Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)
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HGM02-03 Room:101B Time:May 26 11:30-11:45

Regarding to the arguing issue; Bioweathering vs Bioprotection in stone historical buildings

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The Angkor complex is the one of the greatest cultural heritages in the world. It is constructed in the early 12th century, designated as a world cultural heritage by UNESCO in 1992. The temples at the Angkor complex are mainly made of sandstone and laterite. However, due to the tropical climate, plants, lichens and various microorganisms are growing well on the rock surface. Black crusts are also easily found on the stone surface. Biological factors are considered as a damage factors for the heritage. The studies suggested that how it can be removed without destroying the substrate efficiently.

We sampled Angkor sandstone covered by black crust at the Angkor Wat and Bayon temples, Angkor complex, and observed the section and the surface of the rock sample by using SEM. Surfaces of the samples are not polished in order to observe the original condition. The depth of the black crust is up to 1 mm. Many filamentous materials were found on the black crust. Average energy-dispersive X-ray spectroscopy data of the black crusts shows that over 70 % of the surface materials are compounds of carbon. And 15% of the mass are made of SiO_2. It seems that these materials are hyphae. The shape of the hypha is like a thread and its size is few μm in diameter and up to several centimeters in length. Black crusts are consisted of elements and compounds of carbon, Na, Mg, Al, Si, Cl, K, Ca, and Fe.

The answer of the controversy question “Do lichens on the historical building protect it or not?” is not fixed. It protects while weathers. It depends on the time scale and the surroundings. We have to focus on the timing of the lichen fall off. Under the lichen coverage, rocks may be protected. When the lichen fall off, it may have lower surface than lichen-free rock surface. Weathering is in progress and is a result of previous process under various facts, not only biological factors but wet-dry cycle, various salt and so on. This is the reason why it is hard to judge whether lichens should be removed or not. We have to check all the environmental data such as temperature, humidity, direction, insolation, rainfall frequency, human effect, weathering degree etc. and decide to remove or not. Therefore, field survey and evaluation standard are needed. Further research has to be continued to find out the better and proper way of conservation for the historical sites as Angkor monument.

Keywords: Angkor Wat, stone cultural heritage, conservation, lichen, biological weathering