

PRECIOUS AND SEMI-PRECIOUS STONES IN THE MINERALOGICAL COLLECTION OF THE NATIONAL MUSEUM OF BOSNIA AND HERZEGOVINA

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Abstract: The National Museum of Bosnia and Herzegovina was founded in 1888 and consists of the Department of Natural History, the Department of Ethnology and the Department of Archaeology. As part of the Department of Natural Sciences, the National Museum of Bosnia and Herzegovina houses a rich collection of the Geological Department with numerous and diverse minerals, rocks and fossils from Bosnia and Herzegovina and neighboring countries, as well as from the most distant parts of the world. The rich mineralogical collection is important as a tourist offer because it contains samples of minerals from Bosnia and Herzegovina and from many parts of the world, and some of them come from mines that are no longer in use. Minerals belonging to precious and semi-precious stones in the exhibition mineralogical collection of the Department of Natural Sciences have been revised. The samples have been analyzed in detail, the weights and sizes of the samples have been measured, the inventory numbers on the samples and inventory books have been checked, after which they have been photographed and entered into a scientific database. The work analyzes the most significant and best-known specimens of precious and semi-precious stones found in the mineralogical collection of the National Museum of Bosnia and Herzegovina. The role of the National Museum in the promotion of tourism is significant because the mineralogical collection of the Department of Natural Sciences contains precious and semi-precious stones from world-famous sites, such as a diamond from the Kimberley region in South Africa, ruby and sapphire crystals from the a world-famous site in Sri Lanka, an emerald from Russia, where the largest known emerald crystal was found. The collection exhibits garnet crystals from the largest European deposits (in the Czech Republic and the European Alps) as well as crystals from the richest deposits in the world, such as topaz crystals from Brazil, beautiful and large rubellite crystals from California (USA) and tourmaline crystals found on the island of Elba (Italy). The setting features prized and beloved amethysts in the form of beautiful geodes from the Czech Republic and agates from the world's richest agate deposits in Brazil.

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Keywords: National Museum, mineralogical collection, precious stones, semi-precious stones, diamond, rubies, sapphires, emeralds, deposits

INTRODUCTION

The National Museum of Bosnia and Herzegovina was founded back in 1888 and consists of the Department of Natural History, the Department of Ethnology and the Department of Archaeology. During the establishment of the Department of Natural Sciences, several experts dealt with geological issues. In their works, they deal with serpentine, stiva, petrographic composition of Bogomil stećak (Radimski, 1889), asbestos deposits, cave bear, moose, deer and wild beef (Grimer, 1987, 1898, 1899). After the foundation of the museum, the mineralogical and geological collection contained a total of 458 specimens, and in the next 5 years, thanks to the efforts of Radimski and Grimer, the number of specimens increased to 4,011.

The arrival of Fridrich Katzer, a well-known European expert, was decisive for the development of the geology of Bosnia and Herzegovina. This versatile researcher works on many problems such as geological mapping, stratigraphy and palaeontology, mineralogy and petrography, exploration of ore deposits of various mineral raw materials and studies tectonics, hydrogeology and mineral waters. He published most of his studies (about 100) in European journals, and relatively few (about 25) in the Glasnik Zemaljsko muzeja (Katzer, 1903, 1904, 1906, 1915).

Within the Department of Natural Sciences in the National Museum of Bosnia and Herzegovina are the collections of the Department of Geology with numerous and diverse minerals, rocks and fossils from Bosnia and Herzegovina and neighboring countries as well as from the most distant parts of the world.

The mineralogical collection contains 4,766 samples, and the petrographic collection contains 1,300 samples. Even more numerous than these two collections is the paleontological collection with about 9,900 fossils. The rich mineralogical collection contains samples of minerals from Bosnia and Herzegovina and from numerous parts of the world, and some of them come from mines that are no longer in exploitation. In the mineralogical collection, the samples are stored in the exhibition display and the scientific collection. The exhibition display consists of minerals from Bosnia and Herzegovina and the General Collection, which contains minerals from other parts of the world, as well as thematic exhibition displays: a showcase of minerals and ores of Srebrenica, minerals of Vareš, minerals of Trepča and others. Precious and semi-precious stones are also found within the General Collection and the collection "Minerals of Bosnia and Herzegovina", where minerals are classified according to crystallochemical classification into non-silicates (elements, sulfides and sulfosalts, oxides and hydroxides, and carbonates, sulfates, etc.) and silicates. In addition to natural precious and semi-precious stones, specimens of artificial (synthetic) stones are also exhibited.

A review of precious and semi-precious stones in the exhibition mineralogical collection of the Department of Natural Sciences in the National Museum of Bosnia and Herzegovina was carried out. The paper analyzes the most significant and best-known specimens of precious and semi-precious stones in the mineralogical collection of the Department of Natural Sciences in the National Museum of Bosnia and Herzegovina. The samples were analyzed in detail, the weights and sizes of the samples were measured, the inventory numbers on the samples and inventory books were checked, then they were photographed and entered into the database.

The mineralogical collection of the Department of Natural Sciences is also significant in that it contains precious and semi-precious stones from world-famous sites, such as a diamond from the Kimberley region in South Africa, ruby and sapphire crystals from a world-famous site in Sri Lanka, an emerald from Russia, where the largest known emerald crystal was found.

The collection exhibits garnet crystals from the largest European deposits (in the Czech Republic and the European Alps) as well as crystals from the richest deposits in the world, such as topaz crystals from Brazil, beautiful and large rubellite crystals from California (USA) and tourmaline crystals found on the island of Elba (Italy). The setting features prized and beloved amethysts in the form of beautiful geodes from the Czech Republic and agates from the world's richest agate deposits in Brazil. All the mentioned minerals are analyzed in detail and presented in the paper.

MATERIALS AND METHODS

In mineralogy, minerals are classified based on their crystallochemical properties, i.e. chemical composition and crystal symmetry. Color is one of the physical properties of minerals and is one of the most important properties of a gemstone and often the most important factor in how a mineral will be used in jewelry. The other two important properties for classifying gems are rarity and price. That is why the first place in gemology is taken by diamonds, rubies, sapphires and emeralds, while less precious minerals such as quartz and agate take the last places. Pearls, corals, amber and synthetic stones are classified in a separate system.

Gemologists mainly use the internationally accepted classification of gemstones according to the RAL 560 A5 guideline of the German Gemmological Society. This classification (J.Bauer, V. Bouska, 1989, p.78) is used in this work.

Specimens of precious and semi-precious stones stored in the exhibition mineralogical collection of the Department of Natural Sciences were reviewed and each mineral was analyzed in detail.

The inventory numbers on the samples and inventory books were checked, the weights and sizes of the samples were measured, after which they were photographed and entered into a scientific database with data on their chemical composition, physical properties, deposits and other significant data. The most significant and well-known specimens of precious and semi-precious stones from the largest European and world-famous deposits were analyzed in detail.

A total of 255 samples of precious and semi-precious stones from the exhibition mineralogical collection were reviewed. In this paper, only some specimens of precious and semi-precious stones that are more significant are discussed in detail. When determining precious and semi-precious stones, methods must be used that will not damage the stone, especially if it is polished. Therefore, an instrument that enables quick determination without damaging the stone, such as a binocular microscope, was used. Numerous methods were used, such as the observation method, the description method, the analysis and synthesis method, the statistical method, the classification method, the comparative method, the genetic method, the historical method, etc.

RESULTS AND DISCUSSION

During the processing process, a precious stone loses up to half of its original mass, but its value increases by several times. The quality and price of a precious stone is determined after its processing. The weight of precious and semi-precious stones is measured in carats. A metric carat defines a precise weight of 0.2 g, while for precious metals, a carat is a measure of purity.

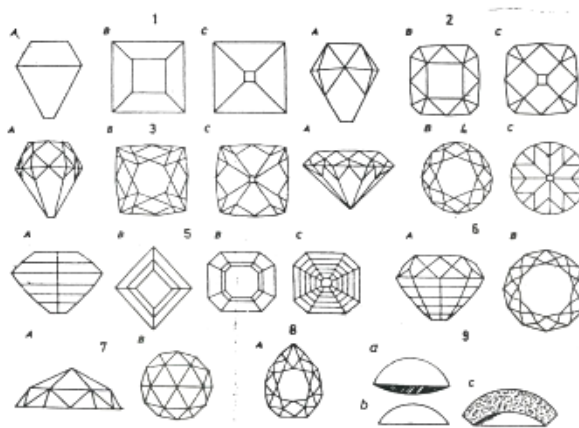


Fig. 1. The main types of gemstone cutting: A - side view, B - top view, C - bottom view; 1 and 2 - simple for small stones; 3 - old brilliant; 4 - modern brilliant; 5 - stepped; 6 - combined, 7 - rosette; 8 - teardrop; 9 - cabochon: a - double, b - simple, c - hollowed

The rich mineralogical collection is important as a tourist offer because it contains samples of minerals from Bosnia and Herzegovina and from many parts of the world, and some of them come from mines that are no longer in use. The fact that the collection is significant as a tourist offer of the Museum is also evidenced by the fact that it contains over 60 specimens of meteorites, among which are world-famous meteorites such as the famous iron meteorites Canon Diablo and Sikhote Alin and the stone meteorites L'Aigle and Stonarov. The collection also includes the stone meteorite Zavid (fallen near Zvornik), which stands out for its weight (over 60 kg) and the iron meteorite Ozren (found on Mount Ozren). Both of these meteorites are included in the world catalog of meteorites that fell or were found on the territory of Bosnia and Herzegovina.

The role of the National Museum in the promotion of tourism is significant because the mineralogical collection of the Department of Natural Sciences contains precious and semi-precious stones from world-famous sites, such as a diamond from the Kimberley region in South Africa, ruby and sapphire crystals from the a world-famous site in Sri Lanka, an emerald from Russia, where the largest known emerald crystal was found. The collection exhibits garnet crystals from the largest European deposits (in the Czech Republic and the European Alps) as well as crystals from the richest deposits in the world, such as topaz crystals from Brazil, beautiful and large rubellite crystals from California (USA) and tourmaline crystals found on the island of Elba (Italy). The setting features prized and beloved amethysts in the form of beautiful geodes from the Czech Republic and agates from the world's richest agate deposits in Brazil.

In total, more than 255 samples of precious and semi-precious stones from the mineralogical collection of the Department of Natural Sciences were reviewed. For all audited samples, the inventory numbers on the samples, as well as in the inventory books, were checked, and the weights and sizes of the samples were measured. Table 1 lists the number of more significant gems and semi-precious gems from the exhibition mineralogical collection that have been revised. Diamond, corundum (ruby and sapphire), beryl with varieties, topaz, garnet, zircon, tourmaline with varieties, quartz with varieties and opal are treated in detail in this paper. The most important data for chrysoberyl, andalusite, kyanite, vesuvianite, lazurite and malachite are also given.

The paper also includes photographs of some of the revised samples of precious and semi-precious stones. All revised samples are entered in the scientific database with more detailed information.

Revised samples from the exhibition and scientific collection of the National Museum will be presented in the exhibition under the title "Precious and semi-precious stones in the mineralogical collection of the National Museum of Bosnia and Herzegovina". The catalog is currently being prepared, along with a planned temporary exhibition. Photos of most of the samples will be shown in the catalog, with detailed information about the presented precious and semi-precious stones with the aim of enriching the tourist offer of this institution and increasing the interest of both foreign and domestic tourists.

Tab. 1. Overview of the most important gems and semi-precious stones in the exhibition mineralogical collection of the Department of Natural Sciences.

No	The name of the mineral	Number of samples	No	The name of the mineral	Number of samples
1	Diamond	1	25	Morion	3
2	Corundum	4	26	Morion and adular	1
3	Ruby	1	27	Sooty quartz	11
4	Sapphire	1	28	Rose Quartz	2
5	Spinel	1	29	Hawk's eye	2
6	Topaz	4	30	Calcedony	15
7	Beryl	6	31	Agate	21
8	Emerald	2	32	Agate and sooty	1
9	Aquamarine	2	33	Banded agate	2
10	Zircon	2	34	Mossy agate	2
11	Hyacinth	3	35	Carnelian-onyx	3
12	Tourmaline	9	36	Plasma	1
13	Rubelite	2	37	Chrysoprase	1
14	Garnet	11	38	Opal	5
15	Chrysoberyl	1	39	Precious opal	6
16	Andalusite	2	40	Resin opal	1
17	Disten - Cyanite	6	41	Hyalite	3
18	Cordierite	1	42	Menilite	1
19	Chrysolite	1	43	Vesuvian	4
20	Quartz	43	44	Aventurine	1
21	Quartz transparent	10	45	Lazurite	2
22	Amethyst	10	46	Diopside	2
23	Amethyst - agate	1	47	Hematite	1
24	Citrine	3	48	Malachite	1

The database for precious and semi-precious stones from the exhibition mineralogical collection of the Department of Natural Sciences includes precious and semi-precious stones that are in the exhibition collection of the Department of Natural Sciences. The attachment provides a view of the database and shows the data contained in the database, such as inventory number, mineral name, physical properties of the mineral (color, scratch, luster, fracture, hardness, density, clay content), country, locality, coordinates (x and y) of the location from which the sample was taken, the date the sample was brought (delivered) to the museum, then who brought the sample, who determined the sample, who inventoried and revised the database, where the sample is located, whether in a depot or in the exhibition collection, in which inventory book the sample is entered, and whether it was photographed and whether a catalog was made for it (table 2).

Tab. 2. Database for precious and semi-precious stones

No	Inventory number	Name of the mineral	Number of samples	Chemical formula	Synonym	Variety	Group
1	1263	Agate	2	SiO ₂	Silicate	Chalcedony	Semiprecious stones
2	1168	Sapphire	1	Al ₂ O ₃	Oxide	Corundum	Precious stones

No	Colour	Streak colour	Luster	Hardness	Density
1	White, yellow, brown	White	Glassy to waxy	7	2,65
2	Blue	White	Vitreous	9	4,02

No	Tenacity	Fracture	Transparency	Country
1	No tenacity	Semi-shelled	Gem varieties are transparent	Brazil
2	No tenacity	Shell-like	Transparent	India

No	City	General locality	Specific locality	X coordinate	Y coordinate	Day	Month
1	Unknown	Unknown	Unknown	-7.971	-55.541	Unknown	Unknown
2	Ceylon	Unknown	Unknown	7.566	80.866	Unknown	Unknown

No	Year	Mineral collector	Determiner of the sample	Date of inventory	Display case	Drawer
1	Unknown	Unknown	Unknown	Unknown	16	Unknown
2	Unknown	Unknown	Unknown	Unknown	16	Unknown

No	Exhibition collection / storage	Who revised the sample	Date of revision	Inventory book number	Sample photograph	Catalog
1	Exhibition collection	Sumeja Mutap	24.12.2024.	II	Yes	No
2	Exhibition collection	Sumeja Mutap	24.12.2024.	II	Yes	No

The most prized gemstone is the diamond, C crystallizes cubically. Crystals are often octahedral, sometimes dodecahedral, rarely tetrahedral. It represents one of two allotriomorphic modifications of carbon, the other being graphite.

It got its name from the Greek. the word diamond which means invincible.

Usually colorless, but can also be of different colors (black, blue, brown, green, orange, pink, red or yellow) depending on the content of impurities. The most valued diamonds are colorless. The value of diamonds increases proportionally to their purity and lack of impurities. Color, clarity, type, quality of cut and carat weight determine the value of a diamond

Hardness 10 on the Mohs hardness scale. Density 3.51.

Diamond is a pyrogenic mineral, which is formed at high temperature and pressure. It is most often associated with ultrabasic igneous rocks. The host rock for most diamonds is kimberlite, named after the Kimberley region of South Africa.

Diamonds were first discovered in Golconda, India, and the most famous examples come from that country. Among these gems is the Hope Blue Diamond (45.52 carats), which is in the Smithsonian Museum in Washington. More than 100 million carats (20 tons) of diamonds are mined each year, mainly in Russia, Australia, South Africa, Botswana, and the Democratic Republic of the Congo. Diamond-rich deposits are found in Russia, Siberia, Venezuela, Angola, Ghana, Tanzania, etc. The largest diamonds found come from South Africa. The world-famous diamonds are the Cullinan (weighing 3,106.75 carats) found in a mine near Pretoria. The Koh-i Noor (weighing 108.83 carats) and the Orlov (weighing about 300 carats) found in central India. The Koh-i Noor diamond (108.83 carats) is part of the British Crown

Jewels. Among the most desirable diamonds in history are Tiffany (the largest yellow diamond), Hope (the famous blue diamond) and Regent.

The Regent (140.50 carats) and Sancy (55 carats) diamonds were the property of the French King Louis XIV and are now on display in the Louvre in Paris.

The value of diamonds increases proportionally to their purity and lack of impurities. Color, clarity, type, quality of cut and carat weight determine the value of a diamond. Hardness 10 on the Mohs hardness scale.

In the mineralogical exhibition collection of the Department of Natural Sciences, there is a diamond crystal from the world-famous deposit of the Kimberley region in South Africa (Fig. 2). The host rock for most diamonds is kimberlite, an ultrabasic igneous rock named after the area.



Fig. 2. Diamond in kimberlite, Kimberley (Africa)

Corundum, Al_2O_3 crystallizes hexagonally. The crystals are columnar or plate-like.

The name of this mineral comes from the Sanskrit word *kuruvinda*, or *kurundu* as it is called in Tamil. The name was introduced into mineralogy in 1798, when it was determined that ruby and sapphire belong to the same mineral species.

Corundum is a typical allochromatic mineral. It can be colorless (leucosapphire), blue (sapphire), yellow to golden yellow (oriental topaz), purple (oriental amethyst) and red to pink (ruby). The red color of the ruby comes from the admixture of chromium, and the blue color of the sapphire is given by the admixture of bivalent iron and traces of titanium. Rubies are often decorated with the so-called optical effect, asterism due to inclusions of needle crystals, most often rutile.

It is very hard, hardness 9 on the Mohs scale and only diamond is harder than it. Density about 4.

The main deposits of corundum are of magmatic origin, although corundum can also be formed by contact metamorphism. Corundum of hydrothermal origin is rare (Operta, 2009).

The largest rubies weighing up to 593.4 carats come from Burma, and the largest sapphire weighing 951 carats from India. Very beautiful examples of crystals can be found in alluvial deposits in Thailand, Burma and in many places in Sri Lanka. The most famous such areas are in the Himalayan region of Kashmir. The famous ruby weighing 167 carats from Myanmar (Burmese) is exhibited in the Natural History Museum in London. A beautiful example is the Rosser Reeves ruby exhibited in the Smithsonian Museum in Washington (USA). Famous blue sapphires include: the 405-carat St. Edward and Stuart sapphire set in the British Crown Jewels: King (392.75 carats); the Star of Asia (330 carats), a 478.68-carat sapphire (set in a Cartier brooch in 1910, sold at Christies auction in May 1991 for \$2.34 million, now owned by Sheikh Ahmed Hassan Fitaihi of Saudi Arabia (Redžepović, 2005).

Corundum is also found in large quantities in Australia. Corundum has been found in the Czech Republic, Greece, Italy, Macedonia, Turkey, Kazakhstan, and Canada. European scientists first encountered corundum in the late 18th century when crystals of the mineral were brought from China, where they were ground into powder and used as an abrasive. Smaller quantities of ruby have been found in Afghanistan, India, Pakistan, China, Montana (USA), and Norway. The palaces and temples of ancient Egypt, Greece, and Rome were a constant stage for rulers to display their power and wealth by wearing ruby or sapphire jewelry. The ancient Hindus considered ruby to be an unparalleled gem (Shoufek, 1991). It was believed that it would help the owner preserve his or her aristocratic heritage.

In Bosnia and Herzegovina, it is found as a rare and minor mineral in granites on the Motajica mountain and on the southern edge of the Krivaja-Konjuš massif in the area of the village of Vijaka near Vareš, where several localities of amphibolite rocks have been identified, some of which contain corundum varieties of amphibolite in which hornblende and plagioclase are essential components (Pamić, 1970, 1971, 1977). More detailed information on corundum in amphibolite rocks can be found in the works of Operta (2003, 2018). Sporadically or in insignificant quantities, corundum occurs as a component in the heavy fraction of sandstone in the series of red clastics of the Upper Permian in the Kulen-Vakuf area (Barić & Trubelja, 1984).

The mineralogical collection of the Department of Natural Sciences is also significant in that it contains ruby and sapphire crystals from a world-famous site in Sri Lanka (Fig. 3). The corundum crystal from Prilep in Macedonia is 45 mm long.

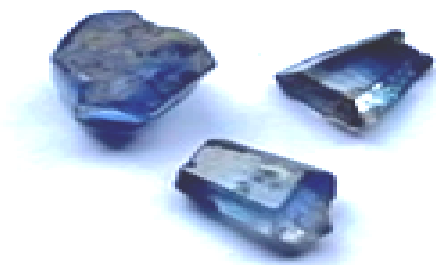


Fig. 3. Sapphire, Sri Lanka.

Beryl, $\text{Be}_3\text{Al}_2(\text{Si}_6\text{O}_{18})$ is a silicate of beryllium and aluminum. It crystallizes in a hexagonal system of symmetry and most often has the form of prismatic crystals with small pyramids at their ends. Specimens of beryl crystals up to 5 meters long have been found. It often creates rod-like and massive aggregates.

The origin of the name is Greek. *beryllos* (the meaning of the word is unknown, but it was used for any blue-green gem, lat. *beryllus*).

Beryl comes in blue, green blue, green, yellow, yellow green, pink and red. Emerald is green, morganite is cherry red or pinkish purple, aquamarine is greenish blue to light blue, and heliodor is golden yellow. A valuable gem, it is a variety of beryl and aquamarine is used as a gemstone. Emerald is the most valuable variety of beryl, which sometimes reaches a higher price than diamond.

A hard mineral with a value between 7.5 and 8 on the Mohs hardness scale. Density 2.63 to 2.9.

Beryl is a typical mineral of granite pegmatite rocks. Beryl of gem quality is formed in the hydrothermal phase by recrystallization of beryl from a high-temperature pegmatite phase. This is how the world-famous Colombian emeralds were created.

Heliodor is identical to beryl in almost all characteristics except for its color, which comes from the presence of small amounts of other elements, most likely uranium (which gives a golden yellow color) or iron (which gives a yellowish green color). The most common cut for heliodor is oval and less often round. The teardrop cut is suitable for earrings because it best emphasizes its golden shine.

A beryl crystal weighing as much as 200 tons was mined near Picua in Brazil. World deposits are in Norway, Switzerland, Italy, Madagascar, Brazil, Ceylon, India, Australia. The largest known piece of beryl was found in Madagascar, 18 meters long, 3.5 meters in diameter and weighing almost 400 tons.

In the Grand Seraglio Museum in Istanbul (Turkey) there is an emerald of 1,400 carats, which decorated the robes of the Great Sultan.

The oldest data on beryl in Bosnia and Herzegovina come from Koch (1899, 1902). More detailed data on optical tests of beryl from this locality can be found in the work of Barić (1960). Spectrochemical tests of beryl were carried out by Ristić and colleagues (Ristić et al., 1965). Motajic beryl occurs in the form of short columnar crystals and crystalline clusters. According to Katzer (1926), in addition to colorless crystals, there are honey-yellow and bluish ones. Beryl of prismatic habit has a maximum length of about 70 and a diameter of about 50 mm (Jelić, 1976). This mineral is also mentioned in their works by Varićak (1966) and Nikolić (1962, 1963).

The mineralogical collection displays an emerald crystal from Russia (Fig. 4), where the largest known emerald crystals were found. An emerald crystal in granite from a significant site in Norway is also on display.



Fig. 4. Emerald crystal, Ural, Russia



Fig. 5. Emerald in granite, Minnesund, Norway



Fig. 6. Beryl (aquamarine), Brazil



Fig. 7. Beryl crystal, Motajica
(Bosnia and Herzegovina)

The beryl specimens stored in the mineralogical collection are of various sizes, from beryl in a pegmatite vein (Arandelovac, Serbia) measuring 20 mm in length. Beryl with quartz and muscovite in a pegmatite vein from the Motajica mountain (Bosnia and Herzegovina) measuring 155 mm in length, and a beryl (aquamarine) crystal from Brazil measuring about 115 mm (Fig. 6 and Fig. 7).

Topaz, $\text{Al}_2\text{SiO}_4(\text{F},\text{OH})_2$ crystallizes rhombically. They are usually crystals of prismatic or prismatic bipyramidal habit. Sometimes it comes in ray, massive and granular aggregates.

According to one interpretation, the name is related to the Sanskrit word *tapas*, which means embers. The reason for this name is its high gloss and yellow color. It is known that the Greeks and Romans already called this mineral topaz and topazion. Greek the word topazion refers to gems from the island of Topazos.

The natural luster makes topaz one of the most attractive gems for jewelry making. The dominant color of topaz is yellow ranging from light yellow, golden yellow to brownish yellow. Pink, blue and honey-yellow topazes have the highest value. Colorless, clear and rounded fragments from Brazilian sites are known on the market as "pingos d agoa" which means "tears" in Portuguese. Citrine is similar in color to topaz and is sometimes used as an imitation.

Hardness 8, and density 3.53 to 3.57. It is the only natural gem with a density similar to diamond.

Topaz is a typical pneumatolithic mineral that originates from acidic magmas. That is why it is found mostly in the area of granite and similar acidic rocks. It is resistant, so it is easily concentrated in deposits. Important deposits are related to

secondary deposits formed by the decomposition of rocks containing this mineral. Such a large deposit is located in the Ouro Preto region of the Brazilian state of Minas Gerais. The Ural deposits are known for their beautifully developed large crystals. In the Schneckenstein area in Germany, 485 high-quality yellow specimens were excavated in the period from 1739 to 1741, and are stored in the British Royal Treasury.

Unique examples of topaz can be seen in many mineralogical collections around the world, including topaz in the American Museum of Natural History (New York) and a perfect blue crystal from Brazil. The Mineralogical Institute in Florence (Italy) also has a pink topaz crystal. One of the most famous is probably the topaz, called Braganca, weighing 1,680 carats, which is set in the Portuguese crown, found in Brazil in 1740, and for a long time considered a diamond (Redžepović, 2005).

Topaz is most often cut in a classic oval shape that reveals its colors and brilliance. Mixed cutting is also used, i.e. a combination of different cuts, most often rectangular and partially columnar surfaces.

The mineralogical collection is also significant in that it contains crystals originating from the richest deposits in the world, such as topaz crystals from Brazil (Fig. 8) size 12 mm. The collection contains topaz crystals 23 mm long found in Milovka schist (talc schist) from Mexico. Also topaz crystals with feldspar crystals and lithium mica in coarse-grained granite from Russia as well as crystals from deposits in Germany.



Fig. 8. Topaz, Vilaricca, Brazil

The chemical composition of garnet can be described by the general formula $A_3^{2+} B_2^{3+} [SiO_4]_3$ where position A is filled by divalent ions of magnesium, iron, manganese and calcium, and position B by trivalent ions of aluminum, iron and chromium.

They crystallize cubically. Crystals are usually of rhombic-dodecahedral and deltoid-icositetrahedral habit or a combination of these two forms.

The name comes from the Latin word *granum*-grain. There is an interpretation that the origin of the name is related to the fruit of the pomegranate plant, which in some countries is called garnet (lat. *Punica granatum* - pomegranate).

The color of garnets is different, depending on the chemical composition. So, for example, pyrope red, almandine brown-red, spessartine red-brown to yellow, grossular white to light green, uvarovite green and andradite light green to brown. Garnets occur in all colors of the spectrum, red like ruby, and green like emerald, but they never appear in blue.

The hardness is 6.5 to 7.5 (ugrandite 6.5 and pyralspite 7.5), and the density varies from 3.6 to 4.3, depending on the chemical composition.

Garnets are formed igneously and metamorphically. The most important deposits are those that appear in various metamorphic rocks (gneisses, amphibolites, etc.), and were formed by dynamothermal metamorphism in a very wide range of PT conditions.

Garnet deposits are in Belgium, Finland, France, Macedonia, Norway, Germany, Poland, Russia, Sweden, Turkey, and in Great Britain, the USA, Brazil and India. Pyrope has been used as a gemstone since ancient times. The largest European deposits of pyrope are in the Czech Republic. It is found in greater quantities in association with diamonds, in South Africa. Almandine is found in the European Alps. Specimens of gem value are found in Sri Lanka. Gem-quality spessartine specimens come from Upper Burma, Tanzania, Sri Lanka, and Madagascar. Emerald-green specimens of grossularite were found in Tanzania in 1968, and in Kenya in 1971. In 1868, during gold panning near Nizhny Taglisk in the Urals, emerald-green specimens of andradite were found. They were called demantoite. The first specimens of uvarovite were found near Syserts in the Urals, and then in South Africa, Turkey, and Finland.

In Bosnia and Herzegovina, they most often occur in metamorphic rocks of the Bosnian serpentine zone, where they have been most thoroughly investigated. Data on garnets in metamorphic rocks of the serpentine zone can be found in the monograph by Kišpatić (1897, 1900). More detailed data on garnets from amphibole rocks can be found in the works of Pamić (1969a, 1971. and 1972c), then Pamić, Ščavničar and Međimorac (1973), and in the works of Operta and her associates (Operta, et al., 2011, 2012) where it is stated that garnets from the area of the village of Vijaka near Vareš occur in the form of crystals and porphyroblasts of garnets (pyrope and almandine) in amphibolite rocks and prenitized plagioclases. Garnets are essential or minor components in the igneous and metamorphic rocks of the Motajica mountain and the Central Bosnian schist mountains. Garnets occur as

products of contact metamorphism south of Prozor and in the magnetite occurrence at Tovarnica near Jablanica (Nöth 1956; Cissarz 1956; Pamić 1960; Čelebić 1967).

The mineralogical display exhibits garnet crystals from the largest European deposits (from the Czech Republic and from the European Alps). A garnet crystal (rhombic dodecahedron) from Tyrol in Austria is 38 mm in diameter (Fig. 9). Garnet specimens from other world-famous and European sites are also exhibited.



Fig. 9. Granat crystal, Tyrol, Austria.

Important deposits of zircon, $\text{Zr}(\text{SiO}_4)$ are in Norway, Russia, Canada, Brazil, Madagascar and Sri Lanka. In Bosnia and Herzegovina, zircon is a component of igneous, sedimentary and metamorphic rocks, as a minor mineral component. Large zircon crystals are found in pegmatites of various compositions, such as the zircon deposited in the mineralogical collection. Zircon is found in a pegmatite vein, Ural, Russia (Fig. 10).



Fig. 10. Zircon in a pegmatite vein, Urals, Russia

Tourmaline $(\text{Na,Ca})(\text{Li, Mg,Al})_3(\text{Al,Fe,Mn})_6(\text{BO}_3)_3(\text{Si}_6\text{O}_{18})(\text{OH})_4$ is a complex borosilicate that crystallizes in a trigonal (hexagonal) system of symmetry. Its crystals are columnar, prismatic or needle-shaped.

Its color is white, red (rubellite), blue (indigolite), dark yellow (calcium tourmalines), colorless (ahroite), pink to red or green (elbait), dark green to black

schorl (scherl) and light brown (dravit). Dravite was named after the river Drava (in the area of Carinthia) where it was found. The beautiful blue color of indigolite is caused by the presence of iron and manganese. A red transparent tourmaline, rubellite is sold under the name Siberian ruby. Emerald-green colored species are called Brazilian emerald. Before, black sherl was also widely used in jewelry. During the Victorian era in Great Britain it was used as a mourning stone. The transition between colors can be gradual, but also sharp. For example, the end of one crystal can be green, yellow, colorless, while the other end of the crystal can be black. Such tourmalines are called moorheads, and crystals with red ends are known as turkheads. Because of its beauty and hardness, rubellite is sometimes used as a gemstone and for making ornaments. It has been known since Roman times, and in China it was valued and used to make buckles on Mandarin clothes. The redder the rubellite, the higher its value.

In addition to cabochons, the most common forms of grinding are pear and step grinding, which are most often used for most elongated crystals. The most popular way of cutting indigolite is in the form of rectangles, ovals and rounds, with the fact that a cabochon is always used if there is a possibility of emphasizing the effect of the cat's eye visible on some specimens. The most beautiful specimens were found in Brazil (Minais Gerais).

Hardness on the Mohs scale ranges from 7 to 7.5, and density is between 3.0 and 3.25. Due to its high hardness, it can only be scratched with topaz, corundum and diamond.

Tourmaline is a mineral of pneumatolitic origin. Beautifully developed crystals, transparent or of different colors, appear only in the last pegmatite phase together with quartz. It is associated with acidic igneous rocks, primarily pegmatites, granites and granitoids.

Most colorful tourmalines are found in Brazil. Other important deposits are in Slovenia, Germany, the USA, Canada, Australia, Russia (dravit), Sweden, Finland and Norway. Also important localities are in Namibia, Mozambique and Madagascar. Green specimens, similar in color to emeralds, have been found in Tanzania. In California (USA) there are beautiful and large rubellites. In the Urals there is tourmaline in numerous pegmatites, and on the island of Elba there are beautiful tourmalines near San Piero and Campoa.

Koch (1989, 1908) mentions tourmaline in the granite massif of Motajica. Koch's data is cited by Katzer (1924, 1926) and he especially points out that black tourmaline is often observed among secondary ingredients. Tourmaline was determined in sandstones from the Upper Permian red clastite series in the Kulen -

Vakuf area (Magdalenić & Šćavničar, 1973). Tourmaline is mentioned by Jurković (1954) in schists of the Central Bosnian schist mountains. Jurković (1961) determined tourmaline in the Hrmza realgar and pigment deposit near Kreševo. Marić (1927) mentions columnar crystals of tourmaline in the gabbro massif near Jablanica. Đorđević (1969) identified tourmaline-quartz rocks in the area of the Srebrenica mine.

The mineralogical display includes beautiful and large rubellite crystals about 80 mm long from significant localities such as a specimen from California (USA), and elbaite crystals from the island of Elba, Italy, which was named after the island where it was first found (Fig. 11). Among the gems on display are other varieties of tourmaline such as schorl from the Czech Republic, schorl in quartz, Seuffenberg, Austria, rubellite in lepidolite, San Diego (USA), as well as several specimens of tourmaline with muscovite and quartz in a pegmatite vein (Babuna, Macedonia).



Fig. 11. Tourmaline (elbaite), O. Elba, Italy

The display contains chrysoberyl, BeAl_2O_4 from the Czech Republic (Maršikov) valued as a gemstone, as well as spinel, MgAl_2O_4 in octahedral crystals from France. The collection also exhibits the most beautiful andalusite (chiastolite) crystals, $\text{Al}_2\text{O}[\text{SiO}_4]$ from Spain (Andalusia), where they were first found and named after the locality. The cross-sectional diameter of the andalusite (chiastolite) crystal is about 20 mm. The largest exposed cyanite crystals, $\text{Al}_2\text{O}[\text{SiO}_4]$ come from Switzerland, 85 mm long, and with prominent zoning of shades of blue, they are from the Czech Republic.

Quartz, SiO_2 , is the most abundant mineral in the Earth's crust and its share is as much as 12%. It is formed magmatic, sedimentary and metamorphic and in the weathering crust.

The largest and most beautiful crystals of different varieties were found in Brazil (Bahia, Minas Gerais and Rio Grande do Sul). There are large quartz crystals in Switzerland, Austria, Hungary, Russia, South Africa, Mexico, USA, Canada, Japan and Madagascar. The largest amethyst geode is in Serra de Mar, measuring 10 x 5 x 3 m, weighing 35 metric tons (Redžepović, 2005). The most beautiful specimens of citrine come from Brazil and the Urals, while sometimes they can be found in Madagascar, France, Spain and Scotland. The most famous sites of soot are in the Alps, especially near St. Gotthard. The crystal, known as Grandfather, from this locality had a length of 70 cm and a weight of 130 kg.

In Bosnia and Herzegovina, quartz is among the most widespread minerals. Conrad (1870) mentions numerous quartz veins on the Radovan mountain, in the central Bosnian schist mountains. Hauer (1879) mentions quartz crystals on dolomite in the vicinity of Žepča, and Koch (1899) describes quartz crystals occurring together with beryl in pegmatite veins on the Motajica mountain. According to Varičak (1971), the localities where quartz (rock crystal, soot, morion, amethyst and citrine) occurs are: Bunarički Potok, Brusnik, Rastova Kosa, Vlaknica and Visovi. In the area of the central Bosnian slate mountains, 165 occurrences of wire quartz of the highest degree of research have been registered so far (Živanović, 1976). Wire quartz occurs in the wider areas of Turbet, Vitez, Busovača, Kačun, Gromiljak, Fojnica, Kiseljak and Kreševo. Among the varieties of quartz there are: mountain crystal, sooty and milky quartz. Quartz strings also occur in the Radalj mountain, west of Travnik, near Donji Vakuf, Jezera (Jajca), Čemernica, Bugojno and Prozor - Rama. Quartz strings are found in phyllite schists and Paleozoic sandstones of Ljubija, Stari Majdan and Stratinska. At the localities of Adamuša and Nova Litica, Katzer (1924, 1925) mentions completely clear quartz crystals. Stringy and in places crystalline quartz also occurs in the Paleozoic of eastern and southeastern Bosnia. Ramović (1957, 1963) points out the presence of quartz in the ore parageneses of Srebrenica. Quartz occurs in beautiful crystals in the area of Pala, Prača, Trnovo, Goražde and Foča, and on the left side of Čehotina, southeast of Foča. Quartz veins also occur in the vicinity of Goražde (16 occurrences of stringy quartz), Čajnič, Ustiprača, Zabork, Marenčić and Đaković (Redžepović, 2005).

The mineralogical display of the Department of Natural Sciences contains the prized and beloved varieties of quartz SiO_2 , amethysts in the form of beautiful geodes from the Czech Republic (Fig. 12). as well as citrine and rose quartz crystals from the Czech Republic (Fig. 13). In the mineralogical collection, crystal druses of soot, crystals of soot and morion from the most famous site in Switzerland are exhibited in the crystal druses, individual crystals are about 60 mm in size (Fig. 14). Among these specimens are numerous samples of quartz and varieties of quartz from Bosnia and Herzegovina and an amethyst crystal about 45 mm long from Kiseljak (Bosnia and Herzegovina).



Fig. 12. Amethyst crystal geode, Nová Paka, Jičín (Czech Republic)



Fig. 13. Rose quartz, Pisek, Czech Republic



Fig. 14. Crystal druse of sooty quartz, Goschenen, Switzerland

The setting features prized and beloved agates from the world's richest agate deposits in Brazil (Fig.15). The best quality agates come from Brazil, especially from the state of Rio Grande do Sul; Uruguay, India, China, the Urals, Madagascar and the USA. Agates found in Siberia, Mongolia, Morocco and Iceland are of lower quality.

The samples are polished and on the polished sections the agate reveals its beauty, so you can see several different colors due to the content of impurities. Iron oxides and hydroxides can color agate yellow, brown and red or black (Fig.15), chromium gives a green color as well as copper which also gives a blue color, and manganese a pink color. Sometimes the color of agate is very intense and such specimens are the most valued among collectors. In Bosnia and Herzegovina, agate has so far been found in Zenica and Sarajevo (Bentbaša along the river Miljacka).



Fig. 15. Agate, Brazil

In the world, the most famous deposits of **opal**, $\text{SiO}_2 \times n\text{H}_2\text{O}$ are in Australia. It is found in Italy, Slovakia, Russia, Ukraine, Turkey, Mexico, Brazil, USA, Egypt, New Zealand, etc. At the beginning of the 20th century, Australia took the lead in the mining of precious opal, and today accounts for over 95% of the entire world production of this precious stone.

The mineral is poorly explored in Bosnia and Herzegovina. In northeastern Bosnia, near the town of Lopara, opal was found in red-brown to brown fragments up to 30 cm in color (Barić & Trubelja, 1984). At that site, opal occurs with sierlsite and is usually light gray to snow white (Barić, 1966). Ramović (1957) and Rakić (1962) mention opal in the Srebrenica lead-zinc mine. Radimski (1889) mentions opal on the Ljubić mountain, south of Prnjavor and in the area of Maglaj.

In addition to numerous opal samples displayed in the exhibition and stored in the scientific depot, there are precious opals, $\text{SiO}_2 \times n\text{H}_2\text{O}$ from the world's most famous opal deposit in Australia (Fig.16). The collection also contains milky opal from the Czech Republic, caholong and hyalite in the form of a fissure coating of eruptive rocks also from the Czech Republic. The collection also exhibits specimens of opal from Bosnia and Herzegovina from Derventa, Tešanj, Žepče, Maglaj and Bugojno.



Fig. 16. Precious opal, Australia

Vesuvian, $\text{Ca}_{19}(\text{Al,Mg,Fe,Ti})_{13}(\text{SiO}_4)_{10}(\text{Si}_2\text{O}_7)_4(\text{O,OH})_{10}$ from Romania (Cziklova) also stands out with its color and crystal form. The collection exhibits transparent and attractively colored apatite crystals, $\text{Ca}_5(\text{PO}_4)_3(\text{F,Cl,OH})$ of blue-green color and purple crystals of elongated prismatic habit in micaceous schist from Canada and the Czech Republic.

Lazurite, or lapis lazuli, $(\text{Na,Ca})_{7-8}(\text{AlSi})_{12}(\text{O,S})_{24}[(\text{SO}_4)(\text{Cl,OH})_2]$ is one of the oldest minerals used in jewelry. It was brought to Europe by Alexander the Great. It was originally called ultramarine. It was much more than a gem, it was a symbol of status and power. The ancient Greeks and Romans called it sapphire. Ancient civilizations, from Egypt to Mesopotamia, valued lapis so highly that it was reserved for royalty, priests, and deities. Tutankhamun's mask was made of lapis lazuli and gold. It was ground into a pigment to produce the blue color seen in Renaissance art. It is known as blue gold, a shimmering thread that connected empires, spirituality, and art. The largest deposits are found in Afghanistan, the United States, Canada, Brazil, Chile, and Burma. Lapis lazuli or lapis lazuli is mentioned in the works of Evliya Çelebi. Later, in the professional literature, laziness is not mentioned anywhere in the territory of Bosnia and Herzegovina.

The mineralogical exhibition display contains a polished sample of azure blue laziness from Mont Blanc, France.

Polished malachite samples show meandering layers of malachite, $\text{Cu}_2(\text{OH})_2\text{CO}_3$ that are concentric in places and of different composition. The exposed cut and polished specimens from Russia (Siberia) look beautiful because of the very pronounced green color in different shades from light green to dark green, which is why it is one of the favorite semi-precious stones. Malachite is too sensitive for widespread use in jewelry making. It is most often used as a decorative stone.

CONCLUSION

The rich mineralogical collection is important as a tourist offer because it contains samples of minerals from Bosnia and Herzegovina and from many parts of the world, and some of them come from mines that are no longer in use. The fact that the collection is significant as a tourist offer of the Museum is also evidenced by the fact that it contains over 60 specimens of meteorites, among which are world-famous meteorites such as the famous iron meteorites Canon Diablo and Sikhote Alin and the stone meteorites L'Aigle and Stonarov. The collection also includes the stone meteorite Zavid (fallen near Zvornik), which stands out for its weight (over 60 kg) and the iron meteorite Ozren (found on Mount Ozren). Both of these meteorites are included in the world catalog of meteorites that fell or were found on the territory of Bosnia and Herzegovina.

The role of the National Museum in the promotion of tourism is significant because the mineralogical collection of the Department of Natural Sciences contains precious and semi-precious stones from world-famous sites, such as a diamond from the Kimberley region in South Africa, ruby and sapphire crystals from the a world-famous site in Sri Lanka, an emerald from Russia, where the largest known emerald crystal was found.

The collection exhibits garnet crystals from the largest European deposits (in the Czech Republic and the European Alps) as well as crystals from the richest deposits in the world, such as topaz crystals from Brazil, beautiful and large rubellite crystals from California (USA) and tourmaline crystals found on the island of Elba (Italy). The setting features prized and beloved amethysts in the form of beautiful geodes from the Czech Republic and agates from the world's richest agate deposits in Brazil.

The audit included 255 specimens of precious and semi-precious stones from the exhibition mineralogical collection of the Department of Natural Sciences in the National Museum of Bosnia and Herzegovina.

The most valuable precious and semi-precious stones were analyzed in detail: diamond, varieties of corundum, beryl, topaz, varieties of garnet, tourmaline, zircon, opal and varieties of quartz (amethyst, sooty quartz, morion, citrine, aventurine, rose quartz, plasma and agate).

A total of 255 samples of precious and semi-precious stones were reviewed in the exhibition of the National Museum, including specimens from world-famous deposits. This paper presents only some of the more valuable gems and semi-precious stones originating from the world's most famous and significant deposits. All of these specimens were measured (weight and size), photographed, then

entered into a scientific database and checked in the inventory book. The database contains detailed information about each mineral (inventory number, physical properties, locality, and others).

The pictures show some of the revised minerals and their varieties that belong to precious and semi-precious stones. The contents of the database, i.e. the data listed in the database, can be seen in the appendix. Among these samples are the most significant and most famous specimens of precious and semi-precious stones from world-famous sites and from the largest European deposits.

Revised samples from the exhibition and scientific collection of the National Museum will be presented in the exhibition under the title "Precious and semi-precious stones in the mineralogical collection of the National Museum of Bosnia and Herzegovina". The catalog is currently being prepared, along with a planned temporary exhibition. Photos of most of the samples will be shown in the catalog, with detailed information about the presented precious and semi-precious stones with the aim of enriching the tourist offer of this institution and increasing the interest of both foreign and domestic tourists.

Previous geological research in the area of Bosnia and Herzegovina has indicated significant occurrences of precious and semi-precious stones. However, in no period of obtaining and using the mineral wealth of Bosnia and Herzegovina have dedicated researches of these occurrences and deposits been carried out with the aim of producing jewelry raw materials. Such research should be planned in accordance with world knowledge and experience and would be a reliable support for the development of the precious and semi-precious stone processing industry and for the development of jewelry in Bosnia and Herzegovina.

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