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NATURAL STONE FOR ARCHITECTS AND BUILDERS. ROMANIAN ORNAMENTAL AND HERITAGE STONES

Abstract: The purpose of this paper is to offer the minimal information necessary for future architects, builders and people working in monuments restoration, regarding the types of rocks that can be used for buildings and monuments, their main characteristics and some details about the influence of the weathering processes on the stone elements put in the work. Also, for the same target group, information was provided about the ornamental stones from Romania that are known and/or are available for sale, as well a selection and presentation of Romanian stones with national and global heritage value.

Keywords: stone, ornamental, durability, architecture, heritage stone

Valentina CETEAN
Radu FĂRNOAGĂ
George TUDOR

Valentina CETEAN

Geological Institute of Romania

valentina.cetean@yahoo.com

Expert in geological engineering and environmental management, working for more than 30 years in the field of stones for construction. She has a high interest, expertise and many researches in the ornamental stone investigation and valorisation, including their performance and final use. In the last decade, she developed an interest and projects related to heritage stone and assessment of the national geological heritage.

Radu FĂRNOAGĂ

Geological Institute of Romania

f50radu@yahoo.com

Senior geologist and GIS expert, with long activity and projects in exploitation and capitalization of mineral, water and geothermal resources.

George TUDOR

Geological Institute of Romania

geo_tudor@yahoo.com

Senior geologist with expertise in mineral resources exploration, assessment and highlighting of the Romanian geological heritage. GIS expert, ESRI and INSPIRE data responsible, related to the specific activity of Geological Institute of Romania.

Introduction

The purpose of this paper is to offer the minimal information necessary for future architects, builders and people working in monuments restoration, regarding the types of rocks that can be used for buildings and monuments, their main characteristics and some details about the influence of the weathering processes on the stone elements put in the work. Also, for the same target group, information was provided about the ornamental stones from Romania that are known and/or are available for sale, as well a selection and presentation of Romanian stones with national and global heritage value.

Besides the general geological data about various type of stones, the main properties that provide the durability of the stone used architecturally were listed: mineralogical composition, porosity, resistance to compression, flexion or abrasion. The links between these properties and the way in which natural stone undergoes physical degradation and/or chemical alteration were also presented, as well as recommendations of indoor or outdoor application of different types of stones, for façade, roofing or paving.

The limitations in this paper are given only by the amount of information presented, which took into account the usual curriculum of the students or the basic knowledge of the people who work with stone. The information was selected from the long experience in this area and from previous projects of the authors, most of the examples and images being presented here with novelty character. Among these are: the location of the 67 Romanian ornamental stone deposits, of which 29 in operation, data regarding their colour, the owner of the exploitation, and recommendations of application for some Romanian ornamental stones, depending on the type of stone elements and place of application.

Natural stone for architects and builders - classifications and properties

Rocks represent solid fragments from the crust of the earth, with composition and properties depending on their origin and specifically transforming stages during geological time. When used for building purposes, the rocks are commonly referred to as *natural stones* (to distinguish them from the artificial ones). The large majority of natural stones used in construction are non-homogeneous materials, presenting slight to strong variations in terms of their mineralogical and chemical composition. They also present specific physical and mechanical properties, including color, fabric, natural porosity and water absorption, density, compressive and flexural strength, hardness, etc.

Natural stones can be described either by their geological origin (including post-depositional processes) or by their mineralogical content. The main groups from each category are presented in Table 1 and detailed further.

Igneous (magmatic and volcanic) stones

Granite, granodiorite, rhyolite, dacite, diabase, porphyry, andesite, basalt are the main types of stones from this category. They are, in general, very resistant to chemical and physical weathering, thus being appropriate for use in every type of climate. They present good mechanical resistance (compression, flexion), and most of the varieties can also be used not only for ornamental flooring, paving and cladding, but also as load bearing elements in building structures. However, there are some igneous rocks with lower resistances, usually containing a lot of mica or feldspar, that are weathered in clayey minerals or iron hydroxides.

Sedimentary stones

This stone group includes very different types, with different properties and behavior. The most important ones for architectural purposes are briefly described below.

Compact limestones can be used for any kind of building application (except roofing), but depending very much on the climate. They are normally not recommended in Romania for applications in contact with or close to the ground, as load bearing elements or exposed to intense rainfalls or to insolation effect.

Table 1. Classification of natural stone depending of different criteria

Classification criteria	**Categories**	**Type of stones general used for architecture purposes**	**Details**
according to the geological origin	**Sedimentary rocks**	sandstone, limestone, travertine, shale, conglomerate, breccia	Rocks formed by deposition, aerial or submarine, after disintegration of pre-existing rocks under weathering processes or different geological events.
	Igneous rocks	granite, granodiorite, rhyolite, dacite, diabase, porphyry, andesite, basalt	Rocks consolidated from magma, under crust of earth (plutonic rocks) or at the surface of earth (volcanic rocks).
	Metamorphic rocks	marble, gneiss, slate	Rocks resulted by the alteration of pre-existing rocks, in response to changing environmental conditions, such as variations in temperature, pressure, and mechanical stress.
according to the mineralogical content	**Silicate stones**	**Hard silicate stones** granite, gneiss, diabase, syenite, quartzite, schist; silicate-sandstone	Consists of silicate minerals containing a SiO_2 part. Stone types consisting of hard silicate minerals as quartz, feldspar, pyroxene and mica.
		Soft silicate stones	Stone types containing soft clay minerals.
	Carbonaceous stones	marble, limestone, travertine, aragonite	The main components are minerals containing CO_3 which is sensitive to reaction with acid substances. Common minerals are calcite, dolomite and in certain cases Serpentine.

Porous limestones (and sandy limestone) have a low abrasion resistance and, in general, are not recommended for use in outdoor or indoor floor applications. Although they show no high values for flexural and compressive strength tests, they can be used as massive building elements. However, in a humid environment, most of the limestones weather strongly and have to be replaced soon.

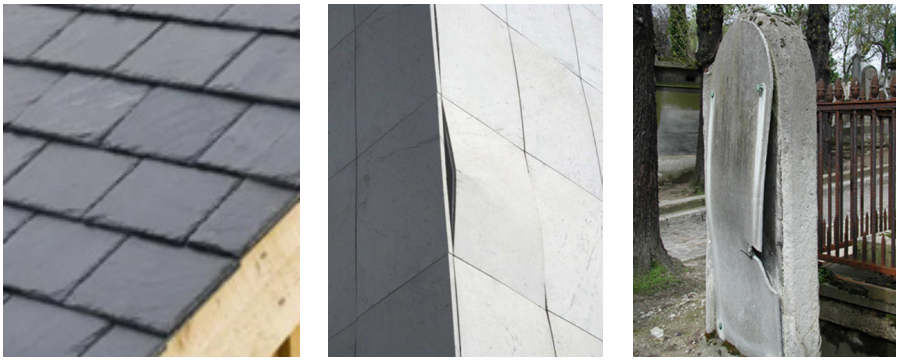
Sandstone with silica bound is better indicated to be used for outdoor application (except roofing), instead of sandstone with carbonate bound. When the sandstone is quite porous, it is best to use it for indoor applications only, if the climate is humid or many thermal cycles are counted.

Chert is a very hard and compact stone. It will give no problems in any kind of climate, but the workability is problematical for this type of sedimentary rock. It is not often used as cladding or floor tiles because it is too hard and energy consuming for an easy polishing.

Metamorphic stones

Many metamorphic stones have a low porosity and good bonding between the crystals and, thus, are suitable for external use in every type of climate. *Slate* and *schist* as building materials are especially known for their roofing application (Fig. 1a). However, some types of *marble* can show bowing (Fig. 1b, c) and severe strength loss when used in a humid climate.

Some details regarding the types of stones and their important properties and behavior are given below.



a) b) c)

Fig. 1. Examples of applications of metamorphic rocks used as stone elements: a) slate roof; b), c) bowing process of large marble panels in humid climate or having unfit anchorage system. Source: (TEAM, 2005)

Granite (and granitic type rocks) present small, medium or high crystallinity and has a big variation of visual appearance, referring to the color, size of minerals, and compactness. They contain feldspar, quartz and ferromagnesian minerals. With or without being polished on the surface, the stones from this category are very resistant and could present a good behavior under climatic variations (especially the granites with small granulation) and for flooring in public area with intense traffic (Fig. 2a).

Marble and limestone are carbonate stones with metamorphic (marble) or sedimentary origin. Marble is a recrystallized limestone; it usually lacks layers (bedding plane), while limestone has more or less developed layers (sometimes containing other minerals with a higher porosity than the rest of the stone), which often make up a weakness zone. In international natural stone contexts, often no difference is made between limestone and marble. Well polishable limestone is sometimes called marble, for commercial purposes, but the difference lies in their crystal structure and composition. From a constructive point of view, with a polished surface finish they are not hard enough to keep the shine when subjected to wear in public environments (Fig. 2b, 2c). As a walking passage (e.g stairs, commercial traffic area), a dull surface can easily form after a while. A polished surface in a public environment often needs regular finish with polish or crystallization if it is to remain shiny. On the other hand, some types of marbles used like finishing outdoor elements in the regions with many freeze-thaw cycles could suffer modification of intracrystalline strength (reflected in the rapid decrease of the dynamic modulus of elasticity, demonstrated by many laboratory tests, even if the visual appearance doesn't suffer significant changes). The limestone presents an irregular variation during climatic ageing, fdepending on its genesis: different porosity, large palette of color (what induce a different absorption degree of daylight or sunlight), massive until breccious structure, sometimes with recrystallizations, with or without fossils, etc.

a) b) c) d)

Fig. 2. Examples of application for different stone types: a) stairs from Măcin polished granite; b), c) improper exterior old application of Ruşchiţa marble at Ministry of Eonomy building from Bucharest; d) Borsec travertine, Ruşchiţa marble and Măcin granite used for stairs and vertical cladding at Gara de Nord underground station in Bucharest.

Travertine has a good behavior under different climatic variations, but the petrographic types of stone with a large number of vacuoles looses quickly their resistance due to the periodical infiltration of water and the effect of an intense traffic (Fig. 2d).

Sandstone is a sedimentary rock normally containing quartz and feldspars held together either by siliceous or carbonaceous natural cement (Hallsworth, 1999). The sandstone gets dirty quickly and is difficult to clean, but due to its large availability it can be seen being used in various circumstances, from wall elements to facade material, in particular in areas and countries with a long tradition of use and where it is the only locally available material (as Romanian Eastern Carpathian area). Sandstone usually presents high water absorption, in comparison with other stone groups, and, for this reason, its use is limited in building and construction works. Due to the normally high contents of quartz as grains, sandstone is often hard. However, the hardness of the stone is very much dependent on the binding agent: silicate, carbonate, clay or iron. The last two are present in old buildings but they are not very important as building and construction materials today. Sandstone cannot be polished, except for quartzite, which is metamorphosed sandstone and behaves like granite.

Durability of stones in moderate climatic area. Weathering and erosion

The rocks are the hardest natural materials on earth and it may take thousands of years to disintegrate them. By definition, weathering is the general deterioration process by which rocks, soils and minerals are broken down (through contact with water, atmospheric gases, sunlight, and biological organisms) at Earth's surface and are displaced gravitationally to isostatic position. This process takes place in two ways:

_Chemical weathering – when the minerals in a rock are chemically altered or dissolved. The blurring or disappearance of lettering on old gravestones and monuments is attributable mainly to chemical weathering;

_Physical weathering – when solid rock becomes fragmented by physical processes that do not change its chemical composition.

Physical and chemical weathering interact and reinforce each other. There are numerous examples that demonstrate the faster decay manifests, the more susceptible the stone pieces are to breakage. The smaller the pieces, the greater the surface area available for chemical attack and the faster the

decay. On the other hand, through erosion, the weathered material is moved, carried away and deposited somewhere else. Thus, new, fresh, unaltered surface rocks are exposed to other cycles of weathering.

The weathering is influenced by the mineralogical composition and internal structure of natural stones, due to the fact that different minerals weather at different rates. For example, constructions made with igneous rocks (as granite, andesite, dacite etc.) may remain unbroken and uncracked for centuries (Fig. 3a, b), though they may show evidence of superficial chemical weathering. The granitic, andesitic or dacitic massive elements may have no planes of weakness that contribute to cracking or fragmentation. In contrast, limestone with high porosity (Fig. 3c, d) or shale, a sedimentary rock that splits easily across thin bedding planes, could break into small pieces quickly only a few years after placing; the stone will turn into sand and gravel.

a) b) c) d)

Fig. 3. The durability of stones used for outdoor application has a decisive role in the architecture of the built space: a), b) Bologa Church, Hunedoara county, made with Bologa dacite and Bologa-Hent andesite; c) improper use of the Podeni limestone for external balusters at Palace of Parliament, Bucharest; d) Vratza limestone showing cracking processes after thermal shock laboratory tests.

High temperatures and heavy rainfall speed up the chemical weathering, while cold and dryness impede this process – in arid regions water is relatively unavailable, and in cold climates water may be chemically inert because it is frozen; in both cases, chemical weathering proceeds slowly. Freezing water may act as a wedge, widening cracks and pushing the stone pieces apart (Fig. 3c). The durability of stone elements can also be influenced by the stress along natural zones of weakness (Fig. 3d) and by biological and chemical activity (Fig. 4a).

Most stones have natural zones/planes of weakness along which they tend to crack. In sedimentary rocks such as sandstone and shale, these zones are the stratification planes formed by the successive layers of solidified

sediments. Metamorphic rocks such as slate form parallel planes of fractures that enable them to be split easily to form roofing tiles. Granites and other rocks are massive – that is, large masses that show no changes in rock type or structure. Massive rocks tend to crack along regular fractures at intervals of one to several meters called joints. These and more irregular fractures form while rocks are still deeply buried in Earth's crust.

Beside the climate parameters, both chemical and physical weathering are influenced by the activity of organisms – from bacteria, algae (Fig. 4a) to tree roots – all working in ways that destroy the rock, by widening the cracks formed by weathering.

Porosity depends on the size and shape of the grains and on how the grains are packed together. Rock itself may have a specific porosity, fractures (cracks and joints) or natural lineation (cleavage, schistosity). Sometimes, dissolution features may create a second (higher) porosity, especially in the carbonate rocks. The interaction of these porosities is very complex.

Stone elements can be also weakened or even break as a result of daily alternation between hot days and cold nights, rainfalls or freeze-thaw cycles. These processes may be weakening for the stone because of its expansion in the heat and contraction during the cold. So, it becomes very important to correctly select the type of stone on facades exposed for a long time to humidity, sunlight or strong winds (Fig. 4b). Sometimes, very important negative visual changes occur due to the humidity resulting from the method of fixing the plates (wet installation) (Fig. 4c), or physical degradation due to the chemical processes resulting from the anchorage system (Fig. 4d).

a) b) c) d)

Fig. 4. Examples of degradation of stone elements: a) algae, urban polution and weathering processes drasticly change the visual appareance of a limestone hotel façade in Bucharest; b) cracks in a Podeni architectural limestone element at the Palace of Parliament in Bucharest, due to the weathering and load bearing, c) improper interior wet instalation of Baschioi limestony sandstone in a residential house; d) degradated limestone tiles due to the anchorage metallic system.

Depending of the stone type, some recommendations for outdoor application of the stone elements with architectural purposes are presented in Table 2.

Table 2. Recommendations for applications of stone elements, depending of their genetic type (***I-STONE project, 2005)

APPLICATIONS / STONE TYPES			IGNEOUS ROCKS		SEDIMENTARY ROCKS					METAMORPHIC ROCKS		
			granite	basalt	chert	sandstone	porous limestone	compact limestone	shale	slate - phyllite - schist	marble	quarzite
OUTDOOR	façade	massive elements	xx	xx	xx	xx	-	xx	-	-	xx	xx
		thin slabs	xx	xx	-	xx	x	xx	xx	xx	xx	xx
		elements in contact with floor	xx	xx	xx	xx	-	xx	-	xx	xx	xx
	roofing		-	-	-	-	-	-	-	xx	-	-
	paving	slabs	xx	xx	-	xx	-	xx	xx	xx	xx	xx
		setts	xx	xx	xx	xx	-	xx	-	-	xx	xx
		kerbs	xx	xx	xx	xx	-	xx	-	-	xx	xx

xx: suitable x : can be used but not recommended -: not suitable

Ornamental stone from Romania – types, availability for use, recommendations for architects and builders

Ornamental and Dimensioned (cut-to-size) Stone is "the collective description of natural stone which has been extracted from the earth in an orderly manner, further worked by cutting and processing, then used in various building activities either structurally or for decorative purposes" (***I-STONE project, 2005).

An increasing market induced a big demand for high quality stone construction and decorative materials, for interior or exterior application, due to their durability and aesthetical unique properties, while also having a

positive role in the improvement of the quality of building environment. The final commercial stone products include tiles, panels, ashlars, solid masonry units for walling or different other purposes, or for architectural elements (Cetean, 2009).

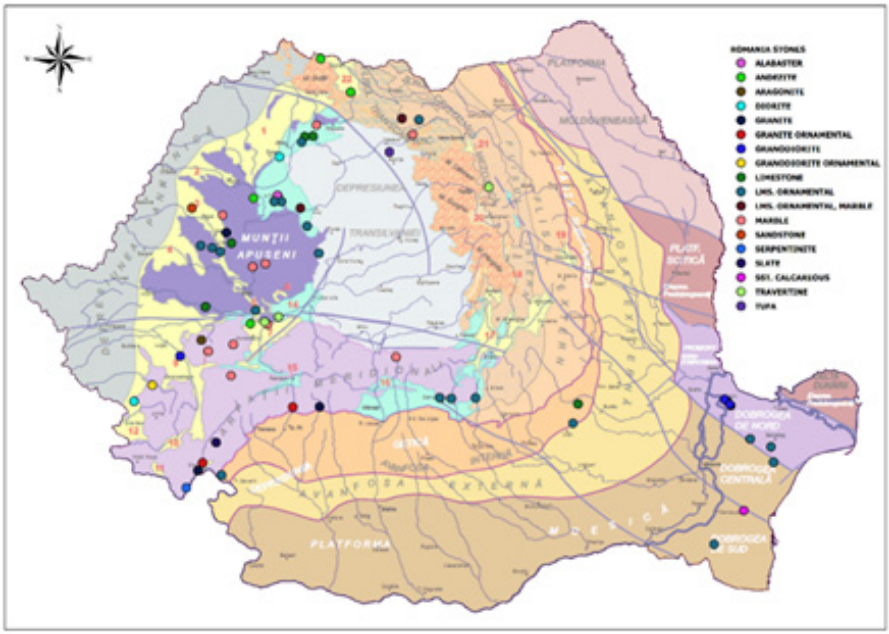


Fig. 5. The location of the ornamental stone deposits included in the national annex (no. A.2.18) of the EN 12440:2017 – Natural stone – Denomination criteria, represented in relation to the structural geology information of Romania.

From a total of over 130 ornamental stones from Romania inventoried by PROCEMA GEOLOGI Ltd in in the period 1999-2002, respectively Geological Institute of Romania between 2019-2022 in the frame of RoQ-Stone project, almost 80 perimeters (corresponding to 67 deposits – Fig. 5) are included in the National Annex (no. A.2.18) of the European Standard EN 12440:2017 – Natural stone – Denomination criteria (this European regulation establishes the criteria for the designation of natural stone from raw material to finished products).

As of 2023, only 29 of these are registered in the official records as being in operation, or at least with valid operating licenses (Table 3).

Table 3. Active Romanian ornamental stone quarries

	Name of deposit / perimeter	County	Type of stone	Colour	Quarry owner
1	Albești - Muscel	AG	Limestone	yellow-beige	ROCAS S.A. Albeștii de Muscel
2	Anieş – Valea Secii	BN	Limestone	white-grayish	VALSECMAR S.R.L. Anieș
3	Başchioi – N. Bălcescu	TL	Sandstone	yellow-beige	MACIMO SRL
4	Bologa-Henţ	CJ	Andesite	dark grey	GRANDEMAR S.A. Cluj Napoca
5	Bratcu Meri	GJ	Granite	white-grayish	CARIERA MERI S.R.L. Bumbești Jiu
6	Buteasa (II), V. Ursului – Buteasa	MM	Marble	white-grayish	C.M.C. S.R.L. Cărbunari
7	Cărpiniş – Banpotoc 1	HD	Travertine	yellow-beige	MARMOSIM S.A. Simeria
8	Ciolanu Mare - Gornenți	MH	Slate	grey-greenish	MERIDIAN CC S.R.L. Orșova
9	Codru Babadag	TL	Limestone	yellow-beige	TIB 90 COM S.R.L. Tulcea
10	Cresuia - Beiuş	BH	Marble	light grey	MARMOCALC S.A. Vașcău
11	Dealul Blidarului (Zărnești)	BV	Granodiorit	red	MORANI IMPEX SRL Zărnești
12	Forotic	CS	Diorite	grey-whitish	GABROU CARIERE S.R.L. Timișoara
13	Geoagiu (Băi)	HD	Travertine	beige-yellowish	MARMOSIM S.A. Simeria
14	Gura Văii – Vărănic (Dl. Pârlipatului)	MH	Limestone	beige-yellowish	MARMURA SA București
15	Iardaștița Mică	CS	Tuff	whitish	GRANIT STAR S.A. Orșova
16	Luncani (Pârâul Popii)	TM	Aragonite	yellow	BEGA MINIERALE INDUSTRIALE S.A. Timișoara

17	Măcin - Izvoarele, Greci - Măcin	TL	Granite	reddish-grey	HIDROMINERAL S.A. Greci MINERAL EXTRACT S.R.L. Călărași
18	Mateiaș - Valea Mare	AG	Limestone	yellow-beige	MINERAL ROM SRL(FOSTA)
19	Moigrad	SJ	Diorite	grey-whitish	CARIERA MOIGRAD S.R.L. Mârșid
20	Năieni - Nifon	BZ	Limestone	yellow-beige	FINCOM CONSTRUCT S.R.L. Năieni
21	Novaci, Novaci - La Brazi	GJ	Granite	grey-reddish	NOVAGRAN S.R.L. București
22	Orko - Sf. Gheorghe	CV	Sandstone	beige-reddish	TERRACOTTA STAR S.A. Sfântu Gheorghe
23	Pietroasa - Deva	AB	Andesite	grey	MARMOSIM S.A. Simeria
24	Podeni	CJ	Limestone	grey-whitish	MARMOSIM S.A. Simeria
25	Porumbacu	SB	Marble	whitish	MARM WORK SRL București
26	Ruşchiţa - Cariera Veche, Dealul lui Ionel, Dealul Maria, Pârâul Porcului, Dealul Plumbului	CS	Marble	pink, white-grayish, white-yellowish grey	MARMOSIM S.A. Simeria DORECO 2001 S.R.L. Rusca Montană OMYA CALCITA S.R.L. București
27	Sohodol, Sohodol - Valea Verde, Sohodol - Vădăoiești	AB	Marble	white	MARMURA SA București
28	Stana (Petrindu)	SJ	Alabaster	grey-whitish	COMINEX NEMETALIFERE S.A. Cluj
29	Vaşcău Câmp Moţi Sat (Lara - Câmp Moți)	BH	Limestone	reddish	B.A.A.S. S.R.L. Timișoara

In Table 4, recommendations of application for some Romanian ornamental stones, depending of the type of stone elements and place of application, are presented.

Table 4. Romanian ornamental stone – recommendation of end-use

Application		Ruşchiţa, Porumbacu, Sohodol marble	Podeni, Năieni limestone	Pietroasa – Deva Andesite, Moigrad dacite	Geoagiu, Cărpiniş Travertine, Mateias limestone	BASCHIOI sandstone	Macin Novaci granite
interior	flooring	*		*	*	*	*
	walling	*	*	*	*	*	*
	solid masonry units	*	*	*	*	*	*
	tablet, kitchen tops	*		*			*
	other: stairs, architectural elements	*		*	*	*	*
exterior	paving and flooring			*			*
	elements in contact with the floor			*	*		*
	non-vertical part or elements sticking out of the facade			*	*	*	*
	solid masonry units	*		*	*		*
	wall cladding units	*		*	*	*	*
	other: columns, basements for monuments, architectural elements	*		*	*		*

Romanian stone with heritage value

Under the name of HERITAGE STONE are included those natural stones that have special significance in the human culture, as the stones that have been used for centuries to build the architectonic heritage of world sites, some of them recognized by UNESCO for their importance in humanity culture. Some of these stones are no longer extracted or even the extraction was stopped for millennia. Other stones continue to be commercially important, but their heritage uses have not been well documented in widely available sources for the interested parties.

Historical use of natural stone can be a major contributor to understand past civilizations and how different civilizations evolved over the millennia, from antiquity to the present. The geological attributes of the stones, which have survived for millennia, enrich our cultural heritage, and they should be documented and studied for the present and future generations. With few exceptions, making the connection between these stone monuments and the historical quarries from which the stones were extracted require important resources.

Up to now, the International Union of Geological Sciences (IUGS) Executive Committee, through its Sub-Subcommission on Stone Heritage (part of the International Commission on Geoheritage - ICG), has adopted 32 Heritage Stones distributed in 17 countries. These stones with global heritage value are: Lede Stone (Belgium), Petit Granit (Belgium), Échaillon Stone (France), Rochlitz Porphyry tuff (Germany), Connemara Marble (Ireland), Carrara Marble (Italy), Rosa Beta Granite (Italy), Pietra Serena Sandstone (Italy), Globigerina Limestone (Malta), Larvikite (Norway), Estremoz Marble (Portugal), Lioz limestone (Portugal), Brecha da Arrabida (Portugal), Podpêc Limestone (Slovenia), Alpedrete Granite (Spain), Villamayor Stone (Spain), Macael Marble (Spain), Bernardos Phyllite (Spain), Kolmården Serpentine Marble (Sweden), Hallandia Gneiss (Sweden), Bath Limestone (UK), Portland Limestone (UK), Welsh Slate (UK), Piedra Mar del Plata (Argentina), Tyndall Stone (Canada), Teozantla Tuff (Mexic), Jacobsville Sandstone (USA), Tennessee Marble (USA), Makrana Marble (India), Deccan Basalt (India), Jaisalmer Limestone (Indi) and Alwar Quartzite (India).

On the other hand, from this list of over 130 ornamental stones used/usable as shaped (dimensioned) stones, 28 of them (from which 19 in operation) were selected by the authors as fulfilling the conditions of a stone with heritage value of national and global significance. The main criteria applied include: their significance in the human culture (for the architectural heritage of world sites or in significant works), wide-ranging geographic application, ornamental properties, and ongoing availability.

Table 5. The "short list" of Romanian ornamental stones which fulfil the heritage value criteria (Cetean et al., 2023)

	Name of natural stone	Petrological family/ group	Typical colour	Status	Coordinates	
					X	Y
1	Ruşchiţa	marble	pink, white-greyish, white-yellowish, grey	in exploitation	45.6462480	22.4057590
2	Moneasa	breccia marble limestone	Reddish, red to brownish, black, grey	in exploitation	46.4737580	22.2793560
3	Alun	marble	white-yellowish-grey	ceased	45.7054670	22.6816530
4	Vaşcău	limestone	polychrom; grey to dark grey, reddish or black	in exploitation	46.4690140	22.4253930
5	Podeni	sandstony limestone	grey-whitish	in exploitation	46.4371030	23.6282500
6	Albeşti	fossiliferous limestone	yellow-beige	in exploitation	45.3081569	25.0074577
7	Geoagiu & Cărpiniş	travertine	beige-yellowish to yellow-beige	in conservation; in exploitation	45.9315790	23.1854460
8	Viştea	limestone	yellow-beige	in exploitation	46.7988280	23.4650950
9	Măcin	granite	reddish-grey	in exploitation	45.2357038	28.2179546
10	Pietroasa-Deva	trachyte	grey	in exploitation Pre-Roman quarry	45.8700958	22.8706598
11	Codru Babadag	sandstony limestone	yellow-beige	in exploitation	44.8607970	28.6791229
12	Borsec	travertine	beige-yellowish	ceased	46.9651360	25.5699590
13	Măgura Călanului	oolithic and clastic limestone	cream, whitish, cream -yellowish	ceased, Pre-Roman quarry	45.7635790	23.0501571

The biggest challenge was the lack of accessible information regarding the stones used in public and/or heritage buildings (Cetean et al., 2023). Usually, there was information about the construction itself, especially in the case of heritage buildings, and at most the petrographic type of rock used was mentioned (e.g., limestone, marble, granite, basalt, etc.); very rarely the name of the stone (source-area) was mentioned. Another obstacle was the fact that the vast majority of the old quarries changed their owner repeatedly, and their archives no longer exist. Thus, in order to constitute the files supporting the heritage value of these rocks, important human, material and time resources must be allocated.

A "short list" of 12 stones (Cetean et al., 2023) was prepared in order to focus the efforts and laborious work of documenting the monuments and other historical buildings where the stones were used. To these it was added the most important quarry from a historical-cultural point of view, that contributed to the building of the Dacian fortresses in the Orăștiei Mountains, but which was abandoned since the 2nd century AD (Table 5).

Seven types of these stones were used the Palace of the Parliament (Fig. 6), the third largest administrative building for civil use in the world (with a floor area of 330,000 m^2). The construction of this impressive building required a huge amount of stone: Podeni and Viștea limestone tiles and panels for the exterior (approx. 750,000 m^3), and Rușchița and Alun marbles as the preferred materials for the interiors (over 1,000,000 m^3) or Moneasa limestone, but also, even in small quantity, Borsec, Cărpiniș, and Geoagiu travertine – already stones with national heritage value at the time of use.

Fig. 6. The Parliament Palace, the iconic building where a huge volume of Romanian ornamental stones was used for flooring, cladding and different architectural elements.

Conclusions

The exploitation of raw materials has always been one of the most important activities in the human evolution, due to the fact that all productive activities have a mineral material at the base of their development. Natural stones will remain the most resistant construction material, but their use must always take into account efficiency in operation. The fundamental recommendation is that the architects and builders should always find the balance between the desired ornamental characteristics, the maintenance cost and long-term environmental sustainability.

References

*** (2005-2008) I-STONE - *Re-engineering of natural stone production chain through knowledge-based processes, eco-innovation and new organisational paradigms*, Contract no.: NMP2-CT-2005-515762, D5.23: Handbook on care and maintenance of Natural Stone (SP), D5.28 Handbook for proper selection of stone to each application and climate (BBRI, SP, BGC, MoG and PCG)

Cetean, V. (2009) - Romanian dimension stones: behaviour under climatic variations and final use, Abstract in Studia Universitatis Babeş-Bolyai Geologia (Studia UBB Geologia), Ed. nr. Special Issue 2009, ISSN 1221-0803

Cetean, V., Filipciuc, C., Fărnoagă, R., Tudor, E., Ion, D., Lörincz, S., Dincă, G. (2023). TOP 12+1 Ornamental stones from Romania with national and global heritage value. In Lopes, L., Peres, M., and Marques, C. (Eds.), *Proceedings of the VII Global Stone Congress*, Batalha, Portugal, 18-23 June 2023.. Departamento de Geociências da Escola de Ciências e Tecnologia da Universidade de Évora, Portugal. pp. 132-140. ISBN: 978-972-778-327-4

Hallsworth, C. R., and Knox, R. W. O'B. (1999). BGS Rock Classification Scheme, Volume 3, Classification of sediments and sedimentary rocks. *British Geological Survey Research Report*, RR 99–03.

TEAM, Testing and Assessment of Marble and Limestone, Final Technical Report, Oct. 2005.EC-Project: TEAM—G5RD-CT-2000–00233.