Ecological approach to the genesis of calcium oxalate patinas on stone monuments

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SUMMARY. The genesis of calcium oxalate patinas on stone monuments gives rise to controversial opinions. One of the proposed hypotheses links this phenomenon to the past presence of lichens on the exposed surfaces of monuments. However, the growth of a biological species cannot occur if environmental conditions are not compatible with its autoecology. Analysis of variations of the environmental factors that can act as «limiting factors» shows that in most monuments, the various exposures are not always compatible with biological growth. The environmental factor that seems to be the most limiting is the amount of surface water that is frequently below the range of tolerance of even the most xerophyloous species. In the case of Trajan’s column in Rome, the distribution of oxalate layers shows an opposite trend with respect to what we would expect for lichen colonization. Presently other kinds of biological colonization cannot be excluded.

Key words: Biodeterioration, calcium oxalates, ecology, stone monuments.

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INTRODUCTION

The presence of calcium oxalate layers (both monohydrate or whewellite, dihydrate or weddellite) has been frequently observed on the surfaces of stone monuments. These chemical compounds are the result of an oxidation of organic materials, such as proteins or lipids, that can originate through very slow but spontaneous chemical reactions, such as mineralization processes (Matteini and Moles, 1986). Frequently, oxalates are final metabolites of a wide number of species, especially fungi, lichens and higher plants, but with a great quantitative difference in the accumulation and excretion (see Pinna, in the same volume). The interpretation of their genesis on monuments where actually no biological growth is detectable is, therefore, controversial.

Different hypotheses on this subject have been formulated by various authors. Some ex-
plain the phenomenon as the residues of ancient treatments or polychromes (Franzini et al., 1984; Gratziu, 1986) or hypothesize an anthropogenic origin derived from urban and industrial activities (Saiz-Jimenez, 1989; De Santis and Allegrini, 1989). Others consider these patinas as the result of a specific microbial colonization that occurred in the past, or as the result of the polishing of stone (Guidobaldi et al., 1984). With regard to the biological hypothesis, a prime role was attributed to lichens (Del Monte and Sabbioni, 1987; Sabbioni and Zappia, 1991). The authors supporting this hypothesis observe, in fact, that these patinas are often present on monuments that have never been treated or in natural outcrops. They explain the current absence of lichens and other organisms as the result of pollution increase in cities in recent decades, causing the death of these organisms which are sensitive to pollutants.

Logically, however, the occurrence of this phenomenon requires the contemporary presence of a biological colonization by organisms that can produce physiologically a considerable amount of oxalates and of environmental conditions compatible with their survival. In the past this last aspect has been insufficiently considered by authors who automatically explain the presence of calcium oxalates on monuments as the result of biological activity.

The aim of this paper is, therefore, to demonstrate that this hypothesis is acceptable only when ecological conditions support the causes and that a generalization of this phenomenon is not possible from a scientific point of view.

MATERIALS AND METHODS

Various observations on the distribution of calcium oxalate layers on Roman stone monuments (Arch of Constantine, Antonine Column, Trajan’s Column, Caestia Pyramid, etc.) have been carried out. Their chemical and petrographical composition and their morphological appearance and distribution have already been well documented in the literature (Guidobaldi et al., 1984; Gratziu, 1986; Alessandri et al., 1986).

For Trajan’s column, a detailed mapping of the patinas at various exposures and at various heights was made, taking advantage of the fact that scaffolding had been put up around the column (Figs. 1 and 2).

A collection and elaboration of environmental data concerning variations in wind, incident rainfall and solar radiations as a function of exposure was made. Historical data and old photographs from the beginning of this century were also collected and analyzed.