

Article

Studenica Marble: Significance, Use, Conservation

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Received: 20 June 2019; Accepted: 12 July 2019; Published: 18 July 2019



Abstract: Studenica marble is the stone used in creating the mediaeval Serbian cultural heritage. This is a historical overview of the importance and use of stone from prehistoric times to the Middle Ages, when the most imposing religious architectural structures were built. The significance of Studenica marble is particularly manifested in the Virgin's Church at the Studenica Monastery. For its marble façades and artistic architectural elements, among other things, the church was inscribed in the UNESCO World Cultural and Natural Heritage List in 1986. Through centuries, the Virgin's Church suffered multiple destructions. In order to restore the marble façades properly and its architectural elements, the marble deposits where the stone was once quarried had to be located anew. When the stone material characterisation had been performed, the right stone was selected for the complex conservation works on the churches in Studenica and Sopocani. A practical implementation of the research results raised the awareness of the marble deposits in the Studenica vicinity, being also part of the national heritage. The Studenica Monastery Cultural Landscape Management Plan envisions preservation of the deposits and their sustainable use for restoration purposes in the future.

Keywords: UNESCO cultural heritage; Studenica; Sopoćani; marble deposits; quarry characterisation; restoration; sustainability; management

1. Introduction

This paper starts with the perspective of the importance and role of the natural stone—the marble as a particular type of material—whose beauty and natural properties, from the time immemorial, has always symbolically indicated the presence of the divine, and through its various forms, have emanated its artistic and architectural characteristics.

In the Serbian mediaeval lands, there was one authentic, religious and architectural work built of marble in the 12th century. It was first envisioned as a burial church of Stefan, the founder of the Nemanjic Dynasty, and it was dedicated to the Virgin Evergetis [1]. So, even today, the Studenica Monastery Virgin's Church stands as a testimony to the beauty, the varieties and durability of marble it was made of. For its marble façades and shaped architectural elements of high stonemasonry, artistic and iconographic mastery, among other necessary criteria, the church was inscribed in the UNESCO World Cultural and Natural Heritage List in 1986 [2].

So far, the domain of our scholarly research has remained short of considerations about this fine material and its significance in building the Serbian religious identity and about its artistic shapes and sites it was extracted from. Studying Serbian mediaeval art and architecture for decades now, a substantial body of scholarly material has accumulated along with an extensive bibliography on the Virgin's Church of Studenica [3].

The architecture of the Nemanjić Dynasty's first endowments, including Studenica, has been extensively researched in the works of Canak Medic, M. and Bosković Dj., from 1990 [4]. The first major conservation and restoration works on the monument were conducted in the mid-1950s, as well as the works on renovating some parts of the architectural marble decorations, published by Nenadović S. in 1957 [5]. One of the most important studies of the mediaeval architectural sculpture on the mediaeval monuments was conducted by Maksimović, J. in 1971 [6]. Subsequently, she turned her focus on the Studenica sculpture in 1986 [6]. As for some more recent investigations, there is a special contribution by Erdeljan, J., pointing to the Constantinople models of using the marble in building the ruling dynasty identity and the Virgin's Church [1]. Besides some serious studies of style, sculpture and iconography and some analyses of architectural marble ornamentation and its individual elements, no complex research has been conducted on the origin, types and properties of the marble material. Also, there is an absence of any serious studies of an extraordinary importance of the geological area where the marble was once quarried and its definite impact on the choice of the place for building the principal endowment of mediaeval Serbia.

The only relevant studies were published back in 1956 and 1957, by an author Simić, V., which today provide a broader view of the area, along with some particular results pertaining to investigation, based above all on geological and anthropological aspects. In addition, they include references to the historic quarries where the marble for the Virgin's Church had been extracted from [7,8]. Also, general regional geological surveys give description of the area [9,10]. Furthermore, petrologist Bilbija N. initiated petrographic and chemical tests conducted on five samples taken directly from the marble façades, which is an important contribution to understanding the marble built in the Virgin's Church. The research was started due to extensive remedial and restoration works on the marble façades, that lasted for almost two decades. The investigations are recorded in a report made in 1996, being a part of the Studenica Virgin's Church Marble Façades Restoration Project of 2003 [11].

As a starting point, the research takes that Studenica marble is of special significance in terms of ideology and artistic concept in building the ruling Nemanjić Dynasty's endowments. In its preserved form, the origin of the marble deposits and the exact location can be traced to the quarries it was extracted from and then built particularly in the mediaeval religious structures. Throughout their turbulent history, they were often damaged, and the most vulnerable spots even lost their architectural sculptural elements. So, an important aspect of their restoration would be a proper choice of the original material, traditional quarrying techniques and the art of stonecutting. When the marble is applied in such a way, it facilitates its sustainable use and management of the much broader area—the cultural landscape around the Studenica Monastery. The area itself stands out even more for its quarries as a testimony to an interaction between man and nature. Since this is about a complex explanatory research process, the following goals are set: To establish a special significance of Studenica marble, which will enable a more profound understanding and interpretation of the aspects of its use that are manifold in meaning; To give a description of its use in the construction of some of the most significant monuments of the Serbian Middle Ages; To identify and confirm all the historic quarries that were opened and mined in the Middle Ages; To establish the classification of the marble from the sites and draw a comparison with the previously obtained results from petrological analyses and chemical composition tests in order to define its use in restoring the architectural heritage; Upon obtaining all the results, to conduct research and start with the restoration of the missing elements of architectural sculptural ornamentation on the most important monuments inscribed in the UNESCO World Heritage List; To draw up protection and conservation plans for a broader area around the Studenica Monastery in order to protect the marble quarries, as a special type of cultural and natural heritage, and to make it possible for the local population to participate, in a sustainable way, in managing the World Heritage Site—thus clearing a way for a sustainable development through utilisation of the cultural asset provided by the heritage itself, which would largely contribute to preserving its values for future generations.

The paper consists of a short overview about the use of stone from the prehistoric times to the Middle Ages when the most important ruler's endowment, the Studenica Monastery, was built in mediaeval Serbia. Analysing the use of marble on the most significant mediaeval church structures, we give an overview of the style features, but also of the ways and techniques of manifesting the architectural sculptural ornamentation. Surveying the area around the Studenica Monastery, quite a number of marble quarries have been discovered, with several that have been in use since the Middle Ages. Also, a poll has been conducted to establish a number of families in the surrounding villages, who have been traditionally in the business of marble quarrying since the late 19th century up to the present day.

Descriptions of a geological character of the area and the marble sample testing have determined the choice to have determined the choice of the material for the architectural decorations restoration project in both the Sopocani and Studenica.

The most significant results have been provided in two case studies, when after the works were completed, numerous hitherto lost values have been augmented. In the end, the Discussion gives a reflexive process leading to recognising and valorising the Studenica historic marble quarries as an important cultural resource, which allows for a sustainable development by raising and spreading awareness of the significance, use and preservation of Studenica marble as an integral part of the cultural and historical architectural stone heritage.

2. Historical Background of The Marble Stone Works and Use from Prehistoric Times to The Middle Ages

The use of stone and stonemasonry are as old as humanity itself. The first traces of human spirit and of the ability to act creatively were imprinted in stone; marking the beginnings of the cultural history of mankind, testifying to the intellectual strivings and endeavours of the first peoples in shaping their environment. A tactile relationship of man with stone has been identified in eastern Africa some two million years ago, where the fossilised remains of the first genus *Homo*, the *Homo habilis*, were found along with numerous stone tools. More improved stone objects, in terms of technology, design and variety, have been discovered in south-eastern Asia and India some 1,600,000 years ago, whereas in Europe they started to occur about 1,500,000 years ago. The genus *Homo erectus* learnt how to "coax" fire from stone around 600,000 years ago, leaving this precious craft to posterity, so that some 300,000 years ago, his descendant, *Homo sapiens*, could make a variety of specialised stone tools, and to use the stone as his first consecrated object—a tombstone [12]. Anthropological and archaeological investigations record that 35,000 years ago a man called *Homo sapiens* inherited all the hitherto acquired skill of shaping and working the stone, already developed as a coherent technological system. Besides their utilitarian value, the produced stone artefacts also had a powerful symbolic and religious role. Durability, strength and power of the material initiated an idea of its sacredness [13]. Sculptural imagination in a shape of a woman's figurine known as the "Venus of Willendorf", dated to the Upper Palaeolithic (c 25,000), marked the birth of the first stone art.

However, one of the most amazing prehistoric monuments of stone architecture is the artistic stone works of Göbekli Tepe, discovered in the Upper Mesopotamia region, present day Anatolia. It represents a hierarchical architectural structure made of limestone rings. They are of high artistic and craft value, a series of massive pillars topped with heavy stone blocks in the shape of the letter T, presenting a narrative, mythological, zoomorphic and anthropomorphic stories committed to relief. The site was identified as the oldest and most exciting work of religious architecture. A highly developed system of beliefs had been a prerequisite of the civilisation progress from the Mesolithic to the Neolithic era [14]. In its vicinity there were numerous prehistoric quarries and plateau-like workshops, where the T-shaped pillar "negatives" were found, as well as numerous remains of the pillars, resulting from the work process. The stone and bone tools are the evidence of the level of technology implemented in quarrying and building this magnificent architectural complex that is a real masterpiece of the human creative genius [15] (Figure 1).



Figure 1. Göbekli Tepe © DAI whc.unesco.org/en/documents/165845.

Later on (6800-5800 BCE), the Lepenski Vir culture brought individual stone figures of human and fishlike attributes, in various sizes and of specific artistic workmanship and symbolic function [16]. Similarly, on the territory of present day Turkey (6000 BCE), the use of marble as an aesthetically valued material was recorded in the shape of human figures. Then, in the fifth millennium on the Balkans, we have anthropomorphic marble figurines discovered in present day Bulgaria. Also, some marble artefacts have been discovered in present day Romania [17]. In the late fourth millennium, at the very end of the period that we call the *Stone Age*, we frequently find *menhirs*, the freestanding upright stones that were sanctifying the open space area—forever marking the human creativity in service of the divine presence [18].

The establishment of the first historical civilisations, that lasted from 4000 to 3000 BCE, relates to the end of a millennium long process of stone conceptualisation, discovery of its special properties and the possibilities of its use. Marble, as a material of special characteristics that enabled its fine processing, was used in establishing the magnificent Cycladic art. It goes back to 4500 BCE, but from 2600 to 1000 BCE, we find the real pieces of art made in marble of a highly sophisticated minimalistic form [19]. Besides the common interpretations, the prehistoric cultures art aesthetics should also be understood in the frame of religious meanings and social power within the given time and space [20]. This is evident in different and territorially remote sites where various stone ritual figures were found [21]. However, more intensive and developed stone quarrying and working for building purposes occurred in the Iron Age when the application of iron and tool making enabled, although primitive, a more organised exploitation of hard stone masses for imposing stone structures of the periods yet to come [22]. All the subsequent periods of human culture inherited the millennia long experience and knowledge of the stone complex properties and its symbolic meanings. Also, in a technological sense, certain stone types and properties were selected over others, only to be used in creating a vast variety of forms and shapes in architecture, religion and art of different peoples and cultures.

The civilisation advances throughout history are most distinctively identified by their architectural heritage made in stone. Due to its excellent physical and mechanical properties, the stone is a long-lasting material. Monumental architecture from the Ancient Egyptian period is the most striking testimony to the power of architectural expression and the durability of stone material. In the Nile River Valley and the areas towards the Red Sea, as many as 196 ancient quarries have been identified, providing various types of igneous (magmatic) and metamorphic rock material [23]. The most intensive temple building activities have been recorded in other lands of ancient civilisations such as Phoenicia, Mesopotamia or the Aegean basin, where the structures were built of natural stone. In many cases,

the technology of quarrying, large stone blocks and megalith cutting in those regions have remained a mystery until the present day.

In the lands of the Far East, the history of human civilisation has recorded some of the most striking examples of cultural and religious structures made in stone. A remarkable manifestation of human artistic creation consisting of almost 110,000 Buddha stone statues, more than 60 stupas and 2800 inscriptions carved into the stelae have been preserved in the unparalleled grandiose sculptures of the Longmen Grottoes in China. In a continuous evolution from the 5th to the 8th century CE, an exceptional interaction between man and nature have been recorded, consisting of giant figures carved in the Chinese cave art, containing original Buddhist culture and its spiritual and aesthetic functions [24] (Figure 2).



Figure 2. Longmen Grottoes (China) © NDRistić.

The most fruitful architectural and artistic stone creations in Europe belong to Ancient Greece and Rome, when numerous architectural and structural works were done, such as the sacred complexes and temples areas. Those range from exceptional sculptural works, sarcophagi and votive objects to the Roman grandiose ones—forums, bridges and aqueducts.

The aesthetic and technological perfection of the stone works in architecture and art was reached with the use of marble in Ancient Greece. The Parthenon (447–432 BCE) ranks among the most harmonious and artistically perfect work of architecture of the Antiquity. It was constructed from a fine grained white Pentelikon marble quarried in the famous Mount Pentelikos quarries [25]. The marble was used for temples and various public Agora buildings, whose lavish sculptural ornamentation made them distinct from other structures. Marble polishing, the texture and polychromatic effect under the sunlight gave out an impression of a superhuman nature emanating from the gods [26]. For such creations, first there had to be a special marble extracting technology at quarries where large blocks were being prepped and the marble cut on the spot, applying advanced cutting techniques. The blocks were then transported on for further use in construction where it was worked into final shapes. Carving sculptural forms in ancient architecture was a special architectural and artistic process with an implementation of various methods—from shaping creative ideas, making the drawings and then doing the practical work, to the final mounting and fixing in position in the already designated place in the structure. The most magnificent marble sculptural works in human history on the European Continent were made in the 5th century BCE (Figure 3).



Figure 3. Acropolis, Athens (Greece) © Ko Hon Chiu Vincent. whc.unesco.org/en/documents/156667.

The use of marble flourished in Rome. Besides its extensive use in architecture, bringing new building systems and materials, it was used to make portraits, carve in epigraphs and in funerary works of art, where the sarcophagi, as permanent repositories for the remains of the dead, were usually made of marble as a symbolic material of eternity [27]. The meaning of the ancient world art made in stone is to be understood as a pinnacle and the final goal of the ancient principles of beauty made in stone.

Following the tradition from Antiquity, the mediaeval period transforms the stone into some specific inherited forms, introducing the complex Christian symbolism. Since the Antiquity sculpture was considered pagan, new messages started to be imprinted into the stone of religious buildings; accomplishing impressive artistic architectural advances, so much recognisable in Western Christianity. The pre-Romanesque and Romanesque architecture manifested a somewhat reduced expression, whereas the Gothic structures brought it to its fullest potential, often called the “books of stone” [28]. That said, the primary principles and the knowledge were drawn from the world of Antiquity where the *septem artes liberales* and *quadrivium* in particular enabled an integral development of religious architecture where the sculptural ornament was just a part of a whole that symbolised the entire Divine Universe.

Ever since Justinian, in Byzantine architecture marble was used by the Constantinople master builders, constructing the temples of the Capital City, which is manifested in many pieces of preserved architecture as well as in numerous texts—the *ekphrases*. Marble as a material and its use in creating consecrated church areas unmistakably bring forth the presence of a divine power in generating the beauty of the temples [29]. A marvellous skill of the craftsman to create sculptural church ornaments is described in “surprising, supernatural and noble properties of stone”, possessing and evoking power and mystical meanings with an aim to leave a profound and long-lasting impression on a spectator. In their theological and ideological sense, the architectural and artistic creative works of Byzantium was quite profoundly reflected in the mediaeval Serbian lands.

The mediaeval Serbian religious architecture and its artistic stonework were drawn from two different worlds. A long-lasting presence of the Roman civilisation in the region and the vicinity of the Western world in the Adriatic region on the one hand, and the artistic stonework crafts brought from the vast influence of the Byzantine cultural tradition generated some original architectural, artistic and iconographic masterpieces. Although the mediaeval Serbian art of stone carving and sculpting cannot match the high artistic spheres of the Western and/or Byzantine religious architecture, their presence on the endowment monumental temples testifies to the impact, understanding and historical developments of the Serbian culture and religious aspirations expressed in artistic stone formations [30].

This short overview of the heritage use of stone and the origins of architecture within the world culture development does not aim to provide a chronological systematisation of this immense subject, instead it aims to give a short and perhaps subjective glance at—and once again remind people of—the significant achievements of civilisation with regard to the architectural works in the time when Studenica Virgin's Church was erected. It was valorised as the World Heritage owing to its marble attire. Today, our goal is not only to protect the monument itself, but also to preserve the cultural landscape, as it includes the marble deposits whence the material for the Virgin's Church comes from.

3. Research Process Phases

3.1. *The Use of Studenica Marble on The Mediaeval Serbian Churches*

Artistic stone work in the lands populated by the Serbs is well-known from as far as the Lepenski Vir and Vinca cultures, through the times of Antiquity that left us skilful stone work in architecture and sculpture, all being direct sources and models in the times yet to come. A long-lasting presence of the Roman civilisation, an easy access to the Western world via the Adriatic region and the artistic stonework crafts coming as an influence from the vast Byzantine cultural tradition generated in these lands some original pieces of church architecture built in natural stone.

The architectural exterior forms of the mediaeval Serbian churches built in the period of the rise of the Serbian state and Church in the 12th and 13th centuries are reflected in an articulated three-section interior plan with a central dome, coming as a result of Byzantine influence. On the other hand, the Romanesque influence dominates the façades, featuring compositions made of carved stone decorations on the blind arcade friezes, marble portals, corbels, windows and pedestals, columns and capitals. The basic church building structure was constructed from various stone materials, whereas the exterior architectural and sculptural elements were mostly carved in marble, shaped from clearly profiled architectural elements: from modest ornaments to floral, zoomorphic and anthropomorphic images with figural compositions of highly complex symbolic content. They were carved by experienced master carvers, most probably coming from the Adriatic region. Visible impact of the Romanesque architecture came from the Apennine Peninsula, while the Byzantine influence is present in the symbolism, iconography, themes and in certain stylistic details ([6], pp. 63–82).

One of the most significant mediaeval Serbian endowments, the Studenica Monastery and the Virgin's Church (Holy Theotokos), was built by the Great Prince Stefan Nemanja. The church represents the greatest feat of an authentic architectural style called the "Rascia School" [31]. This original piece of architecture came about as a reflection of a specific position and political orientation of the mediaeval Serbian state. By making a synthesis of the two architectural models—one coming from Byzantium and the other from the West—the marble-wrapped Virgin's Church was materialised. The use of the polychromatic marble on the church exterior façades may have been drawn from the extensively applied material in the church architecture of Constantinople [1]. Its "Romanesque" portals and windows are shaped according to an already set geometrical scheme, completed with various figural images, lavish floral ornamentation and interlaced combinations of both (Figure 4).

On the one hand, the entire aesthetic of the church structure is visible in a synchronised materialisation of the portal and the windows, while on the other, the stone carved decorations on certain architectural marble elements were formulated in a variety of ways. There is a special classic feeling in shaping the capitals of the free-standing colonnettes, showing visible differences in the manner and the extent of their construction. On the south portal there is a luxuriously carved frieze made of Corinthian capitals with human heads, whereas the north ones feature only an abacus. It is quite normal for the Romanesque portals to have differently carved capitals that flank the portal, as well as the entire door frame [32].



Figure 4. (a) The Church of the Holy Virgin 12th century view from the northeastern side. (b) Southern portal © LiveViewStudio.

The bifora windows feature a variety of carved capitals unevenly decorated but evenly shaped at one and the same workshop. Besides sculptural carvings with the use of chisels and picks in order to generate classical motifs of a stylised Ionian volute with a Romanesque-like leaves or floral pattern on the calathos, here we also have a specific use of drills for making numerous holes in order to free the carvings from the rest of the material, but also for decorative purposes, for creating a sense of inner dark shades. In order to make a better visual impression, the holes were filled with molten lead. Such a way of doing the stone capitals was going to be used as a model for carving capitals on other church structures in the 13th century [33] (Figure 5).



Figure 5. (a) Sopocani Monastery 13th century (b) Gradac Monastery 13th century © NDRistić.

By the end of the 13th century, sculptural decorations were applied on the churches from the Nemanjic Dynasty period. In somewhat simpler architectural shapes, the stone sculptural ornamentation was accentuated with the use of polychromatic marble, quite characteristic for the Holy Trinity Church of Sopocani, an endowment of the King Uros I and for the Holy Virgin's Church in the Gradac Monastery, an endowment of King Uros's wife, the Queen consort, Helen of Anjou. Wishing to reach the architectural and aesthetic harmony of the temple built by the founder of the Nemanjic Dynasty, the ktetors of the subsequent churches brought in the carved ornamentation as a heritage of dynastic architecture, trying

to emulate Studenica. The marble for the ornaments was being transported from the Studenica deposits, from the same quarries the Studenica Virgin's Church was made eternal [34].

However, the mediaeval Serbian church architecture saw some rather turbulent time. Some of the most significant buildings endured both destructions and renewals. The most sensitive spots of destruction were the elements of architectural sculptural ornamentation, particularly at times of tectonic movements and earthquakes. However, the material traces that remained, made it possible to restore what had been demolished.

The 20th century was focused on renewing the most significant monuments of mediaeval Serbia. If the level of damage or the total level of authentic data and architectural elements that were preserved made it possible to restore the original shapes without any arbitrary inputs or hypothesising, then either partial or total restoration was to be undertaken. Such restoration comprised all the primary steps and procedures based on detailed and reliable analysis of all the available data and knowledge gathered through archaeological, architectural, historiographical, archival and other investigations [35].

The full awareness of the importance of the artistic and aesthetic valorisation in interpreting the historic monument's architectural characteristics was a prerequisite for their conservation within their twofold nature of both tangible and spiritual artefact [36]. The process of defining the steps in conservation and restoration of architectural elements, with regard to an overall architectural structure, was always an important starting point for each subsequent activity. Depending on the material data and the number of archaeological finds of architectural sculptural ornamentation, different steps were taken in their recording, processing, further use, inset into a building and presentation. An order of possible interventions was changing from case to case. At first, materials used in restoration, particularly in carving new marble elements, were not considered much, save their type and colour.

Therefore, in recent decades, while working on remedying the marble façades on the Virgin's Church of Studenica and in the restoration works on the churches in both Sopocani and Studenica, there was a special focus directed to selecting the material from the original marble quarries that had been used in the Middle Ages to obtain the marble blocks. Bearing in mind that both sites are on the UNESCO Heritage List, special care was taken in analysing the available data for the restoration and conservation, as well as in selecting the material for the reconstruction of the missing architectural elements.

3.2. Identification of the Mediaeval Quarries in The Vicinity of The Studenica Monastery

The conservation and restoration works on an architectural heritage built in natural stone require investigations and tests to be done previously to determine the overall condition of the monument, the nature and forms of periods alternations on the structure itself, a macroscopic examination, sampling the used materials, then certain petrographic and chemical tests, and also going back to the places where the stone material was quarried for that particular structure because of its potential use today, as well as the cultural, historical and natural significance of preserving the broader area of the monument site.

The Studenica Virgin's Church is a unique monument of the Serbian national heritage where the entire structure, save the narthex that was built on a later date, was erected in one single type of marble, the varieties of the Studenica white marble that come from the same petrographic structure but from different quarry sites (Figure 6).

Marble is a compact crystalline rock consisting of minerals and is used in shaping architectural elements, since it possesses properties necessary for ornamentation, so it is classified as a decorative stone [37]. This fine material of quite specific properties is suitable for building structures and here it was most probably used for the first time for erecting the Studenica Virgin's Church.

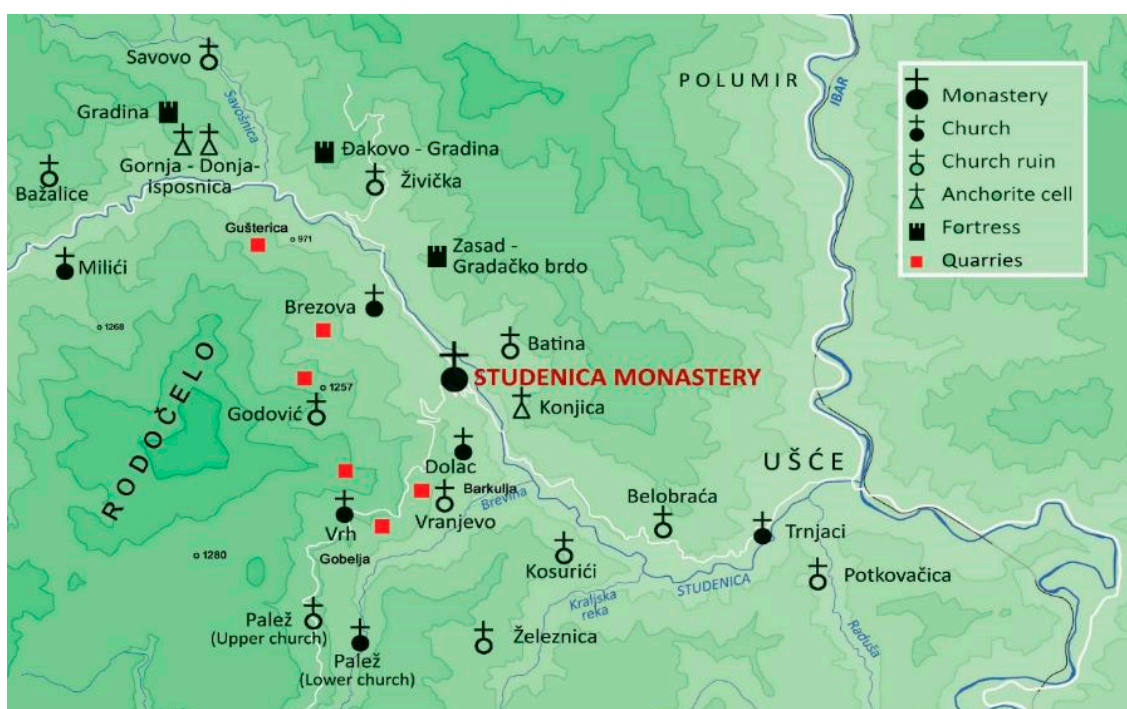


Figure 6. Map of Studenica river basin—Monastery, Church, Church ruin, Anachorete cell, Fortress and Quarries © A. Stanojlović (Management Plan of Studenica Monastery 2018).

About 4000 marble elements of various sizes and shapes were used to build the exterior church walls, which points to substantial amounts of the rock that had to be extracted from the local quarries. The largest elements were used for the portals, but a macroscopic survey of the façades pinpointed a certain number of marble blocks in the architectural structure that were even 2.25 m long [11]. The marble elements in the façade walls possess significant properties of the rock mass where they were quarried from: heterogeneous appearance coming from a pronounced lithological discontinuity in the form of thin layers with exokinetic fractures of various prominence. The structure was built in an alternating horizontal row of perfectly dressed stone elements of uneven dimensions and heights, which may be attributed to the rock mass they were extracted from [11]. The whole process of extracting, selecting, shaping and transporting the blocks may be reconstructed to a certain extent. As the quarry sites are distant from one another, on average about 4 km between them, the church marble is pretty heterogeneous. Land trails have been identified, still not archaeologically investigated, though, which indicate a possible path the marble was being brought to the construction site. The abundance and a fine quality of the stone, as well as the particular features of the natural surroundings may have been a deciding factor in the choosing of the site for erecting the most significant endowment of the Nemanjic dynasty.

According to his biographer, the selected site for building the Studenica Monastery, as an endowment and a burial place of Stefan Nemanja, the place had once been “an empty hunting ground” [38]. The place where the monastery was built is a naturally flat area above the Studenica River right bank, lying under the north slope of the Radočelo massif. The existing shape of the terrain, the surrounding rock massifs and the composition of the soil were obviously primary factors in selecting the area and the location for building the monastery complex, as well as in deciding on an architectural concept of shaping and constructing the monasterial settlement, the Virgin’s Church in particular [39] (Figure 6).

The Radočelo mountain massif belongs to a group of older geological formations with areas of white and polychromatic marble, while the flat area itself consists of a hard rock bed of green-brown schist serpentine rock occurring at various depths in regard to the land surface [40]. A particular natural resource was a productive marble belt in the eastern and north-eastern slopes of Radočelo, with quarry

sites between three villages, today known as Vrh, Dolac and Brezova. In that area, where marble has been quarried until the present day, numerous deposit sites have been identified, which we know have been exploited since the Middle Ages. With time, along the rocky massif, in places that were almost inaccessible, stonecutting settlement communities were formed, which today help us in orienting and locating the marble quarries. Each of the said villages extend to several hamlets—Vrh with its Gobelja hamlet, Dolac with the hamlets of Vranjevo, Backulje and Bozici and Brezova with its hamlets of Godovic and Gusterica (Figure 7).



Figure 7. Historical Quarry in Vrh (Kotline) © NDRistić.

The Vrh village quarries are situated on the south slopes of Backa Stena, at elevations of 1150 to 1050 m, known as Draskovac. One old Studenica quarry was identified also near Gobelja hamlet, in the place called Kotline. Along the quarry goes the Brevina River gorge formed by the deposits of marble material. Here, the traces of old marble quarrying techniques have been found. Inspecting the rock, the positions of the holes have been observed, where wedges and iron levers were used on the rock to extract large blocks. Also, some old tools have been found such as a massive sledgehammer of about 7 kg with one side shaped into a pick, as well as one plug made of hard solid iron [7].

Strip blocks of blue-grey marble on the Virgin's Church come from this quarry site. Although there are varieties of marble strips in other quarries in the vicinity, these fine types are of very fine grain structure, basically white or blue-grey in colour. The exquisite beauty of the marble is the section where white, unpigmented stone alternates with the pigmented ones, mostly grey to black-grey shades. Horizontal marble strips are of 2 mm to 10 mm thick, quite eye-catching at places or sometimes rather low-key. When looked at closely, it may be observed that within one pigment vein there is a strip-like structure with millimetre thick blue-grey lines of different intensity [7]. Some of the most beautiful are varieties on the church façade with 4 strips at 12 cm. Their depth of extraction could not have been more than 60 cm, which apart from the aesthetic effect, points to a functional choice of this construction variety. In its consistency, it is classified as natural stone easy to carve, cut and polish, which is best manifested in the work done on the Studenica Virgin's Church windows and portals. The marble stripe layers were cut into blocks that were then very carefully, depending on the cutting directions, fitted into the façade walls. Choosing different directions of cutting relative to the stone structure, the builder wanted to accentuate certain church elements. The portals are mostly built of this variety marble blocks, although there are details of carved architectural elements in pure white blocks, like for instance, toned portal columns in the south vestibule. A special dynamism is achieved in vertical pilaster strips cut in blue-grey veined marble, combined with white short columns.

Those quarries, at much deeper layers, there are varieties of pure white, fine grained marble deposits, however, in smaller amounts. The fact that there were small amounts of the pure white marble at the time of the church construction is confirmed in only a few architectural elements carved

in white stone, such as the altar trefoil, the west façade *biforas* and 3 m tall cylindrical columns on the main portal. There is less than 10% of the white block on the exterior façades.

The finest small grain marble varieties come from the quarries in Draskovac, Kotline and Godovic, belonging to the same name hamlet of Brezova-Godovic. The Godovic quarries are situated on the north-east slopes of Krivaca, at elevations of 1280–1380 m. There are several deposit sites, but the largest and most productive ones are the Godovic quarry, the Stari Majdan (Old Quarry) and Secina. It is believed that most of the marble used in the church construction was quarried from these sites. As for the old tool finds, only one iron plug has been discovered, but no old traces of stone extraction have been observed, as marble quarrying has been going on constantly since the construction of the monastery [7]. The remains of an erstwhile settlement of dugout dwelling houses lined with broken marble set in an uneven course indicate that it was the period of the Middle Ages. Nearby, at the settlement there is a water source and quarry above. The very name of the place, Secina (from Serb. *Seći*—to cut) is a typical mediaeval toponym for places where marble blocks were extracted, cut into smaller ones and transported to the construction sites. The marble from these sites are of pleasant tones from white and blue-grey to ochre and ivory shades. In the same area, there are belts of marble deposits called Zmajevac, of monochromatic character, at 1640 m of elevation. However, there is a drawback due to the large amount of schist, so when cut, it separates along the diaclases.

The area and steep cliffs make the sites rather hard to access in modern times, as well as the application of modern stone extraction techniques, save the old ones using picks and hammers. So, until the present day, marble extraction has been done manually. Furthermore, and interestingly, in cutting and polishing processes, no water was ever used, although the area abounds with it (Figure 8).



Figure 8. Historical Quarry in Godović © NDRistić.

Godovic is a stonecutting settlement with centuries long marble quarrying tradition. It has always been far and wide famous for its marble gravestones that caravans transported to distant lands [7]. Similarly, many other hamlets and settlements in the area fostered the stonecutting craft. Almost every house earned their living by working the stone. The mastery of the craft was conveyed from generation to generation, and entire families have been known as stonecutting masters for several generations. Some old census records show all the villages and houses that have been working with marble since the late 19th century. The latest publicised information about it dates from 1957. However, a recently conducted poll have shown a rapid decline in the craft due to migrations to towns and cities.

In the mid-20th century there were some attempts to extract Studenica marble using an industrial exploitation model and on that occasion the mining and geology experts surveyed the structure and

character of the stone from several quarrying sites. In addition, this form of exploitation lasted for several decades and on various sites, particularly in Kotline. However, due to land ownership structure changes and rather unfavourable exploitation conditions, this model was abandoned. Nevertheless, at that time, the commercial names for Studenica marble came about: fine grained “Studenica White” and large grained “Studenica Crystalline” that are dominant varieties in the north slopes of Radocelo, from Brezova towards the mid-section of the Cemerno mountain range where new quarries have been opened up [41].

Surveys of the geographical area of the Studenica Monastery and the surrounding quarries once again highlighted the primary significance of this precious resource that is manifested in an interaction between the features of the area, architecture and local traditions. A special aspect here focuses on traditional craft mastery, techniques and technologies that are still being conveyed to future generations. Also, the information gathered in the field show that, for instance, a proprietor of the Godovic quarries, a resident of Godovic, is at the same time the quarry manager, and that his family have been in the stonecutting business for more than a century.

Owing to the preserved stonecutting tradition, this was the quarry where the original marble blocks for restoring the bifora on the Sopocani Monastery St Trinity Church came from. In addition, this was the same source of marble for conducting one successful restoration on the Studenica Virgin’s Church.

All the anew collected information and knowledge point to a significant resource in the form of a natural stone—Studenica marble. The natural landscape has been shaped for millennia, now featuring rural scenery marked by the quarries that are an integral part of the present, so recognisable, Studenica Monastery cultural landscape. Raising awareness of the tangible and intangible characteristics and values of this natural material facilitates promoting the area sustainable preservation and transference of knowledge and cultural meaning to future generations. This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

4. Studenica Marble Geology and Petrographic Description

4.1. Geological Fabric of Studenica Olistoplaque and Its Immediate Surroundings

According to its position, the Studenica olistoplaque as a geotectonic unit of the lower level is bounded to the west by ophiolitic mélange of the Senonian age at the point of contact with the Dinaric flysch of the same age, in the east its border is almost everywhere covered with allochthonous ultramafic rock, and only in the northeast clearly follows its tectonic contact with the Triassic metamorphic rock of the Kopaonik Mt. “In the south, this unit spreads over Cemerno, with characteristic metamorphic rock of the ‘Studenica series’ as a substrate [10] (75)” (Figure 9).

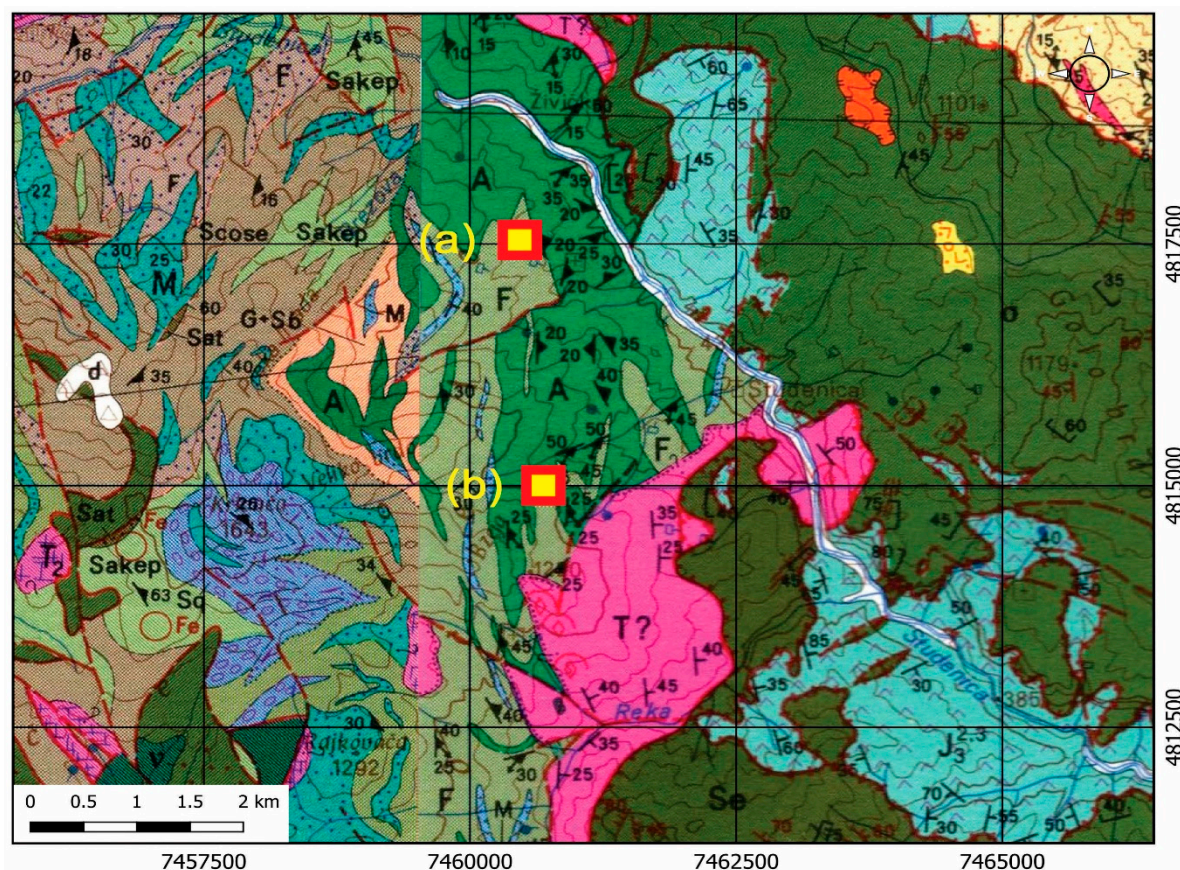


Figure 9. The geological map of Studenica olistoplaque, according to Basic Geological Map. Ivanjica and Vrnji sheets [42] (a) Quarry in Vrh. (b) Quarry in Godović.

According to its position, the Studenica olistoplaque as a geotectonic unit of the lower level is bounded to the west by ophiolitic mélangé of the Senonian age at the point of contact with the Dinaric flysch of the same age, in the east its border is almost everywhere covered with allochthonous ultramafic rock, and only in the northeast clearly follows its tectonic contact with the Triassic metamorphic rock of the Kopaonik Mt. In the south, this unit spreads over Cemerno, with characteristic metamorphic rock of the ‘Studenica series’ as a substrate [43]. Due to the complexity of this geological mass, the mentioned authors divide it into two parts. In the upper part of this series there are limestone and dolomite, that is, marble and dolomite marble ([44], p. 200), depending on the degree of metamorphosis. The floor of this carbonate series includes phyllites, green rocks and amphibolite. According to Rampoux J. ([44], p. 202), in this marble floor, crystalline schist alternates with marbles, which is a result of a very complex tectonic structure. Dimitrijevic, M.D. assumes that the Studenica series can be an original part of the Drina-Ivanjica element that, during geological history, has separated and merged with the Vardar zone, “... , a part of which it can be (but not necessarily!) considered from the Senonian age onwards ([10], p. 81).”

4.2. Petrographic Description

Marble deposits in the Studenica olistoplaque have been used for a very long period as a technical-construction and architectural-construction stone [10] Studenica marble quarries which are even today exploited in a traditional way, are located on the right bank of the Studenica River, between the settlements of Gušterica and Vrh.

As a universal medium of multiple architectural significance, Studenica marble is characterised by durability in terms of time, resistance to the adverse effects of atmospheric agents, abrasive influences and chemical-biological agents. These features were, in addition to old master, recognised in modern

Serbia by the pioneers of geology and mining as peculiar, thus in the Review of Minerals in the Kingdom of Serbia for the Paris Exhibition in 1900 the following was stated:

“Studenica marble. At Radočelo, near the Studenica Monastery, and especially in Brezova, there are still famous marble quarries from ancient times. This Studenica marble was used for the embellishment of many endowments of the Serbian kings from the Middle Ages. Marble intercalations are found here in amphibolite, actinolite and various other Archaean schists. Two varieties can be distinguished: grainy and schisty; the former is white and forms thicker banks than the latter which is often bluish ([45], pp. 101–102).”

Previous studies of five samples of the Studenica marble, which were obtained by probe drilling of the built-in stone of the Church of the Virgin, show the following characteristics:

Petrographic studies have found that the marble for its mineral composition is heterogeneous and anisotropic. The Studenica marble is distinguished by an irregular grainy structure, thus small, medium and large-grained varieties can be found in the same mass ([45], pp. 101–102). The marble is permeated with millimeter-size strips, indicating the lamination of the primary carbonate rock. In some lamina, richer in clay component, the formation of non-carbonate minerals—finely-flaked sericite, quartz, and subordinate albite occurred during metamorphism. Graphite powder, anthracite, formed by transforming organic matter, is the cause for blackish-striped parts.

Based on chemical tests, a very high content of calcium carbonate (98.9%) in an average sample dominated by non-pigmented parts was identified [11]. The chemical composition of marble is shown in Table 1.

Table 1. Average chemical composition of samples of Studenica marble ([11], p. 47).

Chemical Composition	SiO ₂	Al ₂ O ₃	FeO	Fe ₂ O ₃	MgO	CaO	Other
Presence	0.82%	1.13%	0.20%	0.17%	0.87%	55.55%	41.26%

Tests of marble fragments with schisty texture and macroscopically visible sericite content and dark pigmentation indicate an increased non-carbonate component content in the insoluble residue that varies about 9%, of which an organic component is 0.15%, on average.

Based on X-ray analysis of an insoluble residue, which is not annealed, the following minerals have been identified: quartz, mica (muscovite), dolomite and calcite. In annealed insoluble residue, using the same type of analysis, the following minerals have been identified: quartz, mica (muscovite), periclase and graphite ([11], p. 48).

The properties of the stone include a series of properties that condition its application and impose restrictions on its use.

The physical properties of Studenica marble include color, density, porosity and hardness.

No new data were found on the color of the marble, while the following descriptions refer to its visual appearance:

“The Godovic quarries marble: fine, white, bluish, rarely striped ([7], p. 252).”

“The most widespread are masses of monochromatic, fine-grained marble, the color of light ivory at the Zmajevac mines site and Preka Livada” ([7], p. 253).”

“Marble mass is fine-grained; it is white with greyish tones. There are also grayish, monochromatic and striped marble masses in the village of Vrh, Kotline quarry ([7], p. 250).”

“The Brezova marble is exclusively coarse-grained. The color of marble is white with grayish tones ([7], p. 250).”

“The Brezova marble is exclusively coarse-grained. The color of marble is white with grayish tones ([7], p. 253).”

“Marble from Radočelo-Studenica: Full crystallinity and varied grain orientation. Shiny shale gloss. Beautiful whitish and yellowish color ([9], p. 140). “White types of the Studenica marble still tend to “absorb” dust, thus if exposed to the east winds for a long time can turn yellow ([9], p. 142).

Tests on bulk density, water absorption and open porosity were performed on all five samples, and the results are presented in Table 2. Based on the obtained results of open porosity and water absorption, it has been established that this is a very compact marble.

Table 2. Physical properties of the Studenica marble ([11], p. 48).

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Bulk density (g/cm ³)	2.68	2.69	2.67	2.67	2.64
Water absorption (% of mass)	0.16	0.11	0.18	0.30	0.36
Open porosity (%)	0.44	0.30	0.49	0.80	0.97

According to Janjic ([9], p. 140), the Studenica marble in situ is characterised partially by stronger brokenness and sporadically large grain size. This is supported by the findings of Bilbija, on the physical defects manifested by the separation of smaller or larger fragments and the appearance of very pronounced secondary cracks, which links these phenomena to very strong stress in the construction of buildings ([11], p. 51).

Considering that the Studenica marble mass consists of small, medium and large-grained varieties, the following observation by Janjic, is very important: “In marble, medium-sized types are more favorable for dressing than small-grained ones, because in their decomposition they rarely create uneven and shell-like surfaces—as in onyx and marble limestone. On the other hand, lamellar grains of large-grained marbles are always more easily damaged, so they are more resistant to weathering ([9], p. 130)”.

4.3. Results of The Study Of the Studenica Marble at The Sites of Godovic and Vrh

During the field visit at the sites from which the Studenica marble was extracted for the restoration works on architectural sculptural ornamentation on the Church of the Holy Trinity in Sopoćani and the Church of the Virgin in Studenica, a total of three samples were taken, that is, two from the quarry in Godovic, and one from the quarry in the village of Vrh.

Leica DMLSP Polarizing Light Microscope and Leica DFC290 HD digital camera were used for the tests which were carried out at the Geological Institute of Serbia in Belgrade.

Sample 1 (quarry in Godovic)—marble (Figure 10)

The rock has saccharoidal appearance, it is white with very rare dotted pigments—yellow-brown stains. It has massive texture and granoblastic structure. In the specimen analyzed with the microscope, it was noticed that it was formed by irregular to polygonal growth of grains of carbonate—calcite ± dolomite in the size of 0.2×0.1 to about 1.5×1 mm (dominated by grains of size about 1 mm).

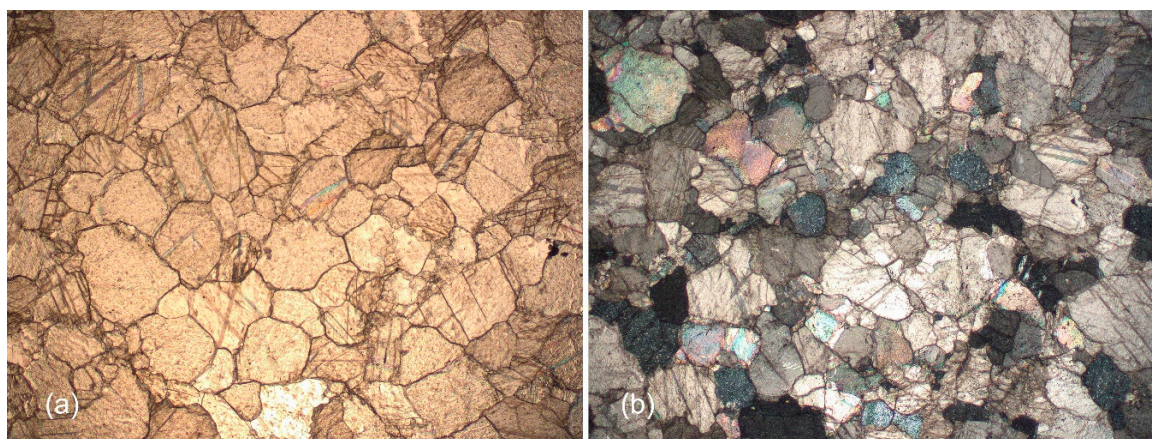


Figure 10. Macroscopic structure of sample 1 marble: (a) With parallel nichols (b) With crossed nichols.

Very rarely, small deposits (0.1 to 0.3 mm) of fine-grained chlorite were observed in the interstices between the grains. It is dominated by calcite and CaCO₃ component.

Sample 2 (quarry in the village of Vrh)—**marble** (Figure 11)

The rock is white and has saccharoidal appearance. It has massive texture and granoblastic structure.

It was formed by irregularly polygonal intergrown grains of carbonate—calcite ± dolomite in the size of 0.2 × 0.1 mm to about 1.5 × 1 (dominated by grains of size about 0.7 to 1 mm). Very rarely were fine rounded grains of quartz up to 0.1 mm in size observed, as well as occasional sericite and chlorite flakes. Rare irregular forms (0.1 to 0.2 mm) of non-transparent matter (metallic or organic?) were also observed. It is dominated by calcite and CaCO₃ component. The rock has very similar properties as in sample 1.

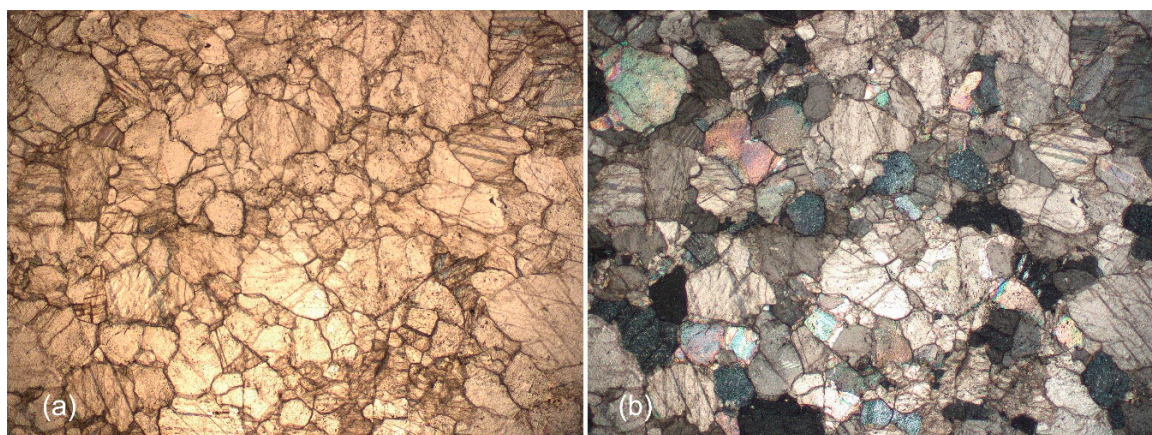


Figure 11. Macroscopic structure of sample 2 marble: (a) With parallel nichols (b) With crossed nichols.

Sample 3 (quarry in Godovići)—**schistose marble** (Figure 12)

The rock is light grey. The texture of the rock is schistose with strips, and granoblastic structure.

It was formed by irregular polygonal inter-grown grains of carbonate—calcite ± dolomite, which, due to the effect of pressures, were elongated and with its long axis oriented parallel schistose. Grain size varies from 0.2 × 0.1 to about 1.5 × 1 mm (dominated by grains of size about 1 mm). Muscovite lamina up to 1 mm, oriented parallel schistose, which in certain parts form small stripe-like deposits were occasionally observed. Apart from these, striped and luminal deposits made of small flakes of sericite, chlorite and non-transparent matter were also observed.

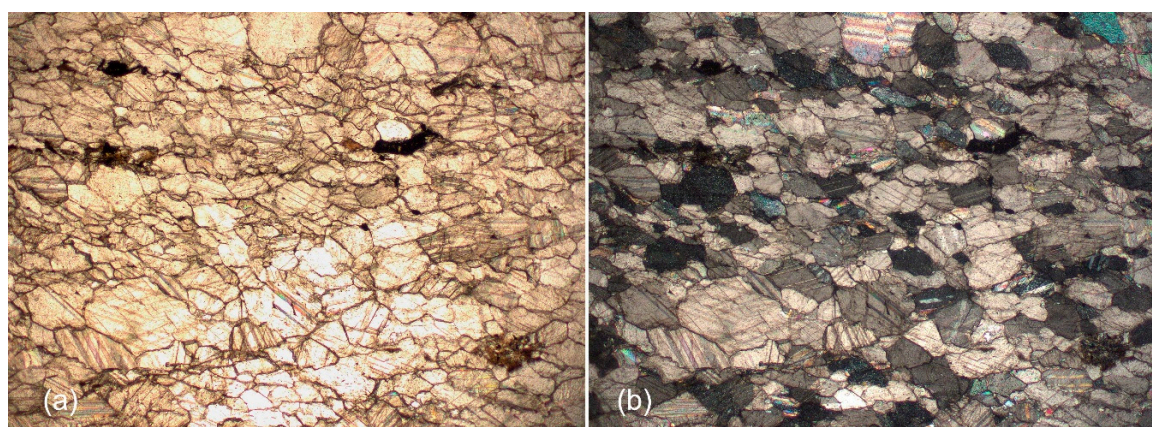


Figure 12. Macroscopic structure of sample 3 rock schistose marble: (a) With parallel nichols (b) With crossed nichols.

In addition to the aforementioned form, the deposits of the aggregates of these minerals were observed under the microscope at the contacts between the calcite grains. Rounded quartz grain (about 0.05 mm in size) was very rarely noticed in the rock.

On the basis of an analysis of the available published papers on the Studenica marble, the tests of the built-in marble on the façade of the Virgin's Church of the Studenica Monastery, as well as the tests of the samples from the quarries in Godovic and the village of Vrh, the following has been established:

The occurrence of the Studenica marble on the right bank of the Studenica River is metamorphosed rock that occurs in very complex geological conditions, which are not yet fully understood.

Petrographic tests carried out on the embedded material indicate that the Studenica marble is of very high quality and favorable technical properties. According to the three quarries specimen's microscope analysis, it is clear that it is the same type of marble, but should be also furnished with chemical and analysis of its mechanical characteristics.

Although the Studenica marble was observed as an exceptional rock for construction and architectural-construction, used for building churches in the Middle Ages, its limited extent of occurrence (about 20 km) and difficult exploitation conditions contributed to the lack of interest in greater commercial use and hence more detailed study.

Based on the analysis of the samples from quarries, it was concluded that marble sample 1 (Godovic) and sample 2 (the village of Vrh) have very similar properties, saccharoidal appearance and white color, and that sample 1, due to its very rare yellow-brownish dotted pigments falls behind sample 2 in terms of beauty.

By comparison with the results of the examination of the built-in stone, it was found that the white marble was used from quarries in both villages, and the light gray marble from Godović.

With regard to the Studenica marble use in the monumental medieval endowments of the Rascia Style, it is necessary to carry out additional geological tests on all existing quarries, sampling and petrological testing of rock samples in order to define all the technical characteristics of this material.

After carrying out the aforementioned research and obtaining the results, a selection of the representative Studenica marble profile should be performed, which should be then protected as natural geological heritage sites.

5. Application of Studenica Marble in Restoring the Architectural Ornamentation Elements

5.1. Restoration of the Biforas on the Sopocani Monastery St Trinity Church

Defining the right procedure in architectural elements restoration and conservation relative to the entire architectural structure—the whole building, was the primary step in renewing the biforas on the Sopocani Monastery St Trinity Church. The hitherto conducted investigations comprised thorough and careful analysis of the structure and its component, diagnostics of the overall state, including all the previous interventions. Survey and assessment of the structural system, damages to the biforas and identifying all the missing elements or those that had been restored in the past with the use of inappropriate materials, enabled us to draw up the proper documentation with the evidence of the extant situation.

The primary goal in the biforas restoration was not to impair the church building authenticity but to enhance its aesthetic, artistic and functional values that were lost through centuries. Such an approach included considering the entire configuration, the integrity of the monument, its architectural and artistic values, as well as the use of original materials, their right source, quality, special characteristic and texture.

The St Trinity Church features some special properties with regard to its architectural sculptural ornamentation of the Romanesque style. The first step was to devise an intervention plan that would ensure not only protection of the monument, but would also achieve the structural and functional entirety of the monument. After the evaluation of all the previously collected results and the works

on the monument had been completed, another priority emerged: the question of restoring the architectural sculptural ornamentation on the church main nave biforas and the monumental altar one.

In the second half of the 20th century, there were some decades long architectural and archaeological investigations on the Sopocani Monastery. The monument was one of the first to be inscribed in the UNESCO World Heritage List in 1979 as part of the Stari Ras and Sopocani complex. The said works were managed with care and in accordance with the World Heritage guidelines [46]. The available information on the marble ornamentation is the result of archaeological investigations that lasted from 1973 to 1985 [47]. Fragments of the architectural elements found as archaeological remains had been carved from the Studenica white marble and were considered as a highly valuable starting point for a theoretical reconstruction. Furthermore, this issue had been a subject of investigations and various considerations of earlier conservators [34]. The elements consisted of fragments of four capitals, several fragments of small columns in various dimensions, one whole base of a bifora central column and fragments of two bases. Although severely damaged, the capitals contained enough information for reconstruction, so modes could be cast in gypsum plaster. The process provided some very important information about the proportions and the spatial geometry of the capitals and bases, but also the very shape of the capitals was of a type that could be recognised in certain biforas on the Virgin's Church of Studenica.

In their proportions, the simple bifora form with a tympanum in the line of the wall and the twice recessed window frames with the frontal sickle arches gave an impression of harmony and balance. The photo documentation dating from 1962, obtained before the first extensive church restoration, clearly gives the preserved shapes of the south bifora below the dome. It is obvious that at that time there were no elements of the dividing mullion or any decorations in the shape of a capital. The extant shapes show that the north bifora below the dome was quite preserved as it possessed all the original parts, again except the mullion, the capital and the base, which are generally the most vulnerable spots in times of any tectonic movements, known to have occurred in the past. Other four biforas on the main nave had been substantially damaged, so during the first renovation works, their primary frame shape was restored. Those elements were done in concrete and sandstone, while the mullions, bases and capitals were not restored since at that time no information existed about them. All six windows on the central nave, as well as the altar window were found without the capitals, bases or mullions [47].

Measurements and proportional analysis showed that all the windows are of almost the same dimensions. Based on the available original archaeological finds, the shape and length of the mullion and the capital were determined and later on applied in all the windows. All the previous inadequate interventions in concrete were documented and then removed. The original marble fine grain structure, colour and texture were compared with the analysis results from the previously described samples from the Virgin's Church in Studenica. The structural uniformity with the original mullion elements that were discovered in archaeological investigations and were used as primary models confirmed that the original marble belonged to a group of monochromatic marbles, identical to that from the Godovic quarries in the Studenica area (Figure 13).

Stone carving and sculptural works were done by hand in a workshop, while respecting the essence of the material and the carving techniques whose traces are discernible on the archaeological remains of the original fragments. The missing elements in all the six windows were put back in a synchronised manner. Some smaller interventions, such as carving the tympanum on the nave north window was done in situ. In places where the tympanums had been made of concrete, carved marble elements were put in [48].

The altar bifora was restored according to an architectural ornament on the only one preserved bifora between the nave and the narthex. In terms of proportions and shapes, the same thing was done on the west façade and the altar. The mullion base, shaft and capital dimensions were reached through an analogy and proportions analysis conducted with regard to the opening length and width proportion, as well as to a partially preserved point where the bifora final recessed arches join [49].

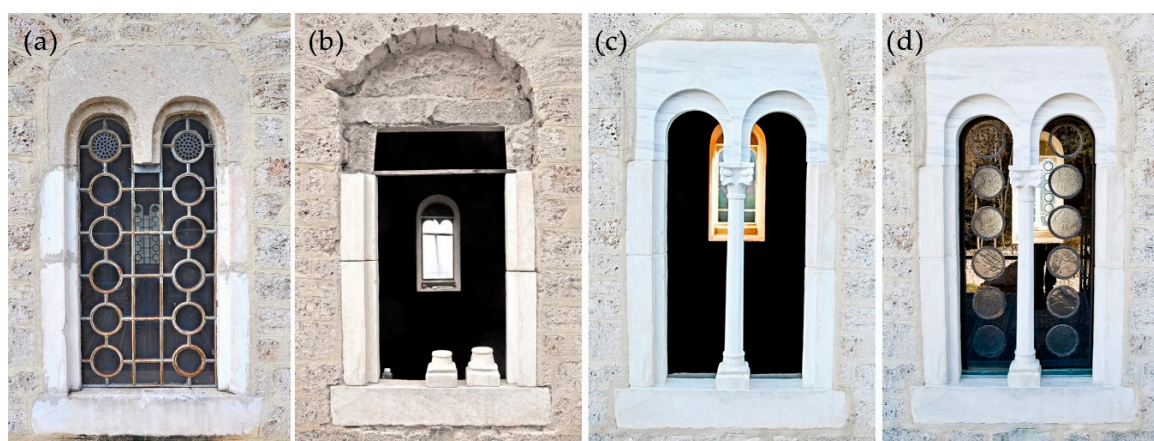


Figure 13. St Trinity Church (a–d) Restoration and conservation process © NDRistić.

Restoration of the biforas on the Sopocani St Trinity Church required traversing a long road—from the finds of the first marble ornamentation elements, the years long study of the origins and project drafting, some concrete finds during the conservation and restoration works, to finding the original material—Studenica marble, to final shaping and producing the missing elements, solving the glass pane surfaces, to their final installation and finishing steps in such a complex task. The result is not only a re-construction and/or restoration of the architectural ornamentation in the form of the bifora, but also a materialisation of a new dimension that points to the traces of the past, to redoing something that actually cannot be repeated, to the markings in marble that strongly highlight the values of a synthesis occurring at the border between the East and the West, leaving behind works of eternal value.

5.2. Restoration of the North Bifora on the Studenica Virgin's Church West Façade

The Virgin's Church of Studenica has suffered multiple destructions throughout its history. In one of the most severe fires and devastations in 1805, the entire church structure was seriously damaged. The proper conditions required for its renewal for the first time occurred after the final liberation of Serbia from the Ottoman rule in 1833 [4].

Some extensive works on the church restoration were conducted in 1839 and they were particularly related to opening thirty-six windows, as well as making and fixing “thirteen marble columns” [50] that still today testify to a special care applied to bringing back the marble parts of architectural ornamentation on the church windows and portals. A unique restoration process was then implemented on fitting in the missing parts in recreating the altar trifora form. The newly carved elements were made clearly visible, completing the overall geometry of the trifora [4]. All the elements were made of white marble, most probably extracted from the nearby quarries. So, most of the primary and sculptural markings of the Virgin's Church were restored then.

Quite extensive investigative, conservation and restoration works were conducted in the Studenica Monastery in the period between 1952 and 1956. Besides various rather complex architectural and engineering actions done on the Virgin's Church, certain segments of architectural ornamentation were restored in that period, like the west façade south bifora [5], among other things.

Pieces of a lunette with a rosette were discovered in the Radoslav's narthex, which in their size and the place they were found indicate that they belonged to the south bifora. There was its base preserved in situ, as well as a fragment of an octagonal bifora column, which left no doubt that it could be completely restored.

All the new parts were cast in toned concrete [11]. In the way it was made and in its style characteristics, the capital that was used for restoring the south bifora mullion belonged to the Virgin's Church architectural programme. However, the two fragments with a sculptural relief of birds, forming a lunette, may have belonged to another, the west façade north bifora, were found built in on top of the pediment of one of the monastery residential buildings. Even then it was assumed that the fragments

may have been parts of the west façade north bifora, since its central part was “carved similar to the tympanum trifora” [51]. Although a masterpiece of the Virgin’s Church carved ornamentation, in the decades that followed, the preserved north bifora lunette fragments have never been returned to their original place.

Things changed with regard to completing the lunette when in the late 1990s, during the archaeological excavation works, another fragment was found that made it possible to define precisely the radius of the lunette outline, as well as the two arches that determine the bifora openings. In the monastery gallery of the Virgin’s Church stone decoration fragments a piece of marble was hiding, whose atypical shape did not indicate any larger place it could belong to. However, it was noticed for its fine grain crystalline structure, the way its outer surface was finished, as well as for a gentle unrecognisable smooth tracery in the shape of an entwined ribbon and the slight curves on its outer and inner borders of the fragment. Although none of its sides could be fitted to the existing three fragments, the lunette’s geometry indicated a position where it could fit in. When the lunette tracery was closely observed, what looked like an entwined ribbon was actually a tail of a bird. Further analysis and measures of the archivolt radius and its recession depth finally confirmed that the lunette with the birds carrying a Holy Trinity symbol belonged to the church west façade [33]. The bifora mullion base and an imprint of an octagonal column were in situ. Analysing the dimensions of the archaeological remains of the capital, it was found that a capital fragment No. P/3, now kept at the stone fragment gallery, may have belonged to the same lunette [32]. Based on the available fragments, a capital was cast in gypsum plaster and then a new marble one was carved to be placed in its original position. So, through proportions analysis, graphical method, assembling and connecting all the available fragments, the original form of the west facade north bifora was obtained.

For the restoration of the missing parts, blocks of marble were extracted manually from the Godovic quarry according to the already defined geometry and dimensions. The hitherto investigations and the experience from the restoration works of the mullioned windows on the Sopocani St Trinity Church, the previously chosen particular spots for extracting the marble, as well as the knowledge of the craftsmen who had been traditionally in the marble business for generations, all indicated one and the same quarry. After the primary extraction, the blocks were transported to a marble carving workshop where the master craftsmen first closely studied the carving methods from the lunette fragments and then, with a use of a hammer and a chisel, sculpted the missing shapes and figures. In parts where there was not enough information for a proper restoration of figural motifs, roughly carved sections were left without any improvisations.

There is visible damage on an important image of two affronted birds carrying an entwined vine scroll; a Holy Trinity symbol was restored with polymerised plaster. The material was also used in restoration works on the Studenica Virgin’s Church façades. The content of the plaster was first chemically tested and then carefully composed, making it a reversible material consisting from a mixture of ground marble of various granulation, cement adhesive and additives, making it highly malleable and elastic [52]. Some major damages were observed on the lunette central trinity motif and on its borders. Plaster preparation and application required an extremely careful treatment and toning so that an aesthetic and visual, as well as structural harmony could be accomplished between the applied material and the original stone surface. A complex methodological process also required consistency and compatibility and synchronised activities between a master sculptor, a stone restorer and an architect conservator. The works on bringing back the bifora to the Virgin’s Church west facade in the Studenica Monastery was of an exceptional cultural significance not only for the professionals but for the broader public as well (Figure 14).

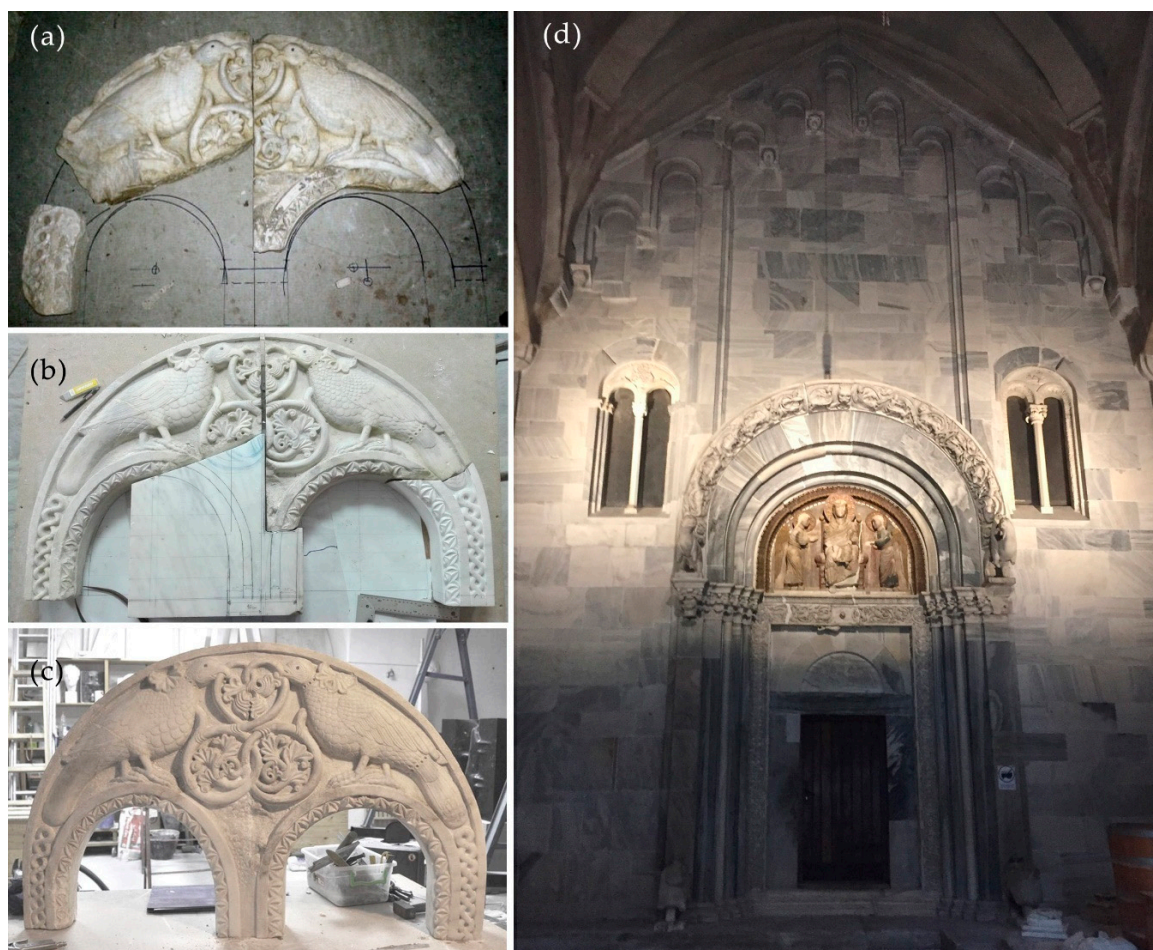


Figure 14. Virgin's Church (a) (b) (c) (d) Restoration and conservation process © NDRistić.

This is an important piece that represents a pinnacle of a subtle stonecutting craft, a fine sense and knowledge of the nature of the material—the white marble. The entire restoration was conducted in 2018, thus completing an envisaged programme of architectural sculpture embodied in the Virgin's Church exterior symbolism. The complex sign-symbolic image of the two affronted birds carrying the Holy Trinity symbol reveals and confirms its strong rooting in profound theological concept held dear by the church founder. In the conducted conservation and restoration works, the Virgin's Church west façade gained its full architectural meaning, whilst its entire sculptural ornamentation and the stone tracery substantiate its deep theological significance.

6. Discussion/Conclusion

The heritage in marble is of a special importance in the making of the mediaeval Serbian cultural and artistic identity expressed in a highly sophisticated understanding of symbolic and aesthetic properties of the material used in various forms throughout the world history of architecture. A need for a methodologically based assessment of Studenica marble values and significance has been a pivotal aspect of this research.

Primarily, its significance has been confirmed "in itself" as it was the material that was used to build some of the most outstanding Serbian mediaeval endowments. Then, by establishing a relation between the historic quarries where it was being extracted for erecting the Virgin's Church of Studenica, using it in its dressed form, the "instrumental" value of the quarries has been established, as places the material originated from, which then gave a special character to the architectural heritage, bestowing it its outstanding value. Its significance is also evident in an authentic synthesis between the local marble

shaped into forms of architectural elements featuring Romanesque style combined with the Byzantine iconographic content [32].

When looking at the Studenica Monastery surroundings, the importance of the area geological structure has to be emphasised once again, as it also had to have an impact on the choice of a spot where the endowment of the ruler, the founder of the Nemanjic Dynasty, was to be built. So far, the investigations have been conducted in the Studenica area geological formations structure and the marble deposits, together with the Virgin's Church marble samples that had been tested earlier in order to establish the methodology and materials in the remedial works and the church marble façade restoration. Also, the samples taken from the two major historic quarries have been tested recently. Combining all the results obtained from those investigations confirmed that the marble was one and same type with certain high-quality varieties of favourable technical properties. Difficult exploitation conditions and a rather limited area of marble deposits made it hard to increase its commercial use, which actually proved as an advantage for a limited, sustainable exploitation and a preservation of traditional quarrying methods. Such an advantage comes as beneficial for any future restoration of the marble monument architectural and other elements that have disappeared and been damaged with time.

The quarry where the material for restoring the architectural ornamentation was extracted from was determined according to several indicators: the research results obtained from petrographic and chemical testing of the fine grained white marble of outstanding technical properties, as in the Godovic quarry; the site where the stone is still actively mined today by the locals in a traditional old way; the possibility of obtaining the right dimensions and uniform aesthetic stone characteristics.

The first major restoration project of the architectural marble ornamentation was conducted on the Holy Trinity Church of Sopocani, where the marble was mined, used and dressed, applying traditional extraction and stonecutting techniques in shaping the elements. The work process included a phase of thorough checking of all the marble components, situation diagnostics, checking the validity of all the previous interventions and subsequently, assessment of all the damages, missing elements, as well as inappropriate materials applied in previous interventions.

Preliminary testing had been conducted of marble samples from both the quarry and the archaeological material, giving positive results. Subsequently, based on the collected documentation, the stone was cut and all the parts made from inadequate material from previous interventions were first identified and then replaced, as well as the missing elements restored in the original material.

On the Virgin's Church of Studenica, a bifora was restored, an important one, as the marble remains of its lunette held a masterpiece of the stonecutting craft, expressed in a symbolic form of two birds carrying a Holy Trinity symbol. Carefully selected white marble from the historic quarry, carving the missing elements and a meticulous restoration of the relief motifs manifested a high level of technical and technological skills of the artists and conservators working on it. Understanding the nature of the material and reading the hidden signs preserved in the original remnants brought back the full character of the missing image.

The choice of applied interventions and steps in the original marble material enhanced the cultural significance of both monuments, thus re-establishing their aesthetic, symbolic, technological, functional and scientific values.

The entire investigative and research process actually started with a question: Where could the original restoration material for the missing elements of architectural marble decorations on the Serbian mediaeval monuments be found? A renewed interest in sites where the marble was quarried in the Middle Ages, visits to the quarries in the vicinity of the Studenica Monastery, talking to the locals, research of the abundant literature on the mediaeval monuments, as well as a rather sparse literature on geological, anthropological, technical and technological investigations of the area, all pointed to the precious natural resource, still hiding unveiled meanings of the sites and the material built in one of the most beautiful edifices of Mediaeval Serbia (Figure 15).



Figure 15. Area of Studenica Monastery © LiveViewStudio.

After completing the restoration and conservation interventions on the architectural marble decorations on two very important cultural monuments, inscribed in the UNESCO World Heritage List, Studenica marble and its still active quarries in the natural landscape have been recognised as a significant resource of sustainable development in the Studenica Monastery entire area. All the marble quarries have been surveyed and valorised as an integral part of the cultural landscape. The cultural landscape protection and conservation plan as part of the Studenica Monastery Special Purpose Area Spatial Plan has established the historic marble quarries as scheduled cultural/natural monuments. They have been identified as geological, natural and cultural and historic monuments.

The cultural landscape boundaries hold three scheduled sites: Korita quarry $43^{\circ}27'13.73''$ N, $20^{\circ}30'31.26''$ E, Godovic quarry $43^{\circ}28'22.83''$ N, $20^{\circ}30'15.51''$ E and Brevina quarry $43^{\circ}27'12.97''$ N, $20^{\circ}30'42.75''$ E [53].

While drawing up a management plan for the UNESCO World Heritage site—the Studenica Monastery, a unique cultural landscape has been identified. The previous evaluation of the Studenica quarries value and significance resulted in their integration into the Plan, as valuable monuments of interaction between man and nature. An important starting point in making the Plan was to broaden the concept of heritage and its special role in sustainable development, which can enhance the contribution to an environmental, social, as well as economic aspect of sustainable development [54]. In those terms, the Studenica quarries were recognised as a cultural resource not only in the context of their utilisation in the cultural monuments restoration and conservation but also as a witness of the past, something that had become a part of the cultural routes system, which would improve a wide spectre of benefits: social, economic and cultural—directly linked to the heritage [55].

Therefore, grasping a cultural heritage wider context occupies a fundamental role in understanding and empowering the identity of a social community. Putting an accent on managing the historic environment based on a participative approach, allowed for the local community to be involved in the cultural property management in a much broader sense. In this particular case, the management of the quarries has been entrusted to the local residents who are also the proprietors of certain sites, which actually means giving support to the locals to provide for themselves rendering various services and goods. The area is identified a one that has been traditionally utilised. Here, education and

research programmes are envisaged about recording, preserving and renewing traditional knowledge and skills applied in building and marble art works of architectural heritage imbedded in the Virgin's Church of Studenica.

All the presented results mirror an aspiration to cast light, as much as possible, on the significance of Studenica marble that has been a building material in erecting an identity of the Serbian most important mediaeval monument. Furthermore, they emphasise the extraordinary role of the marble in any future approach to restoration work, but also direct the focus of the public, the scholars, the experts and anyone else, to some special values of the Studenica Monastery surroundings, where the marble quarrying tradition has been going on from generation to generation for centuries, which has unfairly been neglected and underexplored. The paper also gives a list of the various activities that have, almost instinctively, formed a research process whose results are actively included in the cultural heritage development strategic documents, anywhere with stone as a key material in conserving the outstanding values for both the present and the future generations.

Author Contributions: All authors contributed equally to this paper. Conceptualization and methodology, N.D.R., N.Š. and J.I.Š.; validation, investigation and resources, N.D.R., N.Š., D.M., and J.I.Š.; writing-original draft preparation N.D.R., N.Š., D.M., and J.I.Š.; writing-review & editing N.Š., N.D.R., and J.I.Š. All authors read and approved the final manuscript.

Funding: This research received no external funding.

Acknowledgments: We would like to thank the Geological Institute of Serbia for the analyzes of the samples, and Brkic Milan, B.S. in geology from Geoprofessional in Belgrade for technical assistance and kindness

Conflicts of Interest: The authors declare no conflict of interest.

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