

Results of the Unzen Scientific Drilling Project

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Unzen Scientific Drilling Project (USDOP) is a six-year term international project started in April 1999, co-sponsored by the Japanese Government (MEXT) and International Continental Scientific Drilling Program (ICDP). The project includes not only scientific drillings but also related geological, geophysical and geochemical studies to totally understand the growth history, subsurface structure and magma ascending mechanism of Unzen Volcano. The project is divided in two research phases. Phase I consists of two drilling into the flanks of Unzen Volcano and conducting associated researches mainly to reveal the time-integrated process of Unzen volcano; i.e. three-dimensional structure and the growth history of the volcano. The scientific and drilling strategy associated with the pilot drilling (USDP-3) was also conducted for the conduit drilling. Phase II consists of the conduit drilling (USDP-4) to cross the magmatic path of the 1990-95 eruption estimated to be still hot (ca.600degC) and create a comprehensive evolutionary model of Unzen volcano.

In Phase I, two vertical drillings were conducted at the northeastern and eastern flanks of Unzen. Against the expectation to drill through mainly lavas, many layers of pyroclastic flows and related debris flows were encountered. Systematic geochronology and geochemistry have been conducted not only on both cores, but also on surface volcanic rocks and existing cores from geothermal exploration wells, and the detailed evolution history of Unzen has been constructed: 1. Magmatic and volcanic systems in the Shimabara Peninsula drastically changed at 0.45 Ma at the birth of Unzen volcano, 2. Unzen rapidly grew up in the first 150,000 years, 3. The Unzen graben subsided significantly at 0.3 and 0.2 Ma, and volcanic rocks filled thickly inside the graben. Various geophysical observations during the Phase I along with the borehole loggings enabled the detailed 3D structure of Unzen. Particularly, an inversion seismic tomography showed the existence of the low velocity region at the sea level about 1 km to the west of the Heisei dome suggesting the possible location of the conduit. A seismic reflection experiment also revealed the location of the conduit zone and the subsurface structure of the Unzen graben.

In Phase II, the conduit drilling (USDP-4) was carried out to penetrate the magmatic path of the 1990-95 eruption. Repeated troubles happened at the beginning of the drilling, and the project was forced to have the time of repose to make some modifications of the drilling plan. The drilling was resumed in May 2004 and was successfully ended in July 2004 by reaching to the 1990-95 magmatic path about 1500m beneath the summit of Unzen volcano. Total drilling length was 1995.75m. According to the result of drilling and logging, there was a zone considered to be multiple paths of magma created in the past. This conduit zone is as wide as 500 m, consisting of parallel dikes of up to 40 m wide and pyroclastic veins of up to 20 cm wide embedded in the compact volcanic breccia. Volcanics in the conduit zone are moderately to severely altered by hydrothermal fluids. Temperature of the well increased monotonously toward the center of the volcano and reached maximum in the end of the hole. The estimated formation temperature, however, was about 200degC, which is far below the estimated one before the drilling. The conduit lava estimated to be the magma of the 1990-95 eruption was found at 1975-95. This lava was least altered but was devitrified and the hornblende phenocryst was replaced with chlorite and carbonate minerals. Hydrothermal circulation should have effectively occurred in the conduit zone in the last 10 years, and such fluids cooled and caused the alteration of conduit lava. Detailed petrological and geophysical studies on cores and logging data will reveal the magma ascending and degassing process of Unzen volcano in the near future.