in the Middle Pontid Tectonic Belt [21], south of Tokat province.

Tokat metamorphites [22], which represent the oldest unit in the study area and contain schist, phyllite, marble, and metabasites, are Upper Paleozoic-Triassic and

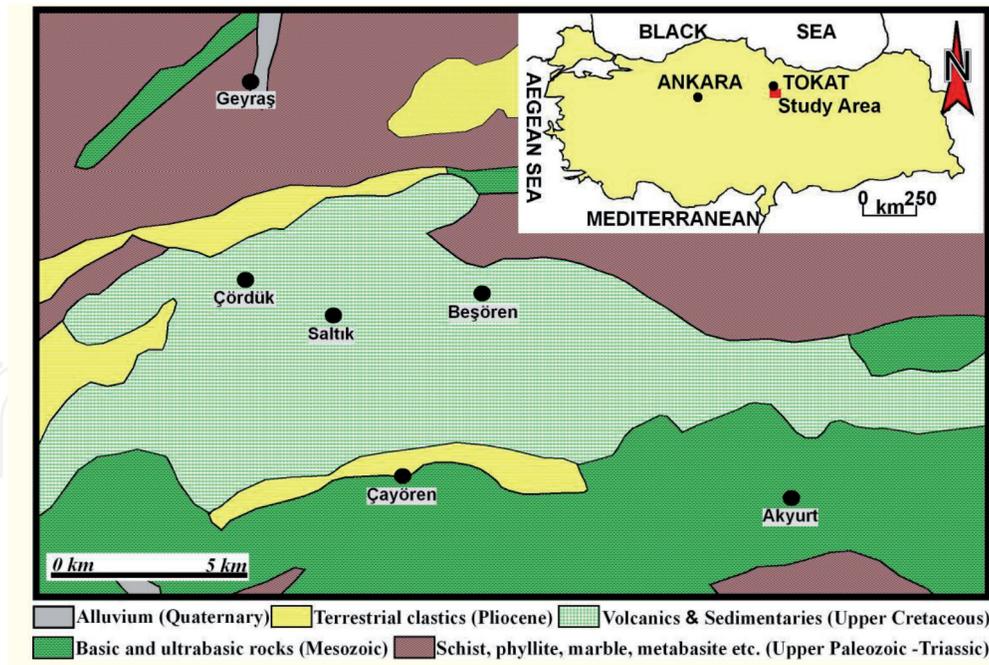


Figure 1.
Geological map of the study area [23].

are overlain by Mesozoic basic and ultrabasic rocks which are part of the ophiolitic series (**Figure 1**). These basic and ultrabasic rocks are overlain by Upper Cretaceous volcanic and sedimentary units. The youngest units in the study area are Quaternary alluviums.

4. Findings

4.1 Field studies

Kammererite formations in the region including Beşören and Saltık Villages within the borders of Tokat province in northern Anatolia are in purple-violet and reddish pink color and are in the form of nodules (**Figure 2a, b, d, e**) or veins (**Figure 2c, f**) within the chromium levels within the Mesozoic basic-ultrabasic rocks reaching up to 40 cm (**Figure 3**).

4.2 Mineralogical-petrographical-gemological investigations

Thin sections prepared in order to determine the mineral associations and textural relationships of the rock samples taken from the study area were examined under a polarizing microscope. Chromium minerals are observed as black color in plane-polarized light and crossed polars because they are opaque minerals (**Figure 4**).

Kammererite minerals has microcrystalline size. While the colorless, grayish, brownish, and pinkish pleochroism was observed in the plane-polarized light in the kammererite mineral (**Figure 4b, d, f, h**), the interference colors in black and white gray tones were observed in the crossed polars (**Figure 4a, c, e, g**).

It was observed in the surface investigations that kammererite minerals did not show a widespread distribution. Kammererite minerals in the study area have different shades of pink color and glassy brightness and are either transparent or semitransparent.



Figure 2.
View of kammererites in the field (kammererite nodules—a, b, d, and e; kammererite veins—c and f).



Figure 3.
Close-up view of kammererite samples taken from the study area.

First, kammererites were processed without any treatment (**Figure 5a**). They have low durability and very fine grain mineral composition. For this reason, treatment has been made in kammererite. Gemmologically better products were obtained (**Figure 5b**).

5. Results

Kammererites in the study area are in the form of nodules or thin veins at chromium levels within the basic-ultrabasic rocks of the Mesozoic age. As a result of

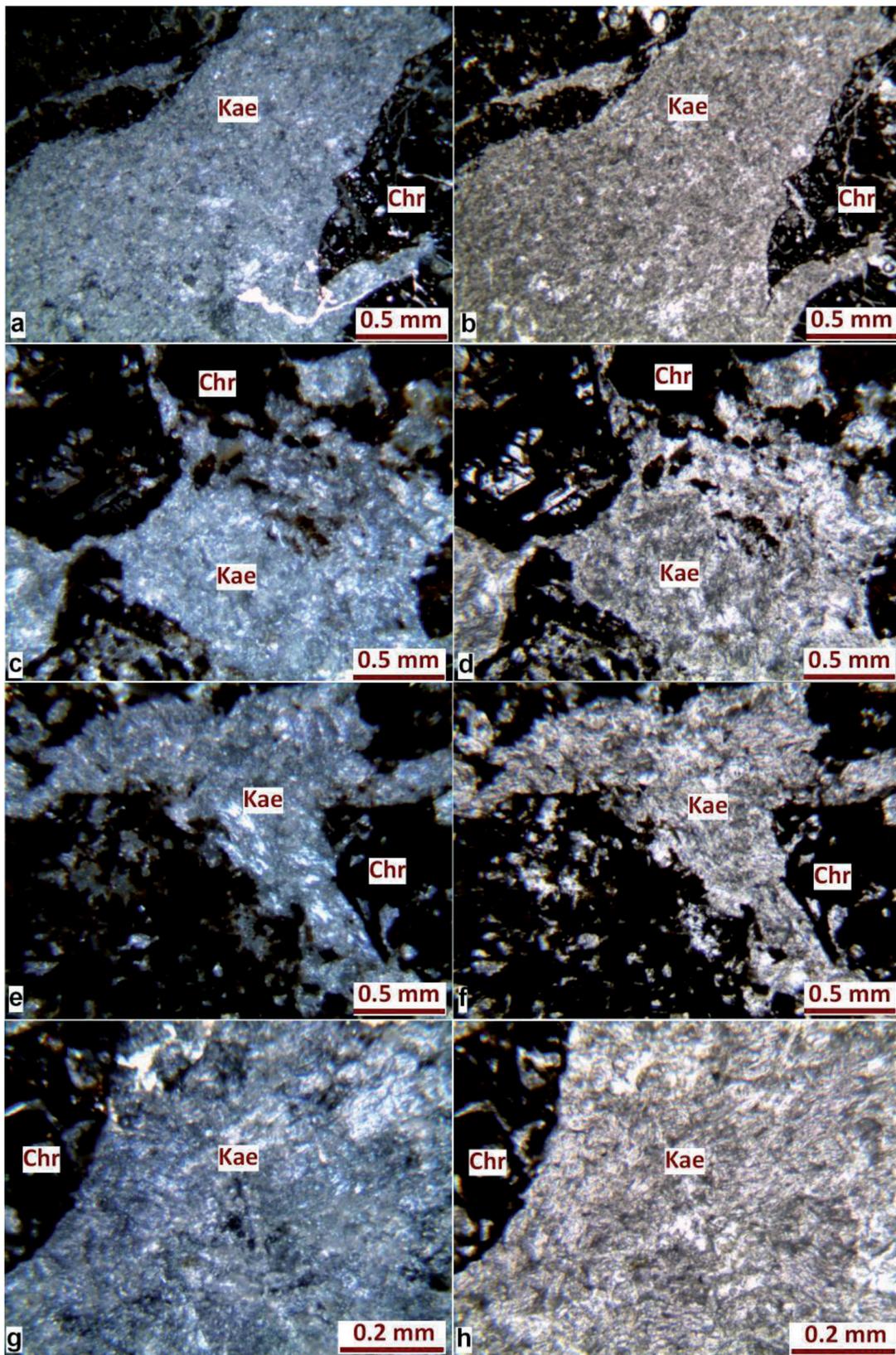


Figure 4. Combination of chromium (Chr) and kammererite (Kae) minerals (a, c, e, g—crossed polars; b, d, f, h—plane-polarized light).

the surface study carried out in the study area, it is observed that the kammererites formation does not show much spread. They are found in different shades of pink in the field with abundant cracked cracks. Thin sections made from kammererite samples taken from the field are colorless, grayish brownish, and pinkish pleochroism in plane-polarized light. In crossed polars, interference colors are observed in



Figure 5. Gemstones made from kammererite samples taken from the study area (a—processed samples without treatment; b—processed samples after treated with epoxy).

black and white gray tones. The opaque minerals that are impermeable to light are the chromium minerals.

Bir mineralin süstaşı olarak kullanılabilmesi için temel özelliklerden olan, nadir bulunma, dayanıklılık, güzellik (renk, saydamlık vb.), işlenebilirlik özelliklerini barındırması beklenmektedir. İnceleme alanındaki Kemereritler nadir bulunma, güzellik ve işlenebilirlik özelliklerine sahiptir. Düşük dayanıklılığı ise iyileştirme yöntemleri ile arttırılabilir. Rarity, durability, beauty (color, transparency, etc.), and processability which are the basic properties of gemstones are expected from a mineral for being used as gemstones. Kammererites in the study area have rarity, beauty, and processability properties. Its low durability can be increased by treatment methods.

As a result of the lapidary studies made from the samples taken from the study area, it was observed that kammererite minerals can be processed together with the side rock and used in jewelry and ornamental production. However, the low hardness of kammererites, while facilitating workability, adversely affects their durability. For this reason, after the treatment (with epoxidation method), both increased durability and visually appealed.

Considering the rarity of studies related to the rarity of kammererite in the world, this study is also important in terms of providing resources for those working and researching in this field.

Acknowledgements

This study was carried out within the scope of the project of MMF.A4.18.014 supported by Kırşehir Ahi Evran University Scientific Research Projects Coordination Unit. We would like to extend our thanks to the Kırşehir Ahi Evran University Scientific Research Projects Coordination Unit, which provided financial support to carry out this work.

Conflict of interest

The authors declare no conflict of interest.

IntechOpen

Author details

İlkay Kaydu Akbudak¹, Zeynel Başibüyük¹ and Gökhan Ekincioglu^{2*}

1 Faculty of Engineering and Architecture, Department of Geological Engineering, Kirşehir Ahi Evran University, Kirşehir, Turkey

2 Department of Mining and Mineral Extraction, Kaman Vocational School, Kirşehir Ahi Evran University, Kirşehir, Turkey

*Address all correspondence to: gokhanekincioglu@gmail.com

IntechOpen

© 2020 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Temur Y. Süs Taşları. SDUGEO e-dergi. 2011;1:9-21. ISSN: 1309-6656
- [2] Aydın ŞN, Bektur Z, ve Çelebioğlu FN. MTA Tabiat Tarihi Müzesinde Sergilenen Mineraller. Ankara: Yayınlarından/Maden tetkik ve arama enstitüsü; 1998. (in Turkish)
- [3] Şahin M, Koşun E, Ağrılı H, Mengi H. Mineraller. Ankara: Yayınlarından/Maden tetkik ve arama enstitüsü; 2000
- [4] Back ME, Mandarino JA, Fleischer M. Fleischer's Glossary of Mineral Species. 10th ed. Tucson: Mineralogical Record Inc.; 2008
- [5] Brown BE, Bailey SW. Chlorite polytypism: II. Crystal structure of a one-layer Cr-chlorite. *American Mineralogist*. 1963;48:42-45
- [6] Bailey SW. Chlorites: Structures and crystal chemistry. In: Bailey SW, editor. *Hydrous Phyllosilicates (Exclusive of Micas)*, Reviews in Mineralogy and Geochemistry. Vol. 19. Chantilly, Virginia: Mineralogical Society of America; 1988. p. 347-403
- [7] Grevel K, Fasshauer DW, Erzner S. New compressibility data for clinochlore, kyanite, Mg-chloritoid, and Mg-staurolite. *European Journal of Mineralogy*. 1997;1:138
- [8] Joswig W, Fuess H, Mason SA. Neutron diffraction study of a one-layer monoclinic chlorite. *Clays and Clay Minerals*. 1989;37(6):511-514
- [9] Zheng H, Bailey SW. Structures of intergrown triclinic and monoclinic IIB chlorites from Kenya. *Clays and Clay Minerals*. 1989;37(308):316
- [10] Theye T, Parra T, Lathe C. Room temperature compressibility of clinochlore and chamosite. *European Journal of Mineralogy*. 2003;15(3):465-468
- [11] Hatipoğlu M, Oğuzer MB, Buzlu HB. Gemmological and mineralogical investigations and genesis of the Kammererite from the Keşiş (Erzincan) and Kop (Erzurum) mountains. *Journal of African Earth Sciences*. 2013;84:20-35
- [12] Rule AC, Bailey SW. Refinement of the crystal structure of a monoclinic ferroan clinochlore. *Clays and Clay Minerals*. 1987;35:129-138
- [13] Hayes JB. Polytypism of chlorite in sedimentary rocks. *Clays and Clay Minerals*. 1970;19:285-306
- [14] Welch MD, Kleppe AK, Jephcoat AP. Novel high-pressure behavior in chlorite: A synchrotron XRD study of clinochlore to 27 GPa. *American Mineralogist*. 2004;89:1337-1340
- [15] Dietrich R, Medenbach O. Kämmererite from the Kop krom mine, Kop Dağları (Turkey). *The Mineralogical Record*. 1978;9:277-287
- [16] Chadwick KM. Chromium-rich clinochlore (Kammererite) from Turkey. *Gems & Gemology*. 2008;44:168-169
- [17] Farges F. Chromium speciation in oxide-type compounds: Application to minerals, gems, aqueous solutions and silicate glasses. *Physics and Chemistry of Minerals*. 2009;36:463-481
- [18] Schumann W. *Gemstones of the World*. Sterling Publishing Company Inc., Inc. 2009
- [19] Arem JE. *Color Encyclopedia of Gemstones*. Van Nostrand Reinhold Company; 1987

[20] Hatipođlu M. Photoluminescence response from the chromian clinocllore (Kammererite). Spectroscopy Letters. 2014;47(10):746-753

[21] Yolcubal HG, Akyazı M, Sezen TF, Toprak Ö, Yasin M, Canpolat FK, et al. Turhal-Pazar-Zile (Tokat) Yöresinin Üst Mesozoyik Stratigrafisi. Geological Bulletin of Turkey. 2014;57(1)

[22] Yılmaz A, And Yılmaz H. Geology and structural evolution of the Tokat Massif (Eastern Pontides, Turkey). Turkish Journal of Earth Sciences. 2004;13:231-246. Copyright ©TÜBİTAK

[23] MTA. 1/500.000 Türkiye Jeoloji Haritası. Ankara: Maden Tetkik ve Arama Genel Müdürlüğü; 2002