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The biodegradation of layered silicates under the influence of cyanobacterial-actinomycetes associations

Ekaterina Ivanova
V.V. Dokuchaev Soil Science Institute, Russian Federation (ektrnivanova@gmail.com)

The weathering of sheet silicates is well known to be related to local and global geochemical cycles. Content and composition of clay minerals in soil determine the sorption properties of the soil horizons, water-holding capacity of the soil, stickiness, plasticity, etc. Microorganisms have a diverse range of mechanisms of minerals' structure transformation (acid- and alkali formation, biosorption, complexing, etc). One of the methods is an ability of exopolysaccharide-formation, in particular the formation of mucus, common to many bacteria, including cyanobacteria. Mucous covers cyanobacteria are the specific econiches for other bacteria, including actinomycetes. The objective was to analyze the structural changes of clay minerals under the influence of the cyanobacterial-actinomycetes associative growth.
The objects of the study were: 1) the experimental symbiotic association, consisting of free-living heterocyst-formative cyanobacterium Anabaena variabilis Kutz. ATCC 294132 and actinomycete Streptomyces cyaneofuscatus FR837630, 2) rock samples obtained from the Museum of the Soil Science Department of the Lomonosov Moscow State University: kaolinite, consisting of kaolin (96%) Al4 (OH) 8 [Si4O10]; mixed with hydromica, chlorite and quartz; vermiculite, consisting of vermiculite (Ca, Mg, ...)*(Mg, Fe)3(OH)2[(Si, Al)4O10]*4H_2O and trioctahedral mica (biotite).
The mineralogical compositions of the rocks were determined by the universal X-ray Diffractometer Carl Zeiss Yena. The operationg regime was kept constant (30 kv, 40 mA).
The cultivation of the association of actinomycete S. cyanoefuscatus and cyanobacterium A. variabilis caused a reduction in the intensity of kaolinite and hydromica reflexes. However, since both (mica and kaolinite) components have a rigid structure, the significant structural transformation of the minerals was not revealed.
Another pattern was observed in the experiment, where the rock sample of vermiculite was used as the mineral substrate. The associative growth of S. cyaneofuscatus and A. variabilis led to the transformation of minerals indicated by the significant decreasing of the intensity of the reflections of vermiculite as well as biotite. Reduction in the intensity of the basal reflections of vermiculite (d001, d004 and d005) three times indicates the process of biodestruction of this component of the rock. The formation of the swelling phase – the product of biotite transformation into the mica-vermicullite mixed-layer formation was revealed.
The study demonstrates the differences in the transformation of clay minerals under the influence of cyanobacterial-actinomycetes association, depending on minerals' crystal chemistry and it's resistance to weathering. The rate of the process transformation of micas into the mixed-layer formation depends on their structure - trioctahedral mica (biotite, part of vermiculite sample) are transformated much faster than dioctahedral.
The growth of associative thallus and monocultures of cyanobacterium and actinomycete promoted the removal of potassium (), magnesium (Mg) and aluminum (Al) from the crystal lattice of the rock sample of vermiculite. Leaching of elements due to the influence of associative thallus exceeded the release of cations observed in the sample under the influence of the growth of cyanobacterium and streptomycete monocultures and in the control sample of vermiculite. Therefore, the association's biodegradation impact on the mineral structure was significantly greater than the influence of the monocultures of cyanobacteria and actinomycetes.