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Control factors for concentrations of elements dissolved in acid hot-spring waters

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Volcanic-magmatic-hydrothermal systems can cause effective heat and mass transports from deep to shallow environments, and provide us potential hot spring resources, mineral resources and geothermal energy resources. In order to enjoy such benefits from the systems, it is necessary to understand physico-chemical conditions of heat and mass transport processes in the systems. For this purpose, acid hot-spring waters were sampled and analyzed, and sources of each element dissolved in the waters and controlling factors of the concentrations were examined in this study.

Elements dissolved in the waters exhibit negative correlations of concentrations to pH. The elements were classified into four following groups. Group-I (S, Cl) derive from magmatic fluids. Group-II (B, F, As, Br, Cd, In, Sb, I, Tl, Pb) also derive mainly from magmatic fluids and partly from other sources (at least for B, As, I). Group-III (Li, Na, Mg, Al, Si, K, Ca, Sc, V, Cr, Mn, Fe, Co, Ni, Zn, Ga, Ge, Rb, Sr, Y, Cs, Ba, REEs, Mo, W, U) derive from rocks through congruent dissolution. And Group-IV (P, Ti, Zr) were insoluble elements. Some elements (Be, Bi, Hf, Th, Cu, Se, Ag, Sn, Au) were not classified due to low concentrations below detection limits of analyses.

Factors controlling concentrations of elements recognized were followings: (a) dilution of magmatic fluids by meteoric water (deduced from hydrogen-oxygen isotope values of waters and negative correlations of concentrations versus pH), (b) potential transition of oxidation/reduction potentials of fluids (implied by concentrations close to sulfide solubilities for Cd, Zn, Pb and Tl), (c) addition of elements derived from precipitates in ancient hydrothermal activities (deduced from higher ratios of As/Cl, Br/Cl and I/Cl in fluids than high-temperature volcanic gases), (d) potential depositions of minerals (implied by supersaturation conditions of waters with respect to minerals for Si to quartz and Al to kaolinite and alunite, saturation index close to zero for Ba to barite, and apparent low concentrations for Group-III (P, Ti, Zr) and concentrations below detection limits for Be, Bi, Hf, Th, Cu, Se, Ag, Sn, Au).Based on these lines of evidence, a transport model for each element in volcanic-magmatic-hydrothermal system was tentatively constructed.

This study might be helpful for future planning of exploration target of metal resources and exploitation of geothermal energy resources toward the central parts of volcanic-magmatic-hydrothermal systems.

Keywords: acid hot springs, dissolved elements, concentrations, control factors