Repetition of Vulcanian Explosions as a result of Conduit Magma Convection

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Vulcanian eruption is characterized by brittle destruction of the cap (plug) at the upper volcanic conduit, and is also characterized by its repetition with various frequency and intervals. Repetition of Vulcanian eruptions require reproduction of the cap at the upper conduit, which is considered as a poorly vesiculated solidified magma. Many volcanoes which repeat Vulcanian eruptions also causes intense and continuous volcanic gas emission, implying the occurrence of magma convection in a volcanic conduit. The dense solidified magma cap at the upper conduit could be repeatedly created by the conduit magma convection.

Many volcanoes, which repeat Vulcanian eruptions, such as Sakurajima and Asama volcanoes, also continuously emitted a large amount of volcanic gases. The continuous degassing implies the continuous occurrence of magma convection in a volcanic conduit, at least during intervals of the eruptions. SO2 emission rate o Sakurajima volcano ranges from 500-3000 t/d, requiring orders of magnitude larger magma supply than of the erupted magma. This implies that the Vulcanian eruptions could be considered as a transient process during the conduit magma convection, which is the dominant magmatic process in the volcanic conduit.

Vulcanian eruption products consists of various materials including crystalline to glassy juveniles and non-juveniles, with various proportion, but always contain poorly vesiculated crystalline magmas, which is considered as the cap of the conduit. The poorly vesiculated magma can be created by magma degassing at low pressure as Diller et al. (2006) demonstrated based on the 1-D numerical model of magma ascent. However, they considered the repeated Vulcanian eruptions occurred during lava-dome eruption at Soufriere Hills volcano, and their model was based on the continuous magma ascent model. In contrast, Vulcanian eruptions occurred not during magma outflow activity at Sakurajima nor Asama, and ascent of a molten magma to the upper part of the conduit is necessary to create the degassed poorly vesiculated magma cap prior to the eruption.

Conduit magma convection continuously supply a magma from a deep chamber through the volcanic conduit to be degassed at the upper part, and the degassed dense magma return to the chamber because of the increase of it density by the degassing. Magma ascent in the convecting magma through the conduit might be similar with the simple magma ascent through a conduit, and magma density variation with the conduit depth might be similar. Therefore, the degassed poorly vesiculated magma, which can serve as the cap for Vulcanian eruptions, will be created at the upper part of the convecting magma. During the continuous degassing, the dense solidified magma cap, formed at the top of the convecting magma, might be continuously destroyed and sink through the ascending magma because of it larger density, avoiding accumulation of gas pressure to cause Vulcanian eruption.

When did the cap form prior to the eruption? In the continuously ascending magma, as modeled by Diller et al. (2006), the cap needs to be formed just before the eruption. The conduit magma convection can create the cap can be created anytime prior to the eruption. If the cap was created long before the eruption, , the cap should have been altered by the intense gas emission and cannot be retained the strength. Although hydrothermal altered materials are involved in the eruption materials in some cases, the altered rocks by high-temperature acid volcanic gases are not common. Therefore, the cap was likely formed shortly before the eruption, and the remnant magma of the previous eruption will not be served as the cap for Vulcanian eruptions. Consequently, the conduit magma convection might be the necessary process to cause the repetition of Vulcanian eruption with various intervals.