

## GRANITE – THE ETERNAL DECORATIVE ROCK MATERIAL

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### ABSTRACT

General information on granite is presented and its role in the history of human civilizations is discussed. The technology and mechanization of extraction and processing of granite materials in Bulgaria are described and assessed to be on a modern level. Definitions of special concepts such as 'rock materials' and 'decorative rock materials' are given. The term 'granite material' is defined and its main parameters considered.

### GENERAL INFORMATION ON GRANITE

**Definition.** The concept 'granite' is not a clear notion to many people in the modern high-tech and computerized world. It is still a common belief that every polished stone is marble. In fact, the difference between marble and granite is very big.

Marble is a carbonate rock that is easy to grind and polish but has lower hardness compared with granite. The products made of this material are not resistant to the adverse weather conditions, which makes them suitable mainly for enclosed spaces. However, marble is much more richly colored and patterned than granite.

Marble is associated with the exquisite sculpture of Venus Miloska, with the spiritualization of the Carrara stone by Michelangelo and the polished slab at home.

Granite is a symbol of hardness, strength and durability. The products made of granite materials are practically eternal.

Granite (from the Latin word *granum* grain) is a granular rock formed by the crystallization of magma in the crust. It is composed of the minerals: quartz, feldspar and mica. Granite has physico-mechanical properties that characterize it as an excellent structural, decorative-facing and monumental material. It has a density of 2700 kg/m<sup>3</sup>, hardness 7 by Mohs' scale and 150 to 250 MPa compressive strength. It is cold resistant and highly resistant to aging and weathering. Polished granite preserves its luster for centuries and millennia.

On our planet granite occurs in inexhaustible quantities and humanity will never feel short of it.

Granite rocks are differently colored, varying between the white Norwegian granite and the black African one, coming in a wide range of various colors such as bluish, pearly-gray,

cream, pink, red and green granites. Some of these are unique in color and have a highly decorative value.

**Granite is the history of human civilization.** Natural stone has always been a crucial part of the material culture of the human race. Mankind faced the need to process stone as early as the beginning of its development.

During the earliest cultural-historical period, the stone age (approx. from 800 to 5 thousand years BC) stone was the main material used to make tools (axes, hoes), weapons (arrow tips, spears), ornaments and attributes symbolizing the meaning of human life, dwellings and religious monuments. The great importance of stone for human life during the time of the primitive community gave the name of that age, the Paleolithic Age (from the Latin *paleo* old and *lith* stone), which started with the appearance of the first stone tools and ended with the discovery of copper during the Bronze Age.

Stone processing during the Paleolithic Age passed through a long evolution from the use of rough unprocessed implements to the invention of various cutting tools. During that period man gradually acquired the manual operations for stone processing in the following technological-chronological sequence:

- dislodging and breaking off during the Early and Middle Paleolithic (800 – 35 thousand years BC);
- splitting and rough hewing during the Late Paleolithic (35 – 10 thousand years BC);
- cutting, grinding and drilling holes during the Neolithic (10 – 5 thousand years BC);

As late as the Bronze (4 – 2 thousand years BC) and Iron Ages (2 – 1 thousand years BC), when metal tools were invented, man managed to master the skill of processing the hardest rock material, i.e. granite. The Egyptians, whose civilization leads us 7 – 8 millennia back from modern world, gave the first data about granite processing. During the

dynasties, in the course of centuries, hundreds of thousands of people worked on the construction of pyramids and creation of pharaohs' sarcophaguses. The truth is that the Egyptian pyramids were built up of numulite stone but Mycerin's pyramid was faced from base to top with pink syenite tiles.

As far as the technological and technical level of granite processing practiced by the ancient Egyptians is concerned, it should be noted that the Luxor obelisk, 25 m high and approx. 250 t in weight, was made of pink granite. Nowadays this monument decorates the Concord Square in Paris. The pharaohs' people were precise and methodical. An example of that is the granite sarcophagus of Senizert II, whose sides were made with 0.2-mm differences in dimensions. Even today we can admire that marvel of precision.

The processing of granite monuments was carried out by thousands of people for centuries but the time factor played no decisive role since the aim was to make beautiful, precise, monumental and grandiose products.

The Greek civilization left a small number of granite products since marble was the Lord in ancient Hellas. It was used to build the world famous monuments in Athens. And yet, we have to mention Agamemnon's tomb in Mycenae made of green porphyry.

The Romans, who used the knowledge and experience of their ancestors, improved granite processing and left many monuments and temples in Europe that have been preserved until the present day.

During the Medieval Age and Renaissance no considerable progress was made in granite processing but that period was characterized by intensive construction. It was the time when the Saint Michel monastery in Bretan in France and the 15<sup>th</sup> century abbey were built up of granite elements.

It is necessary to note that in the 18<sup>th</sup> century, during the construction of Saint Petersburg, gracefully worked-out large-scale granite products were created. In 1782 a monument devoted to Peter the Great was raised with a basement of polished pink granite of weighing 1500 t, overlaid by a bronze group of horses.

The most spectacular granite monolith ever to have been raised by a human so far is the polished column of red granite, 3 m in diameter, 25 m in height, weighing 500 t and placed on a basement of polished granite with 6.5 m sides, 1.5 m in height and 150 t in weight. This monument is an exquisite work of art and decorates the Winter Palace Square, inspiring respect in modern man with its large scale.

#### TECHNOLOGY AND MECHANIZATION FOR EXTRACTION AND PROCESSING OF GRANITE MATERIALS IN BULGARIA

The present technology and mechanization used in extracting and processing granite materials in Bulgaria measures up to the most advanced countries in the world.

**Extraction.** Explosives are not used any more in extraction thus preserving largely the integrity of the extracted blocks. A combined extraction method is now used. Transverse slots, spaced 5 – 8 m, are cut in the bench by a thermal saw. The slots can be as deep as the bench width, the depth being equal to the bench height, though these dimensions usually reach up to 3 – 4 m. The technological width of the slot reaches 12 – 15 cm and the thermal saw output varies between 1 – 1.2 m<sup>2</sup>/h. The vertical and horizontal contouring between the slots is performed by rock drills making holes of 36 – 41 cm in diameter, spaced 10 – 15 cm. The monolith thus contoured is dislodged from the bench mass by wedge-splitting devices placed in the vertical holes. The monolith is then cut out by slitting the rock block into the required dimensions.

**Processing.** The granite block is processed by different techniques depending on the dimensions of the billets and products.

The cutting of granite blocks for making large-sized slabs (2x3÷4 m), 15 – 50 mm wide, is technically possible to perform by using several techniques but the most economical technology is cutting by gang saws with smooth blades and cast iron or steel shot. This technology is applied in Bulgaria, at the plant of the Bulgranite Ltd., Gara Iskar in Sofia, using one of the most advanced gang saws in the world, Masterbreton HG120, for cutting blocks of up to 3300 mm in length, 3000 mm in width and 2000 mm in height. The gang saw is provided with 120 blades and, at a maximum allowable feed rate of 80 mm/h, a fairly high operational output of up to 25 m<sup>2</sup>/h is achieved.

The cutting of granite blocks for making thin slabs with the so-called foot sizes (30.5x30.5x10÷15mm) is carried out by orthogonal disc saws with diamond segments allowing to process the block in a stepped manner.

The edges of the billets and large-sized slabs are cut out by machines of various design equipped with diamond segment discs.

The grinding and polishing of the granite products in a flow process is performed entirely by abrasive grinding and polishing tools. These operations are also performed by diamond tools but only at private companies when grinding single granite products. The specific prime cost of the operations is higher but they are carried out by smaller machines.

#### ROCK MATERIALS

It is a well-known fact that there are no commonly accepted terms and concepts in the Bulgarian science and practice that characterize the materials extracted from various types of rock and their purposeful technological alteration in view of using them properly in construction or for architectural and monumental products. This ambiguity of terms and concepts is inadmissible. The difference between rock and rock material is often blurred and in some cases misunderstandings occur as a result. For instance, even experts sometimes use the term 'decorative rocks', not making it clear whether they have in mind the outer decorative shape of the rock (e.g. the

Belogradchik Rocks or the Pobiti Kamuni/Fossil Forest), or the potential decorative properties that will be manifested provided that rock is used to extract material and process it in the appropriate manner.

This is the reason why we suggest that we discuss our views on those issues.

**Rock.** Rock is a geological concept meaning natural material aggregates of relatively constant composition and structure and considerable volume, formed as a result of a complete geological process. The rock should always be associated with its natural state in the ground.

**Rock materials.** The materials extracted from the rock mass by some technical impacts (mechanical, blasting or thermal) are called **rock materials**. These materials result from their artificial separation from their natural state in the ground and not from various weathering and other processes.

**Types of rock materials.** Modern industry and construction use numerous materials extracted from various types of rock. According to the purpose of use they are classified into the following groups:

- nonmetal building materials used for obtaining artificial construction material (cement, lime, etc.)
- building stone used for constructive building material;
- decorative rock materials.

**Decorative rock materials.** The name of these materials comes from the Latin word 'decoro' meaning decorated. This concept involves natural rock materials which, due to their aesthetic qualities, revealed by means of different processing methods, are suitable for making various decorative-functional products needed for the construction industry and everyday life or products of purely decorative or monumental character.

There is still no generally accepted and standardized term in the Bulgarian technical literature for those materials, which can give accurate and full information about their nature and use.

The term 'decorative stone', used in the past, is incomplete since it refers only to the feature 'decorativeness' and does not give any information on whether the stone has been broken out of the rock as a result of natural destructive processes or produced by artificial separation.

The term 'rock facing material' has begun to gain ground lately because the decorative rock materials are increasing being applied as facing material in construction. However, this concept is inaccurate and limited since it does not reveal the decorative nature of the material and neglects its use for high volume structural elements or for purely decorative purposes (sculptures, monuments, etc.).

On the basis of the above reasoning we propose the term 'decorative rock material', which, firstly, reveals the character (decorative) and nature (rock) of the materials, and secondly, one definition of 'material' is the raw material for making products (according to the dictionaries of the Bulgarian language).

At present many types of decorative rock materials are being extracted but granite and marble materials are of particular

importance for the construction industry, architectural products, monumental plastics, etc.

## GRANITE MATERIALS

**The unspecified concept 'granite materials'.** The terms 'marble materials' and 'granite materials' are used in the practice of processing decorative rock materials in Bulgaria and other industrially developed countries. While the concept 'marble materials' is clear enough, the problem with the term 'granite materials' has not so far been defined accurately and is to a large extent more complicated to solve.

This circumstance causes certain difficulties in the production and, particularly, trades relations between business partners as regards the type and quality of these materials.

It is a well-known fact that every company, which exports some decorative rock material to the market, gives it a name that serves to advertise the product in view of raising its price. On the international market of decorative rock materials there is no institution that obliges the producers to use the correct petrographic term for the material offered. However, the producers and traders sometimes designate the material in such a way that the name often contradicts its real nature. For example, rock materials are offered on the international market, which are not related to granite in terms of either genesis or mineral composition. And yet, they are called granites. Here we will point out only two firmly accepted misleading names: black Swedish granite and Belgian granite.

The "Swedish black granite", also known by the symbol "SS", is an excellent material for making monuments. It is black in color and composed of plagioclase and pyroxene but does not contain quartz. Nevertheless, this material is not granite and neither does it belong to the intrusive rocks which granite materials are usually referred to. The "Swedish black granite" is an effusive rock composed in the so-called fissure effusions and should be named 'basalt'.

A more striking case is the so-called "Belgian granite" which is not even an igneous rock but coquinoïd purple limestone advertised and sold on the market as a granite material.

**Definition of the concept 'granite materials'.** It is obvious that the precise petrographic terminology for the various types of rock is not applicable to the practice of processing decorative rock materials. This is due primarily to the specific scientific character of treating the rocks, classified according to genetic, age, deformation, mineral, chemical and other features which have no direct relationship to the practical aspects of processing decorative materials and their application.

It is a fact that there are terms in petrography such as granite, granitoids, granodiorites, granite gneiss, etc., but these have not been identified and classified by genetic and mineral features. The materials extracted from these rocks are involved in the concept 'granite materials', used in practice, though only as one essential part which, nevertheless, does not cover the whole content of that term.

Having in mind the technological specificity of processing granite materials and their application, we can formulate the definition of that concept in the following way:

Granites are such rock materials that have three basic properties: high hardness, durability and decorativeness.

These conditions are fully met by granite, which logically gives the name to the whole group of materials. Granite materials generally involve a great part of the materials extracted from igneous rocks and, in particular, most intrusive and fewer effusive rocks. The only rock material, which is not of igneous but metamorphic origin, is quartzite which occupies a well-deserved place in this group.

In case more information is required when using the term 'granite material', it can be provided by its genetic and mineralogical characteristics or by its main parameters, viz. hardness, durability and decorativeness.

**Main parameters of granite materials.** The basic identification properties of granite materials are actually the main parameters by which they are assessed.

Hardness is the property of granite material to resist the penetration of a solid body of higher hardness. This parameter depends on the density, location and size of the mineral grains composing the material as well as their cohesion. The hardness of the material is determined by the constituent minerals. They should have a hardness of 6 or higher by Mohs' scale. Hardness is mainly a technological parameter of granite materials and determines largely the technology and labor consumption of their processing. The rock blocks are most economically cut by sawmill cutters and free abrasive (shot). Sometimes the blocks can be cut by cutting machines with orthogonal disc saws. Granite materials are best cut by percussive tools.

The durability of granite material is defined as its capacity to preserve the physico-mechanical and decorative properties of the processed surfaces depending on the service life. This parameter is determined by the strength, structure, mineral composition and cracking of the material. The larger the mineral grains, the lower the strength and durability of the material. Therefore, fine-grained materials are most durable. Besides, the more homogeneous the material, the higher its

durability. The most durable material is quartz whose polished surface starts to destroy after 600 – 700 years. Less durable is granite of high quartz content, then come gabbro, labradorite, etc.

Decorativeness is the most important parameter of granite materials and the main factor determining their prices. At present, the price of highly decorative granite materials in the form of 2cm thick polished slabs on the Bulgarian market varies from \$120 to \$160 for 1m<sup>2</sup>.

The granite material decorativeness is determined by expert assessment according to the color and structural-textural properties. The decorativeness of the granite materials is assessed in 4 classes: class 1 – highly decorative; class 2 – decorative; class 3 – low decorative; class 4 – non-decorative.

The highly decorative granite materials of class 1, which are world-famous, are "Shikshinskiy" quartzite (Russia); "Capustino" granites (Russia); "Elberton" dove-gray-colored granite (USA); Nordmjarkit (Norway); "Golovinskiy" labradorite (Ukraine), etc.

Most granite materials are of class 2. Of these more famous are "Impalla" gabbro (RSA), "Norway" silver-gray labradorite, etc. No granite deposits of class 1 and 2 have been explored in Bulgaria so far.

Granite materials of class 3 are extracted and processed as local raw materials and those of class 4 are extracted in exceptional cases.

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