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CO2/H2O ratio of volcanic gas: Geochemical index for the evaluation of eruptive potential

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The dominant volatile species dissolved in magma is H2O and CO2. The degassing of those species generates bubbles in magma. The bubbles produce the buoyance of magma, driving the magma ascent. Many active volcanoes had been emitting volcanic gas before the eruptions. The amount of H2O and CO2 in the volcanic gas would be affected by the flux of each species degassed from magma. Comparing H2O and CO2, the solubility of CO2 in silicate melt is much lower than that of H2O. If we assume an isolated magma with no supply of volatile enriched magma from a deep source, the CO2/H2O ratio of fluid emitted from the magma will decrease along the progress of degassing. Therefore, the CO2/H2O ratio of volcanic gas could be an index for the remained amount of volatile in magma. I sampled and analyzed volcanic gases at some active volcanoes in Japan. The CO2/H2O ratio of magmatic component in volcanic gas was correlated to the eruptive activity of each volcano. As the result, it is suggested that the volcanoes with the CO2/H2O ratio higher than 0.01 are eruptive. In the following, some examples are described.

Mt Iwate

In 1998, a swarm of volcanic earthquakes happened with the inflation of volcanic body suggesting the intrusion of magma. However, no eruption occurred finally. The fumaloic gas was sampled during the unrest at the geothermal area near the summit. The CO2/H2O ratio of magmatic component was 0.008, which was lower than 0.01. The reason why Mt Iwate had not erupted seems to be the low volatile content by which insufficient of buoyance was generated in magma.

Mt Shinmoe-dake, Kirishima

Before the 2011 eruption, fumaroles with high discharging pressure had been developed within the summit crater. In 1994, the fumarolic gas was sampled and analyzed. The CO2/H2O ratio of magmatic component was 0.03, which was much higher than 0.01. In 1994, a magma enriched in volatile was degassing beneath the volcano, which would be the process of preparation for the eruption in 2011.

Mt Kusatsu-Shirane

Since the steam explosions in 1982 and 1983, no significant eruptive activity happened at the volcano. In 2000, the fumarolic gas was sampled at the geothermal area north of the summit crater. The CO2/H2O ratio of magmatic component was 0.005, which was lower than 0.01. On March 2014, a swarm of volcanic earthquake and the inflation of volcanic body took place. On July 2014, the fumarolic gas was sampled and analyzed again. The CO2/H2O ratio of magmatic component increased to 0.025, which was much higher than 0.01. The low SO2/H2S and H2 concentration were detected, suggesting the temperature of shallow hydrothermal system beneath the summit crater is normal. The increased CO2/H2O ratio suggests an intrusion of volatile enriched magma at the depth.

Keywords: Geochemistry, CO2, H2O, Eruptive potintial, Magma