

EUROLITHOS European Ornamental Stone Resources



EuroLithos Atlas

Ornamental stone resources in Italy

Thematic focus: Country

Responsible partner(s): ISPRA

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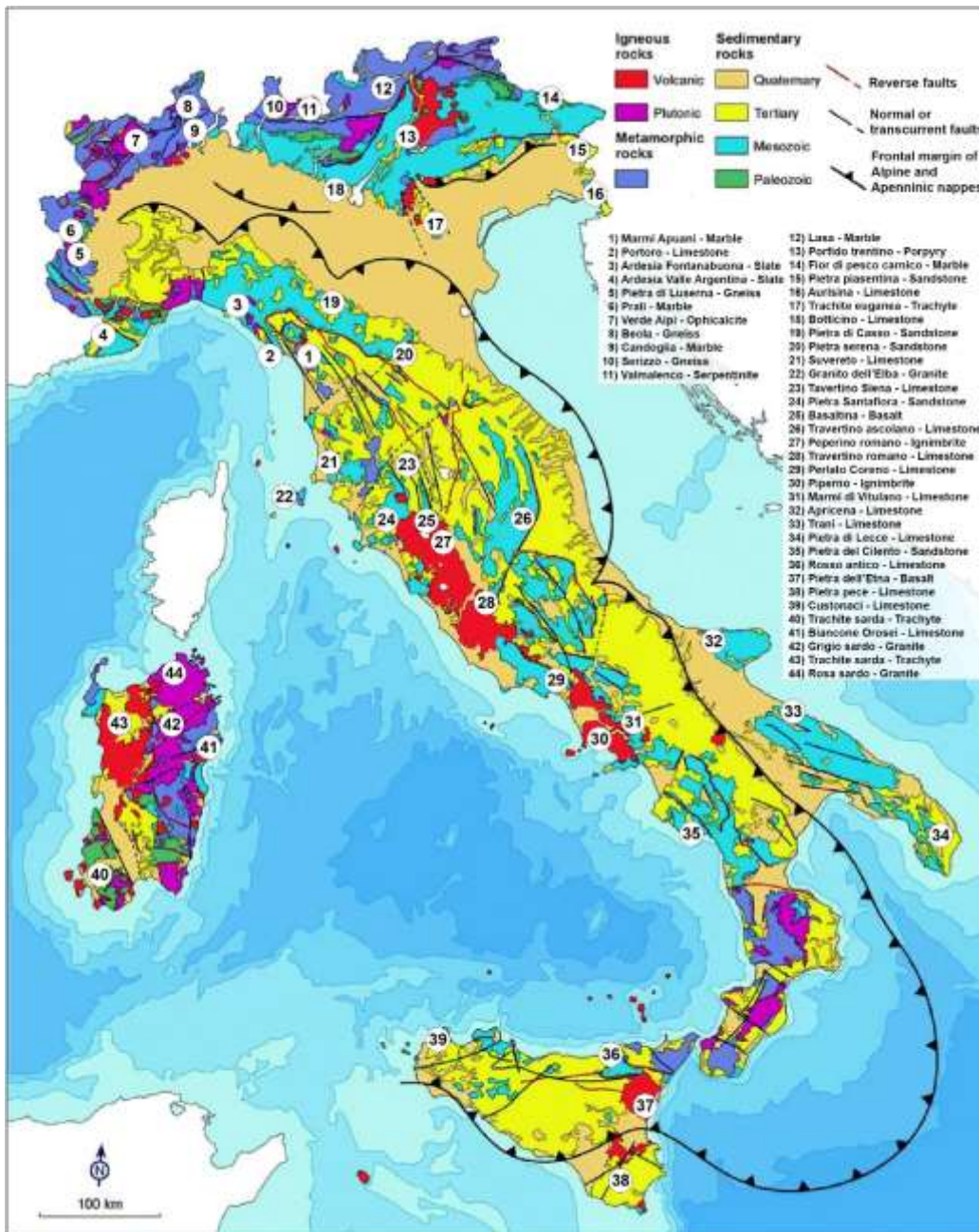
Year: 2021

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Geology of Italy

The Italian peninsula is an extremely active region from the geodynamic point of view as witnessed by the presence of active volcanoes (Vesuvius, Campi Flegrei, Stromboli, Vulcano, Etna) and by frequent earthquakes, as well as witnessed by land and coasts instability. As a matter of fact, Italy, being situated in the middle of the Mediterranean, is subject to the same geological evolution which characterizes this entire region, controlled by the progressive approaching of two megaplates, Eurasia to the north and Africa to the south.



The geology of Italy and its related tectonic setting are therefore the result of this collision, the most evident expression of which is represented by the two main mountain ranges that make up its backbone: the Alps to the north and the Apennines from the center to the south, along the peninsula.

The present geology of Italy, including the two major islands, Sicily and Sardinia, is remarkably varied and contains rock series from all eras and periods (Fig. 1). The Italian territory can be subdivided into seven specific sectors, i.e. The Alpine chain proper, the Po Plain, the Apennines, the Apulia foreland, the Calabrian-Peloritan arc, Sicily and Sardinia.

Fig. 1 – Simplified Geological Map of Italy (Bosellini, 2017, modif.). Location of the main extractive sites (including the historical ones) of ornamental stones in Italy.

Ornamental stone resources in Italy

From a production point of view, the rocks are divided into: Marbles, Granites and Stones.

The term Marble refers to all rocks of a predominantly carbonate nature suitable of polishing, regardless of their origin; this category therefore groups both real marbles (metamorphosed carbonate rocks) such as the Tuscan ones of the Apuan Alps and limestones such as Chiampo, Botticino, Trani, Perlato di Sicilia and others.

Often the term Marble is also extended to ornamental rocks of a non-carbonate nature such as the Green Stones (Verde Aver, Verde Issorie, Verde Imperiale excavated in Val d'Aosta), perfectly polishable and mainly made up of mineral serpentine derived from the metamorphism of igneous rocks basic and ultra-basic.

The term Granite groups all the igneous rocks both intrusive and hypoabyssal and also the metamorphic rocks as long as silicate in nature and in any case polishable (gneiss such as Beole and Serizzi of the Ossola Valley). We thus pass indiscriminately from real granites such as the Sardinian ones, to syenites (Syenite of Balma or Granite of Biella), diorites, anorthosites (Labradorite) and gabbri, rocks, the latter, with basic chemism.

The Stones represent perhaps the most heterogeneous group characterized by rocks of various origins and mineralogical nature, with poor mechanical resistance, easy to work and therefore generally not polishable. As an example we remember the Ceppo della Lombardia, the Ligurian slate, the Peperino Lazio, the Tuscan Pietra Serena, the Venetian Pietra Piacentina and others.

Ornamental stone production

A fairly modest downward trend in production, trading and consumption has continued to characterise the Italian stone sector reflecting the overall trend. Nonetheless, the critical situation has not prevented the sector from showing some positive signs which are worthy of note including a slight recovery in the importation of raw materials for domestic processing, and above all the resistance of the leading average price previously assigned to exports of the finished product. In the final balance of 2019, exports registered a quantitative decrease of 4.5% (aver five times more than the overall world one). This added to the decreases of the previous years, going down to 2.5 million tons as against an historic maximum of 3.6 recorded in far-off 2000. Specifically, the decrease was less significant in raw materials, where it stopped at 33%, while for finished products it increased to 5.8% with a further drop in added value, also confirmed by its impact on the total amounts exported, which went down to 47.5%, but with a major share for raw materials which began to expand its volumes, while its values held relatively fast.

In the short term too there were decreases in all the product types and in 2019 there was also a more accentuated decrease in value. Exports abroad of rough blocks and slabs continue to favour calcareous stone, particularly marbles and travertines, which maintained a quantity of 1.2 million tons in absolute figures, while for siliceous stone (more in demand at a world level but not easily available in Italy) the final balance was for only just over 100,000 tons. For finished products added value was the most requested type, leaving an overall share of about 10 % for simple finished and slate products, which is halved in the overall calculation.

Over a 20-year period the share of exported products has lost 20% wholly in favour of raw materials. Specifically, the exportation of raw materials confirmed China as the main buyer, in terms of both quantity and values, with 51.2% of the specific turnover, while in the next positions we find India and Egypt.

The average value of rough material exports showed it was holding up fairly well, with 352 dollars per ton, confirming the 350 of the previous year, with over 1500 for sales on the US market. Exportation of the finished product maintains its traditional characteristics as regards all the main destinations. The United States and Germany are in first and second position, with very different average prices in favour of the former, which maintain a 27.8% share, with a general decrease of 13% as compared to 2016.

The distribution remains fairly differentiated, with three countries (Switzerland, France and United Kingdom) which each purchased Italian finished products for over 50 million dollars. As for the average price, it may be said that it remains a strong point in Italian export in the sector, having a value per unit of product of over 75 dollars per square metre equivalent (with the standard thickness of 2 cm). This is a 3% decrease, but it remains decidedly at the top of the world market, which shows moments of particular excellence for the United States but also for Russia, Canada, United Kingdom and France, all over 100 dollars per metre (with the minimum of 41 for China).

Looking finally at importations, after a long series of annual regressions (8 in one decade) they showed a recovery of 4.9%. In absolute figures, this means an increase of over 40 thousand tons recorded in 2019, as compared with a total of 940.000 and a difference regarding siliceous materials, the main component of foreign purchases, which over the long term shows significant decreases above all for those from India, unlike the situation in the rest of the world; while materials from Africa and Brazil obtained relatively better results. Nonetheless, it should be remembered that while the growth in raw materials stopped at 4.4%, for the finished product it was 6.3%, placing on the home market 237 tons of products which at the aforesaid thickness are the equivalent of approx. 4.4 million square metres. An amount which gives cause for reflection in the current Italian situation (Montani, 2020).

Use of ornamental stone and heritage values

Italy is, as is well known, a country of ancient mining traditions in the sector of cutting stone in the western Mediterranean. These traditions, which date back to the Greek-Roman world, have been maintained and renewed over the centuries thanks to a great cultural flow that through the Middle Ages and the Renaissance has strongly conditioned art and therefore urban architecture. In recent times the stone industry has reached global importance in Italy; such production, about 8.5 million tons per year overall, places the Country at the top placed in the world with particular reference to marble, limestone and travertine, while for the granites other countries hold the record of production. Domestic production is no longer sufficient to supply processing companies that they import materials from all over the world; some marbles, however, internationally famous (i.e. the "Carrara Marble" or the "Roman Travertine"), continue to represent an important voice in the production of Italian stone.

Ornamental stones have been exploited in Italy since ancient times for the construction of numerous buildings and monuments many of which represent the current national heritage. From the Colosseum (i.e. Travertine) to the Florence Cathedral (i.e. Carrara Marble), from the St. Peter Basilica (i.e. Broccatello Marble) to the Milan Cathedral (i.e. Candoglia Marble), passing through countless monuments and buildings in almost every city, town or village of the Peninsula, ornamental stones have characterized places with various styles and in different times.

Descriptions of ornamental stone resources

Some of the most important Italian ornamental stones are described below in the order shown in Table 1.

Stone Name	Commodity	Lithology
Basaltina	Commercial basalt	tephrite
Broccatello di Siena	Commercial marble	marble
Bronzetto di Trani	Commercial limestone	limestone
Daino - Marmo di Orosei	Commercial limestone	limestone
Travertino Romano	Commercial limestone	travertine

Travertino Romano

Lapis Tiburtinus (Latin name)



8 centimeters

Lithoid vacuolar travertine with fibrous-concretional structure.

Commodity	Lithology	Typical colour	Place of origin			
			Country	Province	Municipality	Village
Commercial limestone	Travertine	White	Italy	Rome (Latium)	Guidonia	Guidonia

Geological setting



2.5 kilometers

Geology: The Tivoli-Guidonia plain (blue-grey colours in the figure), within the Valley of the Aniene River (flowing southwestwards), is mostly composed of travertine deposits and subordinately of a clayey-candy lithofacies and of alluvial, slope and lacustrine deposits. Travertine deposits are evidenced with TBT acromyms. The quarry areas are evidenced with white background polygons. The deposits cropping out in the western and southern part of the map are mainly pyroclastic deposits of the Alban Hill Volcano, those cropping out at the eastern side are mainly calcareous-marly deposits of the Cornicolani Mts.

Production: Many quarries are escavated around the Tivoli and Guidonia towns for the production of this stone, known from ancient Roman times.

Geological age: Holocene-Upper Pleistocene p.p.

Geological unit: Travertines

Application, use and heritage



The Travertino Romano, extracted since the ancient Roman time, was used for many purposes (e.g. facade cladding, indoor floors, table tops and monuments). The classic Travertino Romano is whitish in colour and has many subtypes with different typical shades of colours (e.g. yellowish grey, light beige, beige, beige with darker veins). In this picture, a detail of the colonnade (284 columns, 16 m of height) of the Vatican Basilica of San Peter in Rome, built by the worldwide known sculptor and architect G.L. Bernini in 1656-1667, made of this stone.

Petrography



3 centimeters

Description: Detailed photo in natural light of a cutting surface of Travertino Romano, showing the appearance of this chemically-deposited mainly calcitic and subordinately anidritic and magnesitic sedimentary rock with porous texture and encrusted plant relics.

Source of information: Geological Survey of Italy, Geological map of Italy 1:50.000 scale, Tivoli Sheet, <https://www.isprambiente.gov.it/en/services/cartography/geological-and-geothematic-maps/geological-map-at-a-scale-1-to-50000>;
Geological Science Department - University Roma Tre, Italithos 2000, <http://www.italithos.uniroma3.it/>

Mineral composition

Calcite (%)	Clay Minerals (%)	Quartz (%)	Fe-Mn oxydes (%)	Fe-Mn hydroxydes (%)		
>95	AM	AM	AM	AM		

MM=main minerals, SM = Subordinate minerals, AM=accessory minerals

Source of information: Geological Science Department - University Roma Tre, Italithos 2000,
<http://www.italithos.uniroma3.it/>

Physical properties

Apparent density (EN 1936) kg/m ³	Open porosity (EN 1936) % vol	Water absorption at atmospheric pressure (EN 13755) % wt	Uniaxial Compressive strength (EN 1926) MPa	Flexural strength under concentrated load (EN 12372) MPa
2247		0.8	109	13.8

Real density (EN 1936) kg/m ³	Total porosity (EN 1936) % vol	Water absorption coefficient by capillary (EN 1925) (g/m ² x s ^{0,5})	Flexural strength under constant moment (EN 13161) MPa

Frost resistance (EN 12371)				
Technological Test (Test A)				Identification Test (Test B): Number of cycles completed prior to stone failure
Flexural strength (EN 12372) after freeze-thaw cycling, MPa	Number of cycles	Uniaxial compressive strength (EN 1926) after freeze-thaw cycling, MPa	Number of cycles	
		110	48	

Resistance to ageing by thermal shock (EN 14066)			
Change in dynamic modulus of elasticity (increase: +; decrease: -) %	Change in open porosity (increase: +; decrease: -) %	Change in ultrasound pulse velocity (increase: +; decrease: -) %	Change in flexural strength under conc. load (increase: +; decrease: -) %

Abrasion resistance (EN 14157)			Resistance to salt crystallisation (EN 12370)	Breaking load at dowel hole (EN 13364)	
Method A - Wide Wheel Abrasion Test, mm	Method B - Böhme Abrasion Test, cm ³ / 50cm ²	Method C - Amsler Abrasion Test, mm	Change in mass (increase: +; decrease: -), %	Breaking load, N	Thickness of the test specimens, mm
		28			

Slip resistance by means of the pendulum tester (EN 14231 / CEN/TS 16165)			Rupture energy (EN 14158), Joule	Thermal Conductivity (EN 1745), W/m·K
Tested surface finish	Slip Resistance Value — SRV			
	Dry test condition	Wet test condition		

Source of information: Geological Science Department - University Roma Tre, Italithos 2000, <http://www.italithos.uniroma3.it/>

Chemical properties

Main elements

SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	FeO (%)	MgO (%)	CaO (%)	Na ₂ O (%)	K ₂ O (%)	MnO (%)	P ₂ O ₅ (%)	SO ₃ (%)	CO ₂ (%)
0.73	0.05	0.05	0.07		55.10	0.14			0.27	0.28	43.40

Trace elements

V (ppm)	Cr (ppm)	Mn (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)
Sr (ppm)	Cd (ppm)	Ba (ppm)	Pb (ppm)	Be (ppm)	Rb (ppm)	Bi (ppm)	U (ppm)
Sc (ppm)	Y (ppm)	Th (ppm)	Sb (ppm)	Ta (ppm)	Nb (ppm)	Zr (ppm)	Sn (ppm)
Ag (ppm)	B (ppm)	Mo (ppm)	W (ppm)	Ga (ppm)	Ge (ppm)	Se (ppm)	Cs (ppm)
Tl (ppm)							


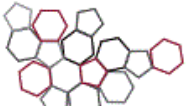
REE

La (ppm)	Ce (ppm)	Pr (ppm)	Nd (ppm)	Sm (ppm)	Eu (ppm)	Gd (ppm)	Tb (ppm)
Dy (ppm)	Ho (ppm)	Er (ppm)	Tm (ppm)	Yb (ppm)	Lu (ppm)		

Methods applied and source of information: Geological Science Department - University Roma Tre, Italithos 2000,
<http://www.italithos.uniroma3.it/>

Sources of more information

Type of information	Name of provider	URL
This data sheet	Geological Survey of Italy -ISPRA	https://www.isprambiente.gov.it/en/services/cartography/geological-and-geothematic-maps/geological-map-at-a-scale-1-to-50000
Non-commercial directory	Geological Science Department - University Roma Tre, Italithos 2000	http://www.italithos.uniroma3.it/
Commercial directory		
Scientific publication	Società Geologica Italiana/ Italian Geological Society, Rend. Online Soc. Geol. It.	https://doi.org/10.3301/ROL.2013.23
Other publication		

Compiled by:	Geological survey of Italy – ISPRA website http://portalesgi.isprambiente.it/	 ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale	 Sistema Nazionale per la Protezione dell'Ambiente
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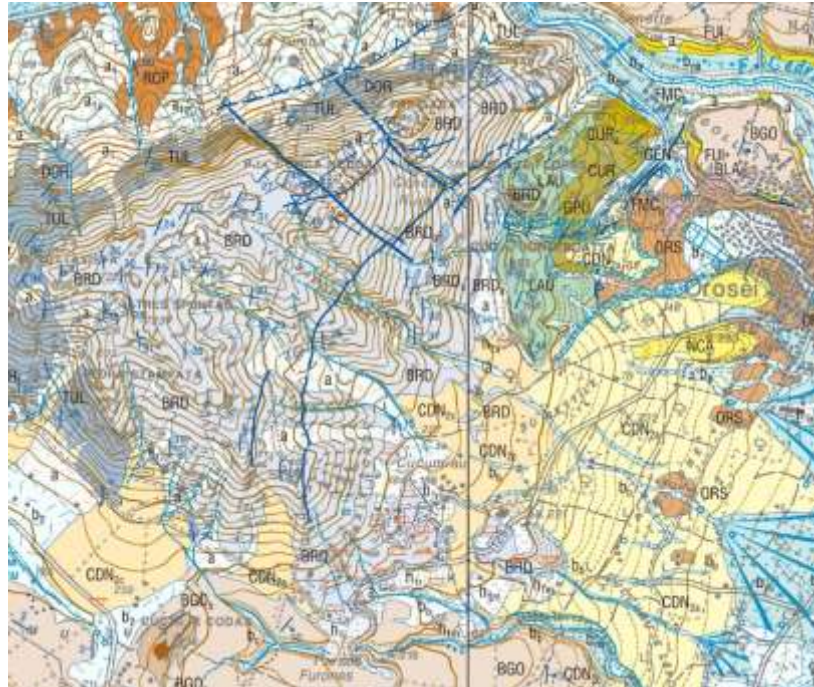
Daino - Marmo di Orosei



Orosei marble, also known commercially as Breccia Sarda, Biancone, Perlato Olimpo, Tigrato d’Oriente, Daino Reale and Daino Imperiale, derives from a carbonic formation dating from the Jurassic-Cretaceous Period present in Monte Tuttavista in Orosei. Characterized by an alternation of layers of calcareous and dolomitic marbles, its coloring ranges from beige to hazelnut-cream and is enriched with darker veins of calcite and laminas of onyx.

Commodity	Lithology	Typical colour	Place of origin			
			Country	Province	Municipality	Village
Commercial limestone	Limestone	Beige	Italy	Nuoro	Orosei	Orosei

Geological setting



scale 1:50,000

Geology: In this area the Palaeozoic basement outcrops are made by decimetric to metric irregular alternations of quartzitic to micaceous metasandstones, grey-to- whitish quartzites, grey sometimes blackish phyllites, attributed to the Filladi grigie del Gennargentu formation (GEN), ?Cambrian - ?Lower Ordovician in age. This medium grade metamorphic basement is intruded by late-variscan granitoids, represented near this area by the cordierite bearing granodiorites. A Mesozoic succession aged from the Oxfordian and the Upper Cretaceous (Upper Albian - Lower Santonian) outcrops on the eastern side of Mt. Tuttavista. The basal terms of the Mesozoic succession referred to the Batonian-Callovia outcrop in western Mt. Tuttavista. It is mainly represented by bioclastic sandy limestones, levels of marls and whitish marly limestones, calcilutites. Except in the area of Mt. Tuttavista, the area is occupied equally by pliocene-pleistocene basalts with fluvio –lacustrine interbedded terrigenous sediments, in the northern and south-western part, and by quaternary sediments in the central and eastern parts.

Production: On the southern and eastern slopes of Mt. Tuttavista there are 15 quarries, all located at short distances from each other, where the Mesozoic limestones of the Monte Bàrdia formation are cultivated for ornamental use. which, once cut and polished, are sold under the (commercially correct though geologically improper) name 'marble'. The deposit extends for about 300 ha with an average thickness of about 560 m.: today, after about 30 years of mining, only 6% of the current reserves in sight has been exploited and only 35 ha are involved in the cultivation of quarries.

From a commodity point of view, ornamental stone products, in the different varieties related to differences in texture (Perlato, Nuvolato, Venato, Breccia etc.) and color (light beige, dark, sometimes pinkish), are used all over the world and exported to all continents for use both in interiors and in the external cladding of buildings, in urban works and street furniture, in the creation of sculptures and works of art.

Geological age: Upper Jurassic (Upper Tithonian) Lower Cretaceous (Lower Valanginian)
Geological unit: "Monte Bàrdia" Formation

Application, use and heritage



The "sound stones" of P. Sciola. The artist models his monoliths (not only the marble of Orosei) through cuts, incisions and grooves of different length, width and distribution, and then plays them with his bare hands or with a plectrum, also made of stone. He says about this rock: *"This is a Biancone of Orosei. Its origin is calcareous, it was formed in the sea, practically it is fossilized water. The sound it emits is liquid, reminiscent of the sounds we hear when we are underwater, and it differs from the marbles of the rest of Italy because Sardinia is a more ancient land. Among the most ancient in Europe"*.

Petrography

Description

Source of information:

Mineral composition

Calcite(%)	Fe-Mn hydroxydes (%)	Fe-Mn oxydes (%)	Hydrated silicates(%)	Cyclosilicates (%)		
5	AM	AM	AM	AM		

MM=main minerals, SM = Subordinate minerals, AM=accessory minerals

Source of information:

Physical properties

Apparent density (EN 1936) kg/m ³	Open porosity (EN 1936) % vol	Water absorption at atmospheric pressure (EN 13755) % wt	Uniaxial Compressive strength (EN 1926) MPa	Flexural strength under concentrated load (EN 12372) MPa
2.673	1,20	0,4	188	12

Real density (EN 1936) kg/m ³	Total porosity (EN 1936) % vol	Water absorption coefficient by capillary (EN 1925) (g/m ² x s ^{0,5})	Flexural strength under constant moment (EN 13161) MPa
		1,411	

Frost resistance (EN 12371)				
Technological Test (Test A)				Identification Test (Test B): Number of cycles completed prior to stone failure
Flexural strength (EN 12372) after freeze-thaw cycling, MPa	Number of cycles	Uniaxial compressive strength (EN 1926) after freeze-thaw cycling, MPa	Number of cycles	
9,2	48	193	48	

Resistance to ageing by thermal shock (EN 14066)			
Change in dynamic modulus of elasticity (increase: +; decrease: -) %	Change in open porosity (increase: +; decrease: -) %	Change in ultrasound pulse velocity (increase: +; decrease: -) %	Change in flexural strength under conc. load (increase: +; decrease: -) %
-0,01			

Abrasion resistance (EN 14157)			Resistance to salt crystallisation (EN 12370)	Breaking load at dowel hole (EN 13364)	
Method A - Wide Wheel Abrasion Test, mm	Method B - Böhme Abrasion Test, cm ³ / 50cm ²	Method C - Amsler Abrasion Test, mm	Change in mass (increase: +; decrease: -), %	Breaking load, N	Thickness of the test specimens, mm
17,2					

Slip resistance by means of the pendulum tester (EN 14231 / CEN/TS 16165)			Rupture energy (EN 14158), Joule	Thermal Conductivity (EN 1745), W/m·K
Tested surface finish	Slip Resistance Value — SRV			
	Dry test condition	Wet test condition		
Smooth				

Source of information: I materiali lapidei della Sardegna, Sardegna Ricerche

Chemical properties

Main elements

SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	TiO ₂ (%)	MgO (%)	CaO (%)	Na ₂ O (%)	K ₂ O (%)	MnO (%)	P ₂ O ₅ (%)	SO ₃ (%)	LOI (%)	CO ₂ (%)	H ₂ O (%)
0,2	0,54	<0,01	0,03	0,39	52,77	<0,01	<0,01	<0,01	0,03	0,10		42,5	3,5

Trace elements

V (ppm)	Cr (ppm)	Mn (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)
Sr (ppm)	Cd (ppm)	Ba (ppm)	Pb (ppm)	Be (ppm)	Rb (ppm)	Bi (ppm)	U (ppm)
Sc (ppm)	Y (ppm)	Th (ppm)	Sb (ppm)	Ta (ppm)	Nb (ppm)	Zr (ppm)	Sn (ppm)
Ag (ppm)	B (ppm)	Mo (ppm)	W (ppm)	Ga (ppm)	Ge (ppm)	Se (ppm)	Cs (ppm)
Tl (ppm)							


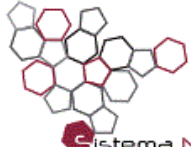
REE

La (ppm)	Ce (ppm)	Pr (ppm)	Nd (ppm)	Sm (ppm)	Eu (ppm)	Gd (ppm)	Tb (ppm)
Dy (ppm)	Ho (ppm)	Er (ppm)	Tm (ppm)	Yb (ppm)	Lu (ppm)		

Methods applied and source of information:

Sources of more information

Type of information	Name of provider	URL
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Non-commercial directory	Geological Science Department - University Roma Tre, Italithos 2000	http://www.italithos.uniroma3.it/
Commercial directory		https://www.sardegnamarmi.com/marmo-di-orosei/
Scientific publication	Memorie Descrittive della Carta Geologica d'Italia, ISPRA-Geological Survey of Italy	https://www.isprambiente.gov.it/it/pubblicazioni/periodici-tecnici/memorie-descrittive-della-carta-geologica-ditalia/la-geologia-di-roma-dal-centro-storico-alla
Other publication		

Compiled by:	Geological survey of Italy – ISPRA website http://portalesgi.isprambiente.it/	 <p>ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale</p>  <p>Sistema Nazionale per la Protezione dell'Ambiente</p>
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BRONZETTO DI TRANI

Pietra di Trani



Pelmicritic limestone with algal lamina and pellet lamina; drying cavities occluded by sparites; fine grain sparitic cement

Commodity	Lithology	Typical colour	Place of origin			
			Country	Province	Municipality	Village
Commercial limestone	Limestone	Beige	Italy	Trani (BAT)	Trani	Trani

Application, use and heritage



Trani Cathedral, column in Pietra di Trani

Petrography



Description:

Pelmicritic limestone with algal lamina and pellet lamina; Clastic structure. The main mineralogical component is calcite (over 99 %), less than 1 % the insoluble residue, composed occasionally by iron oxide, rutile, clay mineral, and silicate (phyllosilicate, garnet).

Source of information:

- "La pietra di Trani" B. RADINA (AGI - RIG n. 5 del 1955) https://associazionegeotecnica.it/wp-content/uploads/2011/09/geot_1956_5_206.pdf
- MARMI ITALIANI - GUIDA TECNICA (ICE) Fratelli VALLARDI EDITORI 1982
- <http://www.elmarstone.com/cava-di-trani/>
- http://www.gaverini.it/it-IT/le_nostre_pietre/pietra_di_trani/PT
- "Tecniche geologiche tradizionali nella ricerca di nuovi giacimenti di pietre ornamentali in Puglia" A. REINA & L. BUTTIGLIONE (Geologi e Territorio n° 1 / 2 - 2005 pagg. 29-40 Ordine Regionale dei Geologi – Puglia)
- ATLANTE CONTEMPORANEO DEI MARMI E DELLE PIETRE DI PUGLIA – Regione Puglia D. POTENZA https://www.assoarchitetti.it/doc/atlante_marmi_pietre.pdf

Mineral composition

Calcite (%)	Fe oxyde (%)	Clay mineral (%)	Rutile (%)	Silicates (%)	Mineral 6 (%)	Mineral 7 (%)
> 99	AM	AM	AM	AM		

MM=main minerals, SM = Subordinate minerals, AM=accessory minerals

Source of information:

- "La pietra di Trani" B. RADINA (AGI - RIG n. 5 del 1955) https://associazionegeotecnica.it/wp-content/uploads/2011/09/geot_1956_5_206.pdf
- "Ricerche sedimentologiche sulla "Pietra di Trani" E. LUPERTO, 1957 Istituto di Mineralogia dell'Università di Bari.
- "Compact limestones as historical building material: properties of the Tarni Stone (Apulia, southern Italy) and preliminary study for self cleaning treatments" A. CALIA, L. MATERA and M. LETTIERI. 12th International Congress on Deterioration and Conservation of Stone – Columbia University, New York, 2012

Physical properties

Apparent density (RD 2232-2234 1939) kg/m ³	Open porosity (RD 2232-2234 1939) % vol	Water absorption at atmospheric pressure (EN 13755) % wt	Uniaxial Compressive strength (EN 1926) MPa	Flexural strength under concentrated load (EN 12372) MPa
2650	2,6	0,54	175,00	18,18

Real density (EN 1936) kg/m ³	Total porosity (EN 1936) % vol	Water absorption coefficient by capillary (EN 1925) (g/m ² x s ^{0,5})	Flexural strength under constant moment (EN 13161) MPa
2715			

Frost resistance (EN 12371)				
Technological Test (Test A)				Identification Test (Test B): Number of cycles completed prior to stone failure
Flexural strength (EN 12372) after freeze-thaw cycling, MPa	Number of cycles	Uniaxial compressive strength (EN 1926) after freeze-thaw cycling, MPa	Number of cycles	
13,62		0,54		

Resistance to ageing by thermal shock (EN 14066)			
Change in dynamic modulus of elasticity (increase: +; decrease: -) %	Change in open porosity (increase: +; decrease: -) %	Change in ultrasound pulse velocity (increase: +; decrease: -) %	Change in flexural strength under conc. load (increase: +; decrease: -) %

Abrasion resistance (EN 14157)			Resistance to salt crystallisation (EN 12370)	Breaking load at dowel hole (EN 13364)	
Method A - Wide Wheel Abrasion Test, mm	Method B - Böhme Abrasion Test, cm ³ / 50cm ²	Method C - Amsler Abrasion Test, mm	Change in mass (increase: +; decrease: -), %	Breaking load, N	Thickness of the test specimens, mm

Slip resistance by means of the pendulum tester (EN 14231 / CEN/TS 16165)			Rupture energy (EN 14158), Joule	Thermal Conductivity (RD 2232-2234 1939), mm/m °C
Tested surface finish	Slip Resistance Value — SRV			
	Dry test condition	Wet test condition		
				0,0037

Source of information:

- http://www.gaverini.it/it-IT/le_nostre_pietre/pietra_di_trani/PT
- ATLANTE CONTEMPORANEO DEI MARMI E DELLE PIETRE DI PUGLIA – Regione Puglia D. POTENZA
https://www.assoarchitetti.it/doc/atlante_marmi_pietre.pdf
- "La pietra di Trani" B. RADINA (AGI - RIG n. 5 del 1955) https://associazionegeotecnica.it/wp-content/uploads/2011/09/geot_1956_5_206.pdf

Chemical properties

Main elements

SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	TiO ₂ (%)	MgO (%)	CaO (%)	Na ₂ O (%)	K ₂ O (%)	MnO (%)	P ₂ O ₅ (%)	SO ₃ (%)	CO ₂	H ₂ O	LOI (%)
<1	<1	<1	<1	<0,1	55	<0,1	<1	<1	<0,1		43	<1	

Trace elements

V (ppm)	Cr (ppm)	Mn (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)
Sr (ppm)	Cd (ppm)	Ba (ppm)	Pb (ppm)	Be (ppm)	Rb (ppm)	Bi (ppm)	U (ppm)
Sc (ppm)	Y (ppm)	Th (ppm)	Sb (ppm)	Ta (ppm)	Nb (ppm)	Zr (ppm)	Sn (ppm)
Ag (ppm)	B (ppm)	Mo (ppm)	W (ppm)	Ga (ppm)	Ge (ppm)	Se (ppm)	Cs (ppm)
Tl (ppm)							

REE

La (ppm)	Ce (ppm)	Pr (ppm)	Nd (ppm)	Sm (ppm)	Eu (ppm)	Gd (ppm)	Tb (ppm)
Dy (ppm)	Ho (ppm)	Er (ppm)	Tm (ppm)	Yb (ppm)	Lu (ppm)		

Methods applied and source of information:

- <https://www.tranigoldstone.it/IT/scheda-tecnica#:~:text=La%20pietra%20di%20Trani%20%C3%A8,colorazione%20havana%20beige%20con%20stiloliti.&text=Calcare%20pelmitritico%20con%20bioclasti%3B%20prevalgono,Alghe%20calcaree%2C%20Ostracodi%2C%20Foraminiferi.>
- BORGHI M, MASI U., TUCCI P. & VIZZINI G. (1996) "Chemostratigraphy of the Upper part of the "Calcare di Bari" (Upper Cretaceous) from Polignano (Apulia, southern Italy)" in vol. TERRANES OF SERBIA pgg 241-246. Simposio di Beograd-Brezovica, 23-27 Settembre 1996.

Sources of more information

Type of information	Name of provider	URL
This data sheet	Geological Survey of Italy - ISPRA	http://sgi.isprambiente.it/geologia100k/mostra_foglio.aspx?numero_foglio=177
Non-commercial directory	Geological Science Department - University Roma Tre, Italithos 2000 Regione Puglia	http://www.italithos.uniroma3.it/scheda8.php?ID=377 https://www.assoarchitetti.it/doc/atlante_marmi_pietre.pdf
Commercial directory		https://www.tranigoldstone.it/IT/ http://www.gaverini.it/it-IT/le_nostre_pietre/pietra_di_trani/PT http://www.elmarstone.com/cava-di-trani/
Scientific publication		“Compact limestones as historical building material: properties of the Tarni Stone (Apulia, southern Italy) and preliminary study for self cleaning treatments” A. CALIA, L. MATERA and M. LETTIERI. 12 th International Congress on Deterioration and Conservation of Stone – Columbia University, New York, 2012 "La pietra di Trani" B. RADINA (AGI - RIG n. 5 del 1955) https://associazionegeotecnica.it/wp-content/uploads/2011/09/geot_1956_5_206.pdf
Other publication		BORGHI M, MASI U., TUCCI P. & VIZZINI G. (1996) “Chemostratigraphy of the Upper part of the “Calcere di Bari” (Upper Cretaceous) from Polignano (Apulia, southern Italy)”

Compiled by:	Geological survey of Italy – ISPRA website http://portalesgi.isprambiente.it/	 
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Basaltina



8 centimeters

Massive or flow lineated grey lava containing some leucite crystals.

Commodity	Lithology	Typical colour	Place of origin			
			Country	Province	Municipality	Village
Commercial Basalt	Tephrite	Dark-grey	Italy	Viterbo (Latium)	Bagnoregio	Bagnoregio

Geological setting



3 kilometers

Geology: The hilly-ravine featured area of Bagnoregio is mostly composed of clayey and clayey-sandy deposits (Lower Pleistocene; yellow in the map) covered by a tuffaceous complex (Pleistocene; light and dark brown in the map) intercalated by tephritic lava flows (red in the map). These latter constitute the exploited geological unit.

Production: Quarries excavated southwards with respect to Bagnoregio town supply a limited but appreciated production of this stone.

Geological age: Pleistocene

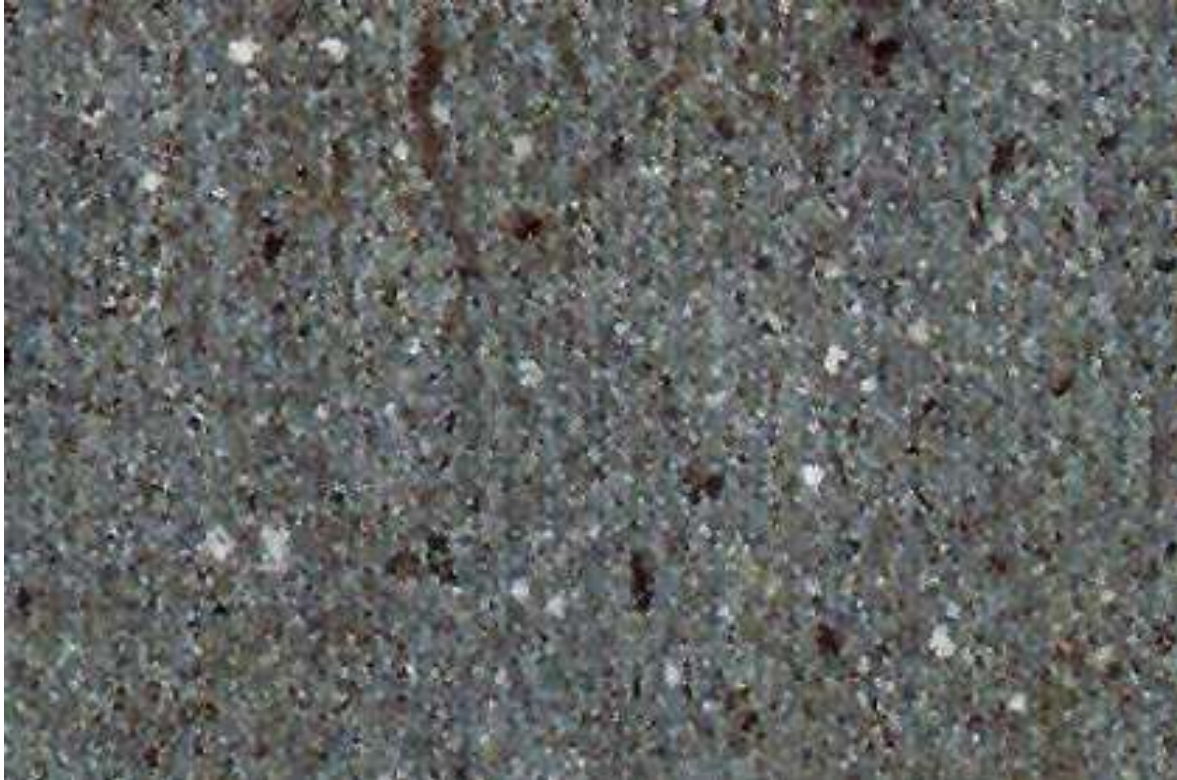
Geological unit: Tephritic lavas

Application, use and heritage



Basaltina is used for many purposes (e.g. facade cladding, indoor floors, table tops, stairs and monuments). The classic Basaltina is dark-grey in colour. In this picture, a detail of a building in Seoul City (South Korea) made of this stone.

Petrography



4 centimeters

Description: Detailed photo in natural light of a cutting surface of Basaltina, showing the appearance of this lava having a hypocrySTALLINE porphyritic texture and containing egirinaugite, leucite, plagioclase and biotite phenocrysts within a microcrystalline groundmass.

Source of information: Geological Survey of Italy, Geological map of Italy 1:100.000 scale, Viterbo Sheet, http://sgi.isprambiente.it/geologia100k/mostra_foglio.aspx?numero_foglio=137
Geological Science Department - University Roma Tre, Italithos 2000, <http://www.italithos.uniroma3.it/>

Mineral composition

Pyroxene (%)	Plagioclase (%)	Leucite (%)	Biotite (%)	Groundmass (%)		
4	3	3	1	89		

MM=main minerals, SM = Subordinate minerals, AM=accessory minerals

Source of information: Geological Science Department - University Roma Tre, Italithos 2000,
<http://www.italithos.uniroma3.it/>

Physical properties

Apparent density (EN 1936) kg/m ³	Open porosity (EN 1936) % vol	Water absorption at atmospheric pressure (EN 13755) % wt	Uniaxial Compressive strength (EN 1926) MPa	Flexural strength under concentrated load (EN 12372) MPa
2229		0.3	83	13.8

Real density (EN 1936) kg/m ³	Total porosity (EN 1936) % vol	Water absorption coefficient by capillary (EN 1925) (g/m ² x s ^{0,5})	Flexural strength under constant moment (EN 13161) MPa

Frost resistance (EN 12371)				
Technological Test (Test A)				Identification Test (Test B): Number of cycles completed prior to stone failure
Flexural strength (EN 12372) after freeze-thaw cycling, MPa	Number of cycles	Uniaxial compressive strength (EN 1926) after freeze-thaw cycling, MPa	Number of cycles	
		87	48	

Resistance to ageing by thermal shock (EN 14066)			
Change in dynamic modulus of elasticity (increase: +; decrease: -) %	Change in open porosity (increase: +; decrease: -) %	Change in ultrasound pulse velocity (increase: +; decrease: -) %	Change in flexural strength under conc. load (increase: +; decrease: -) %

Abrasion resistance (EN 14157)			Resistance to salt crystallisation (EN 12370)	Breaking load at dowel hole (EN 13364)	
Method A - Wide Wheel Abrasion Test, mm	Method B - Böhme Abrasion Test, cm ³ / 50cm ²	Method C - Amsler Abrasion Test, mm	Change in mass (increase: +; decrease: -), %	Breaking load, N	Thickness of the test specimens, mm
		58			

Slip resistance by means of the pendulum tester (EN 14231 / CEN/TS 16165)			Rupture energy (EN 14158), Joule	Thermal Conductivity (EN 1745), W/m·K
Tested surface finish	Slip Resistance Value — SRV			
	Dry test condition	Wet test condition		

Source of information: Geological Science Department - University Roma Tre, Italithos 2000, <http://www.italithos.uniroma3.it/>.

Chemical properties

Main elements

SiO ₂ (%)	TiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	FeO (%)	MgO (%)	MnO (%)	Na ₂ O (%)	K ₂ O (%)	CaO (%)	P ₂ O ₅ (%)	LOI (%)
55.68	0.12	17.85	2.34	0.14	2.57	3.60	2.64	7.83	5.40	1.15	0.40

Trace elements

V (ppm)	Cr (ppm)	Mn (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)
Sr (ppm)	Cd (ppm)	Ba (ppm)	Pb (ppm)	Be (ppm)	Rb (ppm)	Bi (ppm)	U (ppm)
Sc (ppm)	Y (ppm)	Th (ppm)	Sb (ppm)	Ta (ppm)	Nb (ppm)	Zr (ppm)	Sn (ppm)
Ag (ppm)	B (ppm)	Mo (ppm)	W (ppm)	Ga (ppm)	Ge (ppm)	Se (ppm)	Cs (ppm)
Tl (ppm)							


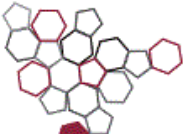
REE

La (ppm)	Ce (ppm)	Pr (ppm)	Nd (ppm)	Sm (ppm)	Eu (ppm)	Gd (ppm)	Tb (ppm)
Dy (ppm)	Ho (ppm)	Er (ppm)	Tm (ppm)	Yb (ppm)	Lu (ppm)		

Methods applied and source of information: Geological Science Department - University Roma Tre, Italithos 2000, <http://www.italithos.uniroma3.it/>

Sources of more information

Type of information	Name of provider	URL
This data sheet	Geological Survey of Italy - ISPRA	http://sgi.isprambiente.it/geologia100k/mostra_foglio.aspx?numero_foglio=137
Non-commercial directory	Geological Science Department - University Roma Tre, Italithos 2000	http://www.italithos.uniroma3.it/
Commercial directory	Basaltina S.r.l.	https://basaltina.it
Scientific publication		
Other publication		

Compiled by:	Geological survey of Italy – ISPRA website http://portalesgi.isprambiente.it/	 ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale	 Sistema Nazionale per la Protezione dell'Ambiente
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Broccatello di Siena

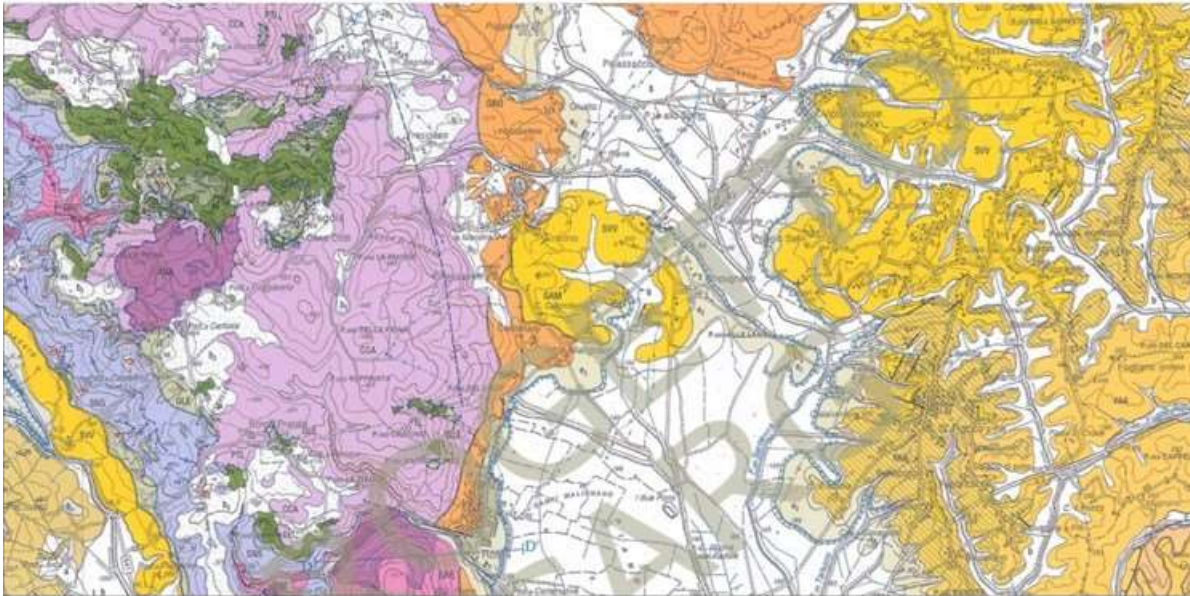


8 cm

Golden yellow breccia marble background with dark or purple spots and stylolitic veins, sometimes very thin.

Commodity	Lithology	Typical colour	Place of origin			
			Country	Province	Municipality	Village
Broccatello di Siena	marble	yellow	Italy	Siena	Sovicille	Sovicille

Geological setting



scale 1:50,000

Geology: In this area metamorphic rocks, in facies of green schists, aged between Triassic and Cretaceous, and to a lesser extent, marine and continental sediments, aged between Upper Miocene and Pleistocene, crop out extensively. Stratigraphically beneath the schists, yellow, white and grey marbles outcrop as well. They are non-layered marbles and, towards the top, they assume a color ranging from pink to veined-yellow to ocher-yellow and golden-yellow. The yellow color is ascribed to an epigenetic enrichment of iron oxides and hydroxides by infiltration along fracture lines. In the upper part, locally and for a thickness of a few meters, they show a clear and thin stratification and a more intense yellow color. This ornamental stone was originally formed as a pelagic limestone sedimentary deposit; subsequently it was compacted by diagenesis and affected by a low-stage metamorphism. It has a fine grain size and it has an homogeneous distribution of pigmentation.

Production: About ninety different quarries have been active on the Montagnola Senese Area, mostly very small in size; their development was due, in the seventeenth and eighteenth centuries, to an aesthetic taste oriented towards the search for marked chromatic effects. In modern times, the annual production has reached 15,000 tons. The product varieties extracted are the yellow broccatello (and its modification known as "paonazzo"), ocher-yellow, veined-yellow, ivory-yellow, Covent-type pink, calacatta, white and arabesque-white, pearl-gray and bardiglio; broccatello, ocher-yellow and pink are the rarer varieties. The different colors have been attributed to the presence of different mineral pigments, such as limonite, hematite, pyrite, organic matter.

Geological age: Lower Lias – Cenomanian

Geological unit: "Montagnola Senese" Marbles Formation

Application, use and heritage



Palazzo Corsini, Florence: Columns in Broccatello di Siena.

Petrography



Thin Section X10

Description: Calcite Crystalloblastic lithotype with locally porphyroblastic serial eteroblastic microstructures. The main mineralogical component is calcite (>95%), markedly anisotropic for the alignment of blasts that generate a band foliation. Together with calcite crystals there are also euhedral quartz blasts in correspondence with veins and patches. Coincidentally with the veins the Calcite Crystalloblastic lithotype is associated with opaque minerals composed of limonite, hematite, chlorite, muscovite fragments and tourmaline.

Source of information: The Marble Laboratory of the Department of Territory, Environment and Geotechnologies Engineering of Politecnico di Torino University.

Mineral composition

Calcite (%)	Fe-Mn hydroxydes (%)	Fe-Mn oxydes (%)	Hydrated silicates (%)	Cyclosilicates (%)		
>95	AM	AM	AM	AM		

MM=main minerals, SM = Subordinate minerals, AM=accessory minerals

Source of information: www.granitalsiena.com

Physical properties

Apparent density (EN 1936) kg/m ³	Open porosity (EN 1936) % vol	Water absorption at atmospheric pressure (EN 13755) % wt	Uniaxial Compressive strength (EN 1926) MPa	Flexural strength under concentrated load (EN 12372) MPa
2710	0,24	0,1	69	16,5

Real density (EN 1936) kg/m ³	Total porosity (EN 1936) % vol	Water absorption coefficient by capillary (EN 1925) (g/m ² x s ^{0,5})	Flexural strength under constant moment (EN 13161) MPa
		0,04	

Frost resistance (EN 12371)				
Technological Test (Test A)				Identification Test (Test B): Number of cycles completed prior to stone failure
Flexural strength (EN 12372) after freeze-thaw cycling, MPa	Number of cycles	Uniaxial compressive strength (EN 1926) after freeze-thaw cycling, MPa	Number of cycles	
		160		

Resistance to ageing by thermal shock (EN 14066)			
Change in dynamic modulus of elasticity (increase: +; decrease: -) %	Change in open porosity (increase: +; decrease: -) %	Change in ultrasound pulse velocity (increase: +; decrease: -) %	Change in flexural strength under conc. load (increase: +; decrease: -) %

Abrasion resistance (EN 14157)			Resistance to salt crystallisation (EN 12370)	Breaking load at dowel hole (EN 13364)	
Method A - Wide Wheel Abrasion Test, mm	Method B - Böhme Abrasion Test, cm ³ / 50cm ²	Method C - Amsler Abrasion Test, mm	Change in mass (increase: +; decrease: -), %	Breaking load, N	Thickness of the test specimens, mm

Slip resistance by means of the pendulum tester (EN 14231 / CEN/TS 16165)			Rupture energy (EN 14158), Joule	Thermal Conductivity (EN 1745), W/m·K
Tested surface finish	Slip Resistance Value — SRV			
	Dry test condition	Wet test condition		
Smooth	42	10		

Source of information: Università di Pisa - Politecnico di Torino

Chemical properties

Main elements

SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	TiO ₂ (%)	MgO (%)	CaO (%)	Na ₂ O (%)	K ₂ O (%)	MnO (%)	P ₂ O ₅ (%)	SO ₃ (%)	LOI (%)	CO ₂ (%)	H ₂ O (%)
4,51	1,3	0,5		0,08	52,02							40,97	0,41

Trace elements

V (ppm)	Cr (ppm)	Mn (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)
Sr (ppm)	Cd (ppm)	Ba (ppm)	Pb (ppm)	Be (ppm)	Rb (ppm)	Bi (ppm)	U (ppm)
Sc (ppm)	Y (ppm)	Th (ppm)	Sb (ppm)	Ta (ppm)	Nb (ppm)	Zr (ppm)	Sn (ppm)
Ag (ppm)	B (ppm)	Mo (ppm)	W (ppm)	Ga (ppm)	Ge (ppm)	Se (ppm)	Cs (ppm)
Tl (ppm)							



REE

La (ppm)	Ce (ppm)	Pr (ppm)	Nd (ppm)	Sm (ppm)	Eu (ppm)	Gd (ppm)	Tb (ppm)
Dy (ppm)	Ho (ppm)	Er (ppm)	Tm (ppm)	Yb (ppm)	Lu (ppm)		

Methods applied and source of information: Pieri M. (1964) - I Marmi d'Italia. Ed. Hoepli, Milano, pp. 480.

Sources of more information

Type of information	Name of provider	URL
This data sheet	Geological Survey of Italy -ISPRA	https://www.isprambiente.gov.it/en/services/cartography/geological-and-geothematic-maps/geological-map-at-a-scale-1-to-50000
Non-commercial directory	Geological Science Department - University Roma Tre, Italithos 2000	http://www.italithos.uniroma3.it/
Commercial directory		
Scientific publication	Memorie Descrittive della Carta Geologica d'Italia, ISPRA- Geological Survey of Italy	https://www.isprambiente.gov.it/it/pubblicazioni/periodici-tecnici/memorie-descrittive-della-carta-geologica-ditalia/la-geologia-di-roma-dal-centro-storico-alla
Other publication		

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