

Hreša - native Sarajevo stone

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Abstract: Limestone breccia of Middle Triassic age from the area of the village of Hreša, 6 km northeast of Sarajevo, was the main dimension stone for the construction of a large number of public and private buildings in Sarajevo from the end of the 15th century until almost the end of the 20th century, especially during the Ottoman Empire and Austro-Hungarian rule. Urbanization and the expansion of the city core created a recognizable, hewn appearance of the red stone surface of the walls, staircases, paved squares and pedestrian areas of Sarajevo. In previous mineralogical petrographic investigations, they have been identified as breccia limestone (intrasparudite), fossiliferous microcrystalline limestone (fossiliferous micrite) and fossiliferous partially lumpy limestone (fossiliferous pelmicrite). Limestone breccias and breccia limestones known under the commercial name "Hreša" are extracted in the Hreša site. The locality belongs to the structural tertiary unit Vučja Luka - Hreša - Ljubogošča (geological map of the Prača area) and D. Crepoljsko - Trebević - Treskavica - Prača (geological map of the Sarajevo area).

Keywords: native stone, "Hreša", Middle Triassic limestone breccias

Hreša - autohtoni sarajevski kamen

Sažetak: Vapnenačka breča srednjetrijske starosti s područja lokaliteta sela Hreša, 6 km sjeveroistočno od Sarajeva, je bila glavni arhitektonsko-građevni kamen za građenje velikog broja javnih i privatnih građevina u Sarajevu u razdoblju od kraja XV. st. skoro do kraja XX. st., posebno u doba osmanskog carstva i austro-ugarske vladavine. Urbanizacijom i širenjem gradske jezgre stvarao prepoznatljiv bunjast izgled rumene kamene površine podzida, stubišta, popločanih trgova i pješačkih zona Sarajeva. U dosadašnjim mineraloško petrografskim ispitivanjima su identificirane kao brečasti vapnenac (intrasparudit), fosiliferni mikrokristalasti vapnenac (fosiliferni mikrit) i fosiliferni djelimično grudvasti vapnenac (fosiliferni pelmikrit). Na lokalitetu Hreša se eksploatiraju vapnenačke breče i brečasti vapnenci poznati pod komercijalnim nazivom „Hreša“. Lokalitet pripada strukturno-tercijalnoj jedinici Vučja Luka – Hreša - Ljubogošča (geološka karta područja Prača) i D. Crepoljsko – Trebević – Treskavica - Prača (geološka karta područja Sarajevo).

Ključne riječi: autohtoni kamen, „Hreša“, srednjetrijske vapnenačke breče

1. CHARACTERISTIC DATA FROM THE HISTORY OF THE WIDER AREA OF THE CITY OF SARAJEVO

The human presence in the Sarajevo region from prehistoric times is indicated by the remains of several investigated sites, such as Butmir, Soukbnar, Zlatište, Debelo Brdo and others, of which the "Neolithic Butmir culture" deserves the most attention. A unique cultural group ("Central Bosnian cultural group"), extending to the Romanija mountain in the east, and to Jajce in the west was registered in the upper area of Bosna and Vrbas from the late Bronze Age (from the middle of the 11th to the middle of the 8th century BC), until the Roman conquest (in 9 AD). From the written sources of the Roman time, it was established that the tribal territories of the Daesitiates, a politically active tribe, were present in that area at the beginning of the new era with its principal base in Breza. A tombstone of a tribal elder ("princeps Daesitiatum") was found in the area of Breza, and the end point of the road "a Salona ad He. . . , castellum Daesitiatum", which was built in 20/21 AD, was also probably there. The development of urban settlements, which grew on the basis of conjunctural branches of the economy, mining and medicinal springs, was characteristic in the Roman time. Thus, the colony of Aquae S(ulphureae) was formed in the Sarajevo area, [2].

The parish of Vrhbosna, which covered the area of the upper course of the Bosna river and the basins of its tributaries Miljacka, Željeznica and Zujevina, was established in the area of Sarajevo and Visoko poljes in the Middle Ages. According to historians, the fortified city of Katera, one of the two cities mentioned in the work of the Byzantine ruler Constantine VII. Porphyrogenitus (*De administrando imperio*), was located in the territory of Vrhbosna parish in the middle of the 10th century. The emergence of feudal districts followed the process of dissolution of early feudal parishes, because previously *"parishes were not adequate for the late feudal concept of authority"*. In the late 14th and early 15th century, the parishes of Vrhbosna, Gradčac-Smučka, Mokro-Glasinac and Pale were established on the territory of the former Vrhbosna Parish. The central part of the former district kept its old name, while the newly formed parishes were named after fortifications and squares, which became the centers of the districts. The parish of Gradačac-Smučka remained in the area directly controlled by the Bosnian king, in the so-called "contrata del re" - the King's region. It is the area in the Zujevina river basin (present-day area of Hadžići), while the area around the confluence of the Zujevina river with the Bosna river remained within the Vrhbosna Parish. The other three parishes were an integral part of the Pavlović land. This type of organization held up during the first half of the 15th century, the only change took place in 1435/1436 related to the authority over the Vrhbosna Parish. With the help of the Ottomans, in the aforementioned year, the Kosačas put the center of Vrhbosna Parish - the town of Hodidjed and its larger part - under their control. The expansion took place over the territory of today's municipality of Trnovo, [2].

With the first arrival of the Ottoman army, the area of Vrhbosna Parish was transformed into the Bosnian krajište (border province), which was mentioned under this name for the first time in the letter of Herceg Stjepan Vukčić Kosača dated 19 July 1453. The Bosnian krajište marked the area that was under the administration of the Ottoman Empire from the beginning of their permanent rule in the parish of Vrhbosna (1448) until the fall of the Bosnian kingdom and the establishment of the Bosnian Sanjak (1463). In the summary cadastral census from 1455, Bosnian krajište is mentioned under the name Vilayet Hodidjed, after the main fortress, and then under the name Vilayet Saray-ovasi, after the market town in that vilayet, [2].

In the late Middle Ages, the territory of the large early medieval parish of Vrhbosna was divided into several smaller parishes (districts or principalities). The distribution of medieval towns around Sarajevo confirms the intensive development of socio-political relations, which led to the formation of smaller parish territories. The late medieval parish of Vrhbosna covered the territory from the Bistrica river and the confluence of Paočica and Mokranjska Miljacka in the east to Binježevu in the west, to the Vogošća river in the north, and via Zoranovići and

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Kijevo over the Kasindol stream to the slopes of Jahorina in the south. Two natural entities are distinguished in that territory, the Sarajevo polje and the Miljacka valley, in the basin of which the center of the city of Sarajevo with its surrounding northern and southern hills are located. This is where three late medieval towns were built: Teferić above Krupac, on the southeastern edge of the Sarajevo polje, the Old Town in Bulozi and the town on the site of today's Bijela Tabija (White Bastion) on Vratnik. From the Sarajevo polje, on the territory of which there are monuments from the early Middle Ages, the center shifted to the territory of today's Sarajevo city center approximately in the 13th century, [7].

Medieval Hungarian Gothic architecture was the basis of the ground plan and shape of the town on Vratnik. The old medieval town is supposed to have existed until 1878, when a new Austrian fortification was built on the site. It seems that the last visible remnant of the old town is incorporated into one rampart of the new fortification. The irregularly shaped area of 495,596 m² was encircled by the Vratnik ramparts. The thickness of the walls is about 2 m. Five tabijas (Bijela, Strošička, Žuta or Jekovačka, tabija on Ravne Bakije and tabija on Zmajevac) and three gate towers (Višegradska, gate tower on Ploča and gate tower on Širokac, as well as five gates and several small gates) were built as part of the ramparts, [7].

After the establishment of power in our region, Austria-Hungary began the construction of a new fortification system more adapted to new ways of warfare and modern war techniques. Namely, the existing fortification system inherited from the Ottoman army did not meet the new criteria of military architecture. Outdated Ottoman fortifications in Sarajevo, Zvornik and Višegrad were refurbished and new barracks were built to defend against the aggression of neighboring countries and suppress possible uprisings of the local population. One of the levels was the construction of belt fortifications, i.e. a ring consisting of several independent fortresses and intermediate positions around a larger settlement. At the end of the 19th century, the border with Montenegro began to be determined, and after the Balkan Wars (1912-1913) also with Serbia. On the first line of defense, belt fortifications were erected in Trebinje and Bileća and a barrier area in Avtovac, and fortifications in Stolac, Nevesinje, Ulog-Obrnja and Kalinovik were built as the second line of defense. The third line of defense consisted of the Neretva river with belt fortifications in Mostar and Sarajevo. In addition to the said fortifications, a large number of defensive barracks were built in eastern Bosnia in places along the Drina river in Zvornik, Višegrad, Goražde and Foča. The Austro-Hungarian military engineering administration referred to the complex of fortifications in southeastern Europe with the abbreviation BHD (Bosnien, Herzegowina und Dalmatien). The Sarajevo defense fortification system was built from 1882 to 1908. In the vicinity of the city, several strong fortifications were built on Trebević, Grdonje, Pašino hill, Zmajevac and Vratnik. The significance of these structures from the military point of view was primarily strategic, because the entire city can be monitored from the surrounding hills. Five stone fortifications were built on the dominant elevations of Trebević, which can still be seen. The Trebević fortresses and towers "survived" two world wars, but were destroyed in the last war (1992-1995). After that, they were finished off by collectors of secondary raw materials who took off everything made of metal from the abandoned and devastated structures. These imposing structures are deteriorating in sight of the social community and should be protected from further devastation, restored and, if possible, put into the function of tourism development.

In Sarajevo, four forts were built of hewn stone, characterized by their revolving steel turrets with howitzers and cannons in open platforms. In addition, there were two Zwischenbatteries (intermediate positions with open artillery platforms). Some structures on Vratnik from the Ottoman period were additionally developed, like Weissbastion (Bijela Tabija) Figure 1.

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Figure 1. Bijela Tabija is a fortress on the eastern elevation of the Sarajevo Basin, on the Dariva-Mošćanica road

The fortress was built around 1550 on the site of a medieval fortress. The upper part of Tabija, in large stone blocks, originated in the Austro-Hungarian period. From Bijela Tabija, the view reaches eastward to the Old Town in Bulozi (three hours' walk), southward to the entire northern side of Trebević and the Miljacka canyon, and westward to Sarajevo polje and all the hills around it, and eastward to Faletići and Hreša. Two trade and military roads passed there: the first through Vratnik, Hreša and Mokro to eastern and northeastern Bosnia, and the second over the Miljacka valley to Kozja Ćuprija (Goat Bridge) and further to Pale and upper Drina valley.

Three guard forts of the Wachhaus type were also built, two of them on the slopes of Trebević. There were a number of barracks in the city itself with all the necessary infrastructure, and there was also a military air base in Rajlovac. Trebević and its peaks acquire a military and strategic significance, and the fortress on Draguljac (1164 m a.s.l.), the Bistrik tower (1000 m a.s.l.), the tower on Palež (1080 m a.s.l.), the tower on Zlatište (823 m a.s.l.) and the fortress on Vrace (645 m asl) were built. Two artillery positions were also developed, one in the area of Bijele Stijene (White Rocks) (1426 m a.s.l.), and the other on the summit ridge of Trebević - Sofa (1629 m a.s.l.). To the west of the fortress on Vrace, at a straight-line distance of about 350 m, at an altitude of 643 m, a special Schanze (Šanac, trench) fortification was built. The fortress in the Šanac category represents a larger uncovered structure with a large trench, adapted for artillery and light weapons operations. Until the beginning of the First World War, the military and political situation was such that the Austro-Hungarian army kept only the necessary number of units with a low man power at these forts. The First World War marked the decline of classic fortifications, and with the departure of the Austro-Hungarian government, these structures lost their military and defensive function, [1].

The Bistrik tower (Figure 2) was built in the late 19th century and probably had the function of an observation post. In 1969, it was converted into an Astronomical Observatory, and in 1975, the Observatory building was built in the immediate vicinity of the Bistrik tower. It retained the function of the observatory until the 1992-1995 war events. After the last war, the area was cleared of mines, but the structure still stands devastated.

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Figure 2. Bistrik Tower and Observatory



Figures 3-4. Vraca Fortress - Memorial Park

For the purposes of building the fortification system, and for mutual communication between the defensive structures, two access roads were built from the city to Trebević. The first access road was built on the route: Bistrik - Hrid - Pogledine - Mala Kapa - Čolina Kapa - Ravne - Dobra Voda - the peak of Trebević. The road was named "Appel's Road" after Baron Johann von Appel, the Austrian general in command of the 15th Austro-Hungarian Corps stationed in Sarajevo. One part of the route of this road was demolished during the construction of the bobsled and sledding run for the needs of the XIV Winter Olympic Games "Sarajevo '84". At the foot of Mala Kapa above the road on a rock there is a partially damaged stone plate on which a carved inscription is clearly visible: Appel - strasse (Figure 5). The second access road was constructed in 1909 on the route: Kovačići - Vranjače - Hambina Carina - Knjeginjac - Ravne where it joined the first access road. On the steepest part of the road, where there are

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hairpin bends known as "Eights", massive iron hooks were embedded in the stone support wall, which were used to pull out artillery pieces with the help of a horse-drawn carriage. The hooks are still standing firmly in the stone support wall.



Figure 5. Inscription on Appel's Road

In 1912, a road was constructed on the route: Ravne - Brus - Čelina - Jasik - Vlahovići - Bistrica. At the spring of Bistrica (1270 m a.s.l.), a water tapping building (Figure 6) and a collection tank of the water system for the supply of drinking water to a part of Sarajevo, several public fountains and the first hydroelectric power plant on Dudin Hrid were built. This water supply system is still in operation and all its structures can still be seen, [1].



Figure 6. The tapping building at the Bistrica spring

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2. DATA FROM THE HISTORY OF THE HREŠA DEPOSIT

The village of Hreša is located at 1072 meters a.s.l. It is 10.02 km far from Sarajevo by the shortest road communication in the direction of northeast. With the administrative organization of Bosnia and Herzegovina based on the Dayton Peace Agreement from 1995, the settlement of Hreša became the center of the Municipality of Istočni Stari Grad (East Old Town), Republika Srpska (Figure 7).

In 1455, the village of Hreša (Hriša) numbered 18 families and represented the timar¹ of Isa-bey's hizmećar² Sufi Jahšija and brought him 1491 akce. Timar Hreša together with timar of silahdar³ Jusuf, who held Jošanica and part of the village of Vogošća was given to Sofial Karadža on 20.07.1463 (03.11.867 according to Hijra), with the provision that he serves in the same city. In 1485, Hreša was separated from the timar of the Hodidjed crew and entered into Sanjak-bey's hass⁴, [2].

On a prominent hill to the west of the Municipality building of Istočni Stari Grad and the sports field, there is a necropolis with stećak tombstones, a national monument of Bosnia and Herzegovina ("Historical site - Necropolis with stećak tombstones at the site of Han on Hreša, Istočni Stari Grad", Decision No. 05.2-2.3 -58/16-6 dated 2.2.2016). Paola Vračko-Korošec, Jozo Petrović, Šefik Bešlagić, Vesna Mušeta-Aščerić wrote about the stećak tombstones. When preparing the decision to declare the necropolis at Hreša a national monument, 22 stećak tombstones were technically recorded; 11 boxes and 11 gabled ones, [2].



Figure 7. Hreša - the settlement in the municipality of Istočni Stari Grad, (Wikipedia)

¹ Timar is a small feudal estate in the Ottoman Empire that brought an annual income of 1,000 to 20,000 akce (silver coins) to its owner. Its supreme owner was the Ottoman sultan, who gave it for use with the obligation of the timar sipahi to perform a certain military service. Sipahi had no real right to timar and could not alienate the land and only received rent from it. Since timar was the most numerous and widespread property in the structure of Ottoman land relations, the entire Ottoman feudal system is sometimes called the timar system. Timar was abolished in 1834.

² Hizmećar - one who serves, a servant

³ Silahdar - chief armorer in the service of the sultan, vizier or pasha

⁴ Hass - a large feudal estate in the Ottoman Empire. Hasses were the property of the sultan and members of his family, then of high state servants, sanjak-beys, and until the 1470s also of soubashis. Possession of hass was not unconditionally linked to military service. Sandjak-bey's hass brought an income of about 500,000 akce a year.

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The necropolis with stećak tombstones is situated on a small hill at a distance of 40 m to the west of the municipality building, which is separated from it by the space of the sports field. The name Han is used for the site in the literature, [2].

The late Middle Ages in the territory of Bosnia, as well as in the rest of Bosnia and Herzegovina, and some Dinaric regions in Croatia, Montenegro and Serbia, is characterized by the construction of massive stone tombstones - stećak tombstones. They were built mainly from limestone, but often from other types of rocks that were available in a certain area. More than 1000 necropolises with several tens of thousands of stećak tombstones have been preserved in Bosnia alone to date. In addition to the construction of stećak tombstones, stone was mostly used in the construction of medieval fortifications in that period. The remains of hundreds of these stone witnesses of our past are scattered, mostly on the tops of hills all over Bosnia, [4].

The tradition of making tombstones from stone - nišan tombstones - emerged a little later, during the Ottoman rule in Bosnia. They are mainly made of limestone. In the vicinity of Sarajevo, nišan tombstones were mainly made from Hreša, a carbonate breccia of Middle Triassic age, which was extracted in the area of the village of the same name, northeast of Sarajevo, [4].

Limestone breccias and breccia limestones known under the commercial name "Hreša" are extracted in the Hreša site. Limestone breccia of Middle Triassic age from the area of the village of Hreša was the main material from which buildings in Sarajevo were built from the end of the 15th century until the middle of the 20th century, when new, cheap materials took priority. A large number of public and private buildings were built with this stone during the Ottoman Empire and Austro-Hungarian rule in Sarajevo, [3].

During the Austro-Hungarian construction of residential buildings, the building of the Faculty of Law, the Post Office and some other important buildings, after the First World War, and especially after the Second World War, many buildings structures and memorials were made of "Hreša" limestone.

3. GEOLOGICAL STRUCTURE OF THE WIDER AREA OF THE CITY OF SARAJEVO

A. Boue (1856, 1862) provided the first written data on the geological structure of the wider area of Sarajevo. This author's overview map served as a basis for further geological research.

In the period from 1878 to 1918, numerous researchers of the Vienna School (*Mojsisovics, Bittner, Tietze*) worked in the territory of Bosnia and Herzegovina. Their geological map for the territory of BiH provided detailed data on the geological structure of the wider area of Sarajevo. The monograph "Geologie der Umgebung von Sarajevo", Jahrbuch d.geol. Reichsanstalt, Bd. 53, pro. 1903, erch. 1904, Wien, presents a synthesis of stratigraphic and paleontological studies of the surroundings of Sarajevo in the second half of the 19th century.

Kittl very seriously and responsibly used all published works, especially Mojsisovics' on the cephalopods of the Hallstatt facies, then Bittner's and Hauer's works. He spent the time from 1892 to 1899 developing the said geological map, which covers the terrain from Tarčin to Prača and Kladanj to Trnovo. From present-day point of view, that map contains a lot of inaccuracies, but at the time of its coming out it was really of the highest quality. The division of the Triassic of this area is unsurpassed to date. That is why we put here Kittl's "General scheme of division of the Triassic near Sarajevo". It is still topical, and can serve younger generations as a model. It should be emphasized that Kittl wrote this monograph after seven years of field investigations from 1899 to 1903. and that he used the data of all works published up to the first years of the 20th century, [6].

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Table 1. General scheme of the division of the Triassic near Sarajevo (E. Kittl), taken from [6]

Limestones prevail	Ret		Megalodon limestones; Pusto Selo and Bjelašnica		Dolomites and dolomitic limestone near Sokolac
	Norik		Light-colored limestones; Hrastiši and Gazivoda		
	Karnik		Cephalopod limestones, Draguljac, near Udež and Očevlje Halobian banks of Draguljac and near Očevlje		
	Ladinian	Cassian layers	Red limestones of Vaganj		
		Wengen layers	Shale cherts of Han Vidović (Grabovica layers) Glaucopitic tuffitic sandstones Red nodular limestones (old town layers)		
		Hor.d. Marmolata	Limestones of Šiljansko Polje		
Upper Muschelkalk (Schreieralm strata)		Bulog limestones	Red cephalopod limestones with Ptychites* Cephalopod limestones with Proteusites*; Han Vidović and Blizanac	Light-colored reef limestones with corals and Diplopoda	
Lower Muschelkalk (Recoar layers)		Brachiopod limestones of Trebević White or yellow reef limestones			
Layer boundary	Lower Muschelkalk (Gutenstein layers)		Gray nodular limestones; Bistrik (Sarajevo), Dolovi, valley of Lapišnica and Bakija		Dark gray limestones in the southwest (Zujevina valley, surroundings of Špilja)
Colorful sandstones	Werfen	Upper	Gray marly limestones (Mučer layers) in the Željeznica valley		Banks with Naticella ⁵ , Brezova Glava
		Medium	Yellowish sandstone - Sarajevo sandstone		Bistrik stream, Potoci, Dovlići, Brezova Glava, etc.
		Lower	Red and green, also brown shaly sandstones and marls (Alpine type)		

The scientific heritage that Kittl left us is one of the examples of the most precious heritage, especially when it comes to the geology of the younger Paleozoic and, especially, the Triassic. In the 1890s, other researchers also appeared, mostly geographers and geomorphologists. Their creativity continued in the first decades of the 20th century.

3.1 Geological structure of the Hreša deposit

The first significant geological explorations of the decorative stone Hreša were carried out as part of regional geological investigations in 1978. Data on the earliest extraction of limestone from the "Hreša" site date back to the period of the Ottoman Empire, as well as the Austro-Hungarian period. In the area of Hreša, earlier extraction of decorative stone was also carried out in smaller pits that were opened in the narrower localities of Raški Do, Šiljato Brdo, Dugi Do and Žljebine.

Until the beginning of 1992, stone from this deposit was quarried on a smaller scale by the company GP "Vranica", OUR "Kamenorezac" from Sarajevo.

Today's deposit of decorative stone "Hreša" is located about 6 km northeast of Sarajevo, and is connected by the road Sarajevo-Vučja Luka.

⁵ fossil snail fauna

*cephalopod fossil fauna

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Limestones of Triassic age in the vicinity of Sarajevo, the so-called local limestone, were exploited under the market name "Hreša". Tombstones in the Sarajevo area were made of limestone of the "Hreša" type, but it was also used for covering mosques and many other buildings, staircases, walls, etc.

During the urban development and expansion of the city core, the local limestone Hreša created a recognizable, hewn appearance of the red stone surface of support walls, staircases, paved squares and pedestrian areas of Sarajevo.



Figure 8. The bank protection for regulation of the right side of the Miljacka river and pavement curbs made of the Hreša limestone

The Hreša locality belongs to the structural tertiary unit Vučja Luka - Hreša - Ljubogošča (geological map of the Prača area) and D. Crepoljsko - Trebević - Treskavica - Prača (geological map of the Sarajevo area - Figure 9).

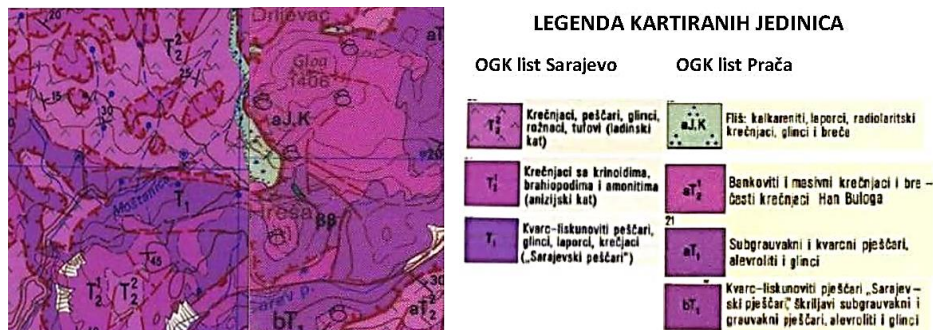


Figure 9: Geological structure of the wider study area (used Basic Geological Map, sheet Prača and sheet Sarajevo, M 1: 100,000, FGI Belgrade, 1977 and 1982)

The Middle Triassic of Hreša from the BGM sheet Prača consists of:

aT_2^2 : Platy limestones, multi-colored cherts, striped tuffs, marly limestones, limestones with cherts, limestone inserts and clays;

aT_2^1 : Banked and massive light gray and red limestones and breccias with ammonites⁶, stratified gray limestones with brachiopods⁷, crinoids⁸ and foraminifera⁹

⁶ Ammonite fauna - Ammonites are extinct four-gilled cephalopods, which were most often planispirally coiled (disappeared at the end of the Triassic).

⁷ Brachiopod fauna - Brachiopods are marine animals similar to bivalves; brachiopods

⁸ Crinoid fauna - Crinoids (Crinoidea) are a group of ancient fossils that first appeared in the seas of the Middle Cambrian, about 300 million years before the dinosaurs.

⁹ Foraminifera (lat.: Foraminifera) are a phylum of chromista classified in the currently unrecognized class of rhizopods (Rhizopoda). and to the presently recognized infraclass Rhizaria.

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Limestone breccias of the Hreša type are light gray to white, rarely reddish in color. The breccia fragments are connected by a calcite binder. Joints of different orientation, length and aperture can be observed in the rock mass. Joints with smaller aperture are mainly filled with calcite, while those with larger aperture are either gaping or filled with terra rossa. In the process of extraction, special attention must be paid to the position of these joints within the rock mass. The rock contains stylolitic seams, with black, brown or greenish infill. Rock cracks do not occur along these seams, so they do not pose a problem during extraction or dressing of this stone, [3].

Brecciated limestone (intrasparudite), can also be called limestone breccia, is composed of fragments of micrites, fossiliferous micrites and pseudomicrites, and the intermediate mass or matrix is crystalline calcite.

Carbonate breccias from the "Hreša" deposit are composed of pieces of microcrystalline limestones consisting of calcite, with a binder of micro- and fine-grained calcite, [3].

Geological research in the area of Gornje Biosko, east of Sarajevo, was carried out in recent times. The goal was to find a deposit of limestone breccias from which commercial blocks could be extracted. The Nova Hreša quarry was opened soon. It is less than two kilometers from the existing Hreša quarry. This stone is almost identical in appearance and quality to "Hreša" (it is the same geological formation and mineral composition). However, this quarry was soon closed due to the possibility that the extraction in it could endanger the water from the nearby tapped spring Crnil, [3].

The Middle Triassic of Hreša from the BGM sheet Sarajevo consists of:

T₂¹: Three zones were identified in the Anisian stage: Zone with *Ceratites trinodosus* (ammonite fauna) red brecciated limestones; Zone of brachiopod limestones (brachiopod fauna) - gray-white and red limestones in some places with chert nodules and Zone with *Dadocrinus gracilis* (crinoid fauna) white and red massive limestones and dolomitic limestones. T₂²: The Ladinian stage is represented by limestones with lenses of cherts, claystones, sandstones, marls and tuffs. Limestones are gray or reddish in color, compact, thinly stratified and usually contain chert nodules.

4. TEST RESULTS

Table 2. Available test results of stone from the "Hreša" site

Property	2003	Categorization [5]	2007 (X)	Categorization [5]	2007 (XII)	Categorization [5]	2013	Categorization [5]	2016	Categorization [5]
MPA stone identification	brecciated limestone (intrasparudite ¹)		fossiliferous microcrystalline limestone (fossiliferous micrite ²)		brecciated limestone (intrasparudite)		fossiliferous microcrystalline limestone (fossiliferous micrite)		fossiliferous partly lumpy limestone (fossiliferous pelmicrite ³)	
bulk density (with pores and cavities) / dry state/ (kg/m ³)	min. 2643 max. 2738 avg. 2689	heavy	2606 2686 2655	heavy	2595 2585 2665	heavy	2665 2695 2677	heavy	2619 2715 2687	heavy
specific gravity (density) (kg/m ³)	min. 2789 max. 2803 avg. 2795		2760 2815 2785		2745 2835 2785		2755 2770 2760		2765 2798 2782	
mass coefficient	0.960		0.953		0.957		0.970		0.965	
general (absolute) porosity (%)	4.0	moderately porous	4.7	moderately porous	4.3	moderately porous	3.0	moderately porous	3.5	moderately porous
open porosity (%)	min. 0.25 max. 0.25 avg. 0.25		1.1 3.3 2.2		0.56 1.38 0.88		0.47 0.93 0.80		0.30 0.72 0.50	
water absorption (%)	min. 0.10 max. 0.10 avg. 0.10	very small	0.4 1.4 1.0	small	0.20 0.52 0.33	very small	0.18 0.35 0.28	very small	0.11 0.28 0.20	very small
compressive strength /dry state/ (N/mm ²)	min. 61.0 max. 126.6 avg. 95.6	medium high	100.4 148.3 119.8	medium high	99.8 133.5 116.7	medium high	120.9 141.3 132.0	medium high	100.6 161.2 122.4	medium high
compressive strength /water-saturated state/ (N/mm ²)	min. 67.6 max. 107.7 avg. 90.5		86.2 122.4 110.9		75.9 113.3 110.8		94.6 129.2 111.7		100.8 132.3 115.1	
coefficient of softening	0.94		0.82		0.850		0.945		0.895	
tensile strength when bending /dry state/ (N/mm ²)	min. 12.4 max. 15.5 avg. 13.7		10.9 14.0 12.3		9.6 13.5 11.5		6.9 8.7 7.7		6.6 13.4 9.4	
resistance to abrasion wear - volume loss (cm ³ /50cm ²)	min. 20.4 max. 23.4 avg. 21.2	moderately hard	20.8 21.7 21.2	moderately hard	14.6 15.7 15.1	hard	16.7 18.0 17.3	hard	16.6 17.6 17.0	hard
frost resistance (refrigerator 50 cycles) - drop in compressive strength expressed through the frost coefficient	min. 0.636 max. 0.957 avg. 0.830	without loss of mass	0.570 0.745 0.602	fragmentation and cracks	0.734 0.976 0.792	without loss of mass	0.716 0.647 0.741	fragmentation and cracks	not determined	
resistance to frost-crystallization test Na ₂ SO ₄ - loss of mass after 5 cycles (%)	min. 0 max. 0 avg. 0	without loss of mass	-	fragmentation and cracks	0.16 0.76 0.39	without loss of mass	-	fragmentation and cracks	0.15 0.29 0.23	without loss of mass *

*by continuing the test after 2 cycles, fragmentation occurred in larger pieces (assessment fragmentation and cracks).

¹Limestone containing at least 25% of intraclasts and in which sparitic calcite cement (binder) predominates over carbonate-silty matrix (micrite).

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Hreša – native Sarajevo stone

¹Descriptive term for designating a semi-transparent crystalline matrix of limestone consisting of chemically precipitated carbonate (calcite) silt whose crystals are less than 4 micrometers in diameter. The term is now usually used in a descriptive sense with no genetic implication. Other specialists later widened the application of the term to include unconsolidated (non-cemented) material that can be of either chemical or mechanical origin (and possibly biological, biochemical or physical-chemical).

5. CONCLUSION

In Bosnia and Herzegovina, building with stone is not present everywhere to the extent that in all its regions it could be called tradition, as a kept, observed, sedimented system, method, pattern. Certain conditions must exist for such a tradition to exist.

In order for a characteristic building method in a certain area to be formulated, developed and kept on in the form of a set of knowledge, customs, technologies, techniques and relations to the material and the environment, the most important factor is the natural matrix. In addition to geographical, geomorphological and climate factors, geological factors carry a significant part of that matrix.

The immediate natural environment is exceptionally important for the formulation of a native architectural tradition, whose maintenance and sedimentation gradually forms the ambience. Ambient value is therefore qualitatively different from architectural value; criteria by which it is evaluated. Always, in one way or another, they stand in a certain relationship with the immediate environment of the built structures themselves. The recognition of these values and a refined sense for identifying the quality of ambient, rural and other entities in the field of heritage protection is of immense significance, [8].

Joints of different orientation, length and aperture are observed in the rock mass of the Hreša deposit. Joints with smaller aperture are mainly filled with calcite, while those with larger aperture are either gaping or filled with terra rossa. In the process of extraction, special attention must be paid to the position of these joints within the rock mass.



Figures 10-12: Non-uniformity of cracks and damage in the busy pedestrian zone of the old town of Sarajevo (left and middle), as well as the original internal stairs in the space of the BiH Art Gallery in Sarajevo¹⁰

¹⁰The building in which it is located today was built around 1912 as a department store of Ješua and Mojca Salom. It is assumed to be the work of Josip Vancaš. According to its characteristics, it belongs to the late works of historicism, and in addition to Renaissance-classicist forms, it also features elements of Art Nouveau. The building was repurposed after the war, and since 1953 it housed the Art Gallery of Bosnia and Herzegovina. During the aggression and siege of Sarajevo, the building was heavily damaged by shelling. After the end of the war, thanks to the Government of the Swiss Confederation and its own efforts, the BiH Art Gallery managed to find donors for almost complete restoration of its building.

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