Conduit zone and magma ascent: Unzen Scientific Drilling Project (USDP)

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Drilled formations under the volcano peak were occupied mainly by massive and homogeneous volcanic breccia, lacking any features indicative of sedimentation at the ground surface. Their porosity is less than 0.2 vol.% and density is close to 2.5 g/cm3. These measurements are consistent with the fact that mud loss seldom occurred during drilling in the volcanic breccias of the conduit zone, implying little fracture development and very low permeability. The mass of volcanic breccia is intruded by seven lava dikes, ranging in thickness from 7 to 40 m, and by multiple pyroclastic veins up to several tens of centimeters thick. Lava dikes are interpreted to be magma conduits of older eruptions, which are not pipe-shaped but are plate-like under the anisotropic tectonic stress field. Based on analysis of formation microimages, the dikes and veins are nearly vertical and parallel to each other, trending in the east-west direction. The zone intruded by dikes and veins is as wide as 0.5 km in the south-north direction; named conduit zone.

Lava dikes are commonly accompanied by vertically layered pyroclastic margins. The dikes are dacite in composition but with chemical contrasts among them. This is suggestive of different formation ages of dikes. Pyroclastic veins are composed of fragments of lava and host volcanic breccia (ash to lapilli in size) in various proportions. The pyroclastic veins obtained from the 1,748 m drilled depth are relatively fresh and contains many originally glassy clasts. The freshest dike (though altered already) was encountered in the 1,975 to 1,995 m interval of drilled depth. The temperature at this depth was 180 C, much cooler than expected. It is likely that hydrothermal fluid circulation within the conduit zone accelerated cooling and alteration of even this newest conduit. Major and trace element compositions and the Sr isotopic ratio of the lavas are essentially identical to those of the dome lava.

The conduit lava is porphyritic dacite with phenocrysts of plagioclase, biotite and hornblende, the latter of which is replaced by chlorite, carbonate and rutile due to hydrothermal alteration. The groundmass, which was originally glassy, consists of feldspars and silica minerals reflecting complete devitrification, even in relatively quenched samples near the dike margin. Small euhedral crystals of pyrite are also contained in the groundmass due to hydrothermal alteration. Few bubbles occur in the conduit lava, due to either destruction during devitrification or complete escape or resorption of bubbles before solidification. Three wt % of water would have been retained in the melt at the pressure (40 MPa; 1.3 km). As the initial water content of melt within the magma reservoir was about 6 wt. %, a half of the initial water should have been lost by the time reached this drilled depth. Permeable degassing from fast ascending magma into the wall rock is unlikely, due to the reasons described above. Therefore, it is concluded that degassing may have occurred first through cracks that were propagated vertically ahead of the ascending magma (conduit) and contributed to the precursory eruptive activity and then continued along brecciated, sheared margins of the conduit after the magma column was connected to the surface. It is important that the conduits of different eruption events are not bundled into the other ones but isolated to one another. This means that magma of every eruption event prefers an intrusion path independent of older conduits. Normal repose periods are more than an order of magnitude longer than cooling times so there is no thermal influence of one eruptive episode on the next. In contrast to the limited number of lava dikes, pyroclastic veins are abundant in the conduit zone. It is likely that isolated tremor events reflect formation of cracks in the country rocks along which volatiles and volcanic ash intruded before magma ascended along one of veins.