



## **The atmospheric degradation of a durable lithotype used in Northern Italy: the Oira stone**

Lucia Toniolo (1), Roberto Bugini (2), and Davide Gulotta (3)

(1) Dept. Chemistry, Materials & Chemical Engineering, Politecnico di Milano, Milan, Italy (lucia.toniolo@polimi.it), (2) Institute for the Conservation and Valorization of Cultural Heritage, CNR, Milan, Italy (r.bugini@icvbc.cnr.it), (3) Dept. Chemistry, Materials & Chemical Engineering, Politecnico di Milano, Milan, Italy (davide.gulotta@polimi.it)

The cathedral of Monza is a masterpiece of the northern Italian architectural heritage dated at the beginning of the XIV century. Its façade was modified over time as a result of the variation of the general plan and its current appearance is defined by six main pillars which identify five sectors, the central one hosting the main portal and a huge rose window. All the architectural elements and sculptures were realized in stone using several and different local lithotypes, including marbles, limestones, sandstones and volcanic stones. One of the most distinctive hallmarks of the façade is the alternated presence of rows of white and dark stones for the flat blocks which cover the masonry. Originally, the white rows were realized with different types of whitish marbles, whereas the dark ones were made by Varenna stone, a local black sedimentary rock. Unfortunately, this stone type extensively deteriorated as a result of the outdoor exposition and it was therefore completely substituted with blocks of dark green-coloured Oira stone during the restoration of the façade carried out at the end of XIX century by the famous architect Luca Beltrami [1].

Pietra d'Oira is a dark green peridotite, with olivine crystals partly altered to serpentine and pertains to Metabasites embedded in gneiss and micaschist of Strona - Ceneri zone (late Palaeozoic) and outcrops on the western shore of lake Orta (North-western Piedmont) near the Oira village. In the early XX century, Pietra d'Oira replaced some stone by then badly decayed as Triassic black limestone from several quarry sites of Prealps or dark grey limestone from Saltrio quarries. Several buildings were involved in these restoration works: the façade of the Church of Certosa (Pavia, XV century), Cappella Colleoni (Bergamo, last quarter of XV century) and, as reported, the façade of the Monza cathedral.

The present paper reports the study of the degradation of the Oira stone exposed to outdoor atmospheric conditions since the early XX century. The onsite evaluation of the stone blocks of the façade after more than a century of exposition showed a distinctive surface colour alteration. The formation of a fragile superficial layer of few millimetres thickness with scaling and progressive detachment, has been observed and documented by portable digital microscopy. Samples of the stone have been collected and studied by optical microscopy and scanning electron microscopy on loose fragments, thin sections and polished cross-sections. An interesting and unusual phenomenon of alteration of the olivine phase has been pointed out [2]. The mineralogical and compositional features were also investigated by means of XRD and FTIR analyses. The results showed that the colour variation can be correlated to the chemical alteration of the stone, which results in the deployment of the magnesium and aluminium content of the most external portion of the material.

The study has been conducted in the framework of the diagnostic and monitoring activity for the ongoing conservation work of the façade.

[1] Cassinelli, R. (Ed). 1988. Monza anno 1300. La Basilica di S. Giovanni Battista e la sua facciata. Edizioni Cariplo, Milan, Italy.

[2] Beard, J. S. et al. 2009. Onset and Progression of Serpentinization and Magnetite Formation in Olivine-rich Troctolite from IODP Hole U1309D. *Journal of Petrology*, Vol. 0, pp. 1-17.