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Research Article

Investigation of Geological and Gemological Characteristics of Opal-Chalcedony Formations Observed in Listwaenite in the Hatip-Çayırbağı (Meram-Konya) Region

Eyyup Hikmet Kinaci[1*], Alican Ozturk[2], Bilgehan Yabgu Horasan[3]
[1]Batman University TBMYO, Department of Jewelry and Jewelry Design, Batman, Turkey *(ORCID Number:0000-0002-0267-7387)*
[2]Konya Technical University, Department of Geological Engineering, Konya, Turkey (*ORCID Number: 0000-0003-2748-6322)*
[3]Selcuk UniversitySarayonu Vocational School of Higher Education Department of Environmental Protection and Technologies (*ORCID Number: 0000-0003-1899-0041)*

Abstract

The geological and gemological features of the chalcedony formations in the Listwaenite found in the ophiolitic rocks in the Hatip-Çayırbağı (Meram-Konya) region are emphasized. The basis of the study area is the Late Triassic-Late Cretaceous Lorasdagı formation and the Late Cretaceous Midostepe formation. These units cover the Late Cretaceous Hatip ophiolite complex with a tectonic contact. All these units are overlain by the Late Cretaceous Çayırbağı Ophiolite with a tectonic contact. It is associated with the Çayırbağı ophiolite, which is unconformably overlain by the Upper Miocene-Lower Pliocene Ulumuhsine formation. It is thought that the chalcedony formations in the region are composed of siliceous solutions associated with Listwaenite and entering into fractures and cracks due to tectonism. As a result of the geological, gemological, Raman, and FTIR studies, it was determined that the formations in the listvenite were chalcedony. Chalcedony formations are generally found between 1-15 cm. Yellow, white and brown banded colorations were observed in the chalcedony formations formed in the spaces in the Listwaenite. The samples were processed as cabochons and facets in the gemstone processing laboratory. As a result of shaping, it was determined that the samples were of cuttable, workable, and polishable quality. In line with the data obtained, it was concluded that it would be appropriate to study other listvenite occurrences in the region and Turkey regarding gemstones.

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[1] Corresponding Author Email: eyyuphikmetkinaci@gmail.com

INTRODUCTION

From the past to the present, stones have been a part of daily life in every age Mankind lived. From the first people, stones have made essential contributions to the development, change, and transformation of human beings and societies, from unique stones to ordinary stones, they are used as weapons, symbols for beliefs, and bricks to build homes. Ornamental stones are seen as one of the most valuable objects in human history [1,2]. We see traces of these stones in all social communities around the world. Even in prehistoric times, ornamental stones were a sign of the beauty, power, and status of the person [3]. Ornamental stones are formed by elements such as oxygen, carbon, aluminum, silicon, calcium, and magnesium that are commonly found in nature [4].

The first description of listwaenite was made by [5] in a study conducted in the Ural region and it was defined as silica-carbonate enrichment of peridotites. In the following years, listwaenite were also defined as carbonitized and silicified serpentinites [6]. Listvenites are formed by medium-low temperature hydrothermal/metasomatic alteration of maficultramafic rocks and are often found in or near major faults and shear zones [7]. Listwaenites typically contain quartz, carbonate minerals (magnesite, ankerite and dolomite) and/or fuchsite, as well as sulfides and other hematite, magnetite, cobalt minerals and chromite inclusions. Except in some cases, they are formed by metasomatic/hydrothermal alteration of serpentinites [8, 9, 10 11].

This study aimed to determine the gemological properties of chalcedony developed in listvenite formations in the Konya region (Figure 1) and to investigate whether it is a potential gemstone source. It is difficult to make a precise definition because not all of the qualities/properties that a material must have in order to be defined as a gemstone are measurable/experienced. However, it is possible to call all of the stones, minerals, rocks, and fossils that are generally beautiful and relatively rare gemstones. Gemstones are divided into 2 categories; precious and semi-precious gemstones in terms of economic classification. The chalcedony formations in listvenite, which is the subject of this study, are in the semi-precious gemstone category.

MATERIAL AND METHOD

The chalcedony formed in the listvenite samples were sliced with a 60 cm sintered diamond cutter and made suitable for cabochon shaping. The sliced stones were marked so that the maximum size cabochon could be processed, and they were formed with a thin slicing machine with a 15 cm diamond sinter blade. The Cabochon shape was given on a manual cabochon machine with a 200 mesh diamond sintered disc. Afterward, it was polished by abrading with 220/400/600/800 mesh size SiC (silicon carbide) and using Al_2O_3 (Aluminium oxide) polish, respectively, in a vibro drum.

Gemological identification methods are identification and analysis methods that do not harm the already processed (cut) ornamental stones. For this purpose, scans were obtained with the FTIR (Fourier Transform Infrared Spectroscopy/Fourier transform infrared spectroscopy) instrument equipped with the MAGILABS GemmoFtir™ spectrometer low-noise DLATGS- detector at a resolution of 4 cm^{-1} for a measurement time of 20 seconds. With these methods, peaks were formed by detecting the characteristic fingerprint of each sample and these peaks overlapped with chalcedony peaks. Measurements were made with Renishaw inVia Reflex Raman, which is used for another non-destructive identification purpose. Specific gravity, color, refractive index, and FTIR analyses were performed in MTA Mineralogy-Petrography and Gemology Unit laboratories for gem identification purposes, and Raman Spectrometer analysis was performed in Necmettin Erbakan University BİTAM laboratories to verify FTIR analysis.

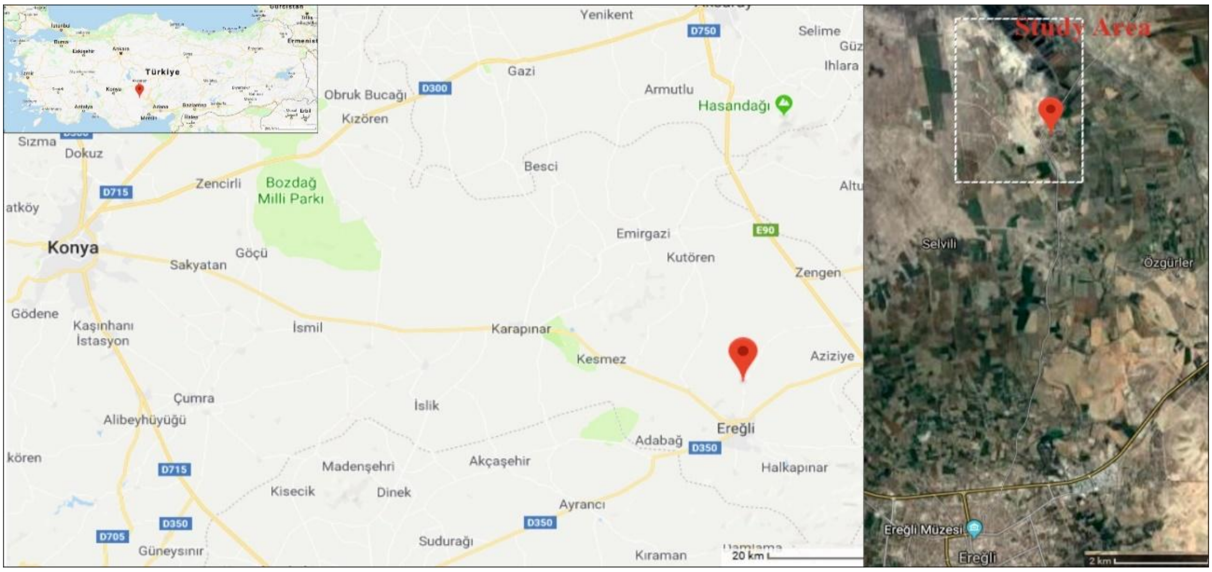

Figure 1. Location of the research area

CONCLUSION and DISCUSSIONS

Regional Geology

Ophiolites and ophiolite complexes belonging to the Alpine Orogenic Belt are spread almost all over the geography of Turkey and cover approximately 8% of it. Although ophiolitic rocks are mostly observed in discontinuous belts, it is possible to encounter ophiolitic units with massive character (it cannot be determined whether they belong to any ophiolitic belt). The Meram-Çayırbağı ophiolites, located just west of the Konya city center, are such an isolated complex. The settlements of ophiolites in Turkey are generally Upper Cretaceous. The age of formation probably goes back to the Lower Paleozoic period.

Hatip-Çayırbağı region is located on the southwest border of Konya city center (Figure 2). The tectonic and stratigraphic features of the region are very interesting from a geological point of view and it has been the subject of intense research because it has the largest magnesite deposits in Turkey [12 -33].

Discussions still continue about the existence of the Inner-Tauride Ocean, which is considered a branch of the Neotethys Ocean. Some researchers have stated that the ophiolitic rocks found in the form of tectonic slices on the carbonate rocks of the Taurus Platform were tectonically transported from the İzmir-Ankara-Erzincan Suture Zone [34]. Yılmaz and Yılmaz (2013) divided the North Anatolian Ophiolite Belt into two sub-belts and stated that the ophiolite slices observed along the belt extending from the south of the Menderes and Kırşehir massifs to Erzurum-Kars can be included in the Inner-Tauride ophiolite belt [35]. According to some authors, all of the ophiolites in the Taurus belt were formed in the oceanic basin, which is located to the north of the Taurus carbonate platform and defined as the Inner Taurus ocean, during the Late Cretaceous and gained their present positions due to the later nappe movements [36-46]. The ophiolitic rocks in the Çayırbağı-Hatip (Konya) region are located on the Taurus mountain belt (Middle Taurus).

The Late Triassic – Late Cretaceous Lorasdagı formation, which forms the basis of the study area, consists of multi-cracked crystallized limestones, while the Late Cretaceous Midostepe formation consists of radiolarite and pelagic limestones with red-pink colored chert interlayers. The Hatip ophiolite complex, which is composed of Late Cretaceous mudstone, sandstone, and serpentinized units, and the two gray-colored, heavily cracked, locally chert alternating, and locally varying sizes of İkivritepe olistoliths examined at the member level, was emplaced by tectonic contact on other units in the Hatip ophiolite complex. Çayırbağı ophiolites are located on this unit, again emplaced with a tectonic contact and composed of dark, bright green, serpentinized peridotite and pyroxenites.

In the Çayırbağı ophiolite, localized listvenite occurrences were observed. The late Miocene-early Pliocene Sille formation is overlying the Çayırbağı ophiolite with an angular unconformity. The late Miocene-Early Pliocene Ulumuhsine formation is located on top of the Sille formation with a lateral vertical transition. Again, during this time period, the interacting volcanism in the region also developed due to the fractures developed as a result of block faulting and there are Erenlerdagi volcanics consisting of volcanic breccia, tuff, tuffite and agglomerate. Quaternary-aged Alluvium overlies this unit with an angular unconformity (Figure 2).

Reddish, brown, and yellowish Listwaenite have been observed in the region, especially due to the Çayırbağı ophiolite. In relation to these formations, silica-containing (opal-chalcedony) levels, which are formed by silica-rich low-temperature solutions entering the fractures and cracks due to tectonism in the region, were determined.

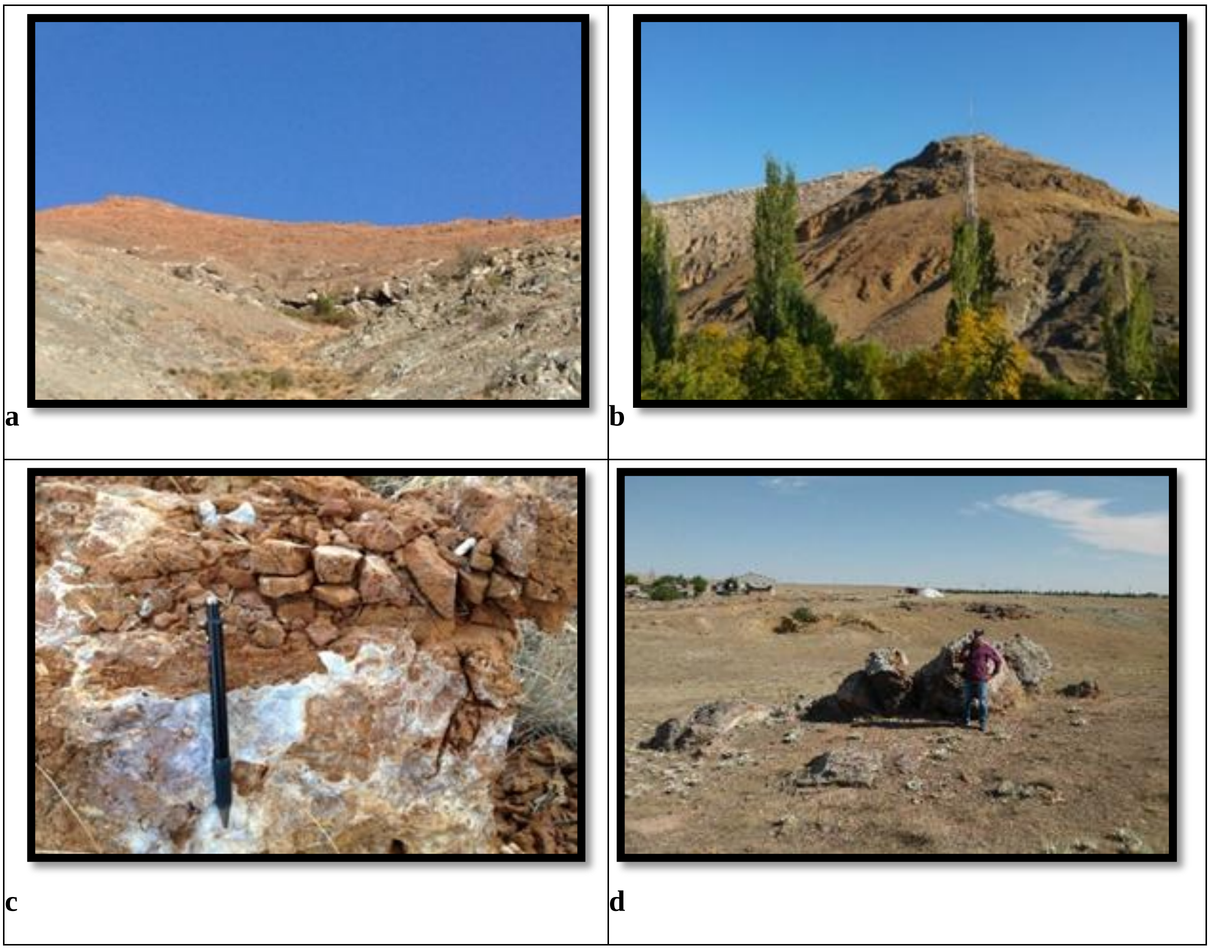

Figure 1 a and b View of the study area c and d View from Listwaenite

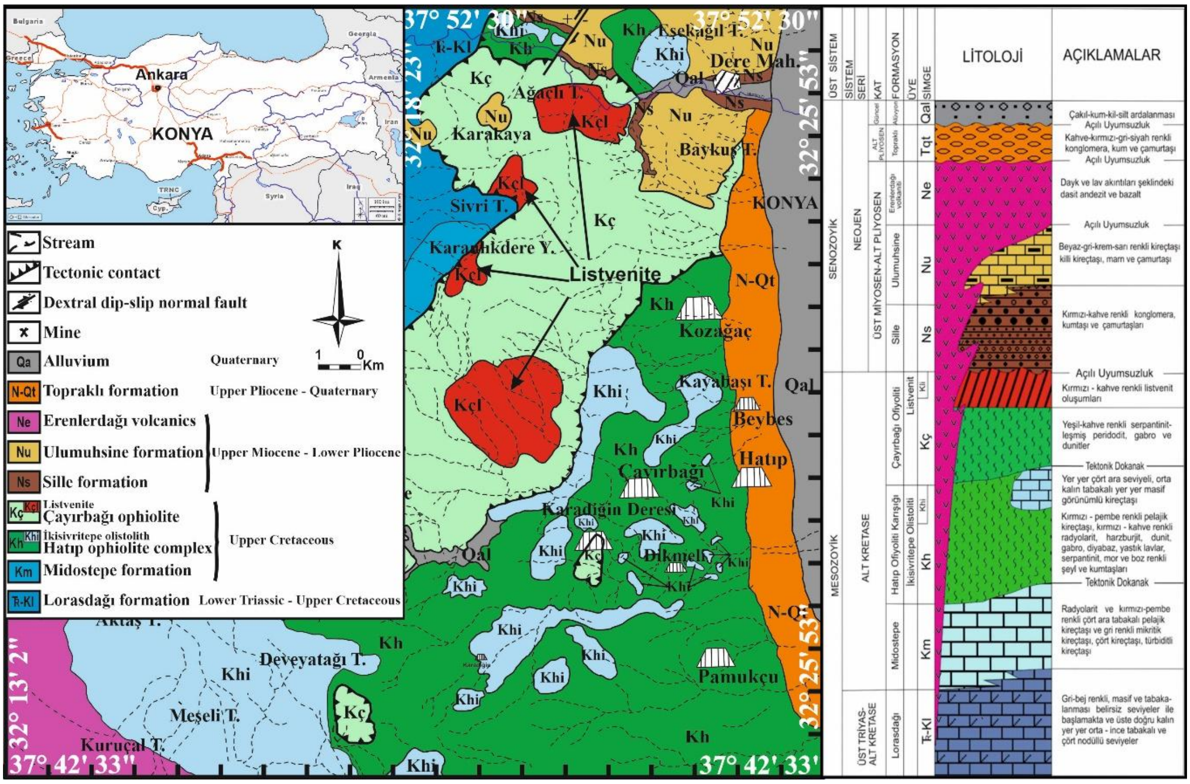

Figure 2 General geological map of the region [47].

Listwaenite

Listwaenite are rare rocks with very complex formations and have been described by many authors [48-53]. In general, they can be defined as hydrothermal and metasomatic rocks originating from ultramafic and mafic protoliths (called "true listvenite" - [50]) or silicic igneous and sedimentary protoliths [53]. They consist of heterogeneous mineral associations; quartz, Cr-muscovite (fuchsite), Fe-Mg-rich carbonates, followed by pyrite, spinel, serpentine, talc, Cr-rich chlorite, actinolite, and many other minerals [54]. Listwaenite are generally the name given to silicified, carbonated ultramafic rocks [55]. (Figure 3) (primary, secondary)

Figure 3 Chalcedony formations in listvenite

Although there are some uncertainties regarding the terminology of listvenitic rocks, the close association of listvenitic with ultramafic rocks (especially serpentinites) and mafic rocks is universally observed [50]. Although the rocks from which listvenite originated were not discussed in detail by [5], the geological conditions recorded by her and later mapped by Murchison (1845) stated that the 'listvenite' type came from ultramafic rocks and was spatially related to serpentinites [50]. The most important element that serves to define these rocks is the traces of residual (relict) ultramafic rocks (serpentinite) observed in them [55]. The ultrabasic rocks, which are the components of the oceanic crust that make up the Listwaenite, have undergone various alterations, but the three most important of them are; serpentinization, lateralization, and listvenitization [56]. The simplest definition of serpentinization can be made as the conversion of Mg-rich silicate minerals (olivine, pyroxene) in the composition of ultrabasic rocks into serpentine group minerals by the hydrothermal alteration process. This process can develop in different ways, either directly by sea water in the ocean floor rocks that are not yet above water, or by the effects of meteoric water in ophiolite bodies located on the continental crust [56]. During the decomposition of ultrabasic rocks under surface conditions, lateralization is the name given to the process of the elements in the composition of the minerals they contain, which have high mobility in the active conditions, leaving the environment as dissolved in water, while the ones with low mobility are enriched by precipitation in the form of covers on the main mass [56]. Listvenitization is the name given to the process of subsequent carbonation and/or silicification of serpentinized ultramafic rocks. According to Buisson and Leblanc (1985), the name listvenite was first used by Soviet writers for various carbonate rocks that were supposed to have formed as a result of the carbonatization of the confined ultramafic rocks formed along the boundaries of the Alpine-type ultramafic massifs.

According to the authors, the majority of these green-gray carbonate rocks are composed of Mg-Fe-Ca carbonate and quartz. They contain serpentine, talc, Mg-chlorite, fuchsite (Cr - Muscovite) as accessories and hematite, magnetite, Co - minerals, chromite residues, Au minerals, and Fe-Ni or Fe-u sulphides as ore minerals [56].

Mineral carbonization can be defined as Mg-rich rocks gaining CO_2 into their bodies through alteration. For example, when serpentinites take CO_2 into their bodies, it turns into carbonate form, and CO_2 binds to stable carbonate minerals in the process. The silica carbonate alteration of these serpentines is expressed as a mineral carbonization reaction with the following formula:

$Mg_3Si_2O_5(OH)_4 + 3CO_2 = 3MgCO_3 + 2SiO_2 + 2H_2O$

Serpentine (Chrysotile) + Carbon Dioxide = Magnesium Carbonate (Magnesite) + Silicon Dioxide (Chalcedony-Opal-Cristobalite + Water

As seen in this formula, the serpentine group minerals transform into magnesite and quartz. Listvenitizations were also formed by this mechanism [57].

According to Ploshko (1963), Listwaenite are divided into two main types:

1st Type Listwaenite: Those formed by hydrothermal alteration of serpentinites by seawater

Type 2 Listwaenite: These are divided into two subspecies;

2. a) Those associated with granite intrusions.

2. b) Quartz - those associated with porphyries.

The 1st type Listwaenite, which are observed as interconnected or disconnected lens-shaped masses, are generally expressed as follows;

It is stated by all researchers that they are related to tectonic structures. Accordingly, listvenite lenses were formed either along thrust boundaries or along vertically positioned suture zones in the last stages of serpentinization and tectonic emplacement. According to Buisson and Leblanc (1985), type 1 listvenite lenses show a gradual transition to the serpentinite host rock with a talc-carbonate zone or a black serpentinite zone containing disseminated magnesite. This transitional contact and the residual chromite and serpentine mineral contents of the Listwaenite are accepted as an indication that they are derived from serpentinized ultramafic rocks. Listwaenite were historically often used as decorative stones in the former USSR [58].

Chalcedony

The chalcedony mineral is one of the cryptocrystalline varieties of the quartz mineral [59,60] Chalcedony, which is defined as a microcrystalline quartz type, can have a wide variety of colors thanks to trace elements such as iron (Fe), chromium (Cr), manganese (Mn), nickel (Ni) included in its body [61]. The color of chalcedony is translucent gray or white. There are also grayish blue or brown shaded or even blackish ones [62]. (Figure 4)

Figure 4. Cabochon processed chalcedony in various forms taken from Listwaenite.

Chalcedony, which has an oily sheen, consists of very thin quartz fibers arranged in very thin layers [63-66].

Figure 5 Raw and truncated listvenite occurrences

Chalcedony is considered a secondary, metastable, transitional stage. The distinctive features that distinguish chalcedony from ordinary quartz may be a result of nucleation and growth in solid material (silica glass, opal, silica gel, or cristobalite) [67]. For example, the refractive indices of chalcedony are measurably lower than those of quartz, and chalcedony is biaxial [69,70]. Chalcedony is more soluble in water than quartz [70, 71] and is more reactive in the presence of alkaline liquids [72,73]. It shows that chalcedony consists of inviscous liquids at relatively low temperatures [74]. (Fig. 5).

Raman Spectroscopy Studies

As a result of the Raman shots made on the samples, it was determined that the peaks of the samples were compatible with the peaks of chalcedony in the light of the match values obtained from the microscope's own database (Figure 6).

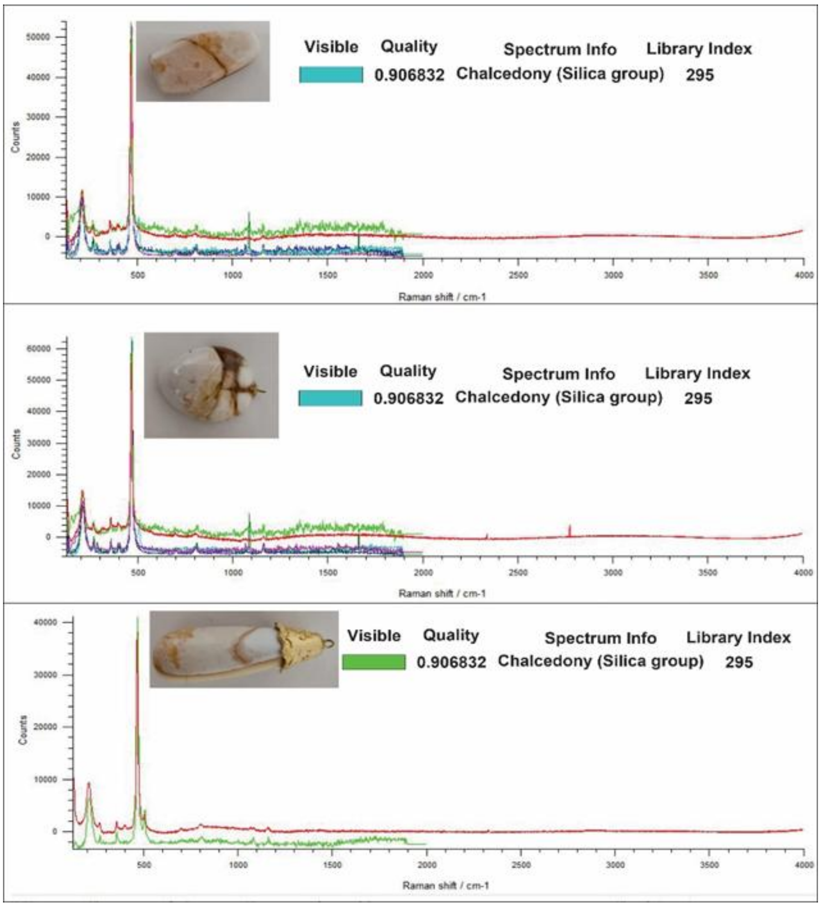

Figure 6. Raman graphs of samples taken from the region.

Studies for the Determination of Gemological Characteristics

According to the results of the FTIR analysis, it was seen that the samples (green line) were compatible with reference to the standard wavelength (white-colored line) (Figure 7). Gemological identification was made on one of the specimens in the MTA gemology laboratory and a certified certificate of the specimen was issued accordingly (Figure 8).

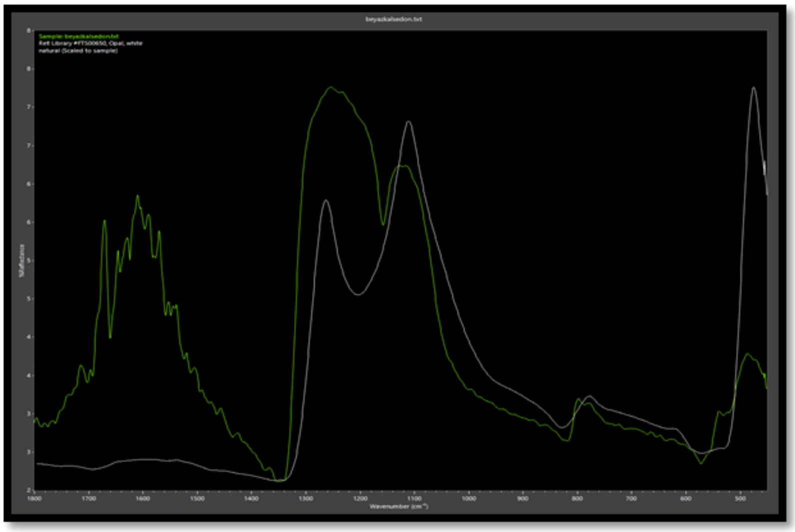

Figure 7. FTIR plots of samples taken from the region (white lines FTIR standards, blue lines chalcedony sample).

	
Weight	~16.38 g
Cutting shape	Cabochon
Color	White-Yellow
Transparency	Semi-transparent
Definition	Chalcedony
Descriptions	Chalcedony is a cryptocrystalline type of quartz (silicon dioxide-SiO2) that is widely found on Earth. It is used in making ornaments such as rings, earrings, necklaces, and rosaries.
Specific weight	1.952

Figure 8. Gemological Definitions

Forming

The samples were shaped like cabochons in the gemstone processing laboratory. If the gemstone shaping processes are to be used in the field of jewelry, they are processed as a cabochon and facet shaping. However, in gemology, facet shaping is preferred for precious/transparent gemstones, and cabochon shaping is preferred for semi-precious/opaque gemstones. The main goal here is to achieve maximum glare/reflection. Since transparent ornamental stones transmit light, facet (angled) cutting is appropriate, while opaque stones do not have light transmittance, so the surface reflection should be at maximum, so cabochon cutting is a more suitable processing standard (Figure 9).

Figure 9. Cabochon forming stages of chalcedony formations in Listvenite.

RESULTS

Listvenite occurrences in the study area are observed in the ophiolitic rocks in the Hatip-Çayırbağı (Meram-Konya) region. It is thought that low-temperature solutions rich in silica form chalcedony formations in fractures and cracks developed due to tectonism in the region. Chalcedony formations are in the form of fillings between 1 and 15 cm. These formations show coloration in white, yellow, brown, and tones. As a result of gemological, Raman, and FTIR studies, it has been determined that the formations in listvenite are cryptocrystalline or amorphous silica, quartz, and chalcedony. It is very difficult to make a precise definition because not all of the properties that a material must have in order to be defined as a gemstone are measurable. However, it is possible to call all stones, minerals, rocks, and fossils that are generally accepted, beautiful and relatively rare gemstones. It was determined that the samples were of cuttable, machinable, and polishable quality. It would be appropriate to study in more detail to evaluate other listvenite occurrences in the region and in Turkey in terms of gemstones.

It has been determined that the listvenite samples collected from the study area are gemstones in terms of physical and chemical properties and that these samples can be included in the semi-precious stones group in the economic classification as a result of the cabochon process.

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