



ModihMA

MOisture detection in historic MAsonry

Methods to prevent and reduce dampness in masonry



POLITECNICO
MILANO 1863



Consiglio Nazionale
delle Ricerche



UNIVERSITÀ
DEGLI STUDI
DI MILANO

Moisture monitoring experience in the old town of Genoa (Italy)

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The old town of Genoa

The old city of Genoa has medieval origins, developed within the walls of the ninth century and then those of the twelfth century determining a compact urban fabric, already complete in the thirteenth century.

In the following centuries the buildings are modified, merged, raised by 2 or 3 floors but always within the walls saturating each space and closing the possibility of access to the subsoil.



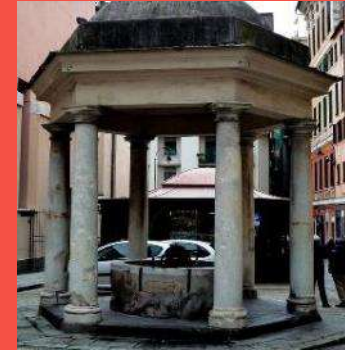
Pliocene marls
and alluvial clays



gravestones
50 km



reservoirs
public and private



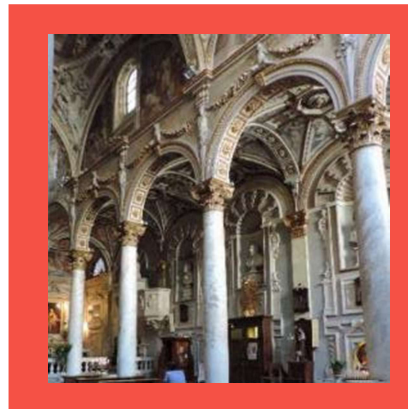
historical aqueduct
1295-1355

The study case of St Matteo Abbey

The Abbey was built in 1278 by the powerful noble Doria family. In the first half of the '500 century Andrea Doria appointed Giovanni Angelo Montorsoli to renew the crypt, the chancel and the dome. Than, Giovanni Battista Castello, known as Bergamasco, and Luca Cambiaso were then appointed to radically renew the design of the Abbey.



Montorsoli
crypt 1540-46



Castello and Cambiaso
decorations 1560-65



bas-reliefs
XV-XVI cent.



Orlando Grosso
restoration 1934

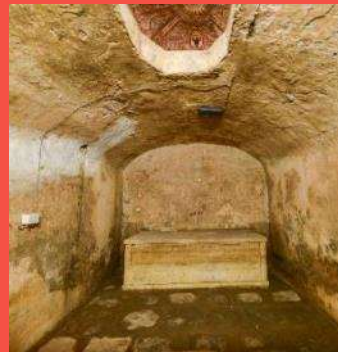
Humidity is an old problem

The Abbey has had serious problems with rising damp both in the hall. Montorsoli improved the crypt's aeration with an air duct reaching the roof and grates connecting the crypt and the hall. Several authors complain about humidity problems over time (1768, 1934).

During a restoration campaign in 1962, a previously undocumented room was rediscovered under the crypt.



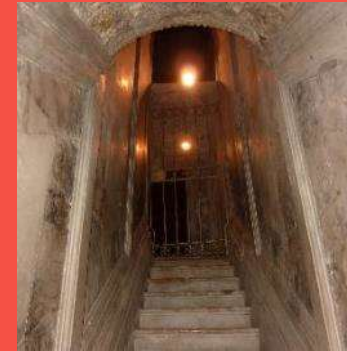
Soprani 1768
Grosso 1934



Raitano 1960
room under the crypt



Superintendence 1992
chemical barrier

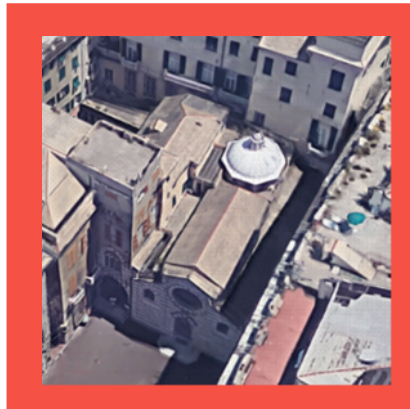


Montorsoli 1540
air duct

The cause of the humidity

In the Abbey's case, the overland flow may be occurring exactly around the church's foundations, as demonstrated by the fact that the main sections of degradation are within the first two metres of the church's walls, as well as in the crypt and the room underneath, which are both completely interred.

The cause of the humidity is a consequence of the geo-morphological context of the Abbey and its surrounding area.



difference in level
about 10 m



Argille di Ortovero
e marl



flood in 2014
60 cm of water



walled conduit

In 2012 an active system of wall dehumidification

ECODRY

deumidificazione senza opere edili

, the company chosen for the dehumidification intervention, granted the use of the equipment for three-four years and at the same time it monitored the dehumidification process, under the supervision of both Superintendence and Archdiocese and in collaboration with the University of Genoa.



Arch. Peirano
Arch. Arcolao



Mons. Rapallo
Dott.ssa Di Natale



Arch. Parodi
Arch. Peirano



Prof. Musso
Arch. Vecchiattini

Ecodyr Italia system

In 2012 Ecodyr Italia installed 5 Zeta III devices in the Abbey, including 4 in the church and 1 in the room under the crypt.

The Ecodyr devices emit long-wave radio-electro-magnetic pulses which, associated with a bimodal magnetic field ($<40\text{nT}$ at a distance of 0.5m), intervene in the ascensional and transversal processes of the water molecules within the entire wall structure.



device installation
5/12/2012



Zeta III device



sensor probes
installation



Biodom Control
data logger

The monitoring activities

The monitoring process started in 2012 and ended in 2016.

The monitoring activities were carried out simultaneously and independently by Ecodry Italia and the University, measurements were taken in the same points with different equipment.

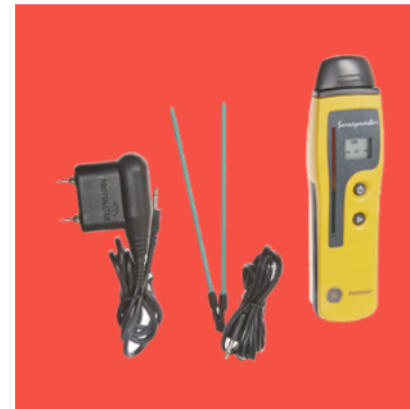
There were four types moisture measurements: environmental, superficial (**Electrical Resistance method**), sub-superficial (Electrical Capacitance method) and deep measurements (**Gravimetric method**).

2012 dec	0
2013 jun	1
2014 jan	2
2014 jul	3
2015 may	4
2016 jun	5

2018 jun planned



Electrical Resistance method



Electrical Capacitance method



Gravimetric method

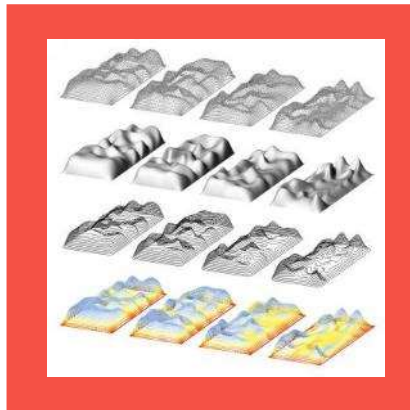
The measurements on the surface

Electrical Resistance method

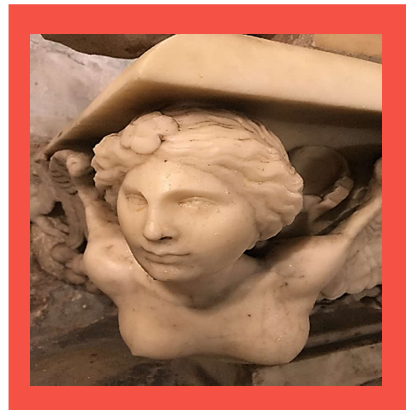
The 3D survey and the algorithm created expressly for the present case accelerated the work process and showed the phenomena observed in a clear form.

The problem of moisture condensation is very evident in the church, so much that it appears overwhelmingly in the summer months on the numerous marble surfaces that cover and decorate the interior of the church and the crypt.

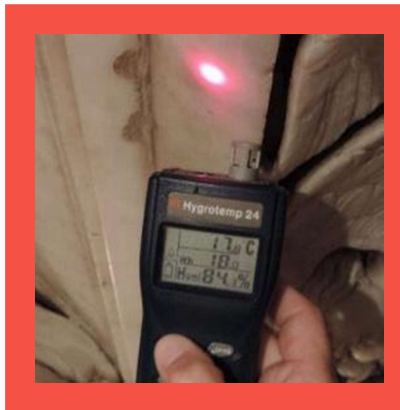
The monitoring of surface moisture has suffered greatly from the condensation during the spring-summer months, so as to provide periodically higher relative readings in the months of June-July compared to the months of January and February.



Software Rhinoceros3D
- plug-in Grasshopper



Moisture
condensation



Relative air Humidity
> 80%



salt efflorescence
nitrates and sulphates

The measurements in depth

Gravimetric method and Sensor probes

The only continuous monitoring, performed in this case, is the one made by Ecodry Italia with the probes-inserted in the walls of the hall and the crypt. Despite the diversity of electrical resistance values recorded from point to point, there is an annual periodicity of the data that corresponds to a recurring phenomenon.



destructive tests



crypt
not investigable



Two depths:
4-5 and 14-15 cm



two heights:
30-40 and 100-110 cm

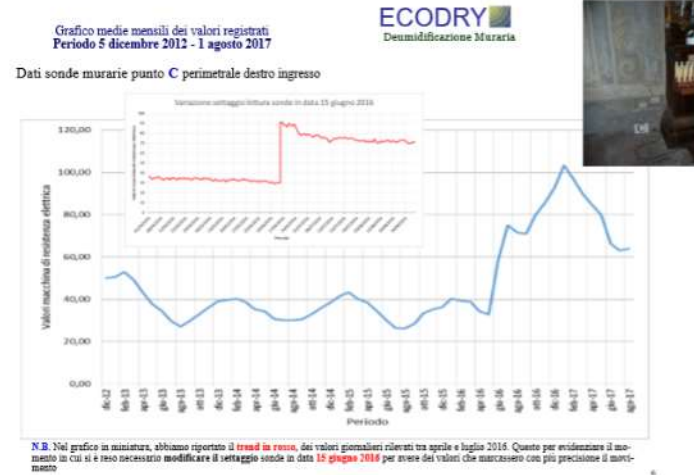
The measurements in depth

Sensor probes

Grafico medie mensili dei valori registrati
Periodo 5 dicembre 2012 - 15 giugno 2016

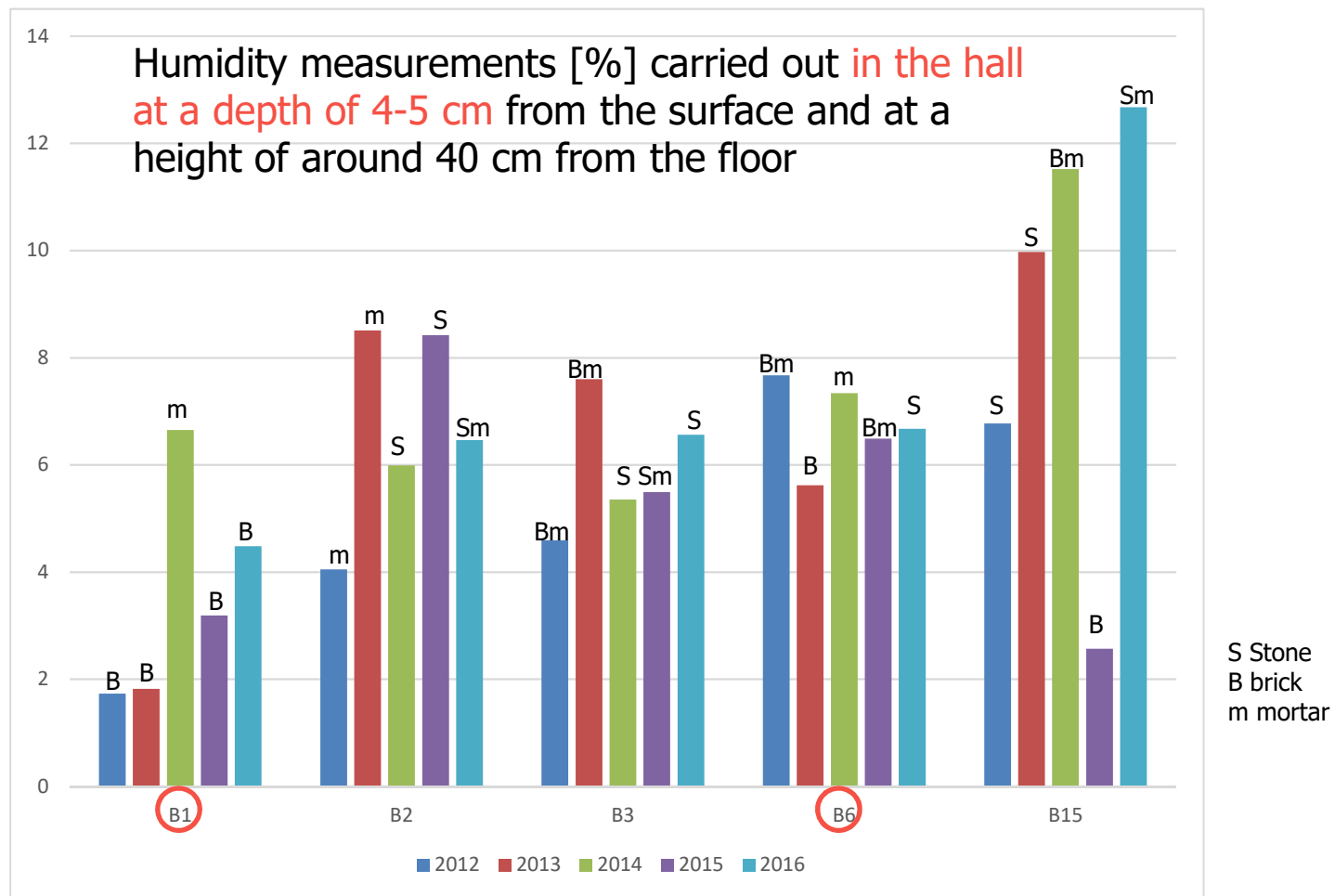
Dati sonde murarie punto C perimetrale destro ingresso

resistenza elettrica



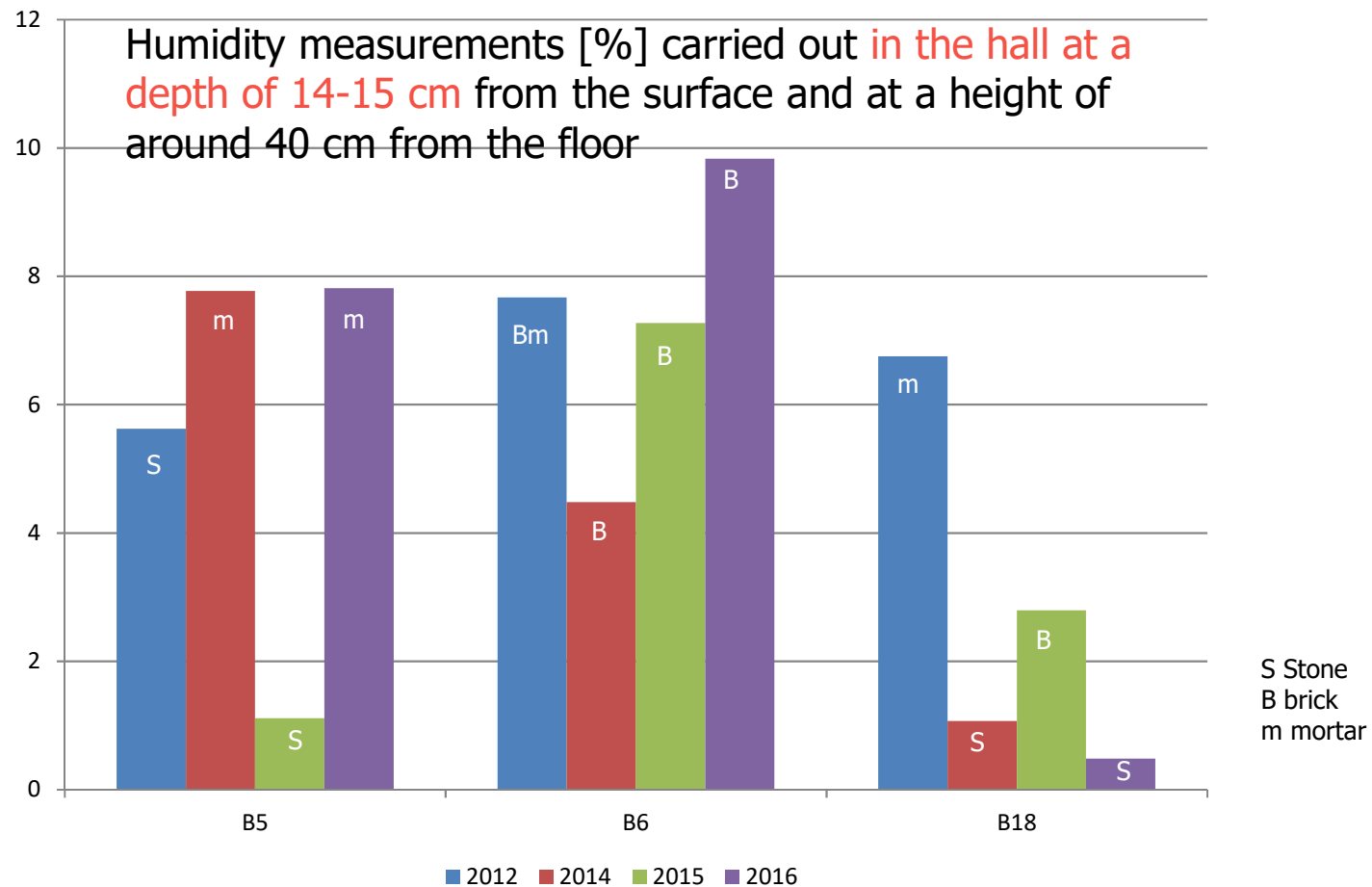
The measurements in depth

Gravimetric method



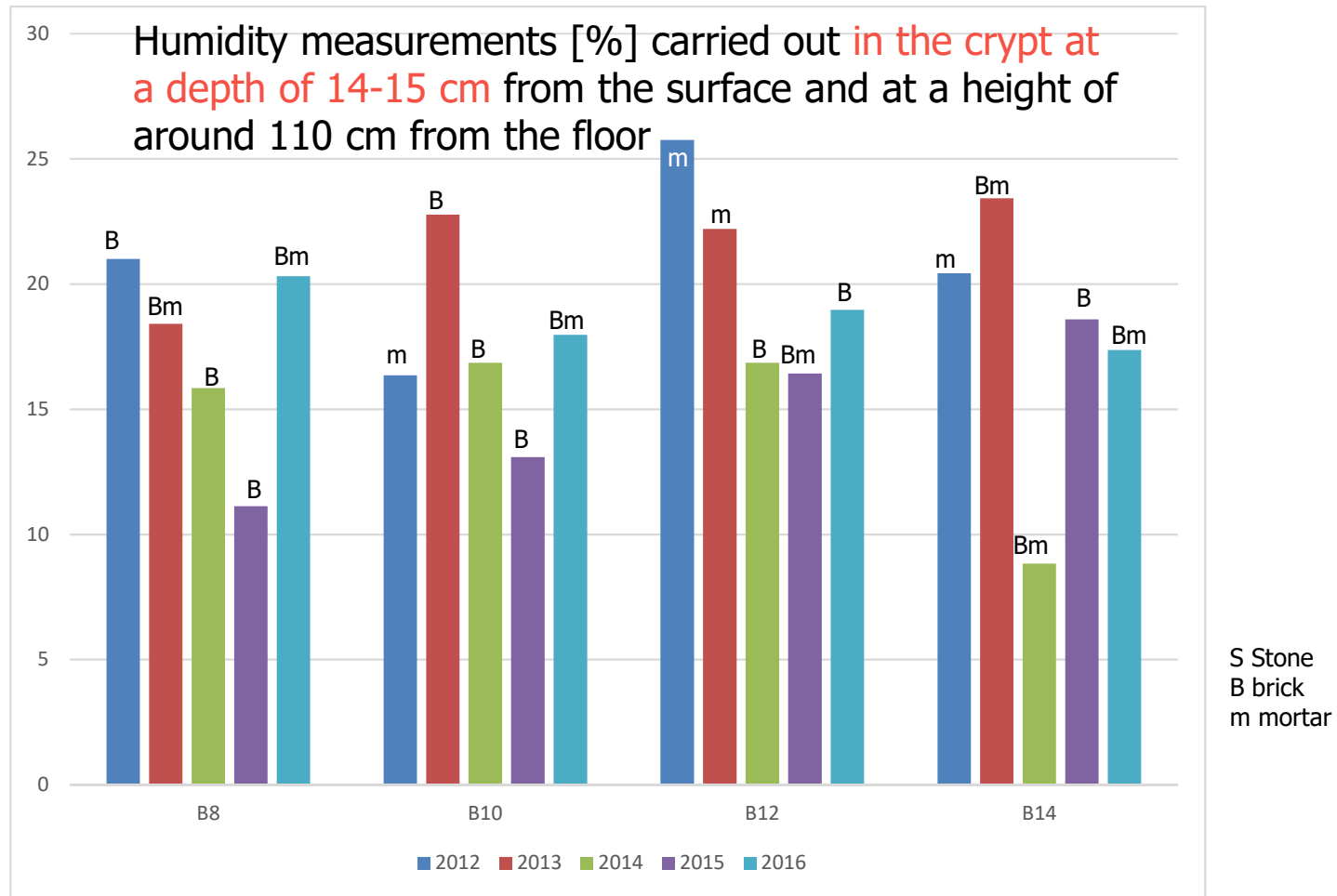
The measurements in depth

Gravimetric method



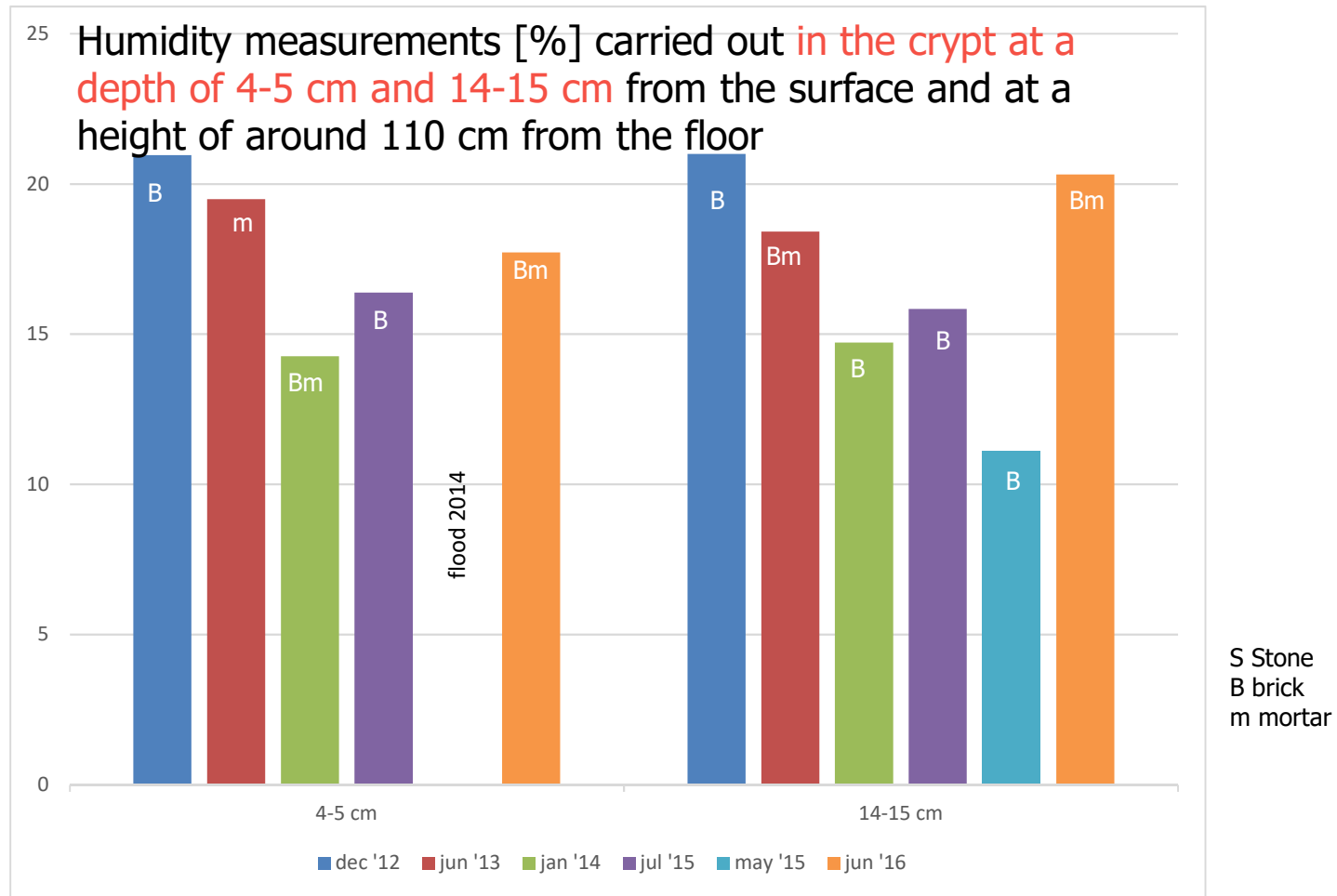
The measurements in depth

Gravimetric method



The measurements in depth

Gravimetric method



Conclusions

The case study presented important issues that should have discouraged the choice and that inevitably reflected negatively on the outcome of the monitoring:

- the incomplete knowledge of the actual cause of rising damp and the impossibility of deepening this aspect without making tests in the ground and inspecting the present underground canals;
- the great wealth of the abbey, which translates into valuable surfaces on all the walls that not only prevent the view of the wall but also prevented it from working a little more freely with samples and tests;
- the presence of a previous dehumidification intervention (chemical barrier), whose existence have altered the capillary absorption capacity of the masonry;
- the presence of a heterogeneous masonry consisting of stones (not very porous), bricks and mortar (very porous) that have a different capillary absorption and therefore determine discontinuity of reading depending on the reference points;

It is not possible to deduce from such a complex case a univocal result that proves that the installed dehumidification system is effectively decreasing the amount of moisture present in the walls of the hall and local under the crypt.

Thanks to



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Mons. Rapallo
Dott.ssa Di Natale
Arch. Crocco



Arch. Parodi
Arch. Peirano



Prof. Musso