Itria Valley (Apulia, Italy): technological properties of a limestone used for traditional buildings

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Introduction

The "Trulli of Alberobello" are in the UNESCO world heritage list and those rural constructions, built in dry mode, are widely spread in the Itria Valley (Apulia, south of Italy). From a geological point of view Itria valley is mostly made up of limestone representing a durable and precious source for stone constructions. The aim of this work is to correlate the geological aspects of a portion of an Apulian territory named Itria Valley with their heritage sites.

The most common rural stone constructions are "Trulli", built with "Chiancarelle", a limestone associated to Sannicandro level (Turonian age), between Bari and Altamura formation.

"Chiancarelle", locally extracted probably from temporary quarries in the vicinity of the rural buildings, were installed either in dry technique or by means a particular mortar based on lime and bolus (red earth). Nowadays the "Chiancarelle" needed for the restoration works of the "Trulli" have a different origin coming from quarries located in the Itria valley.

The aim of this work is to compare the petrographic and physical-mechanical propertie sof the ancient stones used in "Trulli" with those of a limestone exploited as ornamental stone nearby.

Material and methods

The materials tested have been collected from a "Trullo" in Martina Franca, a town of Itria Valley , and in P. quarry in Alberobello (40°46'23.73"N, 17°12'55.89"E) (Fig1).

Fig. 1: (a) Geographical localization of Itria Valley (Apulia, Italy); (b) P. quarry (Alberobello, Apulia, Italy); (c) Martina Franca Trullo.

From the geological point of view Valle d'Itria is split into two main lithostratigraphic units: Bari , and Altamura limestone (Geologic Chart n. 178 - 1:100000). According Reina A. et al. (2005) the "Chiancarelle" are strongly stratified stromatolitic limestones, sometimes affected by karstification and

are at bottom to Altamura lithostratigraphic unit, even if in the geologic chart of 1971 they are located at the top of Bari lithostratigraphic unit (Geologic Chart no 190- 1: 100000)
The "Trullo" samples were collected from a rural construction of the first years of 1800 (fig. 2.). The samples show typical alterations characterized by brown colour and presence of lichen, typical for this kind of constructions.

Figure 2 - The "Trullo" sampled (left) with one of the samples collected (center) and cut into specimen for the tests (right)……

As the "Trullo" samples showed a different degree of alteration (also highlighted by the different coloring) depending on the position in place (external, subjected to the action of climatic agents, or internal protected) two groups of specimens (Trullo inside and Trullo outside) were defined and their data analyzed separately (Table 1).
The tests performed on "Trullo" specimens are the following:

- Petrographycal analysis of the stone samples;
- Ultrasound Pulse Velocity (UPV), according to European standard EN 14579;
- Water Absorption at atmospheric pressure (WA), according to to European standard EN 13755;
- Open porosity (pO), according to European standard EN 1936;
- Flexural strength under concentrated load test (Rtf), according to European standard EN 12372.

On the specimens coming from P. quarry (fig. 3) in addition to the tests listed abovethe following artificial ageing tests have been carried out:

- Thermal shock test, according to EN 14066;
- Thermal and moisture cycles, according to EN 16306.

The potential strength loss have been evaluated performing flexural strength and UPV measurements.

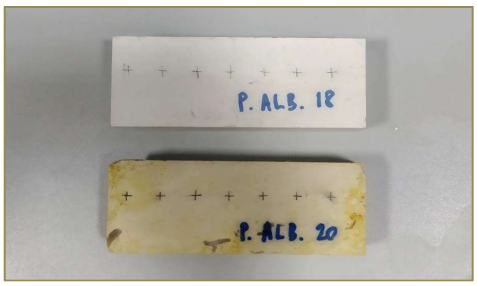
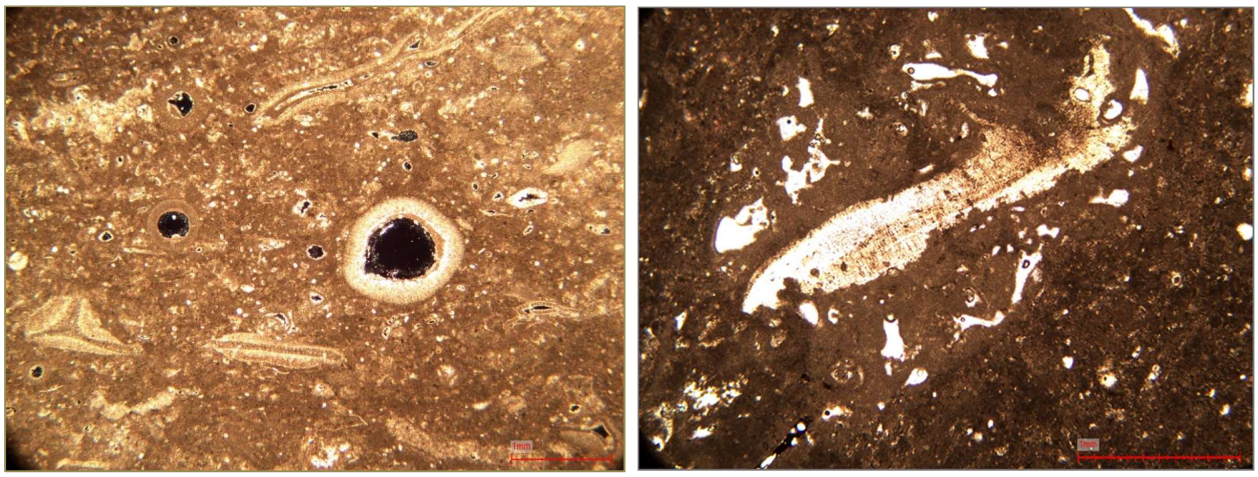


Fig 3: P. quarry sample in natural conditions (top) and after 50 thermal and moisture cycles (bottom)

Results and conclusions

The aim of this research was to characterise natural stone coming from Itria Valley, as it represents an essential component in Cultural Heritage: a deeper knowledge of it is the key for a correct implementation of restoration actions and for the choice of the most adequate materials.
In Fig. 4 the a typical traditional building restored with the new "Chiancarelle " showing an aspect similar to the Trullo roofing slab.
From the petrographic analysis the "Trullo" and the quarry sample can be classified as biomicrite according the Folk classification (R.L.Folk, 1962) . In Fig 5a the microphoto Alveolinidae and algae are well recognizable in thin section. In the microphoto of quarry sample (fig 5b) a fragment, probably a Bivalve, can be observed together with Foraminifera and algae rests.

Fig. 4 Roof of a Itria Valley typical construction built with recent Chiancarella.



(a) (b)

Fig. 5 (a) thin section of Trullo sample where algae and bioclast; (b) thin section of P. quarry sample

The results of the petrographic and physical-mechanical tests are synthetized in table 1 .
Data reported in table 1 demonstrate that the stone actually exploited and used to substitute ancient "Chiancarella" in restoration works do not correspond exactly to the ancient one, mainly according to results of petrographic analysis, even if the mechanical behaviour is similar to the one of "Trullo inside" specimens and its aspect after some decades of use become really comparable to the ancient "Chiancarella" (see Fig.4).
Stones used for "Trulli" were easy to extract from the temporary quarries probably thank to a high degree of fracturing of the first bank of limestone found below the topsoil.

Table 1: Results of the laboratory tests: Ultrasound pulse velocity UPV, Water Absorption WA, Open porosity PO and Flexural strength resistance Rtf, for specimens from P. quarry before and after accelerating ageing and for exterior part of Chiancarella of Trullo and inner portion, fossils percentage and dimension found by means of microscopic observation.

ID	UPV (m/s)		WA (%)		pO (%)		Rtf (MPa)		Bioclast %	Bioclast average dimensions (mm)	Bioclast maximum dimensions (mm)
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.			
P. quarry.	2210	117	4.4	0.89	13.9	2.75	11.4	4.21	10 to 20	0.13	2.0
P. quarry after Thermal shock	2290	116	n.a		n.a		13,7	1,22			
P. quarry after thermal moisture cycle	2290	39	n.a		n.a		13,7	1,15			
Trullo outside	2070	192	5.9	1.96	14.6	3.34	15.1	3.35	45 to 50	0.12	2.3
Trullo inside	2340	87	3.7	1.38	11.3	2.64	15.7	4.70			

On the base of the results obtained from petrographic and physical-mechanical tests it can be stated that:

- The "Chiancarella" from Martina Franca Trullo allowed to assess how the technological properties of these materials are variable, even inside a single stone, depending on the state of weathering and the position of samples inside the whole stone.
- Accelerated ageing, both with thermal shock and thermal/moisture cycles on P. quarry samples tested, did not affect the specimens as it was expected, future studies could investigate further.

The observations, analyses and conclusions produced in this work will serve as a base for further researches to promote the Cultural Heritage of Itria Valley and its natural stone , strongly encouraged also by the scientific work of Heritage Stone Sub Commission.

Keywords: Mechanical performance; Thermal shock; Weathering resistance; accelerated ageing; ultrasound pulse velocity.

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