Imaging of the subsurface structure and magma supplying system of Unzen Volcano

Hiroshi Shimizu[1]; Satoshi Matsumoto[1]; Atsushi Watanabe[1]; Takeshi Matsushima[1]; Kenji Uehira[1]; Norimichi Matsuwo[1]

[1] SEVO, Kyushu Univ.

Unzen Volcano is an active volcano grown in the Unzen graben at the western tip of the central Kyushu rift valley, Southwest Japan. The intensive seismic and geodetic observations were carried out at the volcano during and after the 1990-1995 eruption. Furthermore the seismic experiments using artificial sources were conducted after the eruption. These investigations enabled us to image the subsurface structure including the magma supplying system of the volcano.

The hypocenters of volcano-tectonic earthquakes were mostly distributed within a 12x20 km area on the western side of the volcano, and shallows eastward to the summit. Focal mechanism solutions of those earthquakes suggest a pressure source is located beneath the inclined hypocenter region. Four pressure sources (A-D) detected by the leveling survey and GPS measurement are also situated below the hypocenter region. These results suggest that a deep magma reservoir (D-source) is located at 15 km in depth beneath the Chijiwa bay, and that the magma ascends obliquely eastward with an angle of elevation of 40-50 degrees.

In order to reveal the subsurface structure and to detect the volcanic conduit with higher resolusion, a seismic reflection experiment was conducted using vibratory energy sources (VIBROSEIS) in December 2001 as a program of the Unzen Scientific Drilling Project. About 580 receivers, each consisting of 9 geophones, were deployed at intervals of 25 m along a N-S survey line on the western flank of the volcano. The survey line crosses the Unzen graben and the magma ascent path inferred from geophysical observations. In the experiment, three VIBROSEIS vehicles vibrated at about 280 source points on the survey line at intervals of 25-100 m. Because the source energy of the VIBROSEIS is not enough to penetrate the volcanic edifice, 3-100 sweeps of the vibration signals were stacked to improve the S/N ratio of the data.

The reflection analysis revealed the distribution of structural discontinuities in the N-S cross section of the volcano. The depression structure of the Unzen graben is clearly recognized in the cross section. The strong reflection at a depth of 3 km is consistent with the location of the pressure source B inferred from geodetic measurements, which probably corresponds to the upper boundary of a magma reservoir. On the other hand, the narrow area, in which the strength of reflection is extremely weak, extends almost vertically from sea level down to the pressure source B. Volcanic earthquakes occur along a narrow area. Thus the area is interpreted as the volcanic conduit below the western flank of Unzen Volcano. We attempt to estimate horizontal width of the conduit based on principal of Fresnel zone. The width of conduit is estimated within several hundreds meters to 1 km. Size of estimated conduit is so large comparing with conduit size at the surface of about 20-50 m. Furthermore, no geodetic data support the intrusion of magma with such a large size in the 1990-1995 eruption. It is considered that the conduit detected in this study reflects a set of plural conduits contributing to past eruptions as well as the last eruption.

By using these seismic sources, we carried out a scattered wave analysis. The result shows that a strong scattering region exists beneath the western flank of the volcano. The strong scattering image is well corresponding to the pressure source C. The region coincides the low-Q and low-V area which was obtained by the inversion using natural earthquakes. Therefore the pressure source C must have considerable size, and is thought to be a major magma reservoir of Unzen Volcano.