

## Exploration and Exploitation of Dimension Stone in the Municipality of Livno

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**Abstract:** There is a lot of evidence that people used stone in the construction of buildings, as well as for other purposes in the municipality of Livno throughout history, as evidenced by numerous archaeological finds. Ever since the Bronze and Iron Ages, and through the Roman, medieval and Turkish periods, stone has been the main building material in these regions. In recent times, two dimension stone quarries have been opened on the territory of the municipality of Livno, one in the locality of Pogledala, east of the city, and the other in the locality of Kik, located between the Kamešnica and Dinara mountains. Both quarries were opened in massive limestones of Upper Cretaceous age. High-quality limestone with the commercial name "Silit light" is being exploited at the Pogledala quarry, and at the Kik site exploitation has been interrupted, but there is a great possibility of its continuation.

**Key words:** dimension stone, municipality of Livno, exploration, exploitation, quarry, limestone, Silit light, Kik

## Istraživanje i eksploatacija arhitektonsko-građevinskog kamena na području općine Livno

**Sažetak:** Mnogo je dokaza o tome da su ljudi koristili kamen u gradnji objekata, kao i u druge svrhe na prostoru općine Livno kroz povijest o čemu svjedoče brojni arheološki nalazi. Još od brončanog i željeznog doba, pa kroz rimski, srednjovjekovni i turski period kamen je u ovim krajevima bio glavni materijal za gradnju. U novije vrijeme na prostoru općine Livno otvorena su dva kamenoloma arhitektonsko-građevinskog kamena, jedan na lokalitetu „Pogledala“, istočno od grada, a drugi na lokalitetu „Kik“ koji se nalazi između planina Kamešnice i Dinare. Oba kamenoloma otvorena su u masivnim krečnjacima gornjokredne starosti. Na kamenolomu „Pogledala“ eksploatira se kvalitetan krečnjak komercijalnog naziva „Silit light“ dok je na lokalitetu „Kik“ došlo do prekida eksploatacije iako postoji velika mogućnost nastavka iste.

**Ključne riječi:** arhitektonsko-građevinski kamen, općina Livno, istraživanje, eksploatacija, kamenolom, krečnjak, Silit light, Kik

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### 1. INTRODUCTION

The life of the people of the Livno region has been inextricably linked to stone since ancient times. People walked on stone, built with stone, were buried in stone. People of Livno rely on the field (Livanjsko Polje is the largest polje in Bosnia and Herzegovina with an area of 405 km<sup>2</sup>), however, 60% of the present municipality of Livno belongs to the hilly and mountainous terrain in morphological terms. Until the 1960s and the construction of the Buško Blato reservoir, Livanjsko Polje was seasonally flooded every year, and the inhabitants of this area built their settlements mostly on the edge of the polje, resting on the surrounding mountain slopes. They built houses and farm buildings mainly from stone that they found in the near or far vicinity. A large part of the cultural heritage of the Livno area is related to stone. It was so until the invention of new materials, such as brick and concrete. These materials are more suitable for construction and over time they supplanted stone as the main architectural and construction material.

In recent times, stone is returning to architecture with an increasing success. Now it is mostly not used as the main load-bearing element of building structures, but is used more as a decorative element, and as a link with nature and building tradition. This is possible due to the progress of technique and technology that has enabled us to cut stone into thin plates or other elements suitable for installation in modern buildings.

We should take advantage of the increasing demand for stone as a natural material and allow businessmen who are engaged in the extraction of these mineral raw materials to use at least a small part of the potentials that we have in this area. The municipality of Livno has significant resources of this valuable material, which are almost completely unused. Currently, the exploitation of dimension stone in the municipality of Livno takes place at only one quarry, while at another one a study on reserves is made and after trial exploitation the deposit is currently being prepared for continuous production. Continuation of quarrying on existing deposits, as well as work on finding new deposits of dimension stone, while increasing the capacity for processing this material, would strengthen the Livno economy, employ the local workforce and help people stay in this area.

This paper is, among other things, a modest attempt by the authors to point out the existence of promising locations for finding different types of stone suitable for use as dimension stone. All of this is not possible without investing in geological investigations of this mineral raw material, which were symbolic until now and were limited to investigations to determine reserves in the preparation of studies on reserves and quality.

### 2. A BRIEF HISTORY OF THE USE OF STONE IN THE CONSTRUCTION OF MONUMENTS, RELIGIOUS, RESIDENTIAL AND CULTURAL BUILDINGS IN THE LIVNO AREA

The area of the municipality of Livno has been inhabited since prehistoric times, and this is confirmed by the remains of the stone walls of about forty hill-forts located on the mountain slopes around Livanjsko Polje. These stone forts date from the Bronze and Iron Ages and testify to the use of stone for construction purposes. On the territory of the city of Livno there are three prehistoric forts (Velika Gradina, Mala Gradina and Kasalov Gradac) and one necropolis with tumuli. Since the Iron Age, these areas were inhabited by the Illyrian tribe Delmatae, who widely used stone, and are known for building chest-shaped stone tombs. Delmatae, like all Illyrians, also built dry walls of crushed stone.

The construction of buildings of dressed stone began with the arrival of the Romans. Due to the great need for stone, the Romans opened numerous quarries where they extracted stone for construction of military fortifications, municipia, colonies, palaces, villas and roads. From stone they also made sarcophagi and tombstones in the form of urns, stelae and cippi.

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Numerous stone objects found in the Livno area, which date from the Roman period, are kept in the Franciscan Museum and Gallery of Gorica.



Figure 1. Fragment of pluteus (altar partition) from the basilica on Rešetarica, (5th-6th century) made of Miocene freshwater limestone (probably from the quarry on Bužanin hill) (Franciscan Museum and Gallery Gorica Livno, 2008)

The use of stone for construction in the early Middle Ages is evidenced by the remains of early Christian basilicas, such as the one the foundations of which were found at the Rapovine cemetery in Livno, or the one the remains of which were found in Rešetarica south of Livno. Limestones of Mesozoic age, as well as Miocene freshwater limestones, which are known in this region as *muljika*, were used in their construction. In the basilica from Rešetarica, church furniture was also made of *muljika* (Figure 1). Travertine was also used in the construction of the basilica in Rešetarica.

The late Middle Ages in Bosnia and Herzegovina, as well as in some Dinaric regions in Croatia, Montenegro and Serbia, are characterized by the construction of massive stone tombstones - *stećaks*. The area of Livno is no exception, and in this municipality we find a large number of *stećak* tombstones, the most famous of which being the necropolis of *stećak* tombstones in Mramorje Grborezi and two necropolises in Lištani - Mali Han and Veliki Han. In addition to the construction of *stećak* tombstones, stone was mostly used in the construction of medieval fortifications in that period.

The tradition of making Muslim tombstones - *nišans* emerged a little later, during the Turkish rule in these areas. They were made of stone, mainly of freshwater limestone, which is called "*muljika*" in this area. They are known for their shape characteristic of these areas, and often for their monumentality (some from neighboring Glamoč, which were built of similar stone, are higher than four meters). Some of the most famous stone buildings in Livno, the Balaguša and Glavica mosques, and the Smajlagić's (Pirija's) tower, also date from that period. The Franciscan monastery and the church of St. Peter and Paul in Gorica were built at the very end of Turkish rule, in the middle of the 19th century.

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Later, with the advent of new materials that were easier to install, the use of stone for architectural purposes gradually decreased. Stone was increasingly used as aggregate in road construction and in the production of concrete mixes. Several quarries and borrow pits of crushed stone aggregate have been opened in the Livno municipality in recent decades. The quarries are mostly in the Mesozoic limestone massifs, and the borrow pits are in Quaternary and Pliocene-Quaternary gravels. It was only at the beginning of the 21st century that quarries of dimension stone began to open again in Livno.

### 3. PROMISING GEOLOGICAL FORMATIONS IN THE LIVNO MUNICIPALITY FOR FINDING DEPOSITS OF DIMENSION STONE

In geological terms, the territory of the municipality of Livno is an interesting area to investigate the presence of possible deposits of high-quality dimension stone. The municipality of Livno is slightly elongated in the northwest-southeast direction, so we can say that it follows the Dinaric direction. Livanjsko Polje extends approximately in the middle of the municipality. It is bounded by the Dinara and Kamešnica mountains from the southwest, Šator mountain from the north, Staretina, Velika Golija, Mala Golija and Krug mountains from the northeast, and Tušnica from the southeast. All these mountains belong to the geotectonic unit "Dinaride Carbonate Platform" and are mostly composed of Mesozoic limestones and dolomites, less often of Paleocene-Eocene or Eocene-Oligocene formations. As a post-orogenic formation, Livanjsko Polje is composed of Oligocene, Neogene and Quaternary formations.

Regarding the prospects of finding compact rock masses suitable for use as dimension stone, it should be pointed out that they must meet certain conditions. From these rock masses, it must primarily be possible to obtain stone blocks of satisfactory size, and from them to obtain stone plates and other stone elements of standard dimensions. The stone itself must have appropriate physical and mechanical properties, which should meet the standards prescribed by the applicable regulations.

Geological factors that influence the evaluation of a dimension stone deposit are: deposit size, type of mineral raw material, quality of mineral raw material, possibility of exploitation, sufficient satisfactory thickness of layers (if it is the case of sedimentary rocks), tectonic fracturing of the rock mass, geomorphological characteristics of the terrain and the degree of geological exploration of the deposit.

The first geological investigations of these areas began during the time of the Austro-Hungarian Monarchy and were part of the regional explorations carried out by the Geological Survey from Vienna. At that time, these areas were explored by famous geologists: Hauer, Bittner, Tietze, Mojsisovitz, Cvijić, Neumayer, Grimer. In his works from 1918 and 1921, F. Katzer describes in detail the characteristics of all freshwater Tertiary basins of Bosnia and Herzegovina. He presents recent data on fossil finds as well as coal outcrops in the Livno and Duvno freshwater basins (Papeš, 1962-1967).

In the middle of the 20th century, I. Soklić gave two reports on geological explorations of this terrain. Then, the first geological mapping of the Livno coal-bearing basin was carried out at a scale of 1:50,000 using the data obtained from several structural wells drilled between Livno and Tušnica. A little later, development of the Basic Geological Map (BGM) at a scale of 1:100,000 was undertaken. First, J. Papeš produced the sheet Livno (1962-1967), in the meantime A. Ahac, J. Papeš and V. Raić produced the sheet Glamoč (1963-1965), and then J. Papeš, R. Marinković and V. Raić produced the sheet Sinj (1968-1980). These sheets of the Basic Geological Map provided basic data on the geological structure of the terrain, structural-tectonic composition of the terrain, rock types, etc. They were made by the Geological Institute Sarajevo.

In the area of the municipality of Livno, investigations were conducted in several directions: investigations for the development of BGM sheets Livno, Glamoč and Sinj,

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investigations to prove coal reserves, hydrogeological and hydrological investigations of water for energy purposes (Buško Blato), investigations of drinking water, and more recently investigations to prove the reserves of crushed stone aggregate and dimension stone.

Not all rocks are suitable for use as dimension stone. Of all the rock masses suitable for opening a quarry of this purpose in the area of the municipality of Livno, we can single out only a few of them:

- limestones and limestone breccias of Lower Jurassic age with lithiotids,
- limestones of Upper Cretaceous age (parts of the Turonian and Senonian) with globotruncana,
- massive and banked Upper Cretaceous limestones with rudists,
- alveoline-nummulitic limestones of the Lower and Middle Eocene and
- freshwater limestones of Miocene age.

In some places, other rock masses suitable for use as dimension stone may also be found, but the most promising are the specified geological formations.

**Limestones and limestone breccias of Lower Jurassic age with lithiotids** are recognizable by their light brown, sometimes gray to dark gray, rarely completely black color with the white shells of lithiotid bivalves (the best known being *Lithiotis problematica*), which give this stone a particularly attractive appearance and high architectural value. Several quarries of this stone have been opened in the Republic of Croatia, especially in Lika.

In the Livno area, these rocks can be found in two areas: on the Krug mountain north and east of the Mrđanovac peak, and to the right of the Livno-Glamoč road in a narrow strip extending in a north-south direction from the Debelo hill to Jukovac and further to the north.

**Limestones with globotruncana of Upper Cretaceous age (parts of the Senonian and Turonian)**, which are characterized by a light beige color and the appearance of stylolitic seams. These are cryptocrystalline limestones that mostly occur in thicker layers, banks or less frequently as massive.

We find them in a narrow strip several hundred meters to a kilometer wide, and they extend from the city of Livno in the southeast direction through Kremenjača, Zagoričani and the Ivovik hill, all the way to the Eminovo Selo village on the edge of Duvanjsko Polje. A quarry of dimension stone "Pogledala" was also opened in these limestones.

**Massive and banked limestones of the Upper Cretaceous with remains of rudist bivalves** that can be found in a large number of sites in the municipality of Livno. Most of these deposits are made up of cryptocrystalline limestones composed of dense pelitomorphic calcite mud. Many layers are composed of microcrystalline limestones, and layers made of rudist shells themselves can also be found. Along with rudists, microfossils (foraminifera) are also common.

Rudist limestones form the northern slopes of Tušnica. They are most common on the southeastern slopes of Dinara, where the Čaička Draga peak and Suhi hill make their northern boundary, the Kik and Visibaba peaks the eastern, the Vaganjsko saddle and Demerovac peak the southern, while to the west they extend across the border into the Republic of Croatia. In this area, two quarries of dimension stone, "Kik" and "Kik 2", are in the opening phase.

The next area composed of rudist limestones is northwest of the previous one and is smaller than it. It is located in the heart of the Dinara mountain. It is bounded by Kovijovac and Žrvanj from the north, Modra Greda from the east, Trpina Kosa from the south, and reaches the Croatian border to the west.

On the Kamešnica mountain, which represents a syncline with the axis extending approximately in the west-east direction, Upper Cretaceous rudist limestones are part of the composition of both limbs of the syncline. They concordantly overlie the Upper Cretaceous limestones with chondrodonts, while being discordantly overlain by Paleogene deposits in the syncline axis. The northern limb of the syncline made of rudist limestones extends in the strip from the top of Kamešnica in the west to the town of Podgradina on the shore of Buško Lake. The

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southern limb of the syncline extends from the top of Medina and Jasenov Umac in the west to Rešetarica on the shore of Buško Lake.

**Alveoline-nummulitic limestones from the Lower and Middle Eocene** are preserved in a small area near Golinjevo, where they discordantly overlie rudist limestones of the Upper Cretaceous. These are mainly cryptocrystalline limestones, and foraminiferal calcarenites also occur among them. They are light gray or white in color. They are massive or their bedding planes are weakly expressed. They do not contain macrofossils, but are rich in remains of alveoline and nummulite shells. They are solid, compact and slightly tectonically disturbed and are suitable for use as dimension stone.

**Freshwater limestones of Miocene age** have been a suitable material for centuries, which the inhabitants of Livno and its surroundings have been using in the construction of residential, commercial, religious and other-purpose buildings since ancient times. The local name of this stone in Livno is "muljika". Many buildings in the Livno area are completely or partially built with this stone. Some of them are the Franciscan monastery and the church of St. Peter and Paul in Gorica, Balaguša and Glavica mosques, Smajlagić's (Pirija's) tower and others. The numerous tombstones of all three religions built from this stone should also be emphasized.

These are microcrystalline limestones cream white to light yellow in color. They can be marly to a greater or lesser extent, which significantly affects their usability as dimension stone. It is a very porous rock that easily absorbs moisture, but also easily releases it. The advantages of this material in the construction of buildings are that they have a lower bulk density, are easier to work with and take mortar better than most other types of stone.

Deposits of these limestones extend along the entire Livno Neogene basin. There is no doubt that there were numerous quarries of this stone from the Roman period until the end of the 19th century, but they are overgrown with vegetation or buildings are built on them, so it is difficult to find them today. The old craftsmen knew how to find the highest quality outcrops of this stone and opened quarries in those places. Today, the sites of old quarries should be investigated more closely and geological research should be carried out in these places in order to find stone that would meet the criteria necessary for opening dimension stone quarries. It would also be necessary to use the existing geological data obtained during the development of the Basic Geological Map, as well as all other geological investigations for specific purposes such as investigations of coals in Livanjsko Polje, investigation for the construction of infrastructure facilities, for the foundation of building structures and the like.

## 4. CURRENT STATE OF DIMENSION STONE QUARRYING IN THE MUNICIPALITY OF LIVNO

Today, there are two quarries of dimension stone on the territory of the municipality of Livno. They are the "Pogledala" and "Kik 2" limestone quarries. At the "Pogledala" quarry, extraction began in 2002 and has been going on without interruptions to this day, while at the "Kik 2" quarry, trial exploitation was carried out in recent years, and preparations are being made to set up a continuous exploitation. The following is a brief overview of characteristics of the stone at these two quarries.

### 4.1 Pogledala

The dimension stone deposit Pogledala is located about a kilometer east of Livno, in an area called Kremenjača. The deposit is made up of light colored, massive Upper Cretaceous Turonian and Senonian limestones, the structure of which indicated the possibility of their use as dimension stone.

Trial exploitation of this deposit was started back in 2002. Then a certain number of blocks were extracted from the trial exploitation level for laboratory and technological analyses. Since

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the analyses established that the stone meets all quality aspects, the development of a study on reserves and quality was undertaken in 2003 (Bilopavlović, 2003). From then until today, the extraction at the Pogledala limestone deposit has been going on continuously (Figure 2).



Figure 2. Part of Pogledala quarry (Photo Silit d.o.o. Livno)

In Bosnia and Herzegovina, surrounding countries and beyond, this stone is better known under the commercial name "Silit light". The company Silit d.o.o. Livno, which is engaged in the exploitation of this stone, has its own stone processing facility, where it cuts blocks into plates of different thicknesses, then formats plates and other stone elements, and performs final processing, which consists of polishing, bush hammering, flaming and other modern methods of processing stone surfaces (Figure 3). Tables 1 and 2 show the physical and mechanical properties, mineral composition and field of application of limestone from the Pogledala deposit.

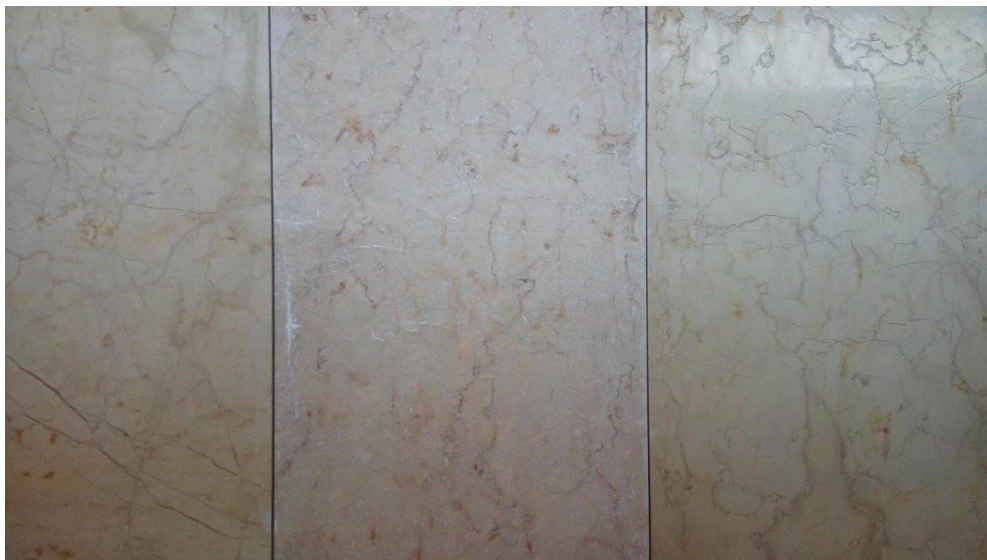


Figure 3. Final processing of Silit light plates, from left to right: polished, flamed, antique (photo Silit d.o.o. Livno)

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*Silit light* is light gray, less often light brown in color. It can be polished to a mirror finish. Cracks filled with calcite are observed on the polished surfaces, which gives it a distinctive appearance. Stylolitic seams with brownish infilling, which gives this stone a special decorative touch, are observed on most samples. The warm color of this stone is especially attractive when it is installed in the interiors of residential spaces.

Table 1. Physical and mechanical properties of limestone from the Pogledala deposit

Number	Determination type	Value
1.1.	Compressive strength in dry state	mean = 122 MPa
1.2.	Compressive strength in water-saturated state	mean = 95.5 MPa
2.	Water absorption at atmospheric pressure	= 0.28%
3.	Bulk density	= 2689 kg/m <sup>3</sup>
4.	Bulk density without pores and voids	= 2703 kg/m <sup>3</sup>
5.	Coefficient of bulk density	= 0.994
6.	Absolute porosity	= 0.63% (vol.)
7.	Resistance to frost (after 5 cycles of immersion in Na <sub>2</sub> SO <sub>4</sub> )	= 0.1% - resistant
8.	Resistance to abrasion wear	mean = 17.8 cm <sup>3</sup> /50 cm <sup>2</sup>

Laboratory tests have proven that *Silit light* stone has all the properties necessary for long-term use in the case of installation, both in interiors (Figure 4) and for outdoor use (Figure 5) in Mediterranean and continental climate conditions. It proved to be stable when installed on horizontal and vertical surfaces.

Table 2. Mineral composition and applicability of limestone from the Pogledala deposit

Mineral composition	Limestones with a microcrystalline structure composed of dense microcrystalline calcite mud, with a CaCO <sub>3</sub> content of about 99%. It contains oolites, which are bounded by a micritic binder. Microfossil shells are rare. Its color is light gray, rarely brown or ivory. Stylolitic seams with brown infilling, which give this stone a special decorative quality, are visible on most of the polished samples.
Applicability	External and internal vertical cladding, external and internal horizontal paving of pedestrian surfaces with high and very high pedestrian traffic load, for the production of window sills, stairs, monuments, channels and similar elements, then for the production of decorative objects, etc.

The increasing demand for this stone indicates that its quality has already been proven. It is increasingly in demand in Croatia, but also in our market. Among the buildings in which *Silit light* was used for construction or renovation in Bosnia and Herzegovina, we single out the facade on the BiH Parliament building, the ceremonial entrance and hall in the Sarajevo City



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Hall, the pavement in several streets in Bašćaršija, the Franciscan Museum of Gorica in Livno, Hotel "Casino" in Brčko, the church of Our Lady of Angels in Livno. In Croatia, in fierce competition with stone from numerous Dalmatian quarries, it has secured its place in the market, where it is constantly increasing its share. The waterfronts in Makarska, Rijeka, Trogir, Ploče, Šibenik are paved with silit, and so are the main street in Skradin, the port in Ploče, Kalalarga street in Makarska, the facade of the HP Post Office building in Split, the Skywalk Promenade on Biokovo. In addition to taking its place in the markets of Bosnia and Herzegovina and Croatia, Silit light is installed in numerous residential and commercial buildings in Germany, Italy, Great Britain, and Slovenia. Today, this stone is exported to Croatia, Slovenia, and Italy, and thanks to its quality, it has also found its place in the distant Chinese market.



Figure 4. Interior of the Church of Our Lady of Angels in Livno made of Silit light stone (Silit d.o.o. Livno)

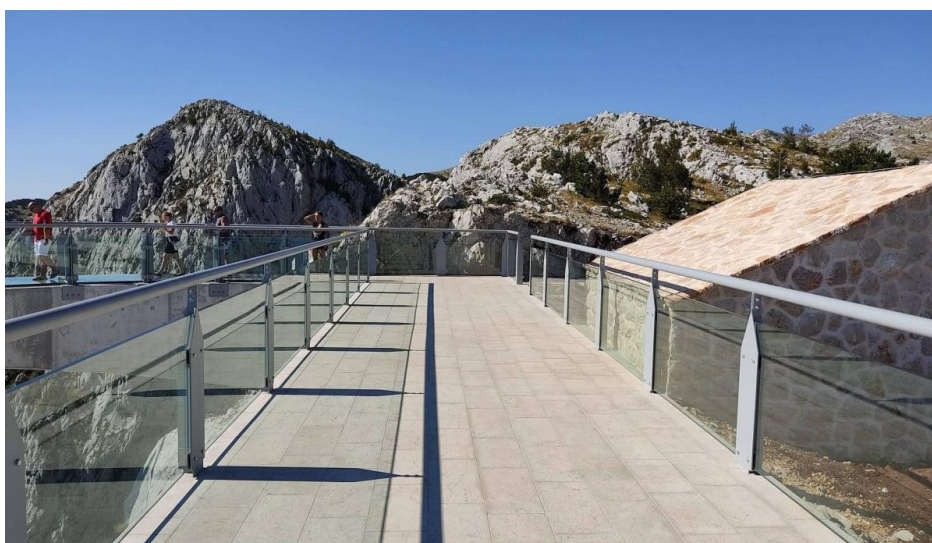


Figure 5. Skywalk on Biokovo (Republic of Croatia) paved with Silit light stone (Silit d.o.o. Livno)

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### 4.2 Kik 2

On the southeastern slopes of the Dinara mountain, in the Upper Cretaceous rudist limestones, there is a deposit of dimension stone "Kik 2". It is located on the southwestern slopes of the Kik hill, which descend towards the Vaganj mountain saddle. On this terrain, the company "Kik stone" d.o.o. Livno conducted investigations in two localities. The first locality is about 200 meters from the asphalt road leading to the town of Sinj in the Republic of Croatia. The investigation area was named "Kik". Soon thereafter, the same company started investigations about 200 meters to the north in the investigation area "Kik 2", the area of which is 4.73 hectares. Geological investigations have shown that the rock masses in this locality are less fractured and of higher quality than in the previous locality. A decision was made to elaborate the reserves of dimension stone at the "Kik 2" locality and to conduct a trial exploitation of the allowable quantities of stone (Figure 6).



Figure 6. Works on the opening of trial exploitation levels at the "Kik 2" quarry (Kik stone d.o.o. Livno)

It is a mountain-type deposit the reference elevation of which is 1090 m a.s.l. The deposit area is an uninhabited hilly area, covered with rare bushy vegetation. The deposit is composed of banked limestones, predominantly micrite and sparite without allochems, formed in a shallow marine environment. The remains of rudist bivalves were found in these limestones, but they are very poorly preserved and it is very difficult to determine them. They mostly occur in nests. These are banked limestones, the bedding planes of which are very weakly expressed in some places. The deposit area is intersected by several minor faults of the Dinaric strike, which do not significantly disturb the compactness of the rock mass. Karstification has penetrated the massif up to 5 meters, and below that depth there is a competent rock that is very suitable in terms of use as dimension stone and gives a fairly high percentage of usability, which is 15.7%. Extraction of dimension stone will be carried out by cutting the rock mass with vertical and horizontal cuts, and if necessary, with slanting cuts with planned development of the excavated space by excavation fields (Penava and Knezović, 2019).

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Geological investigations presented in the study on reserves and quality proved the existence of high-quality limestone reserves in the "Kik 2" deposit for exploitation over a number of years. Laboratory tests have shown that the stone from this deposit has very good physical and mechanical characteristics (Table 3). Of particular note is the high uniaxial strength, the mean value of which in the dry state is 224 MPa, which is a very high value for this type of stone.

Table 3. Physical and mechanical properties of limestone from the Kik 2 deposit

Number	Determination type	Value
1.	Compressive strength in dry state	mean = 224 MPa
2.	Flexural strength	mean = 7.2 MPa
3.	Flexural strength after 48 freezing cycles	mean = 5.2 MPa
4.	Water absorption at atmospheric pressure	= 0.206%
5.	Bulk density	= 2690 kg/m <sup>3</sup>
6.	Bulk density without pores and voids	= 2730 kg/m <sup>3</sup>
7.	Coefficient of bulk density	= 0.985
8.	Absolute porosity	= 1.41%
9.	Open porosity	= 0.62%
10.	Resistance to frost (after 5 cycles of immersion in Na <sub>2</sub> SO <sub>4</sub> )	= 0.1% - resistant
11.	Resistance to abrasion wear (Böhme test)	mean = 10.4 cm <sup>3</sup> /50 cm <sup>2</sup>

The color of the limestone from the "Kik 2" deposit is light gray, less often gray-brownish to ocher. Shades of darker color occur in some places (Figure 7). The stone is massively homogeneous in texture. On the cut surface of the stone, irregular forms of millimeter size, which are lighter in color than the base, can be observed. Straight fractures 1 to 2 mm wide, most of which are filled with lighter calcite infilling, occur in some places. There are also those the calcite infilling of which is darker in color. Stylolitic seams can also be seen. The stone has an irregular fracture.



Figure 7. A polished sample of limestone from the Kik 2 deposit (Kik stone d.o.o. Livno)

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Due to the quality of stone from the "Kik 2" deposit, which is primarily reflected in good physical and mechanical properties and attractive color, the possibilities of its application are wide. It is suitable for external and internal horizontal paving of pedestrian surfaces of all loads, as well as for external and internal vertical cladding. The wide possibilities of its use are listed in Table 4.

Table 4. Mineral composition and applicability of limestone from the Kik 2 deposit

Mineral composition	The rocks that make up the Kik 2 deposit are determined as fossiliferous micrites or limestones with a calcilutite base that contains foraminifera shells (ostracods are visible) and their fragments. The shells have a micrite composition, while calcite cement is in their interior. Straight subparallel fractures filled with calcite occur in the rock itself. Irregular forms filled with micritic calcite cement are also present, and mosaic transparent dolomite of microcrystalline structure can also be observed in some of them. Some grains of authigenic quartz can rarely be found.
Applicability	External and internal vertical cladding, external and internal horizontal paving of pedestrian areas with very high pedestrian traffic load, for the production of various for-use and decorative stone elements, for building decorative masonry walls, for building retaining masonry walls, for the construction of bank protection and for various needs in construction.

After preparing the study on reserves, the company "Kik stone" d.o.o. Livno also prepared the Main Mining Project of Exploitation, and obtained a license for exploitation. Currently, preparations are being made for the beginning of continuous exploitation at this quarry.

## 5. CONCLUSION

The municipality of Livno belongs to the medium developed municipalities of the Federation of Bosnia and Herzegovina. For decades, its economy was primarily based on several companies that employed the majority of population and brought the most income to the municipality. Now, when there is no longer a planned economy and when most of the companies from that time are closed, it is necessary to adapt to the new market economy. This means that entrepreneurship and the development of small and medium-sized enterprises that can employ enough inhabitants of the municipality of Livno and bring much-needed revenues should be encouraged. The recovery of the economy is slow, and every new business launched and every new job is precious, especially at this time when the working-age population is leaving in great numbers not only Livno, but also the entire Bosnia and Herzegovina in search of work and better living conditions.

In the first place, the comparative advantages offered by the municipality of Livno should be used. One of them is undoubtedly the wealth hidden in its mineral resources. One of these,

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so far almost untouched, resources is also dimension stone. Dimension stone means stone that is quarried in blocks, which are further processed by cutting and in other ways, and thus stone elements that are used in construction are obtained (Hajdarević & Babajić, 2018). Today, there is a growing demand for these natural materials in the world market. We should take advantage of this situation and allow businessmen who are engaged in the exploitation of these mineral raw materials to use at least a small part of the potentials that we have in this area. Of course, it is necessary to comply with all legally prescribed environmental standards during the exploration, exploitation and processing of these mineral raw materials.

In Livno, dimension stone is currently quarried only at the "Pogledala" deposit, where the Upper Cretaceous limestone with the commercial name "Silit light" is extracted by the company "Silit" d.o.o. Livno. This company also has a modern facility for stone processing. They have successfully integrated the process, starting with the extraction of blocks at the quarry, cutting them into plates of the appropriate thickness, and ending with the final processing, thus producing a wide range of finished products from their own stone and in their own facilities. By integrating this process, this domestic company creates additional value that helps it survive in the market in the unequal conditions of market competition with importers and traders of foreign stone. Preparations are also being made for the start of continuous extraction of dimension stone at the Upper Cretaceous rudist limestone deposit "Kik 2", which has already been geologically explored, where trial exploitation was successfully carried out and a permit for exploitation was obtained.

Companies that are engaged in the exploitation and processing of decorative stone, or are just planning to do so, should primarily take into account the following:

- conducting high-quality geological research,
- introducing new technologies in the extraction and processing of dimension stone,
- expanding the market and production program selection,
- introducing a valid CE mark,
- introducing a quality system in accordance with ISO standards,
- strengthening marketing activity and
- educating staff.

If the municipality of Livno wants to attract potential concessionaires for the exploration and exploitation of dimension stone, it is necessary to stimulate them in appropriate ways, or at least make it possible for them to obtain permits issued by the municipal authorities within the deadlines prescribed by law. In order to obtain concessions for geological exploration and exploitation, which are issued by the competent cantonal ministry, it is necessary to achieve good cooperation with the government of Canton 10. All these activities require the joint work of competent municipal, cantonal and federal institutions. Certainly, it should be insisted that concessionaires must comply with all prescribed environmental standards.

In order to have a competitive economic branch that implies sustainable growth in the exploitation and processing of dimension stone, it is necessary to pay special attention to geological research, both of the deposits known so far and areas promising for finding these useful mineral raw materials. Suitability for the exploitation of any mineral raw material, including dimension stone, is defined above all by the existence of a deposit, as well as the possibility of profitable production. For a dimension stone quarry to be able to have an economically profitable product, it requires a large competent stone block, and a deposit that has a solid and tectonically undisturbed rock mass. All of this is almost impossible to find without conducting appropriate geological investigations. Based on previous experiences and their own knowledge, the authors of this paper proposed several geological formations of different ages and with different materials suitable for finding economically profitable dimension stone deposits in the municipality of Livno.

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