

## 3.4.P02

### Chemistry of surface water in an andesitic volcanic area, Norikura volcano, central Japan

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Natural surface water samples were collected from an andesitic volcanic area, the Norikura volcano. The analytical data of major elements in the solution were subjected to multivariate statistical techniques to understand the geochemical potential factors affecting the chemical composition. For the interpretation of the statistical results, an experimental study of rock-water interaction was performed using the powdered host rock andesite and acidic water with controlled pH similar to the meteoric water around the observation area.

The variation of major elements was compressed by principal component analysis (PCA) into two principal components. Using thermodynamic calculation, these components were quantitatively interpreted; the first component was interpreted as silicate dissolution with 70% proportionate contribution of all chemical variances; the other component was understood as ion-exchange reaction between (Na<sup>+</sup> and K<sup>+</sup>) and (Ca<sup>2+</sup> and Mg<sup>2+</sup>) with 20% of proportionate contribution. The atmospheric sea salt influence, biochemical or anthropogenic effect was statistically negligible in the major chemical process. The result of the multivariate analysis suggested that the major factor on to control the hydrochemistry in the observation area is rock water interaction.

The geological and hydrochemical environment around the observation area was artificially created in the laboratory, and the validity of the above mentioned statistical interpretation on the natural water chemistry was examined. The powdered typical andesitic rock obtained from the observation area was put in acidic water with controlled pH level similar to the meteoric water. The rock powder and water were put in a batch reactor made of polyethylene and were continuously stirred using a stir bar. The water samples were collected from the reactor and analyzed on a logarithmic time sequence.

The chemical variations of the artificial solution were well fitted with the chemical process observed in the natural surface water of the observation area. In this manner, the result of multivariate analysis and its interpretation on the basis of the natural waters were well supported by the experimental study.

## 3.4.P03

### Groundwater residence time estimations based on heat and <sup>4</sup>He abundance: An application to Western Sicily (Italy) hydrothermal systems

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Two different approaches for the residence time estimation of groundwaters are discussed: the first one based on the <sup>4</sup>He accumulated in the thermal waters and the second one based on the application of the heat balance equation to an hydrothermal system. We propose the results of these applications to the hydrothermal systems of Western Sicily (Italy) hosted in carbonate rocks.

The proposed theoretical methods need the knowledge of both the abundance of radiogenic helium per unitary volume of thermal waters of the deep hydrothermal systems and their thermal state. The thermal state of the deep hydrothermal systems was checked both by the water-rock and the water-gas interactions in a wide range of temperatures. The estimated mixing percentages between hot waters from the deep thermal systems and shallow circulating groundwaters allowed us to calculate the correct abundance of <sup>4</sup>He accumulated in the deep thermal water. The lithology and the geochemistry both of the thermal waters and the gases have allowed us to define the possible models of waters circulation in the hydrothermal systems.

According to the <sup>4</sup>He accumulation method, the residence time water is proportional to the ratio between the <sup>4</sup>He accumulated in the deep thermal waters and the estimated radiogenic helium flux, assuming that all the radiogenic <sup>4</sup>He is dissolved in water. The radiogenic helium flux reaching the hydrothermal systems can be calculated by the U and Th decay in the crust.

According to the second method, the residence time of the thermal waters can be also estimated considering the deep system divided in consecutive elementary volumes and calculating the ratio between the heat required for having an infinitesimal temperature increase and the net heat-flux (flux in from the depth minus heat flux out toward the surface) in each elementary volume. This ratio allows estimating a time for each increasing temperature step. The integration from the recharge temperature to that of deep equilibrium gives the residence time.

The residence time estimated by the use of the two different approaches are very similar, and the residual discrepancies can be reasonably removed by a better definition of the deep geological characters of the crust.