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Evaluation of the microbial effect on the laboratory redox tests

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It is expected that the natural barrier has the sufficient capability of keeping the migration of radionuclides slow around the underground facilities of the radioactive waste disposal. Reduced environment is better for the slow migration of radionuclides. In order to evaluate the redox condition, it is necessary to explain mechanism of its formation. It is possible that oxidized environment is formed by oxygen from ground surface during excavation and operation of the deposition tunnels, but it is expected that reduced environment is reproduced after backfilling. It has been reported that bacteria have an important role in the variation of the redox condition. This research describes the results of laboratory redox experiments and numerical simulation conducted for the evaluation of reducing abilities of rock and bacteria.

In the laboratory tests, crashed fresh pumice tuff, which has not been exposed to the air, is suspended with oxygen-saturated water. Evolution of parameters of solution, for example dissolved oxygen and oxidation / reduction potential (ORP), is measured. PCR-DGGE is also conducted to identify bacterial species or their distributions. In order to investigate the effect of bacteria, tests in different temperatures and with Yeast Extract or acetate as the nutrients are conducted. The dissolved oxygen is reduced as soon as the crashed rock is suspended with water. This first reduction of the dissolved oxygen is considered as the consumption of oxygen by the reducible sulfides because the sulfate increases during the tests. The reduction of the dissolved oxygen is notable especially in the case of 30oC of temperature. These results indicate that microbial effect is important for the reduction of the dissolved oxygen. In the cases that Yeast Extract is added, ORP decreases to the value of highly reduced environment (-450mV vs. Ag/AgCl). However, ORP decreased to 0mV in other cases. The notable difference in microbial communities did not appear among the tests in different temperatures and added nutrients from the results of PCR-DGGE analyses. However, in time course, facultative aerobic bacteria, which had high similarity with *Pseudomonas syringae*, decreased, and obligately anaerobic bacteria, which was identified as a sulfate-reducing bacteria *Desulfitobacterium frappieri*, become dominant during the tests, respectively. These results indicate; (1) aerobic bacteria are dominant while dissolved oxygen is sufficient, (2) sulfate -reducing bacteria become active once dissolved oxygen decreases.

Numerical simulations of above-mentioned laboratory redox tests are conducted using geochemical code PHREEQC2. Behaviors observed in the tests cannot be reproduced quantitatively in the case that only inorganic pyrite oxidation is included. Oxygen consumption by bacteria and the activity of sulfate-reducing bacteria are added to the analytical models. Bacteria are considered one of chemical components, and its growth rate is defined using Monod equation. In the cases that microbial effects are included, calculated results of evolutions of the dissolved oxygen and ORP are in good agreement with measured data. In the cases that sulfate-reducing bacteria are active, calculated ORP decreases to the value of highly reduced condition. The mechanism of the phenomena observed during laboratory redox tests are investigated as follows from the numerical simulations; (1) dissolved oxygen is consumed not only by pyrite but also by bacteria, (2) dissolve oxygen is completely consumed and highly reduced environment is formed when the sulfate-reducing bacteria are active.

Since dissolved oxygen is consumed by sulfide minerals and bacteria, it is predicted that a reduced environment is kept even in the case that underground facility is exposed to the air. Furthermore, highly reduced environment can be formed by the effect of sulfate-reducing bacteria.