Chemical weathering of archaeological monuments and their conservation – J. S. Bhargav

Geological Survey of India, Southern Region , Hyderabad (Email: jsb682002@yahoo.com)

"The necessities lead the human life from barbaric Stone Age man to the modern scientific man and the aesthetic sense of man left many monumental, architectural, pictorial and many other remains".

Therefore if monuments portray the extent of intellectual heights to which a civilization has reached, the effort to protect these masterpieces for posterity shows the inherent values that are still deep rooted in the society. Scientists have made many advances in the field of conservation of stone monuments, still leaving much scope for improvement.

Conservation

The effort to conserve the monument starts with the study of the architecture, building material used, environment and its effect on the monument. Various physico-chemical factors contribute to the degradation of the monument. The degradation manifests itself into various forms which can be broadly classified into:

1. Structural deterioration.
2. Deterioration of execute fine carvings.

Structural deterioration deals with damage of the structure as a whole. It is generally caused due to factors like disturbances or instability in the main foundation of the structure and growth of plants on the monuments.

Structural Deterioration

A. Disturbance or Instability in the foundation is generally caused by the subsidence and unequal settlement of the structure due to loose soils and natural calamities like earthquakes, floods etc.
B. Growth of plants in the joints of the structure should be attended to as the growing plant expands its size thus widening the joints consequently developing cracks in the structure.

Deterioration of Execute Fine Carvings

Deterioration of execute fine carvings is a weathering phenomenon and hence be further classified into physical weathering and chemical weathering.

Physical weathering is caused by parameters such as water, temperature variations, salt laden winds etc

- *Water :* It acts as a good solvent and transporting agent. Capillary rise of salt solutions from ground into the stone surface gives rise to crystallization of the salts within the stone pore. The increase in volume of the crystallized salt, builds up stress and thus ruptures the rock. Contact of the stone surface leads to loss of stone minerals leaving the stone surface more porous and rough. At sub zero temperatures, the water within the pores can freeze and expand to about 9% thus leading to rupturing of the stone.
- *Air:* Strong winds laden with sand particles have an abrasive action on the monumental stone surface. It also acts as a transporting agent for the dust, micro flora, pollen micro soot etc.
- *Temperature:* It is an ever existing factor accompanying almost all processes and bearing on several properties. A rock is a poor conductor of heat and hence the differential thermal expansion between the surface and the crust leads to exfoliation and micro cracks.

Chemical Weathering occurs because rocks and minerals are seldom in equilibrium with near surface environment. The general reaction

Primary minerals + Attacking solution → Secondary minerals+Leaching solution

The nature of the secondary mineral formed and the type of geochemical process involved depends on

1 The nature of the mineral subject to weathering
2 The nature of the attacking agent

Depending on the nature of the attacking agents the reactions have been classified as Hydrolysis, Acidolysis, Alkynolysis, Oxidation etc. The attacking agents which are mainly the acidic gasses could be either natural or anthropogenic. Carbondioxide finds its origin both from the nature as well as through man made sources. Other highly acidic gasses such as NOx and SO_2 and alkaline agents like NH_3 are mostly anthropogenic in nature.

The nature of weathering taking place on the stone monument and the attacking agent can be identified using various analytical methods, which include both classical as well as instrumental techniques, can be used to identify the agents responsible for the damage caused. The subsequent step is the conservation of the monument, which involves cleaning and preservation.

Cleaning and preservation of the monuments is done by skilled personnel under the supervision of a scientist. Suitable chemicals and cleaning agents can first be tested in the laboratory on an experimental basis specially using a similar stone specimen- the result of which can be extended to the monument on site. Similarly protective agents like siloxanes, Polyvinyl acetates, epoxy resins and other polymeric coatings can be applied to the monument based on the experimental results or the experience of the scientist. The preservation step includes:

1. Consolidation which increases the cohesive strength, improves upon the mechanical characteristics and leads to adherence of altered layers to the main stratum..
2. Protection which prevents the environmental parameters from damaging the stone.

The objective of the whole procedure is finally not to make the monument look fresh but to bring it to its original / natural form.

A collaborative effort by archaeologists, geochemists, geologists and engineers can save our past to present it to our future- Let us share the responsibility.

Summary of the lecture to be delivered at the monthly meeting of the Geological Society of India on 25 July 2012.