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Phreatomagmatic explosions associated with the rhyolitic lava: examples of the Hime-Shima Volcanic Group, SW Japan

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The phreatomagmatic explosion is the explosive phenomenon generated by mingling of the magma and the external water (or the wet sediment), resulting in a large amount of high-pressure steam. In this study, a mechanism of phreatomagmatic explosions associated with the rhyolitic lava effusion was considered, based on the geological research of the Inazumi volcano, the Hime-shima Volcano Group.

Outline of the Inazumi volcano

The Hime-Shima Volcanic Group is the Middle Pleistocene monogenetic volcanic group erupted over the Early to Middle Pleistocene subaqeous sediments (Itoh, 1989). The Inazumi volcano, located at the eastern edge in the Hime-Shima Island, comprises a rhyolitic lava and products of phreatomagmatic explosions.

Evidences for phreatomagmatic explosions

The Inazumi volcano is composed of a 40m thick rhyolitc lava and a 40m thick pyroclastic cone. The rhyolitic lava is poor for the phenocryst, and the flow structure is remarkable. The pyroclastic cone consists of 10-50cm thick tuff breccia and < 10cm lapilli tuff, which have the repose angle of about 30 degrees. The pyroclastic cone is composed mainly of non- to poorly vesicular rhyolitic fragments with a minor of quenched obsidian fragments. The morphology of the volcanic glass is almost blocky with smooth surfaces. According to Sato and Taniguchi (1997), the relation of the volume (0.001km^3) and the crater diameter (300m) suggest that the pyroclastic cone was derived from phreatomagmatic explosions. These geological evidences suggest that the pyroclastic cone was formed by phreatomagmatic explosions.

Intrusion of the wet sediment into the magma

The peperite block, the mixture of the magma and the wet sediment, is included in the pyroclastic cone deposits. It is about 15cm in the diameter and comprises the quenched obsidian with the irregular crack filled by the mudstone. The crack, developing without any relation to cooling joints, is < 1cm width and has ragged surfaces. The mudstone that fills the crack is composed of < 0.1 mm crystal fragments and relatively well sorted. These crystal fragments are presumed to be an origin from the country rock because of no inclusion in the ejecta of the Inazumi volcano. The occurrence of the peperite block suggesuts the fluidized wet sediment intruded the rhyolitic magma in the conduit.

A mechanism of phreatomagmatic explosions

From these geological evidences, phreatomagmatic explosions associated with the rhyolitic lava effusion is presumed that intrusion of the fluidized wet sediment into the conduit is a trigger. When the magma intrudes into the wet sediment, the pore water pressure rises. When the pressure in the conduit falls because of the decrease in the discharge rate of magma, the country rock is expected to collapse into the conduit, though the rise of the pore water pressure is canceled

by the permeability of the country rock within a short time. Because shear fractures and cooling joints are formed in the magma, it seems that the hydraulic fracturing progressed by the injection of the fluidized wet sediment into such a temporarily low pressure part.
For the generation of phreatomagmatic explosions, it is necessary to transmit heat from the magma to water in a short time and to generate a large amount of steam nearly simultaneously (Iida and Takashima, 1988). The injection of a wet sediment into the conduit by the hydraulic fracturing enables the expansion of the surface area between the magma and the water. Once water is taken in the magma by the hydraulic fracturing, the concurrence of high-pressure steam becomes possible. The injection of the fluidized wet sediment by hydraulic fracturing is considered as a trigger of phreatomagmatic explosions associated with the rhyolite lava effusion.

References

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