Interactions of heavy elements with microorganisms

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Introduction

The high capacity of microbial surfaces to bind actinides may affect the migration of actinides in the environment. However, we have only limited knowledge of the role of microorganisms in the migration of actinides in the environment. We have been conducting basic scientific research on microbial interactions with actinides in order to elucidate the environmental behavior of actinides under relevant microbial process conditions.

Pu(IV) sorption and reduction

Adsorption of Pu(IV)-desferrioxamine B (DFO) on bacteria indicate that Pu(IV) is dissociated by contact with cells, after which Pu(IV) is adsorbed, and that pH dependence of adsorption density of Pu(IV) on cells is dominated by the stability of Pu(IV)-DFO complexes. Study on reduction of Pu(IV) in the presence of citric acid at pH 7.0 suggested that Pu(IV) is reduced to Pu(III) by the activity of sulphate reducing bacteria.

U(VI) mineralization

Uranium mineralization by the yeast *Saccharomyces cerevisiae* was examined by batch experiment at pH 3.2. Analysis of the U(VI)-bearing precipitates by FESEM-EDS, TEM, and visible diffuse reflectance spectrometry demonstrated the presence of H-autunite, $HUO_2PO_4{\cdot}4H_2O$ and thermodynamic calculations suggest that the chemical compositions of the solutions were undersaturated with respect to H-autunite, but were supersaturated with ten-times more U(VI) and P than were actually observed. These findings indicate that the yeast's cell surfaces, rather than the bulk solution, offer the specific conditions for this geochemical process.

A combined terrestrial and marine geochemical mapping project in Japan

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Spatial distribution patterns of elemental concentrations on land, geochemical maps, are effective for mineral exploration and environmental assessment. In Japan, the Geological Survey of Japan, AIST conducted a nationwide geochemical mapping program at 1:2,000,000 scale using fine stream sediments for these purpose (Imai *et al*., 2004). Japan is, however surrounded by a vast expanse of sea, so that examination of geochemical baseline in coastal-open sea is also essential for environmental assessment. Approximately 3000 surface marine sediments around Japan were collected for this purpose and analyzed for 51 elements including heavy metals (e.g. Cu, Zn, Cd, Hg, and Pb). This project is intended: 1) to elucidate background of elemental abundance in terrestrial and marine areas of young island arc; 2) to find mass transport from land to sea; and 3) to estimate diffusion processes of pollutants.

The elemental concentrations of marine sediments are determined primarily by grain size. Most elemental concentrations increase with decreasing grain size and eventually become constant. Overall, marine sediments and stream sediments show similar elemental abundance patterns, but marine sediments have lower elemental abundance than stream sediments because of dilution effects imparted by calcareous sediments and organic materials. These results suggest that marine sediments in coastal seas originate mainly from terrestrial materials. However, a few examples of direct mass transport from terrestrial area to marine environment are apparent. The spatial distribution patterns of K and Cr concentrations, which are good examples of mass transport, suggest two types of high-concentration area extending continuously from land to sea: high concentration area proximal to a river mouth (20-30km) and high concentration area extending over 60 km offshore along a deep-valley. These results suggest that sediments deposit by fanning out near shore and a part of them are further conveyed along the deep-valley by gravity movement. Diffusion of heavy metals such as Cu, Zn, Cd, Sn, Pb, and Bi is observed in coastal bays surrounded by urban and industrial areas, from which the stream sediments are extremely abundant in those elements. It is noteworthy that the materials with heavy metals seem to remain in the bay without diffusing to the outer sea. The sediments with heavy metals might not diffuse readily to the outer sea because of a strong bottom current (estuary circulation) that flows from outer sea to the inner part of the bay.

References

Imai, N. *et al.* (2004) *Geochemical map of Japan.* GSJ, AIST.