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TEM observations of clay minerals in Lake Tega sediment

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1. Introduction

Like minerals and rocks, microbes are ubiquitous in soils and aquatic sediments. It is well known that the interaction between minerals and microbes contribute to mineral dissolution and precipitation (Dong and Lu, 2012). For example, dissimilatory iron reducing bacteria (DIRB), which are widely distributed in natural environment, transform Fe^{3+} to Fe^{2+} at the surface of an iron oxide particle (Lovley et al., 2004). Thus, the minerals-microbes interaction plays an important role in biogeochemistry on the earth's surface. Transmission electron microscopy (TEM) is commonly used as an experimental technique to analyze the interplay between minerals and microbes (Kawano and Tomita, 2001; Tazaki, 2005). Although, detailed mineralogical researches are highly important to elucidate the minerals-microbes interaction, there is little studies of TEM observation on aquatic sediments. This study is focused to describe compositional and crystal chemical features of minerals in lake sediments by using HRTEM observation.

2. Materials and Methods

Sediment samples were collected from a ca. 20 cm core drilled at Lake Tega in Abiko city, Chiba in Japan. The sample core was divided into two types, upper and lower sediments. The samples were examined for mineralogical details with scanning electron microscopy (SEM), transmission electron microscopy (TEM), powder X-ray diffraction (XRD), and fourier transform infrared spectroscopy (FT-IR).

3. Results and Discussion

The powder XRD patterns of upper and lower layer sediments showed that quartz, orthoclase, plagioclase, and kaolin (kaolinite and halloysite) were included, but clay minerals were mainly composed of the lower layer sediment. The SEM images revealed that organism fragments ranging from 10 to 30 μm in size were widely observable in both upper and lower layer sediments. FT-IR spectroscopy showed that the weak bands derived from organics were observed from the both sediments, indicating that the deposits included the minerals and organic compounds which probably originates from organisms.

The TEM analysis showed that kaolinites in the sediments had plate shape with 1-4 μm in width, which is compatible with previous studies (Sudo et al., 1980; Bergaya et al., 1996). The forms of halloysites with 50-100 nm in length lath-like shape and with ca. 100 nm in width spherical shape are also consistent with those of previous studies (Sudo et al., 1980; Singh and Gilkes, 1992). The EDS analysis of individual particles revealed that kaolinites and halloysites contained not only Si, Al, O but also K, Na, Fe, although the electron diffractions showed clear diffraction spots with their symmetries.

In kaolin minerals, very small amount of Fe^{2+} can be substituted for Al^{3+}, which results in slightly negative charge (Detellier and Schoonheydt, 2014). Therefore, it is likely that substitution of Fe^{2+} for Al^{3+} in the kaolin minerals gives rise to absorption of K^{+} and Na^{+} to stabilize the charge balance.

Keywords: lake sediment, TEM, clay mineral, kaolinite, halloysite