

## Article

# Saint John Baptistery in Florence (Italy): Studies for Conservation of the External Marble Cladding

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**Abstract:** Saint John's Baptistery in Florence (Italy), dating back to the XI century, represents one of the most outstanding historical buildings in the city, and has been under the UNESCO patronage as Cultural Heritage since 1982. In recent years, in the frame of a conservation project, detailed studies and mapping of all the tiles covering the Baptistery have been developed. Based on a laser-scan survey, a detailed wireframe model of all the external sides, reporting all the tiles and decor, has been developed. This model was implemented into a 2D-GIS, georeferenced in real scale and spatial position. An in situ survey of all the tiles, ashlars, inlays and columns, made in contradiction by experts in historical ornamental stones, allowed the recognition of several types of marble in place. All these marbles have been analyzed and characterized as geometric, geological and historical data, and the information implemented into a GIS for obtaining a spatial geodatabase representing a "box" to store all information achieved. All these data are manageable by web through smartphone, tablet and PC for querying or updating, thus representing an effective management tool for further conservation of such important historical cultural buildings.

**Keywords:** Saint John Baptistery; Florence; cultural heritage building; marbles; GIS



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## 1. Introduction

The Saint John Baptistery in Florence (Italy) represents one of the most outstanding historical buildings in the city and is under the UNESCO patronage as a Cultural Heritage building since 1982. The Baptistery, erected onto Roman and Early Medieval ruins by the wish of the people of Florence, was finished in the XI century [1–4]. In the early XIII century, the apse was changed from circular to square; the roof was renewed in the XV century. The whole Baptistery is cladded in white and dark green marbles according to the Tuscan Dichromic. Its maintenance is managed by the Opera del Duomo (OPA), a private institution established in 1296 by the people of Florence with the mission to take care of the building. Since 1296, the OPA has provided the management, maintenance and conservation of the Baptistery.

The Saint John Baptistery was built as a holy place for the Catholic Christian religion to be used for baptisms and religious functions. These uses and functions have been active since its consecration and in the last 30 years, it has also become a site for touristic visits, numbering about 3000 people a day. In 2013, the OPA launched a series of integrated multidisciplinary research and studies for updating historical and scientific knowledge, executing well-addressed conservation works and creating a digital archive and a georeferenced system for managing the maintenance of the Baptistery.

This research has been developed in this frame, with the aim to map all the single ashlars, quoins, columns, tiles, inlays, and columns of the external cladding and implement

all these data into a 2D content model (GIS) to be used as a tool for managing all the available data and planning future conservation work.

This approach has now passed the research stage and is becoming more and more compulsory for the digital upgrade of the management of cultural heritage conservation [5,6].

## 2. Materials and Methods

Since its construction in the XI century, the Saint John Baptistery is entirely covered by marbles, put in place in a squared manner alternating white and dark marbles according to the Tuscan Dichromic (Figure 1).



**Figure 1.** Saint John Baptistery in Florence (Italy), south façade cladded in white and dark marble according to the Tuscan Dichromic.

Therefore, the main goal for this study was a complete mapping of the marbles cladding of the Saint John Baptistery.

The first step of the job was a full laser-scan survey of the building. This is the base to obtain a CAD wireframe of the façades in 1:1 scale, which, in turn, was imported into a GIS, georeferenced in the real space as datum and relative dimensions.

The second stage of the work consisted of determining the type of marble of all the single stone elements of the cladding: ashlar, quoins, columns, tiles, inlays and columns, which total 22,723.

Three different types of approach for determining the type of stone material can be used [7]; an attribution is reliable if more approaches point towards the same attribution:

- Document analysis: carried out on commercial and historical text archives that show orders, origin and types of stone materials.
- Technical analysis: petrographic, mineralogical, geochemical, and isotopic analyses allowing the sample analyzed to be attributed to a lithotype on the basis of existing databases.
- Organoleptic analysis: carried out by experts on the basis of their knowledge and regarding stone grain-size, texture and warp.

In order to collect all the survey data in a content that can allow for easy management of all the acquired information and for furnishing a tool for planning and recording future conservation work, all the data have been implemented into a 2D-GIS of the façades [6,8,9].

To share the stored data, we developed an App (LastraSurvey) usable on site via web by smartphone, tablet and PC.

### 3. Results

#### 3.1. Document Analysis

In the case of the Saint John Baptistery, in the archives of the OPA and in the literature, very little news regards the types of marble used for the cladding. Data are available for the conservation works of the early 1990s, for those of the years 1939–1944 [10,11], and, in general, for purchasing white marble from Carrara and dark marble from Prato, the classic Carrara Marble and Verde Prato, respectively, in the XVI to XIX centuries, for substitution of deteriorated tiles (Table 1).

**Table 1.** Documented substitutions for the cladding stone elements of the Baptistery.

Years	Work	Marble Types
1296	Cladding of the corner pillars	Verde Prato, Carrara Marble
1778–1792	Substitution of tiles	Carrara Marble
1818	Restoration and substitution of basement ashlars	Carrara Marble
1820–1841	Substitution of tiles	Carrara Marble
1854–1856	Substitutions of tiles	Verde Prato, Carrara Marbles from the dismantling of the Choro of the Cathedral
1860, 1861, 1862	Substitution of tiles	Carrara Marble from Ravaccione
1939–1941	Several substitutions of tiles, well documented by maps	Verde Prato, Lasa marble from northern Italy in substitution of the original Hymettus from Greece, not available due to the Second World War
1993–1996	Substitution of a few tiles	Verde Malenco in substitution of the Verde Prato no more available on the market

#### 3.2. Technical Analysis

For technical analysis, the need for samples largely reduces the applicability of this approach. By the permission of the Superintendence, which has in charge of the protection of the cultural heritage buildings, it was possible to collect only 21 samples [7] (Table 2).

**Table 2.** Results from the 21 technical analyses performed on the cladding tiles of the Baptistery.

Sample	Marble Type	Sample	Marble Type
M4	Hymettus	Q8	Carrara Marble
M5	Lasa marble	Q9	Hymettus
M8	Carrara Marble	Q10	Hymettus
M9	Carrara Marble	Q11	Carrara Marble
Q1	Carrara Marble	Q12	Carrara Marble
Q2	Carrara Marble	Q13	Carrara Marble
Q3	Pentelicum	Q14	Thassos
Q4	Carrara Marble	Q15	Pentelicum
Q5	Carrara Marble	Q16	Apuan slate
Q6	Carrara Marble	Q17	Pentelicum
Q7	Lasa marble		

### 3.3. Organoleptic Analysis

A direct survey of each stone element was made in contradiction by experts of historical ornamental stones, working on the scaffolding in place for the conservation work.

This job allowed the recognition of the types of marble for each one of the 22,723 tiles constituting the external cladding of the Saint John Baptistery (Table 3).

**Table 3.** Types of marble in place on the external cladding of the Baptistery.

Marble Type	Elements	Marble Type	Elements
Verde Prato	10,920	Verde Malenco	4
Carrara Marble	6817	Porfido Verde Antico	2
Hymettus Marble	1256	Cipollino Rubrio from Eubea	2
Lasa Marble	584	Calcschist	2
Punta Bianca Marble	315	Thassos Marble	1
Pentelicum Marble	147	Breccia Greca Antica	1
Apuan slate	51	Syenite	1
Porfido Rosso Antico	9		
<b>Inlays</b>			
Verde Prato	2.327	Rosso Cintoia	284

Of course, most of the white marble is from Carrara (Carrara Marble, Punta Bianca Marble). Many tiles are Greek marble (Hymettus, Pentelicum, Cipollino Rubrio from Eubea, Thassos). Trading from Greece was not possible during the X–XI centuries but in those times, Florence conquered and spoiled the near Fiesole, which had been enriched with Greek marble by the Roman Emperors, Claudio and Hadrian. Therefore, we think that those marbles came from spolia of the Fiesole Roman Theatre, Capitolium and Thermae. A few others came from spolia of Roman ruins in Florence or Fiesole (Porfido Verde Antico, Porfido Rosso Antico, Breccia Greca Antica, Syenite).

Other marbles are new local stone material from the surroundings of Florence (Verde Prato, Rosso Cintoia, Apuan slate), or recent substitutions (Lasa Marble, Verde Malenco) due to the lack of original marbles (Hymettus, Verde Prato).

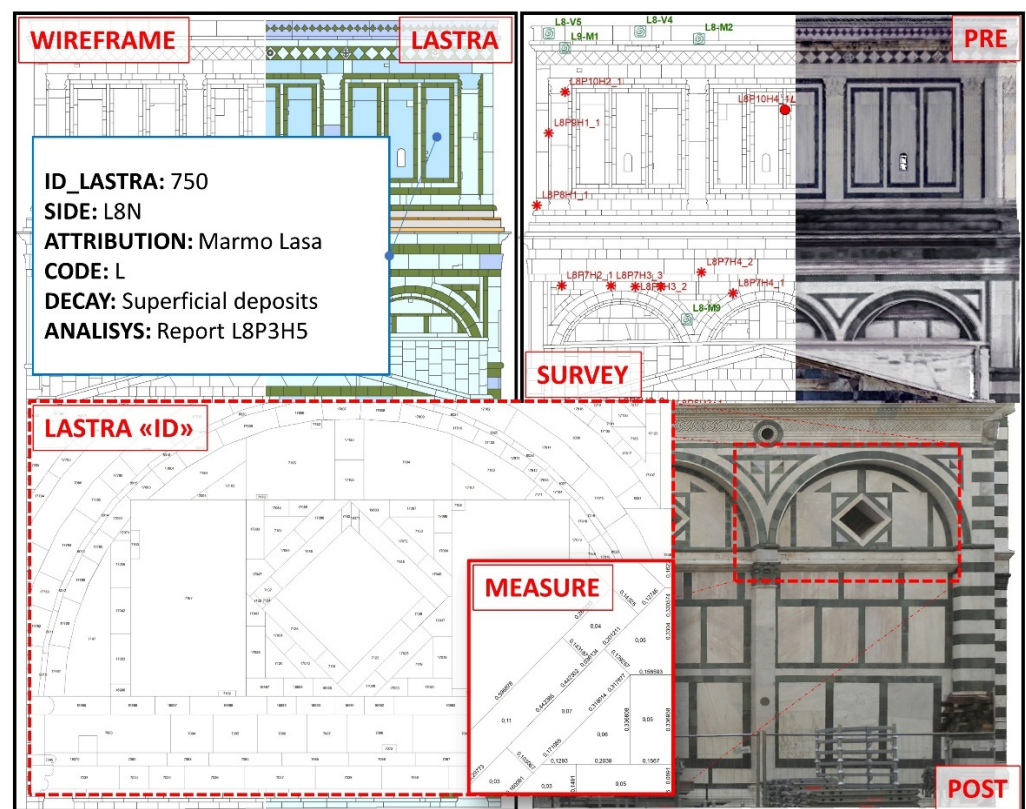
Details for each one of the marble types are reported in Appendix A.

### 3.4. GIS Implementation

The choice of using a Geographic Information System (GIS) applied for the preservation of Cultural Heritage [6,12–15], and in this case, for the management of the state of knowledge on the external cladding of the Baptistery of San Giovanni, lies above all in the extreme versatility of the GIS platform (ArcMap®ESRI) for the representation and analysis of geometries oriented in space at any scale.

Secondly, this technology gives the possibility of updating and implementing the database that is being built in various stages of development of the activity.

The available data, especially in relation to the complexity and importance of the monument and the conservation actions carried out over the centuries, were very heterogeneous, numerous and characterized by different management and organization methods, formats and codes (PDF, raster, CAD). These documents, even in digital formats, are, in any case, functional to the creation and issue of a paper product or an analysis sheet. Moreover, digital drawings did not have, for example, topological rules or extended information associated with the mere drawing. All the CAD drawings often presented the origins in plane coordinates  $xy$  with the  $x$  placed at an arbitrary value and the  $y$  corresponding to the height relative to the base of the drawing. For this purpose, we take the arbitrary  $x$  origin and the  $y$  is considered as  $z$ , resembling the real height of the monument. Many of the diagnostic and cognitive data were provided with a reference to the scaffolding grid in place at the time of the restoration (Figure 2).



**Figure 2.** Composition showing the possibilities of extracting information from the database within a GIS system: Wireframe view, coatings selection (LASTRA), showing ID\_LASTRA, SIDE, STTRIBUTION LITHOLOGY, CODE, DECAY, and the existence of a laboratory analysis. From the system, it is also possible to view the dimensions of each single element and the photo planes.

The storage capacity guarantees simple recovery and unitary management of a large amount of data of different nature. The realized system is easy to use and allows for consultation and updating of the database.

Its main use is for visualization through the simple combination of various information levels, or for creating print layouts, consultation and querying of the unified database complete with accessory files as well as graphic ones (laboratory test results, various reports, photographic documentation of details, etc.).

In the transposition into GIS objects [16], geometries were modeled and aimed at achieving a correspondence to the reality present in situ (compilation of attributes, closure of polygons, subdivision of the different elements on distinct layers, decomposition into simple primitives of complex objects such as inlays).

The concept of a geographical reference system [17] in GIS was forced, rotating the plane and using a system composed of plane coordinates  $xz$ , with the  $x$  set to an arbitrary zero and the  $z$  considered as the effective altitude above the sea level generated by the rotation of a normal Cartesian  $xy$  plane, where the values of the relevant  $z$  component are actually reproduced on  $y$ .

All the data were located and digitized at the nominal scale of 1:10, to obtain a graphic error estimated at 0.2/0.3 cm. This value guarantees a high level of precision and accuracy in the measurements that can be carried out in the project and allows high overall quality standards as well as maintaining low tolerance levels in topological checks. Operatively, the tile is the single stone element that constitutes the marble cladding; each one has been identified and its “history” has been reconstructed—any maintenance, cleaning or restoration interventions, problems relating to decay, etc.

As part of the conservation process, it is very important not to lose the historical memory of all the cognitive data collected in the various phases, in order to also keep track of the interventions carried out from time to time and to have all the data actually existing on the monument.

The GIS implementation (Figure 3) has been addressed to permit:

- Unitary management of different data for themes, characteristics and forms;
- Management of historical data and information, without having to resort to the examination of paper sources;
- Univocal data storage, thus avoiding errors connected to non-unique encodings or data processing carried out by different operators;
- Ease and speed of simultaneous and integrated consultation of a large amount of data, their functional query to the needs and their comparison (Figure 3);
- Possibility of customization according to specific graphic and document query needs;
- Possibility of elaboration, updating and further implementation in the phases following the design phase;
- Integration of data with results deriving from the monitoring phase.

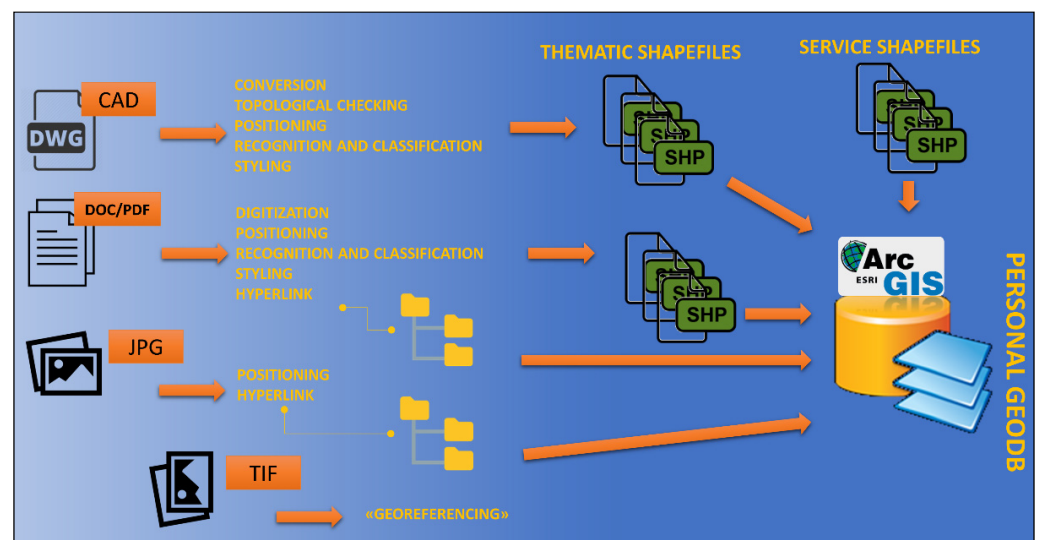
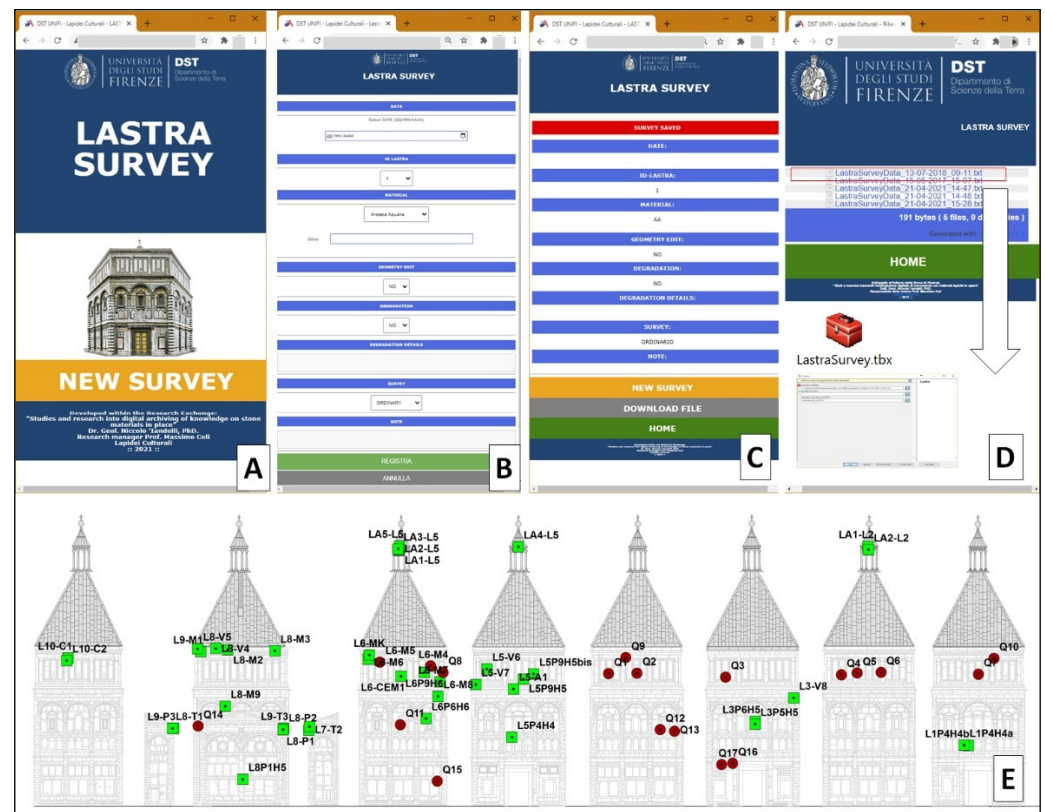


Figure 3. Conceptual scheme of the database implemented within a personal geodatabase.

### 3.5. The LastraSurvey Web App

As part of the project, a web app (LastraSurvey) was created with the aim of providing a cross-platform mobile tool for updating the database implemented within the GIS system. In particular, a tool was created for the direct on place surveying of some considerations and/or criticalities that emerge during operational inspections.

The LastraSurvey is a web application that can be reached via URL on any platform (smartphone, tablet, PC) (Figure 4). The LastraSurvey was developed using web technologies (HTML and PHP) and can be installed on any web space. The survey, which is carried out in situ with the web app, allows one to report points and changes to be made on the database (geometric or attribution changes, etc.).



**Figure 4.** LastraSurvey: (A) Home page; (B) Data entry page; (C) Summary page of the survey; (D) Survey Download Page and LastraSurvey Toolbox interface to conversion and styling; (E) Mapped reports.

The survey is then exported and imported into the GIS system through a specially created specific toolbox, which allows one to view the points detected so that the operator can proceed with the modification and updating.

#### 4. Discussion

This paper has addressed the reconnaissance of the type of marble constituting the external cladding of the Saint John Baptistery in Florence (Italy); the study has outlined several items, some of which were previously unknown:

1. White marble slabs are about 7 cm thick, which corresponds to a Roman *palm* (7.4 cm), and are fixed to the masonry behind by iron clamps.
2. Verde Prato is always as quoins about 15–20 cm deep and mortared into the masonry due to its intense micro-fracturing, which does not allow it to be cut into slabs.
3. Most of the original with marble is from spolia of Roman monuments, while all the others are from Carrara.
4. The concomitance of large restoration works with many tiles' substitution in the Second World War resulted in the forced use of Lasa Marble from northern Italy, instead of the original Hymettus Marble from Greece.
5. It has been possible to define the provenance and the exploitation history of all the marble.

The implementation of all the survey data into a GIS allowed the development of a managing tool for planning future conservation work of the monument, which is highly appreciated by the Opera del Duomo staff.

## 5. Conclusions

The study of the materials constituting the marble cladding of the Baptistery has highlighted the presence of ornamental stone materials of various origins; most of them can be related to the reuse of spolia of materials in opera in Roman times in Fiesole, an Etruscan-Roman town close to Florence.

The Baptistery is, therefore, confirmed as a stone casket full of history and stories of the stones used for its cladding.

The GIS implementation of all the surveyed and collected archive data allows a single and univocal management of the entire amount of existing data in a relational, dynamic, updatable, immediately available, and interrogable way by the operators engaged in the six-monthly inspections of the monuments of the Opera, optimizing the phases that lead to the identification of priorities for scheduled maintenance interventions.

For this purpose, a specific and user-friendly web app (LastraSurvey) has been developed and is now in use for conservation planning and management.

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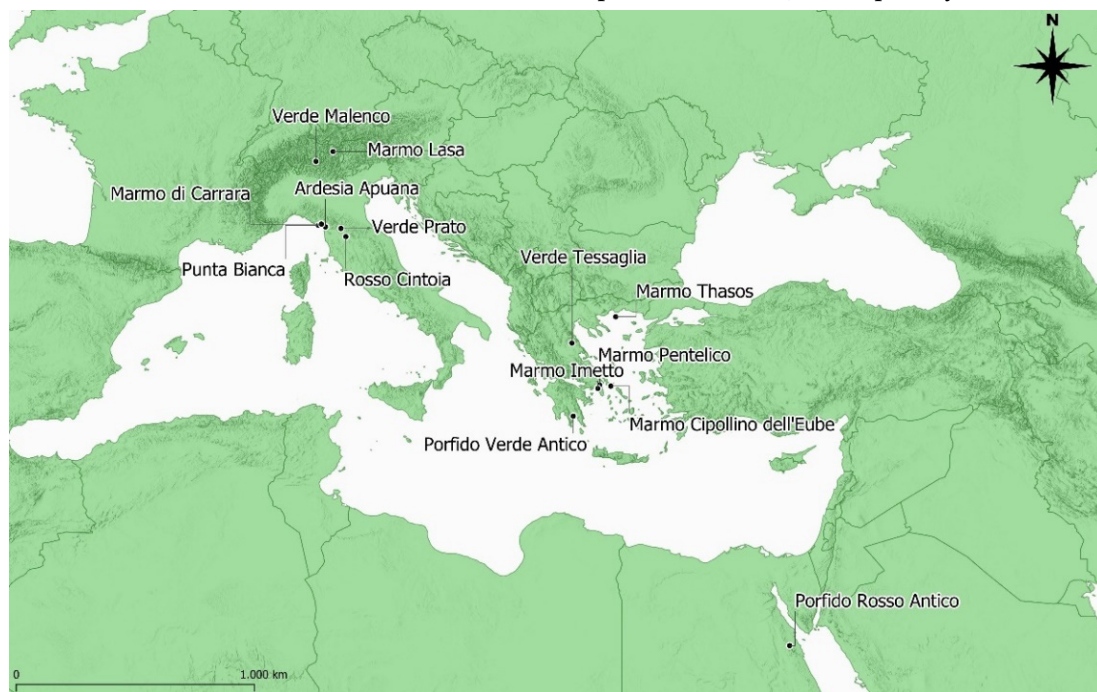
**Conflicts of Interest:** The authors declare no conflict of interest.



## Appendix A

**Table A1.** Marble Types and Source.

**Sites of Provenience of the Marbles in Opera on the Saint John Baptistery**



### *Verde Prato*

- Also known as: Marmo Nero di Prato, Serpentina
- Provenience: from the Monteferrato Hill, located about 20 km NW from Florence.
- Lithology: dark-green Lherzolite with Olivine prevailing (40–90%), Orthopyroxene, Clinopyroxene, partially serpentinized, with veins of Lizardite and Chrysotile, medium to coarse grained.
- Uses: In the XI–XVI and in the XIX centuries for the Tuscan Dichromic. Systematically used for the dark in the dichromic of the façades.



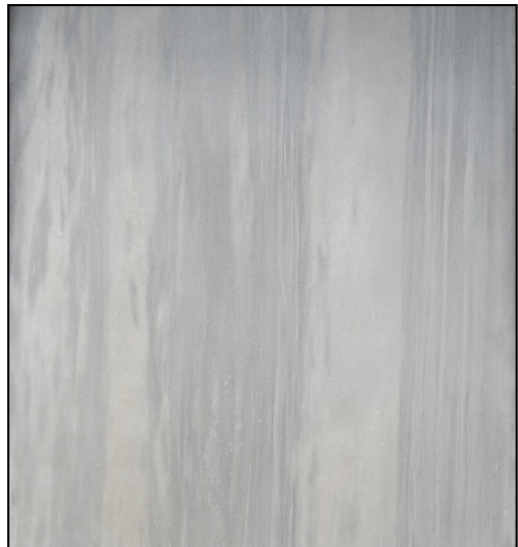
Table A1. Cont.

*Carrara Marble*

- Provenience: from the Carrara and Seravezza (Ravaccione) quarries in the Apuan Alps area about 150 km west of Florence (Italy).
- Lithology: white and pale-white marble, small grain size.
- Uses: since the Romans through the Medieval and Renaissance times up to today. Largely used for the white of the façades.

*Hymettus Marble*

- Also known as: Marmo fetido, Marmo cipolla.
- Provenience: from Mount Hymettus close to the east of Athens (Greece), supposedly spoiled by Fiesole in the XII century.
- Lithology: white marble with grey-blue rows, medium grain size.
- Uses: from the Greeks to the Romans, large reuse in Medieval and Renaissance times, sporadic use in the XX century; today, all the quarries are closed. Largely used for the white of the façades.

*Pentelicum Marble*

- Also known as: Parthenon Marble
- Provenience: from Mount Pentelicum close to the north of Athens (Greece), supposedly spoiled by Fiesole in the XII century.
- Lithology: pale white to pale ivory marble with green-yellowish rows, medium grain size.
- Uses: since the Greeks to the Romans, large reuse in Medieval and Renaissance times, sporadic use in the XX century; today, all the quarries are closed. Used for the white of the façades.



Table A1. Cont.

*Lasa Marble*

- Provenience: from Lasa in Venosta Valley, Northern Italy.
- Lithology: white marble with yellowish to greyish rows, medium grain size.
- Uses: used by the Romans, now largely used since the XIX century. Used in the conservation works of the years 1939–1943 for substituting deteriorated Hymettus tiles.

*Punta Bianca Marble*

- Provenience: from the Punta Bianca cape, north of Carrara (Italy), supposedly spoiled by the Roman city of Luni (close to Carrara) in the XIX century.
- Lithology: matte white marble with grey and bluish twigs, medium to coarse grain size.
- Uses: by Romans for the town of Luni (II century B.C.) and until I century, large reuse as spolia from Luni in the XV and XIX centuries; the quarries have been dismissed since the Roman times. Mainly used for the cladding of the eight corner pillars.

*Thasos Marble*

- Also known as: Tasio marble.
- Provenience: southeast coast of Thasos Island (Greece), supposedly spoiled by Roman monuments.
- Lithology: white marble, fine grain sized.
- Uses: from the Greeks to the Romans, scarcely used in medieval time; today, all the quarries are active. Used for the lion head at the top north corner of the Scarsella.

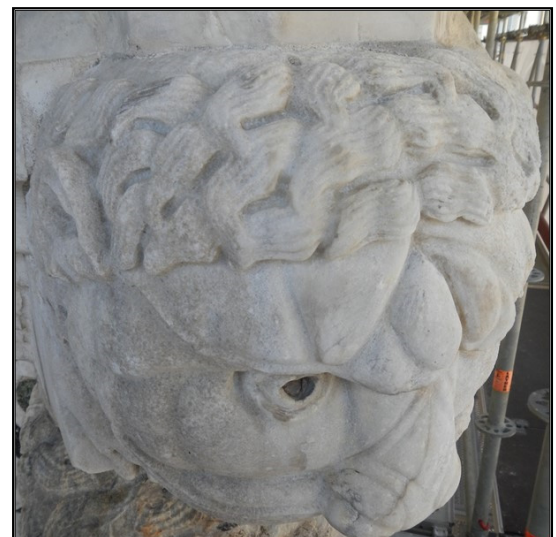


Table A1. Cont.

*Verde Malenco*

- Provenience: from Malenco Valley, northern Italy.
- Lithology: dark green to blackish serpentino-schists, very finely grained, with Olivine aggregates.
- Uses: in the early XX century and in the years 1991–1993 for substituting a few ashlars of Verde Prato; no longer available on the market.

*Porfido Rosso Antico*

- Also known as: Lapis porphyrites, Pietra di porpora, Leucostictos, tebaico, Pietra Romana.
- Provenience: from Mons Porphyrites, Eastern Desert, Egypt. From spolia of Roman monuments
- Lithology: red andesitic meta-porphry with white stains of about 5 mm.
- Uses: by the Romans in the II to IV century, since then, all the quarries have been closed and large use of spolia has been carried out.

*Porfido Verde Antico*

- Also known as: Serpentino, Porfido Verde di Grecia, Verde Sparta, Taygetus Marble, Piganusio Marble, Lapis Lacedaemonius, Lacedemonium viride, Smeraldo di Laconia, Pietra di Laconia.
- Provenience: from Psephi Hills, close to Levetsova, between Krokeès and Stefania, south of Sparta (Greece), spolia of Roman monuments.
- Lithology: dark green andesitic metaporphyry with mm to cm phenocrystals of Albite/Oligoclase, Chlorite, Epidote in star sheaves of about 5 mm.
- Uses: first by the Minoan-Mycenae, then by Romans and Byzantines since I century, through the Medieval age and up to WWII when all the quarries were destroyed.



Table A1. Cont.

*Cipollino Rubrio from Eubea*

- Also known as: Cipollino Rosso Antico, Marmor Caristium.
- Provenience: from Karystos in the Euboea Island (Greece), spolia of Roman monuments.
- Lithology: ivory marble medium grained (0.2–0.6 mm) with greenish-bluish rows and cm to dm reddish clasts of karst origin.
- Uses: used by Greeks, in I century by Romans and largely by Byzantines up to the Medieval age, then largely reused by spolia; the quarries were reopened in the XX century.

*Breccia Greca Antica*

- Also known as: Verde Antico, Marmor Thessalicum, Lapis Atracius, Marmor Atracium, Marmo di Tessaglia, Verde Tessaglia.
- Provenience: from Casambali close to Larissa on the slopes of Mount Mopsion, Thessaly (Greece), spolia of Roman monuments.
- Lithology: ophicalcite breccias with green matrix and dark green, black and white clasts, subordinately okra, pink, red and brown, ranging in size from cm to dm.
- Uses: first used under the Emperor Hadrian, then by Byzantines until IX century, large reuse up to the XVII century; today, the quarries are active.

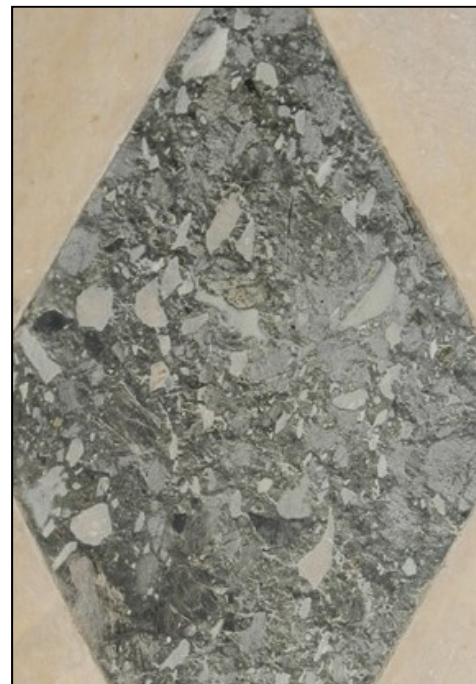


Table A1. Cont.

*Apuan slate*

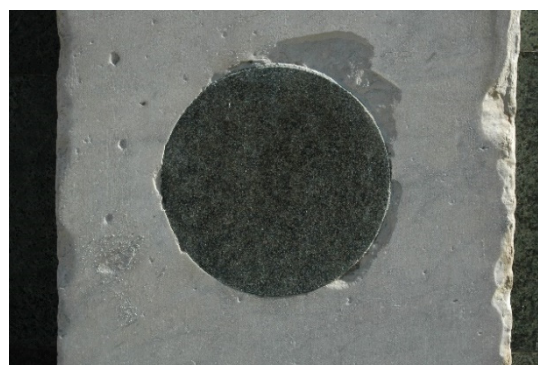
- Provenience: from Stazzema area, north of Cardoso, Apuan Alps, Tuscany (Italy).
- Lithology: dark grey slate, very fine grained.
- Uses: in the XVI century, under the Medici and in the early XX century, today the quarries are dismissed.

*Rosso Cintoia*

- Also known as: Rosso dei Conti, Rosso Gherardesca.
- Provenience: Chianti hills, southeast of Florence, Tuscany (Italy).
- Lithology: pale red or pink marly limestone.
- Uses: sporadic uses from the XII to the XV century for cladding the main religious monuments, in the XIX century for the last façades.

*Syenite*

- Provenience: possibly from Assuan (Egypt), spolia of Roman monuments.
- Lithology: black and white granite.
- Uses: in Ancient Egypt and by the Romans.



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