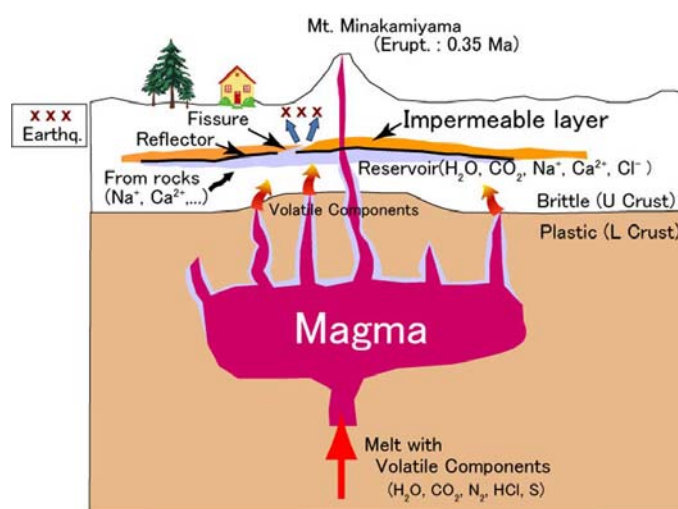


## Understanding the meaning of water discharge at the Matsushiro earthquake swarm area

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Large amounts of hot water and gas, mainly CO<sub>2</sub>, discharged from the ground in the Matsushiro earthquake swarm area. The most active period was from August 1965 to October 1967. Even at present, water and gas are discharging in the area. It is interpreted that the swarm earthquakes were triggered by water migration upward in the upper crust.



### 1. Origin of the water and gas

Yoshida et al.(2002) measured the isotope ratios of d<sup>18</sup>O and dD of the discharged waters at many places in the Matsushiro area. They found that the upwelling waters are mixture of surface water and andesitic magma water named by Giggenbach(1992), i.e.,d<sup>18</sup>O ranging between +5 and +10 per-mil and dD between -30 and -10 per-mil. Further, the isotope ratio of d<sup>13</sup>C of CO<sub>2</sub>(Yoshida et al.,2002), and <sup>3</sup>He/<sup>4</sup>He (Wakita et al.,1978) indicate that CO<sub>2</sub>and He have come from the mantle or magma. N<sub>2</sub>gas also turned out to be the mantle or magma origin (Tsukahara et al.,2006).

### 2. Mechanism for great amounts of water discharge while the swarm earthquake

The rate of generation of water from magma seems to be small since it depends on the cooling rate of the magma. Why great amounts of water discharged in a short period? Nishiwaki et al. (1989) observed a seismic S wave reflective layer beneath the Matsushiro area about 10 km deep. We proposed that there is a reservoir for H<sub>2</sub>O and CO<sub>2</sub>under the reflector(Yoshida et al., 2002). It is known that the volcano of Mt. Minakamiyama erupted at 0.35 Ma in the Matsushiro area. H<sub>2</sub>O squeezed out of solidified magma forms precipitation with upward migration and cooling above the magma, and it must have formed an impermeable layer. H<sub>2</sub>O and CO<sub>2</sub>subsequently has been accumulated under the impermeable layer. When the impermeable sheet broke and large amount of high-pressure water with CO<sub>2</sub>rose into the upper crust, the Matsushiro earthquake occurred.

### 3. Information from the hot water and gas

Most of volatile components, H<sub>2</sub>O,CO<sub>2</sub>, N<sub>2</sub>, He, S-compound, originate from magma. Therefore,

specification for each volatile component, e.g., isotope ratio, gives important information about magma itself. On the other hand, dissolving ions in the water, e.g.,  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{K}^+$ ,  $\text{Li}^+$ , give information about the condition of the passage from magma to the surface, mainly the condition of the reservoir. We need to use different chemical species and analytical instruments for different targets.

## Reference

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