



## **Chemical analysis of black crust on the Angkor sandstone at the Bayon temple, Cambodia**

Wonsuh Song (1,2), Chiaki Oguchi (2), and Tetsuya Waragai (3)

(1) Center for Spatial Information Science, The University of Tokyo, Kashiwa, Japan (wonsuhsong@gmail.com), (2) Graduate school of Science and Engineering, Saitama University, Saitama, Japan, (3) Department of Geography, Nihon University, Tokyo, Japan

The Angkor complex is the one of the greatest cultural heritages in the world. It is constructed in the early 12<sup>th</sup> 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. The 21<sup>st</sup> technical session of the International Coordinating Committee for the Safeguarding and Development of the Historic Site of Angkor (ICC-Angkor) held in 2012 recommended that to preserve both the biofilms and the forest cover and to prohibit the biocides (chlorine-based) and organic biocides. However, there are many reports that lichens and microorganisms accelerate rock weathering. It is important to clarify that how the biofilm on the Angkor temples affect Angkor sandstones.

We sampled Angkor sandstone covered by black crust at the Bayon temple, 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 samples are coated with gold for 180 seconds. 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 five areas of ca. 20  $\mu\text{m}$   $\times$  15  $\mu\text{m}$  in the black crusts shows that over 80 % of the filamentous materials are compounds of carbon. It seems that these materials are hyphae. The shape of the hypha is like a thread and its size is few  $\mu\text{m}$  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.

Further research has to be done to find out the better and proper way of conservation for the Angkor complex.