The rock-forming plagioclase controls water-rock interaction: On the view of strontium isotopic ratio

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The geochemical behavior of elements during water-rock interaction is one of the most important issues with respect to a geological disposal for high-level radioactive wastes. Rubidium-strontium isotopic system is expected to be a good analogue to understand the behavior of alkali and alkali-earth elements. We had examined natural waters (rainwater, river water and groundwater) and surrounding fresh and weathered granites to understand in-situ elemental behavior and the extent of contribution of rock-forming minerals.

Samples in this study were collected in the Mizunami Underground Research Laboratory (MIU), Gifu Prefecture, central Japan. Groundwater of MIU-4 borehole is Na^+-HCO_3^- type, which indicates the late stage of water quality evolution. The Toki granite, Cretaceous basement around this area, has relatively wide range of Sr isotopic ratio (0.71-0.73). The constituent minerals have different Sr isotopic ratios (plagioclase ~ 0.71, K-feldspar ~ 0.72 and biotite ~ 0.85) each other. Therefore, $^{87}Sr/^{86}Sr$ ratios of water and rocks are expected to reflect a present information of water-rock interaction and indicate contribution of each mineral.

$^{87}Sr/^{86}Sr$ ratio of groundwater from the weathered zone (WEZ) and the water conducting fracture (WCF) increases slightly with depth and comes to close to that of the Toki granite. Calcium abundance of goundwater also increases with depth. $^{87}Rb/^{86}Sr$ ratio of groundwater, however, once increases and decreases to that of plasioclase (0.2-1.0). Groundwater flowing in the Toki granite reacts on plagioclase. Both $^{87}Sr/^{86}Sr$ and $^{87}Rb/^{86}Sr$ ratios of groundwater reflect these ratios of plagioclase which is weathered by groundwater firstly.

To the contrary, the weathered granites in WEZ and WCF have much higher $^{87}Sr/^{86}Sr$ and $^{87}Rb/^{86}Sr$ ratios than the fresh Toki granite and those ratios are nearly identical to the ratio of serisite (0.78-0.82 and 150-310) which is secondary clay mineral. Calcium abundance of granites in WEZ and WCF is lower than the fresh granite and potassium abundance of these has less change against fresh granites. The propotion of biotite, K-feldspar and clay minerals, such as serisite, to weathered granites in WEZ and WCF might increase resulting from weathering of plagioclase. As a result, both $^{87}Sr/^{86}Sr$ and $^{87}Rb/^{86}Sr$ ratios of weathered granites increase.

New attempt to geochemical mapping of Sr isotope in Aichi Prefecture, central part of Japan

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Geochemical maps expressing areal distributions of chemical elements of ground surface have been published in several countries with rising concern over global environment. Radiogenic isotopes such as $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ ratios are used as tracers, for example, in the provenance analyses of loess and desert sand on land and marine sediment. In this study, we have applied Sr isotope to geochemical mapping in order to consider the geologic origin, transportation and dispersion of materials in the earth's surface. We analyzed 142 stream sediments from the northeastern part of Aichi Prefecture, central part of Japan (75km x 30km). They were fine-grained particles which passed through an 80-mesh (180 μm) sieve when they were collected in each stream. In order to compare the chemical compositions with basement rocks, 13 rock samples were also investigated.

The results show that Sr isotopic ratios of the stream sediments, except one sample, range from 0.7086 to 0.7315 with an average of 0.7129. The average is higher than the average of the mean crustal material of Japanese island arc (JICC), 0.7077. It can be attributed to small contribution of volcanic rocks, generally having lower $^{87}Sr/^{86}Sr$ values, to the study area. For regional variation, $^{87}Sr/^{86}Sr$ value is higher in the western and southeastern parts, where sedimentary rocks and metamorphic rocks are distributed, and is lower mainly in the central part, where granitic rocks are distributed. The first factor controlling the distribution of Sr isotope is the basement rocks exposed around the sampling points. Rb-Sr isochron plot reflects geochemical features of exposed basement rocks more clearly.

In some locations, the distribution of Sr isotope does not correspond to that of basement rocks on the geological map. One reason is the existence of unmapped basement rock. For example, the Sr isotope reveals that small intrusive mass of granites not drawn on the geological map are studded. The other is fluvial transportation and dispersion. The geochemical map of the isotope suggests that some stream sediments in the granite area include material transported from the upstream surrounding metamorphic rock.