Stone und mineral building materials

(How microbes build their homes on and in houses and how BIODAM tames them)

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Concern with rock decay started early in the history of the mankind. The last two centuries yielded a large wealth of information on the many aspects of rock decay and rock protection related to the physical cultural heritage. Increasing awareness of biodeterioration and air pollution related biological infections has grown over the years. In this overview the evolution of trends and techniques in the study of rock biology is described. Ageing is a term that is not only used for living organisms but also for inorganic and organic materials when used in the production of objects of art and the physical cultural heritage. This natural decay process is ruled by physical and chemical interactions with the environment and can be considerably accelerated and in some special cases slowed down by the interaction with organisms and especially micro-organisms. Many different micro-organisms are involved. Adhesion to surfaces and resistance to stressed conditions are of importance as well as special biochemical pathways to furnish energy, electrons, water and mineral matter to the microbes living in such environments. Lichens and other symbiotic communities, chemolithotroph and chemoorganotroph bacteria, fungi and actinomycetes have been reported to be active in material transformations as well as phototroph micro-organisms. Quantitative data on mere physical and chemical attack in comparison to biologically induced changes have been collected. Studies on the speed of physical/chemical deterioration as compared to biodeterioration were undertaken. In conclusion it is stated that all materials exposed to the natural living environment are more rapidly transferred and cycled biologically than under conditions of a sterile environment. Although water plays an eminent role in all biotransfer processes it is shown, that biologically induced accelerations of decay and ageing of materials takes place in practically all objects of the cultural heritage studied so far.

The processes of rock ageing are very complex physical and chemical processes which can be considerably accelerated or retarded through the influence of biota or biological phenomena in the field of life. Most of the acting agents in inorganic and organic material ageing are invisible microbiota. Interestingly, physicists and mathematicians have calculated the thermodynamical stabilities of many compounds and compound mixtures. It is said that granite is decomposed more rapidly than DNA and that DNA in turn decays faster than some important proteins. The recognition of time is much more complex than can be derived from the simple linearity past-present-future. The terms of physical, physiological, even psychological time are related to the ageing process of art works. For each object and living organism a certain life span or durance is characteristic. The potential age of DNA-regulated living organisms is programmed. If this were not the case, men could aquire offspring with a physiological status of an old woman instead of a baby. From this we can assume that ageing must be related rather to the ageing and alteration of proteins and other compounds. The same is true for ageing of art works. Excellent "young" stone will age slower than defect, "old" stone.

The lecture will focus on the chemical, mechanical, mineralogical and spectral impact of sub-aerial microbial biofilms and networks on the transformation of rocks exposed to atmospheric conditions. Among these are mainly desert rocks, antarctic rocks, high mountain ranges and last not least monuments of the cultural physical heritage. There is quite a record of work and on the influence of micro-organisms on air exposed rock (and glass) surfaces e. g. Bassalik (1912), Mellor (1921), Isacenko (1936), Jaag (1945), Pochon et al. (1951), Krumbein (1966, 1972, 1981), Saiz-Jimenez (1995), and Gorbushina (2001) to name a few. Many have been forgotten and omitted from the record as e.g. Liebig (1852). As a rule most of these authors were focussed mainly on photoautotrophs and chemolithoautotrophs as the causal agents of chemical damage. Few if any authors thought of the ubiquity of chemoorganotrophic life and the tremendous potential of air transmitted organic compounds. We treat preferentially the often more important impacts of chemoorganotrophic micro-organisms on rock surfaces and rock decay. The most

surprising new results are related mainly to groups of micro-organisms usually overlooked in this environment, namely rock adapted coryneform or actinobacteria, and a special group of very stress resistant, highly infective poikilophilic fungi, the so-called black yeasts or yeast-like black fungi. The latter were known for decades exclusively as plant, animal and human pathogens with a few exceptions of soil-borne black fungi. Coloured patinas which have been related to iron and manganese minerals for many years turned out to be organic polymers and pigments firmly attached to the rock minerals and protected from degradation by the intimate organic-rock association.

Carotenoids, melanins and melanin-like Maillard reaction products seem to be the real cause of the pigmentation and spectral changes of rock surfaces in deserts rocks, high mountain ranges and on monuments. The pigments are produced by rock dwelling coryneform bacteria, actinomycetes, and black yeasts. They change the reflection/adsorption pattern of sunlight and UV-radiation and serve as protection screens for the rock associated microflora. The latter receives the organic compounds for their metabolic activities from air-borne organic compounds and pollutants such as pollen, aromatics, pheromones, kerosin, methane and many other volatile organic compounds. It is demonstrated, that the acid attack of all kinds of micro-organisms by inorganic and organic biologically produced acids may at not be the major cause of rock destruction. Some conspicuous rock decay patterns are related to mechanical forces exerted by a microflora thriving on extremely changing environmental conditions. Heat absorption, turgor, active movement and other physical factors are the basis of biogeomorphogentic phenomena such as bio-pitting, bio-chipping, bio-exfoliation, bio-cracking and last not least bio-patination. The phenomena and processes will be documented by macroscopic and microscopic evidence and the analysis of the physical and chemical processes going on on rock and other mineral surfaces. BIODAM is a new venture in using a polyphasic approach in inhibiting microbial growth on building surfaces which acts in multiple ways in order to reduce the toxicity of antimicrobial poisons and chemicals, which can be an environmental and health hazard (Website of BIODAM).

References

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