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Continuous gas monitoring at the Unzen-Conduit-Drilling USDP-4

A. Tretner (1), M. Zimmer (1), J. Erzinger (1), M. Saito (2)

(1) GeoForschungsZentrum Potsdam (GFZ), Germany, (2) Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, Japan (atretner@gfz-potsdam.de / Phone: +49- (0)331 – 288 14 61)

Unzen Volcano, located in the Shimabara Peninsula, Kyushu, southwest Japan, was nominated as one of the Decade Volcanoes of the United Nation's Decade of Natural Disaster Reduction, since it represents an important type of dangerous volcano. The last eruption (1990-95) was monitored and investigated in detail, yielding several models on the eruption mechanism and magmatic processes. The focus of USDP4 - drilling was to further clarify the regional crustal structure and magma evolution processes that control the manner of growth and failure of the volcano. In addition, processes of conduit formation, magma degassing, and magma's interaction with groundwater could have been investigated.

Petrological investigations show, that Unzen magma in the conduit contained 4-5 weight % water, whereas during an eruption at the surface almost no water was present. It was liberated at less that 1-2 km depth. In view of these constraints different physico-chemical models show a strong increase in magma viscosity and a pressure drop directly below the growing dome.

The gas phase dissolved in the drill mud was analyzed continuously with an online gas monitoring system. The aim was to receive a gas profile over the whole borehole length in order to gain information about the volcano fluid circulation system, to detect possible ascension paths for gases produced during magma degassing and to determine hydrothermal and/or volcanic fluid inflow horizons. N_2, O_2, CO_2, CH_4, H_2S, H_2, He and Ar analyses were achieved with a Quadrupol Mass spectrometer, ^{222}Rn was measured with a Lucas cell alpha detecotor. These measurements and subsequent isotopic studies contribute in particular to the discussed model about the eruptive behavior of

Mt. Unzen.

Limitations were given due to the extremely difficult drilling conditions. The highly fractioned rock formation led to loss of drill mud circulation and technical difficulties during directional drilling operations in the shallow parts.

First results show that significant fluid inflow horizons didn't occur above 500 m (drill string lengh). From that depth on, influences of invading fluids could be detected with the real-time gas monitoring system, but major changes (gas peaks) in the mud gas composition occured only deeper than 1000 m.

Of major importance are fluid inflow zones with high $^{3}He/^{4}He$ ratios at 1555 m (7.3 RA), 1755.5 m (7.48 RA) and 1977.4 m (6.21 RA) drill depth. These gas compositions indicate a significant influence of fluids with mantle signature. Furthermore, high methane, radon and helium peaks could also be detected at specific depth.

With respect to major questions related to the Unzens eruption mechanism, the detected major fluid- and gas inflow horizons may be capable of supporting magmatic degassing processes. This is generally true for the lower parts (1470 m and below) and especially for the detected inflows at 1555 m, 1755.5 m, 1977.4 m and deeper major fluid inflow zones.

Furthermore, a correlation between lithology and gas composition was observed. Higher H_2S concentrations were detected while drilling in pyrite rich rocks. Old lava dike horizons and their surroundings seem to comprise of a higher gas and fluid permeability than the other rock formations. Cracks and fissures as well as rock formation changes are often correlated with increasing gas amounts.

Trends with depth, from a minor magmatic influenced to a more magmatic influenced regime were observed together with a change in hydrothermal alteration of the surrounding rock (chlorite-rich to pyrite-rich).

The results of the gas monitoring will be embeded in the scientific network of the USDP-4 drilling program. As analysis of coring material, evaluations of further experiments by other working groups and correlations with our on line gas data are still going on, additional scientific results can be expected in the near future.