Problems of Airborne Particles : Their Effect on the Famous Frescoes of Masaccio Masolino and Filippino Lippi in Florence

Airborne particles in the atmosphere are a problem in that they seriously affect our cities and all those areas where traffic density is particularly high.

At present, the major part of the particles which research workers have been able to capture and analyze, are composed of residual carbon from the combustion of fossil fuels used for heating, for the production of thermal and electrical energy, and for cars.

The number of these particles is extremely high and their size incredibly small but today, scientists from all over the world are only too well aware of their existence since any surface which is analyzed with sophisticated equipment (such as, for example, XPS-Auger spectroscopies) presents carbon traces and must be decontaminated before any measurements can be made.

The build up of carbon particles and of unburned residual hydrocarbons (it should be remembered that we do not even manage to efficiently burn the fuels that we use because the performance of today's thermal equipment is poor compared to the fuel's power) on our monuments, combined with the sulphation of the surfaces of the stone produces, the notorious black crusts. These have a disfiguring effect on ornate surfaces, statues, buildings, etc. and are among the most troublesome issues in restoration and, above all, conservation (Fig. 1). Such crusts are a conglomerate of dusts of different degrees of acidity various oxides, plant residuals (seeds, pollens), carbon particles, unburned hydrocarbon fragments, which are oily and adhesive, and transformation products of the stone surface.

These products are usually of calcium sulphate and nitrates, which, unlike calcium carbonate, are hygroscopic and water-soluble. They act as a « cement » which binds all the components together into a black, amorphous hard mixture.

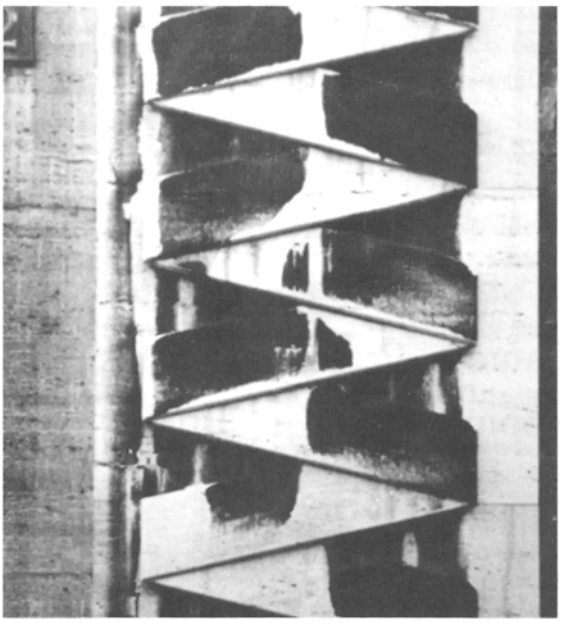


Fig. 1. Milan's Stock Exchange. This external decoration, on the front of the building has taken on the typical aspect of today's city monuments.

The nature of the dust collected by the pumps through a cellulose membrane is shown in Fig. 2 and 3. The scanning electron microscope, SEM, reveals the dust in the particles. We obviously made measurements on this dust with X-ray diffraction, Auger and XPS spectroscopy, mass spectroscopy when possible, and with X-ray fluorescence, in order to determinate the principal elements.

Owing to these properties, black crusts can be dissolved and washed away by rain, in those areas where it can reach them, whereas they remain unharmed and thrive on the basis of more or less acid dew where rain cannot find its way through (see Fig. 1).

This is the present situation with respect to outdoor works of art in our cities. I would now like to discuss, quite briefly, one particular aspect of atmospheric pollution which plays a fundamental role in the restoration and maintenance of some of the most magnificent work of art from the Italian Renaissance inside monumental buildings. Even these can be affected by the environmental attack described above.

I am briefly going to discuss the situation concerning Masaccio's, Masolino's and Filippino Lippi's frescoes in the Cappella Brancacci, inside Florence's Chiesa del Carmine. We can clearly demonstrate that this cycle of frescoes is set in a « container-museum » which, in turn, is set in a much larger building that has no special outlets. However, due to its fundamental religious role, it is a « living » building, with a constant flow of people visiting the church irrespective of whether some frescoes are located inside or not.

Fig. 2. Electron micrograph (SEM) of dust at a magnification of X 1000.

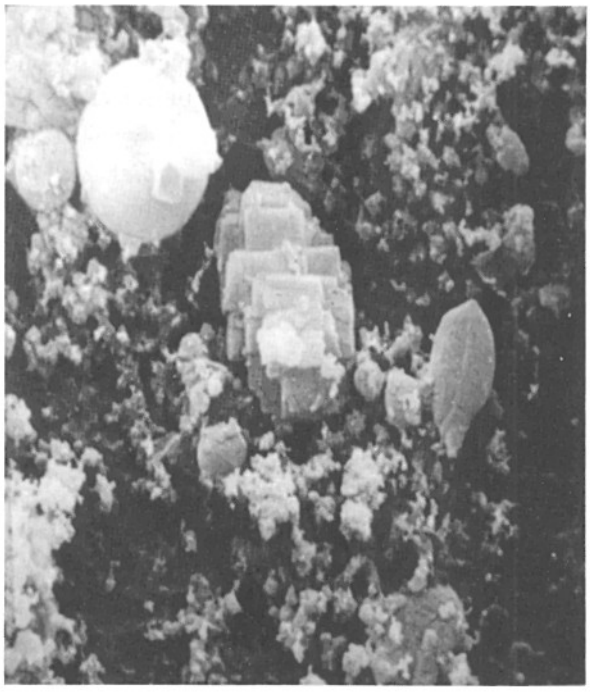


Fig. 3. Electron micrograph of dust at a magnification of X 1500.

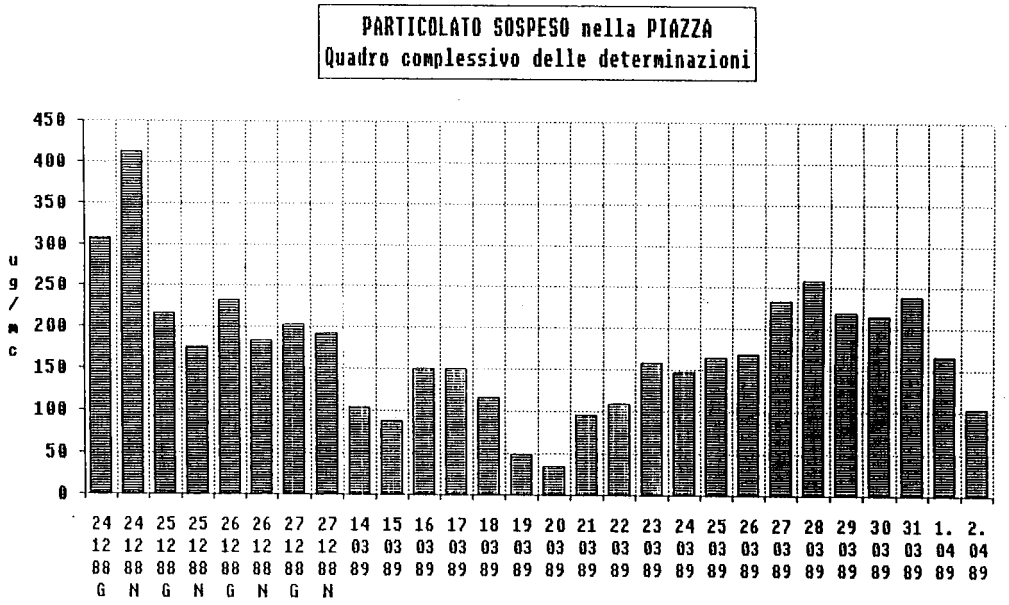
Fig. 4. Masaccio's fresco in the Cappella Brancacci after cleaning - Detail.

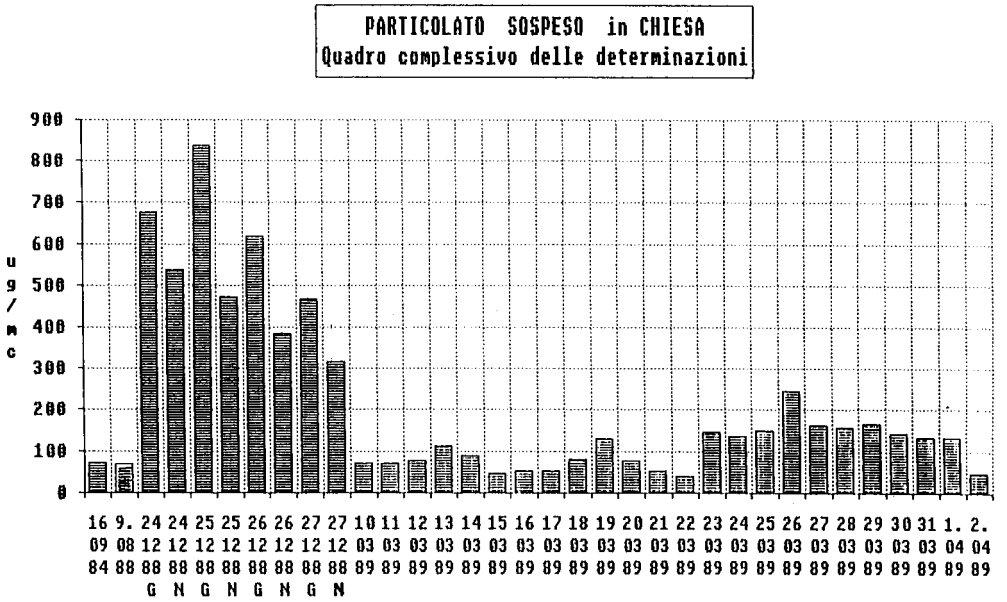
This cycle of frescoes, virtually a landmark, the culmination of XVth century Italian painting, was recently restored to its pristine splendor by one of the most effective scientific interventions ever performed in Italy, whose details obviously cannot be described now (see Fig. 4).

It is sufficient to say that we carried out in-depth studies on the environmental situation before, during and after restoration and, in addition, compared the state of conservation with the work of art.

From this point of view, the frescoes were in excellent condition : they were just covered with a thin, dark incoherent film of carbon dust and various typical particles (soil dust, pollen, etc.), all of which were more or less tightly bound by a thin sulphate layer (3-4 g/m^2) and by an organic protein binder, a residual from early XXth century restorations. This organic layer, basically made of egg white and egg yolk, was applied to enhance the brightness of the colours ; over the years, though, this layer took on a brownish hue which is one of the primary causes for the loss of clarity.

Simultaneous measurements of the frescoes microenvironment and of the outdoor environment led to the discovery that, in the Cappella, the presence of « chemical pollutants » is almost irrelevant when compared with the higher standard levels outside the church (SO_2, NO_X). However, the





Figs. 5 and 6. Histograms of the dust content inside and outside the Cappella during Christmas and New Year Holidays.

measurements revealed a significant presence of black airborne particles which saturated the filtering membranes within 24 h. Most of this dust is « carbon » derived from hydrocarbon combustion and from candle smoke, it also contains *lead traces* due to the proximity of a carpark. Additional components were salt, pollen, etc., whose presence was revealed by electron-microscope analyses.

Even after restoration was complete, further surveys reconfirmed the almost total absence of SO_2 inside the Cappella : (compared with the fixed levels out of doors), and a higher level of CO_2 but also revealed a worrying quantity of *airborne particles.*

This phenomenon is influenced by the trends in the outdoor environment and, of course, more markedly, by the variation in the number *of visitors* and by the management of the « church-container » (use of candles, daily cleaning, etc.). This is especially evident during religious holidays (Figs. 5 and 6), above all Christmas, and Easter.

The flow of church members and, added to that, of visitors will bring the levels detected to alarming peaks. We will have to monitor and prevent their occurrence with the aid of the recently installed air-conditioning system which is now being tested.

Unlike most situations, the object of this air-conditioning system is not so much to constantly adjust the Cappella's temperature and humidity (they are naturally constant), but to remove or drastically reduce the dust content. Only the faultless functioning of this system will prevent another darkening in the colours of the frescoes, as a result of the build up of particles on the plasterwork and the clogging of its pores. In our opinion, this latter represents the most serious danger.

P.L. PARRINI
Via Camperio, 9
I - 20123 MILANO