

WEATHERING OF MONUMENTS AT JETHAWANARAMAYA BY BIOLOGICAL PROCESSES

A.S. Ratnayake and A. Pitawala

Department of Geology, Faculty of Science, University of Peradeniya

Introduction

Anuradhapura, Sri Lanka, commands a great historic interest due to the presence of monuments made from rocks, large brick stupas, temples and man-made lakes. The monuments have suffered various forms of deterioration and the need for restoration is urgent. Researches of the country have become concerned with the eminent loss of these historic sites. As a result, the mechanism of decay and preservation of stone is now increasingly being researched.

It was revealed recently that monuments made from rocks and bricks in the Jethawanaramaya area have been deteriorate due to many natural processes including the involvement of lichens (Jayasingha *et al.*, 2009). The aim of the present study was to (i) examine the role of lichen on physical and chemical weathering of stone monuments and (ii) identify weathering products generated by biological processes.

Materials and Methods

Lichen species of the area were identified during field investigations. Representative rock chips and weathering products were collected for the mineralogical and petrographic studies. X-ray diffraction (XRD) analysis was performed to identify the clay minerals and other weathering products of monuments at the Department of Chemistry, University of Peradeniya, Sri Lanka. The

prepared thin sections were studied using optical means.

Results and Discussion

Crustose and *Usnea australis* were the commonly observed lichens species in the study area. It was also noticed that lichens grow preferably under shady conditions where large trees are available. Lichens are grown on granitic gneiss monuments rather than marble monuments. They are covered around 5-60 % of surface area of monuments, and the size of the patches is in approximately 5 cm². The growth of lichens is characteristically high during the rainy period. Roots of lichens extend few millimeters towards the inner side of stones. These organisms die during the dry season, and detach from the rock surface. When they separate from rock surfaces, the roots carry mineral grains.

The mechanical disruptions on rocks were caused by hyphal penetration, expansion and contraction of their thallus and swelling action of the organic and inorganic salts originating from lichen activities. Lichens have significant impact on the chemical weathering of rocks by the excretion of various organic acids, particularly oxalic acid, which can effectively dissolve minerals and chelate metallic cations. Therefore, the chemical and physical process of lichens can deteriorate stone monuments

(McCarroll and Viles, 1994). The petrographic studies revealed that variable and sparse distribution of

weathering products below a thin, clearly defined lichen thallus.

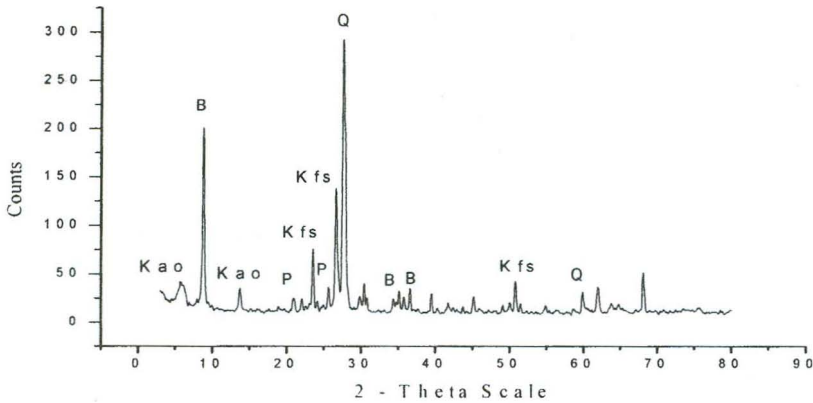


Figure 1. XRD pattern of moderately weathered stone monument (Q- Quartz, P-Plagioclase, B-Biotite, Kfs-K feldspar, Kao-Kaolinite).

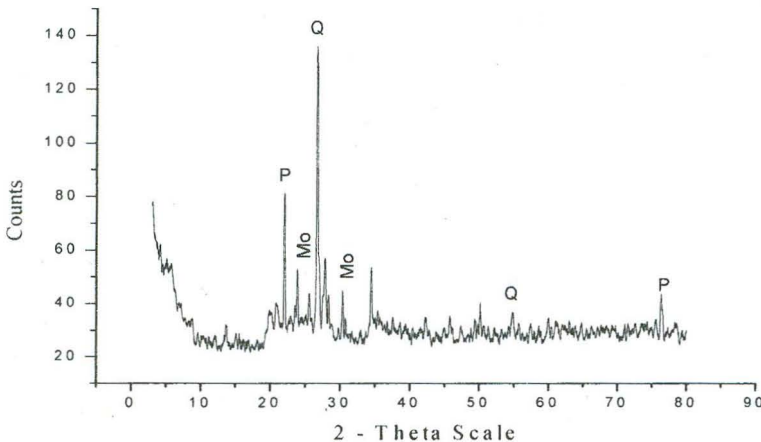


Figure 2. XRD patterns of weathering products due to growth of lichens (P-Plagioclase, Q-Quartz, Mo-Morinite).

K-feldspar, plagioclase, quartz and biotite are the identified primary minerals in the weathering products. Morinite and kaolinite are found as secondary minerals (Figure 1 and Figure 2).

Morinite is a hydrous fluorophosphate $[NaCa_2Al_2(PO_4)_2(F,OH)_5 \cdot 2H_2O]$ mineral that is found in hydrothermal rocks. There is a possibility to form morinite as a weathering product also, if phosphate is released from lichens.

Conclusions

Lichens are the most dominant biological agent which promotes chemical and physical weathering of monuments. The activities of lichen results to form morinite [NaCa₂Al₂(PO₄)₂(F,OH)₅·2H₂O] which was not recorded before from Sri Lanka.

References

- Jayasingha, P., Ratnayake, A.S. and Pitawala, A. (2009). Risk of weathering in monuments of Jethawanaramaya, Anuradhapura, Sri Lanka, 25th Annual Technical Sessions of the Geological Society of Sri Lanka: 17.
- Lee, C.H., Lee, M.S., Suh, M. and Choi, S.W. (2005). Weathering and deterioration of rock properties of the Dabotap pagoda (World Cultural Heritage), Republic of Korea, *Environmental Geology*, 47: 547-557.
- McCarroll, D. and Viles, H. (1994). Rock weathering by the lichen *Lecidea auriculata* in an arctic alpine environment, *The British Society for Geomorphology*, 90:287-297.