EGU21-2022
https://doi.org/10.5194/egusphere-egu21-2022
EGU General Assembly 2021

Decay detection in an ancient column with combined close-range photogrammetry (CRP) and ultrasonic tomography.

Giuseppe Casula[1], Silvana Fais[2,3], Francesco Cuccuru[2], Maria Giovanna Bianchi[1], Paola Ligas[2], and Alessandro Sitzia[4]

[1]Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy (giuseppe.casula@ingv.it; mariagiovanna.bianchi@ingv.it)
[2]Department of Civil and Environmental Engineering and Architecture (DICAAR), University of Cagliari, Cagliari, Italy (sfais@unica.it; fcuccuru@unica.it; pligas@unica.it)
[3]Consorzio Interuniversitario Nazionale per l'Ingegneria delle Georisorse, CINIGEO, Roma, Italy (sfais@unica.it)
[4]Ministero dei Beni e delle Attività Culturali. Direzione Regionale Musei Sardegna; Cagliari, Italy (alessandro.sitzia@beniculturali.it)

The diagnosis of the conservation state of monumental structures from constraints to the spatial distribution of their physical properties on shallow and inner materials represents one of the key objectives in the application of non-invasive techniques. *In situ*, CRP and 3D ultrasonic tomography can provide an effective coverage of stone materials in space and time. The intrinsic characteristics of the materials that make up a monumental structure and affect the two properties (i.e., reflectivity, longitudinal velocity) through the above methods substantially differ. Consequently, the content of their information is mainly complementary rather than redundant.

In this study we present the integrated application of different non-destructive techniques i.e., Close Range Photogrammetry (CRP), and low frequency (24 KHz) ultrasonic tomography complemented by petrographycal analysis based essentially on Optical Microscopy (OM). This integrated methodology has been applied to a Carrara marble column of the *Basilica of San Saturnino*, in Byzantine-Proto-Romanesque style, which is part of the Paleo Christian complex of the V-VI century. This complex also includes the adjacent Christian necropolis in the square of *San Cosimo* in the city of Cagliari, Sardinia, Italy. The column under study is made of bare material dating back probably to the first century A.D., it was subjected to various traumas due to disassembly and transport to the site, including damage caused by the close blast of a WWII fragmentation bomb.

High resolution 3D modelling of the studied artifact was computed starting from the integration of proximal sensing techniques such as CRP based on Structure from Motion (SfM), with which information about the geometrical anomalies and reflectivity of the investigated marble column surface was obtained. On the other hand, the inner parts of the studied body were successfully inspected in a non-invasive way by computing the velocity pattern of the ultrasonic signal through the investigated materials using 3D ultrasonic tomography. This technique gives information on the elastic properties of the material related with mechanical properties and a number of factors, such as presence of fractures, voids, and flaws. Extracting information on such factors from the

elastic wave velocity using 3D tomography provides a non-invasive approach to analyse the property changes of the inner material of the ancient column. The integrated application of *in situ* CRP and ultrasonic techniques provides a full 3D high resolution model of the investigated artifact. This model enhanced by the knowledge of the petrographic characteristics of the materials, improves the diagnostic process and affords reliable information on the state of conservation of the materials used in the construction processes of the studied monumental structure. The integrated use of the non-destructive techniques described above also provides suitable data for a possible restoration and future preservation.

Acknowledgments: This work was partially supported by FIR (Fondi integrativi per la Ricerca) funded by the University of Cagliari (Italy). The authors would also like to thank the Ministero dei Beni e delle Attività Culturali. Polo Museale della Sardegna and Arch. Alessandro Sitzia for their kind permission to work on the *San Saturnino Basilica*.