Multidisciplinary approach to the documentation of the XVIII century marble altars in Sardinia
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1. Introduction
Cultural heritage is a unique resource of information. The process of acquiring this information has a great importance and significance for local, national and international communities. For this reason, the current debate on cultural heritage has placed emphasis on the need for the digitization of this information and the dissemination of the results of the investigations and studies.

“The documentation of cultural heritage requires a multidisciplinary approach, ensuring that recording and documentation tools, as well as, the preparation of information systems provides appropriate and timely information enabling to understand the significance and to detect and monitor the integrity of heritage places” [Patias P., Santana M., 2011, p. 9].

The correct data acquisition requires collaboration between different disciplines. In this way we can easily collect information about the surrounding environment, the history, the object consistency (in terms of dimension and geometric relationship between the parts that constitute it) and the materials from which it is made. In this way, we contribute to highlight the critical points and singularities of the studied objects.

2. Subject of research
On the basis of these principles, our research has focused on the study of the eighteenth century marble altars in Sardinia. This type of artifacts requires an interdisciplinary study because of the geometric and volumetric complexity of the elements that compose them, and the variety of the materials with which they are made. The dimensional geometric survey and the study of materials are, in fact, the basic information required for a thorough knowledge of these altars. They were made by Sardinian artisan, which operated in the island in that period. The artists came mainly from schools of others Italian region as Liguria and Lombardy. Today we have many documents on the activities of these artists. Their works are located throughout the island and led to a major renovation of religious buildings in Sardinia. However, certain attribution to a particular artist is difficult for many artifacts. The accurate execution of the surveys and a careful definition of the materials, conducted according to processes of combined study, will lead to a comprehensive cognitive framework.

Furthermore, all information will be structured in a database and connected to a 3D model that will enable to immediately report the relationship between designs of inlays and materials that compose them. The model thus obtained, will help to clarify some aspects of the construction of these artifacts and will be a useful tool for historical reconstructions and future restoration. The marble altars were among the cheaper items chosen to adapt the existent religious buildings to the Baroque and Rococo style. The erection of the rococo polychrome marble altars in place of wooden altarpieces was perhaps the
most successful expedient to harmonize strict systems of existing buildings, using light and graceful shapes, giving up the monumentality but not color [Scano M. G., 2000, p. 281].

In this sense the choice of color combinations of the various materials and the design of the inlays played a significant role. The most interesting works are certainly those of the major churches among which we remember the Jesuit church of San Michele in Cagliari, the beautiful altar of the cathedral of Cagliari and the works of great value for the cathedrals of Alghero and Ales. However, even in the smaller villages we can appreciate the remarkable spread of such artifacts.

The altars are generally composed of several elements: the frontal, the table, the steps, the niche and the statues that contribute to the final volumetric composition. The complexity of the altar is related to the composition of the inlays and the number of sculptures that enhance it. Each part is made with marbles of different kind and color and assembled with various techniques on a masonry support. The study takes as its point of reference the great works for the cathedrals and major churches. The documents concerning these products, in fact, are often rich in information about the materials to be used, and the specifications of the progress of the work. These supporting materials are thus a source of useful information to deepen the practice of works. Moreover, history informs us that, the shops operating in the island worked at the same time to both the great buildings of cities and the little churches of villages. This often suggests the use of recurrent designs and materials derived from major works.

3. State of art
At present, scholars focused their research on the Sardinian altars only studying the historical and artistic aspects. Comparisons are made mainly on the basis of stylistic analysis. The identification and analysis of archival documents implemented by some scholars [Farci, 2004, pp. 29-102], [Cavallo 2008, pp. 39-55], has enabled us to identify the activity of some of the major artists working in the island and to date the works they perform. There are few studies that have dealt with the survey of the artifacts, the analysis of the recurring motifs, the analysis of color choices and compositional solutions developed by the same artist. In the same way, the different types of used marbles have not been systematically studied in order to determine their provenance or identify a quarry or, at least, a specific geological formation defined in a specific area. However, there are interesting works carried out in other Italian geographic areas and abroad who have taken into account the technical aspects of the design [Marotta, 2005] and the analysis of the materials. These jobs were helpful suggestion to set our search.

4. Research aim
The main goal of the research is the definition of a protocol of investigation conducted in several phases and aimed at the synergistically integrated documentation of the marble altars. The study also defines the most suitable method of survey and restitution. It lays the groundwork for the creation of an
inventory of used marbles by specifying their origin. This investigation process will fill gaps identified in the previous section and allow us to determine the relationship between design and materials. The execution of the drawings will allow a closer comparison between the works of different artists, and they will highlight the diachronic evolution of graphical models, colors and composition. The results obtained will be useful for future investigation related to the completion of the historical context or to restoration. The investigation process, in fact, through the analysis derived from the architectural survey, will also provide useful information regarding changes occurring in artifacts over time, due to displacements related to worship needs or space reorganization. In addition, the architectural survey combined with the material survey will provide useful information on the conservation status.

On the basis of other investigations within the same research, [Casu, Grillo, 2012, pp. 1729-1738] we have refined a cognitive process that can be applied to different cases spread throughout the island. In this paper we choose to illustrate the methodology applied to the altar of Santa Barbara, in the village of Furtei (Sardinia). This kind of altar is an example of a very common decorative element in the whole island.

5. The case study: the altar of the church of Santa Barbara in Furtei
The inlaid marble altar in the church reflects the typical characteristics of other
similar artifacts of the eighteenth century found in many churches throughout the island. It is part of the presbytery area which is bounded by a balustrade also realized using inlaid marble. The altar of Furtei, like many others on the island, was built in the eighteenth century to complement and enrich the architectural interior of the church. The authorship of the altar has not yet been attributed with certainty to anyone. The difficulty of attribution is related to the fact that a document, regarding the assignment of work to a particular artist, has not yet been found. Furthermore, the date engraved on the frame of the table is incomplete. In fact, the top frame shows the following inscription: “Et Am. Rvs. J.V.Dr. Dn. Iosephus Pitzolo et Vila Can cus Huius Preb.de F. F. Expn.is Eccl.e Anno Domini 17..”. It stops after the number 7, the frame is cut coarsely off immediately after this figure. So, the attribution of the work is difficult simply relying on the activity of marble workers in a specific period of time. In this specific case, the hypothesis of attribution are operated for stylistic comparison by referring to the graphic restitutions. The altar is composed of the frontal, the table, three steps for the candlesticks, the tabernacle, the niche for the statue of the patron saint. All these parts are made with inlaid marble. The altar is completed by two white marble statues depicting angels. The technique used for the realization of the polychrome parts is named “a cassina”. Using this technique, the flat slabs of white marble were engraved in order to obtain the space where the craftsman inserted colored elements. The drawings of the frontal are very elaborate. They include compositions of curvilinear figures and floral patterns that surround the oval in which the artist carved, in low relief, effigy of a saint. The inlays on the sides and tops (steps and niche) are characterized by geometric designs accompanied by small motifs of ornate style. The slabs of the various components of the altar were made in the workshop and then transported to the church to be assembled on the masonry structure.

6. Survey and IBM
The research is carried out in accordance with the principles of the London Charter, on the use of ICT (Information and Communication Technology) in the field of Cultural Heritage. The application and verification of these principles has allowed us to define the methodology for the knowledge and representation of these artifacts. The methodology makes explicit the process of virtual reconstruction, data processing and creation of the marble inventory. In the field of architectural survey there isn’t the better and decisive technique. There are several opportunities of choices and integrations of the different methods. That choices are influenced by several factors including the experience, the type of object detected, the material, the purpose of the survey, the required geometric detail, the project budget, etc. [Vernizzi, 2007, pp. 74-85], [Remondino, et al. 2011]. After appropriate considerations regarding the nature of the objects to be surveyed, we chose to document the altars through latest architectural photogrammetry techniques. This choice allowed us to quickly obtain the virtual models. The object of study is well suited to test the IBM (Image Based Modeling), a tool that has recently proven extremely effective in creating, directly from the photographic images, 3D models of small and medium-sized
Fig. 2 - Textured mesh obtained by fotomodeling process; reconstruction of the main volumes from the mesh.

Fig. 3 - Drawing of the inlaid frontal obtained from the model.

Fig. 4 - Geometrical reconstruction of some parts of the altar.
architectural elements. The survey procedure involves the collection of a large number of photos and the recording of a series of control measures, necessary to give the correct size to the model. This procedure allowed us to obtain 3D models of the whole and details. IBM has made possible to reconstruct, in a fast and effective way, the complex geometric elements such as, for instance, baroque volutes or statues. The software used to elaborate the photos is 123D Catch by Autodesk available free and that operate on the cloud. It produces a 3D model from a sequence of photos taken in a very simple way. It calculates the correspondences between the images and creates a triangulated mesh. The photo-modeling process produces a textured mesh exportable in .obj format. The mesh model was then correctly scaled and processed in 3D modeling software. In this way we easily obtained sections of molded parts, rebuilt the curvature of the different parts (in particular the steps of candlesticks), extrapolated photo-plans to be used for the realization of geometric analysis drawings. The images obtained were imported into a CAD program for tracing the drawing. At this stage we identified the symmetry axes of the curvilinear motifs. Moreover, to proceed to better tracing of lines, we made reference to texts of ornate drawing [Burn, 1857] and geometric analysis [Zerlenga, 2008], which suggest several ways for the construction of the drawings.

7. Materials and colors
This paper presents first results of ongoing investigations on the origin of different kinds of marble used in the architecture of the Sardinian altars of 18th century period. We want to investigate whether the marble used are of local provenance or imported marble. The identification of the provenience of the ancient marble is one of the outmost interest to historians and restorers. In Sardinia there is a poor availability of marble and the production is restricted only to few quarries of marble as Rosso Teulada, Rosso Sant’Angelo, Verde Tirreno, Alabastro di Seulo. So the quantity was inadequate for this type of artifacts and many marbles were imported from other countries, mainly from Spain, or others Italian regions as Sicily, Tuscany and Liguria. The altar presented in this paper was made of medium-grained white marble decorated with polychrome marble used for pietradura (Fig.1). The altar of Furtei, unlike other cases, does not show degradation phenomena, therefore we could not take any samples of the marble decoration. So the classification of multi-colored marble was done by naked eye. In the case of the colored marbles it is possible do some degree, to determine the different marbles, often without the use of any analytical methods. However substantial experience of the investigator is a prerequisite. White marbles practically cannot be distinguished simply on macroscopical criteria. The standard methods for the discrimination of white marbles are petrographic investigations and stable isotope analyses. However, on this basis a significant overlap of the compositional fields of the white marbles occur due to the similarity of the analytical data of many white marbles and to the big number of marble occurrences. Therefore we also extended the use of the analytical methods and also involved the analysis of trace elements of the marbles and the chemical analysis of the inclusion fluids [Prochaska, Grillo, 2010]. The classification of white
marble of the Furtei altar is done by micro-samples taken from hidden parts of white marble. The very small size of the samples chips, between 2 and 4 mm, were sufficient only for stable isotope investigations but not for chemical analysis. The samples were carefully cleaned, powdered and analyzed in the isotope laboratory of the University of Leoben/Austria. In the table (Fig. 5) the data of oxygen and carbon isotope analysis are displayed in the usual δ quotation normalized to PDB. In the Fig. 5 the isotopic diagram shows that this marble is a Carrara marble. The colored marbles present in the altar are the same of other similar altar in Sardinia. In particular the polychrome marbles are those present in the altars of the cathedral of Cagliari. Among others the used materials are: Broccatello di Spagna, Giallo di Verona, Diaspro di Palermo, Nero di Portovenere, Alabastro di Seulo.

The macroscopic observation of colored marble and archaeometric characterization by isotope analyses for the white marbles provides an accurate picture of the variety of the coloured and white marbles used for the construction of the studied altar. The identification of various stone materials used in decorating the altars and the definition of the provenance of this material is very im-

Fig.5 - Isotopic diagram: green points are those of Furtei’s altar, yellow ones are of San Sperate’s altars

<table>
<thead>
<tr>
<th>sample names</th>
<th>δ 18O/16O</th>
<th>δ 13C/12C</th>
</tr>
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<tbody>
<tr>
<td>SP-1</td>
<td>-1.14</td>
<td>2.03</td>
</tr>
<tr>
<td>SP-2</td>
<td>-1.55</td>
<td>2.08</td>
</tr>
<tr>
<td>SP-3</td>
<td>-1.77</td>
<td>2.01</td>
</tr>
<tr>
<td>SP-4</td>
<td>-0.56</td>
<td>2.53</td>
</tr>
<tr>
<td>SB-1</td>
<td>-1.55</td>
<td>2.30</td>
</tr>
<tr>
<td>SB-2</td>
<td>-1.23</td>
<td>2.49</td>
</tr>
<tr>
<td>SB-4</td>
<td>-1.87</td>
<td>2.33</td>
</tr>
</tbody>
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Fig.6 - Examples of marbles present in the Santa Barbara altar. From the left: Bianco di Carrara, Nero di Portovenere and Broccatello; Bianco di Carrara, Rosso di Francia, Nero di Portovenere and Broccatello; Alabastro di Seulo, Broccatello e Nero di Portovenere; Bianco di Carrara, Nero di Portovenere, Giallo di Verona e Diaspro di Sicilia
important for investigating ancient trading routes and trade relations. However, it is often found that samples of marble from the same quarry have different properties while others from different quarries, sometimes a long way from each other, are identical [Lazzarini, 1983]. Therefore the analysis of a bigger number of variables it is necessary to safely distinguish the different marbles by multivariate statistical methods. A big databank including 2000 quarry samples of the classical marble locations is available.

8. Conclusions
In conclusion, the proposed documentation methodology is divided into the following phases of work:
1. Preliminary operations: collection of documents and historical information about the object to be studied.
2. Field operations: inspection, metric and photographic survey, visual analysis of the materials, sample collection, annotation of all the singularities of the artifact.
3. Processing operations:
   a. restitution of the survey: creation of the mesh, construction of the 3D model, extrapolation of photo-plans, execution of drawings for geometric and volumetric analysis;
   b. sample analysis and classification of marbles.
4. Final processing of data: comparison and combination of the obtained data, preparation of a final digital document, consisting of the 3D model and the data from the database of materials related to the different parts of the model, containing all the data collected and the subsequent processing.

The case study allowed us to evaluate the correctness of the proposed method. The architectural survey highlighted the geometric, volumetric and constructive characteristics of the artifact, clearly realized in several stages. This hypothesis was confirmed by the analysis of the materials that made possible to classify the marble texture and origin. The shape and dimensions of the various components of the inlay pieces leads us to think that probably the materials used in smaller churches could come from the construction sites of the big churches or cathedrals.

References
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