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# Defining, mapping and assessing deterioration patterns in stone conservation projects

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ABSTRACT

Deterioration patterns are the visible consequences of the impact of environment factors on the stone objects. They depend on the type and severity of the external agents and on the type of substrate and its vulnerabilities. When properly understood, they may serve as key-indicators of the decay processes and of the possible causes of the observed damage. Correctly describing the deterioration patterns is an essential requisite when studying exposed stone objects, to understand the problems, to identify conservation needs and to define conservation actions. This paper discusses a few types of deterioration patterns to illustrate the need of choosing accurate definitions to describe them with the aim of reducing ambiguity when crossing the border between theory and practical application. The paper discusses a few deterioration patterns (detachment forms, black crusts and patina) that are currently found in conservation of built cultural heritage to highlight the importance of reducing the ambiguity that is frequently associated to such descriptive terms, aiming at better using them when acting in the passage from diagnostics to conservation actions. When mapping the spatial distribution of deterioration patterns, the most widely used methodologies are appropriate for scientific studies, but their usefulness to prepare and implement conservation interventions is much smaller. The paper proposes an innovative methodology to identify, describe and classify conservation problems and to prepare the documentation to support the tender documents in conservation interventions. A new methodology to help assessing the risk of structural instability and to help defining priorities in maintenance strategies in dry-stone laid constructions is presented.



## 1. Introduction

Deterioration patterns are the visible component of the decay processes that are operating onsite. They reflect the interaction between the stone intrinsic components and the environment or extrinsic factors. They provide relevant information on the evolving decay mechanisms, but in general they are not univocal signatures of those processes. In complex cases, deterioration patterns alone may be insufficient to interpret the situation, and complementary data may be required to support more consistent diagnostics.

The deterioration patterns are essential tools for the conservation scientist to work with, and constitute the basic units to define the conservation actions to be implemented. To fulfil these essential functions, they need to be conceptualised with this objective in mind, and have to be defined in precise terms, by using unambiguous terminology and by adopting concepts that might be informative for the diagnostics phase and be operative for the intervention action.

Deterioration patterns, under this designation or similar others (erosion, alteration, degradation, decay forms) have a long tradition of use in the Earth Sciences disciplines, namely Geology and Geomorphology. The Building Industry borrowed some concepts from those disciplines and has introduced others that would better reflect the situation on stone ware buildings. Assimilation of terms and introduction of new ones are language and culture dependent, and it is not unexpected that any national or even regional communities would use slightly or even totally distinct vocabularies for describing the same deterioration problems.

In the decade of 1970, an international move was initiated inside ICOMOS to establish a common terminology to describe deterioration patterns on built heritage. The Group Petrography, of the ICOMOS International Scientific Committee for Stone (ISCS), firstly headed by J. Ragot and subsequently by A. Arnold and D. Jeanette, made an enormous effort to gather, harmonise and define a certain number of terms taken from English, French and German scientific literature, and a set of highly valuable internal documents was prepared. However, the task of finding a common understanding

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among the three languages showed to be harder than expected and no final document could be produced. Based on those internal documents, during a period of chairmanship of that Group, the author had the opportunity to prepare a personal selection of terms, which was published in the Group Newsletter [1]. A new impulse to that group was given in the decade of 2000, by Isabelle Pallot Frossard and Véronique Vergès-Belmin and a bilingual version of a glossary was produced and made accessible for personal downloading [2].

Meanwhile, the scientific community continued the effort to better understand decay phenomena and to establish more accurate terminologies to describe and map them. Some of them were typical authored [3] papers, while others were produced as national [4], or group [5,6] contributions.

These documents share a common background to support their definitions: their basic descriptive units are chosen to correspond as closely as possible to a specific degradation process, thus trying to create unambiguous descriptors of the problems that call for the use of this kind of documents.

In this perspective, such documents constitute an enormous progress in the field, and are strong pillars to build up a common understanding, since they use terminologies that can be shared by people with distinct backgrounds, or coming from different regions, or having different mother languages. At the scientific level, the ground is pretty well defined and in spite of improvements that can always be added, the existing elements constitute a solid basis for any professionals wishing to use others', or share their own experience.

In spite of this enormous progress, the passage from the scientific analysis of decay processes to the professional implementation of conservation actions is less developed and still needs additional improvements. The present paper addresses a few topics considered relevant to better translate scientific data into executable conservation actions.

## 2. Defining and using degradation terms

When preparing a glossary of deterioration patterns and concepts, there is a natural tendency to adapt terms currently in use in the profession or in related disciplines. The result of the work of any task group very often ends up in a compromise, when the efforts to harmonise are not enough to produce a fully coherent set of terminological definitions.

One frequent drawback of the standard terminologies is the ambiguity that some terms convey when trying to use the information to support the choice of the appropriate conservation actions. When this happens, the end-user must make an effort to eliminate the ambiguity by providing a precise context for each term or concept he/she is using.

This situation will be herewith illustrated with three common terms used in stone conservation: detachment forms, black crust, and patina.

### 2.1. Detachment forms

When a stone surface is losing mass, the form, size and shape of the detaching elements may vary from powder and very small grains to large chips and plaques. Their characteristics inform on the degradation processes that are causing damage and are an essential input in the preparation of the required conservation actions. A proper description is always to be recommended, but the information conveyed by the terms used in this description has not the same value for both objectives. To discriminate between blistering, contour scaling, peeling and spalling (when thin elements are detaching) is of relevant interest when interpreting the mechanisms and searching for damage causes, but it is of minor interest when defining conservation actions. All forms correspond to a detachment of thin plaquettes, with high lateral continuity, and all of them may require similar gluing actions and sealing of the external contours.

When degradation events are causing detachment, the size of the stone elements in risk of being lost is the critical parameter in the specification of the needed conservation actions. Thick elements (thick plaques, chips and similar) usually need to be glued and eventually securely fastened to the substrate. Thin plaques (plaquettes), contour scaling and similar also need to be glued, but nailing them to the substrate tends to be unfeasible and most likely unnecessary given the lightweight in cause. When detachment is produced as individual grains, the grain size matters, but also the type of substrate has to be taken into account: powdering and chalking, frequent in very porous limestones, tend to correspond to hopeless situations and little is usually feasible to counteract them directly; sand disintegration coming from high porosity sandstones tends to be very difficult to solve or it is even hopeless, while sand disintegration in granites (and also sugaring, in marbles) when surface grains are still in place may have chances to be properly glued back. The detachment of scales is an intermediate situation between individual grains and plaques/plaquettes and usually corresponds to situations of very difficult treatment. Larger scales may accept treatment similar to plaques and plaquettes, while smaller ones tend to configure virtually impossible endeavours.

Therefore, for conservation purposes, the key terms with direct practical implications are: detachment as individual grains (powdering and sand disintegration), as scales (specify actual size and frequency), as plaques, and as plaquettes (Fig. 1).

### 2.2. Black crusts

Black crusts are widespread features in urban environments and are particularly frequent in carbonate substrates. They result from the interaction of urban pollutants with the stone and produce deterioration patterns requiring very demanding solutions. When in advanced stages of evolution, black crusts tend to detach from the substrate bringing about the complete loss of the stone surface. The qualifying term black has no discussion, but the essential descriptive kernel – crust – is ambiguous and some accepted definitions may be of little value for practical purposes. The ISCS Glossary defines crust as “Generally coherent accumulation of materials on the surface. A crust may include exogenic deposits in combination with materials derived from the stone.” and the only connection to the substrate is the possibility of having materials derived from it. When detailing this definition, the same document states that a black crust is a “Kind of crust developing generally on areas protected against direct rainfall or water runoff in urban environment. Black crusts usually adhere firmly to the substrate.”, therefore considering that a strong adhesion is what matters in its relation with the substrate.

The concept underlying these definitions considers that a black crust is in fact a deposit that may eventually have some interaction with the substrate. Translating this concept to practical actions, it is acceptable to infer that *black crusts* can be removed with appropriate cleaning methods, and in the precise terms applicable to a superficial deposit.

However, the concept of black crust may be defined with a significantly different amplitude. In fact, the interaction of the environment pollutants, especially $SO_2$ and its derivatives, may start from the very surface of the object, but it rapidly progresses inside, dissolving calcium carbonate and re-depositing calcium sulphate. The result is the transformation of a thin layer in the outermost part of the stone, creating a brittle and fragile *zone*, very frequently underlined by a powdering and friable layer rich in gypsum. The