Chemical-physical diagnostics propaedeutic to the conservative restoration of the Funus Cippus of Quinto Cornelio Procliano

Emanuele Dell'Aglio[1]*, Maria Luisa Astolfi[1], Maria Pia Sammartino[1], Marco Castracane[2], Giovanni Visco[1], Luigi Campanella[1]

1 Chemistry Department, Rome University, La Sapienza, Rome, Italy, 2 Senior conservator-restorer, Rome, Italy

INTRODUCTION

Diagnostic analyses on a Funus Cippus (fig. 1), in precious white marble, located close to an ancient Roman consular road are here presented. The Cippus is in enough good conservative conditions but almost completely covered by a black patina; so, a conservative intervention was planned.

The Cippus is a memory of the young Quinto Cornelio Procliano and of his mother Valeria Calpurnia Scopele who mourns her 5th child who died at 15 [1].

It perfectly fits into the Roman funerary liturgy and also shows an Etruscan-type iconography with bas-relief of a *Patera* and a *Hydria* respectively on the right and left side of the carved epigraph in the marble body that seem to confirm the Etruscan Gens of the family and the dating to the 1st century AD. The back side, now to the north, being completely smooth, suggests an original location leaning against a wall.

With a base area of about 1m^2 and a height of about 2m, a weight of about 5400 kg is assumed

EXPERIMENTAL

A first visual analysis shows that, as expected taking into account the location in open countryside, the patina is mainly of biological nature (fig. 2) In situ measures of the surface Temperature and Humidity were performed along vertical profiles on the 4 sides of the Cippus. The marble colour was evaluated on the uncovered by patina part of the Cippus and on the clean part of the fallen fragment using comparative Sikken strips and, from the relative codes, the L*a*b* were obtained [2]. Samples of the patina were collected from the west (sample 1), south (sample 2) and east (sample3) sides of the Cippus as well as a small fragments already fallen (sample 4).

Fig.1 - The Funus Cippus

Fig. 2 – Macrophotos of the patina covering the Cippus

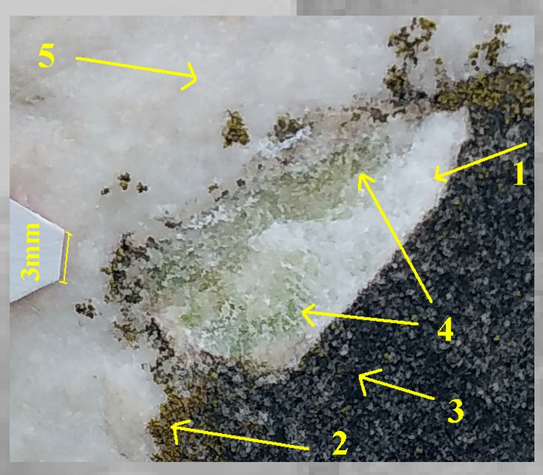


Fig. 3 - photo of the point from which sample 4 fell. 1) original marble colour , 2) microflora growth in progress, 3) microflora dead and decomposed, 4) recent growth of microflora, 5) marble colour altered by decay

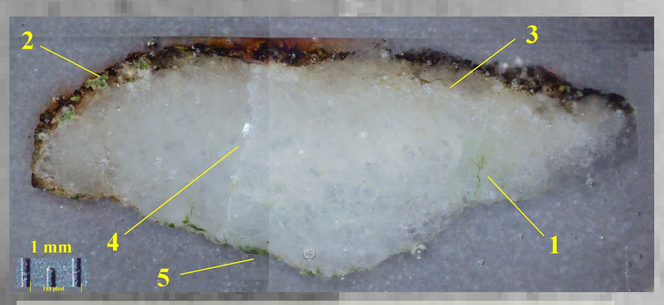
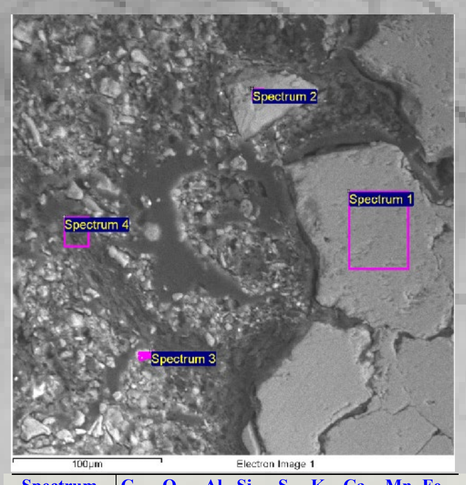


Fig. 4 – polished cross section of the fallen fragment (sample 4) photo under optic microscope at low magnification



Spectrum	C	O	Al	Si	S	K	Ca	Mn	Fe
Spectrum 1	8.4	52.1					32.9		
Spectrum 2	14.2	42.0					32.8		
Spectrum 3		42.1	2.9	6.9			2.0	2.2	42.9
Spectrum 4		68.7	6.1	14.3	2.2	1.3	4.6		2.7

Fig. 5 – SEM image and EDS data obtained for the external part of the polished cross section

RESULTS

Temperature and Humidity resulted almost constant on the Cippus surface; for the first, values ranging between 17 and 19 °C were measured, with the lowers on the base, against an ambient Temperature equal to 21 °C. Humidity, measured using a colour scale, resulted dry.

A macrophoto of the point from which the fragment fell (fig. 3), shows that the microflora infiltrates through probable microfractures causing detachments.

The polished cross section of the falled fragment, observed by an optical microscope under a low magnification (fig. 4), allows to observe both the structure of the marble and the degradation phenomena in progress. In particular, starting from the external part, it shows: the black patina, with a maximum thickness of about 0.64 mm (1), mainly composed of dead microflora with some points where it is still alive (2), a horizontal fracture approximately 0.7 mm deep already colonized by microflora (3), the inner part of the marble, homogeneous in colour and structure, shows a crack that completely crosses it (4), on the internal side the recent colonization that could have caused the detachment of the fragment (5), a vertical crack of about 1.1 mm also recently colonized (see the list in the figure caption).

The SEM image and the X-ray microanalysis (EDS) (fig. 5), allow us to understand that the disintegration mechanism of the marble occurs by infiltration of earth through the grain boundaries (highlighted by the composition in Si and Al, see spectra 3 and 4); in turn, a suitable microenvironment is created for the colonization of the microflora with a consequent increase of the intergranular pressure.

Table 1 summarizes data on the colour of the marble. In particular, it can be seen that the yellow component prevails on the red one and that both increase during the exposition with the environment (lower values for the fragment)

The UNI EN 16455:2014 Norm was followed in order to determine the soluble salts content in the 4 samples. On the solutions coming from the extraction of the soluble salts, Dissolved Oxygen (DO), pH, Redox Potential (ORP) and Conductivity were also measured; Tab. 2 summarizes the obtained results; it can be seen that ORP and Conductivity values obtained from the fragment sample significantly differs from the others being less reducing and with a higher salts content respectively. The lower pH was measured in the sample sampled in the south side of the Cippus

sample	dissolved (g)	pH	ORP (mV)	Conductivity (µS)	µS mesured at °C
1	1.088	9.64	152.6	43.1	22.5
2	1.082	8.85	144.0	29.0	21.7
3	1.085	9.69	149.8	34.4	22.2
4	1.078	9.83	310.6	81.8	22.1

Tab. 2 – Some parameters measured in the solution coming from the extraction of the soluble salts from the samples

test point or sample	Sikken code	L value	a* value	b* value	example
test n.1	F2.07.88	95.81	1.88	9.9	
test n.2	F2.05.85	93.59	1.74	8.64	
test n.3	FN.02.88	95.11	0.86	5.03	
sample n.4	ON.00.90	94.89	0.29	1.76	

Tab. 1 – measured colour by Sikken strips and calculated L*a*b* components

As expected taking into account the conductivity measures, a low content of soluble salts [3] was obtained for all the 4 samples (Fig. 6). Taking into account some European guidelines concerning risk of damage caused by salt contamination in stone materials, no risk results for the samples (values lower than 0.1% for sulphate and chloride and lower than 0.05% for nitrate) with the exception of the south side where a low risk is evidenced for the presence of sulphate. As expected Calcium is the main cation. The charge balance shows that Calcium cannot be balanced by the total found anions so allowing to evaluate the sum of carbonate and bicarbonate; in turn such sum and the pH values (inserted in the Henderson-Hasselbalch equation) allow to estimate the content of the two parameters.

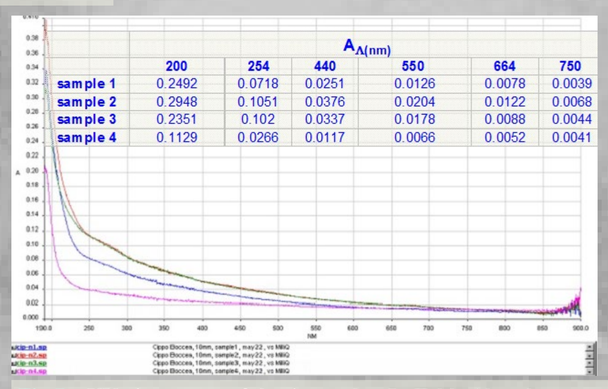
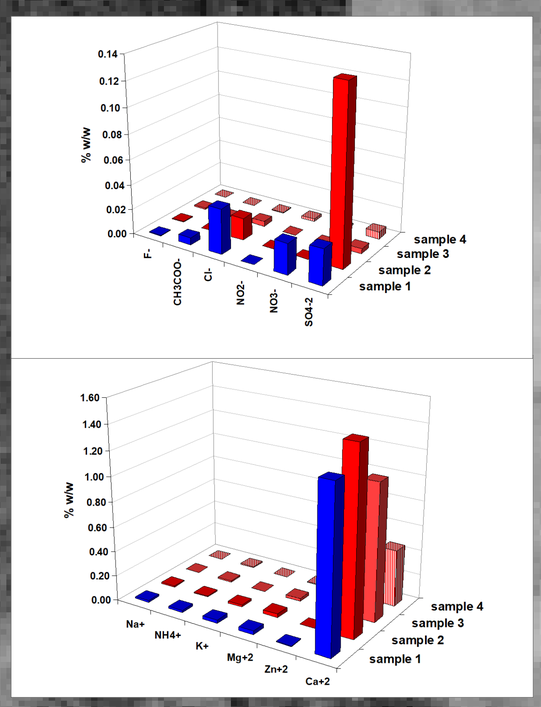


Fig.7 – UV-vis spectra of the 4 samples. In Table Absorbance at different wavelength are considered as index of: nitrite and nitrate presence (200 nm), organic matter, (254 nm), chlorophyll a, b and carotenoids , (254 nm), red photosynthetic pigment (550 nm), chlorophyll A , (664 nm), turbidity , (750 nm)

Spectroscopy

UV-vis spectra (Fig.7) confirm IC data about the lower content of nitrite and nitrate in the fragment. The expected lower content of organic matter and photosyntetic pigments is also evidenced.



sample	total anions neq	total cations neq	carb+bicarb neq	carb+bicarb %
1	21	698	677	97.0
2	34	773	739	95.6
3	3	573	570	99.6
4	2	241	239	99.1

sample	HCO_3^-	CO_3^{2-}
1	37.8	9.6
2	45.8	1.5
3	32.2	7.3
4	13.1	3.8

Fig. 6 – Anions and cations found in the samples by Ion Chromatography. The electroneutrality and the sum of carbonate and bicarbonate are reported in the table on the top; in the other table carbonate and bicarbonate content were calculated using the pH values and the charge imbalance (IV column in the previous table)

CONCLUSIONS

The conservation conditions of the Funus Cippus are affected by biological attack due to the location in the open countryside which also caused micro-cracks in the internal part of the marble due to the initial infiltration of soil that has created a hospitable environment for plant and animal microorganisms. On the other hand, the location allows for ventilation that prevents the stagnation of humidity and its rising which would lead to the access of soluble salts. The large fracture and the large gap, however, can hardly be attributed to biological degradation whose effect is disintegrating and hardly involves infiltrations at great depths. For cleaning it would be advisable to use hydrogen peroxide, preferably nebulized, and subsequent brushing after an initial disinfection with Benzalkonium. A great deal of experience is needed for the consolidation phase that is possible, given the carbonate matrix, with “lime water” in dozens of passes until rejection. It will then be important to protect with a layer of wax which of course must be periodically renewed

ACKNOLEDGMENT

Many thanks to Dr Daniela Ferro for the SEM/EDS analyses . thanks to the Cornelia Antiqua Association for the financial support and to Dr. Roberta Pardi of the Superintendence of Rome for the project's approval by

REFERENCES

1) L'Année épigraphique 1982, n.62, Presses Universitaires de France, 1984

2) M.P. Sammartino, E. Dell’Aglio, A. Peduzzi, G. Visco, Comparison Between Colorimetry and Sensory Panel in Studying Similarity Between Roman andIntegration Bricks, Assisted by Multivariate Data Treatment, Studies in Conservation, 65(8), 2020, 465-474

3) BS EN 16455:2014, Conservation of cultural heritage. Extraction and determination of soluble salts in natural stone and related materials used in and from cultural heritage, ISBN 978-0-580-79016-4

First Symposium for YouNg Chemists: Innovation and Sustainability, SYNC2022, Chemistry Department, La Sapienza University, 20-23 June 2022, Rome ,Italy