"Visible degassing vs. invisible degassing" during magmatic evolution.

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Geochemical studies on volcanic gas during the last 15 years have shown that large amounts of CO_2 are released not only from their active craters but also from their flanks as diffuse soil emanations. Now it becomes possible to discuss general features of the diffuse degassing through soils compared with plume degassing from the craters. Although the diffuse degassing is observed to be highly variable in space and time, the high diffuse CO_2 efflux is typically observed on volcanoes when active plume degassing is low, corresponding to a low-activity stage, as exemplified by the Hakkoda volcano (Hernandez et al, 2003) and Mammoth Mountain (Gerlach et al., 2001). On the other hand, it is not unusual to observe a very week efflux on volcanoes exhibiting intense plume activity from a central crater, as shown in White Island, New Zealand, (Wardell et al., 2001) or Nisyros volcano, Greece (Brombach et al., 2001). The Popocatepetl volcano in Mexico provides an extreme example of negligible diffuse CO_2 emissions of magmatic origin throughout the extensive volcanic edifice (Varley and Armienta, 2001) despite huge emissions of CO_2 from the summit crater. Considering these observations on the two types of volcanic gas release, a five-stage evolutionary model for the release of volcanic gas can be proposed, as shown in Figure 1.

Stage I: When magma pools at a significant depth (e.g., >10 km), neither plume degassing nor diffuse degassing of volcanic gas is typically observed.

Stage II: As magma rises into the subsurface, diffuse degassing through the permeable ground begins, and the efflux at the surface increases as the magma migrates upward. Such increases in efflux have been observed at Mt. Usu, Japan, prior to the 2000 eruption (Hernandez et al., 2001).

Stage III: When magma reaches the surface, volcanic eruptions occur with associated lava extrusion or violent explosions accompanied by an instantaneous release of a large amount of volcanic gas and ash as a plume. This causes a sudden drop in gas pressure within the volcanic body and results in a rapid decrease in diffuse degassing throughout the volcanic edifice. This was also observed just after the 2000 Usu eruption (Hernandez et al., 2001).

Stage IV: While new magma is being supplied to the surface, intense pluming continues and diffuse degassing remains negligible. Examples of this stage have been observed at Mt. Popocatepetl (Varley and Armienta, 2001) and at White Island (Wardell et al., 2001).

Stage V: As magma begins to drain away from the surface, the efflux of plume degassing decreases. After degassing from the volcanic vent stops, if gases are still released from the descending magma at greater depth, diffuse degassing increases considerably due to an increase in the gas pressure of the volcanic body. Diffuse degassing from quiescent volcanoes such as that at Mt. Hakkoda (Hernandez et al., 2003) may represent post-eruptive degassing. This diffuse degassing will gradually recede as the volcanic system returns to Stage I.

[references] Brombach et al., GRL, 28, 69-72 (2001). Gerlach et al., CG, 177, 101-116 (2001). Hernandez et al., Science, 292, 83-86 (2001). Hernandez et al., JGR, 108, 2210 (2003). Notsu et al., PAGEOPH, in press (2006). Varley and Armienta, CG, 177, 157-173 (2001). Wardell et al., CG, 177, 187-200 (2001)

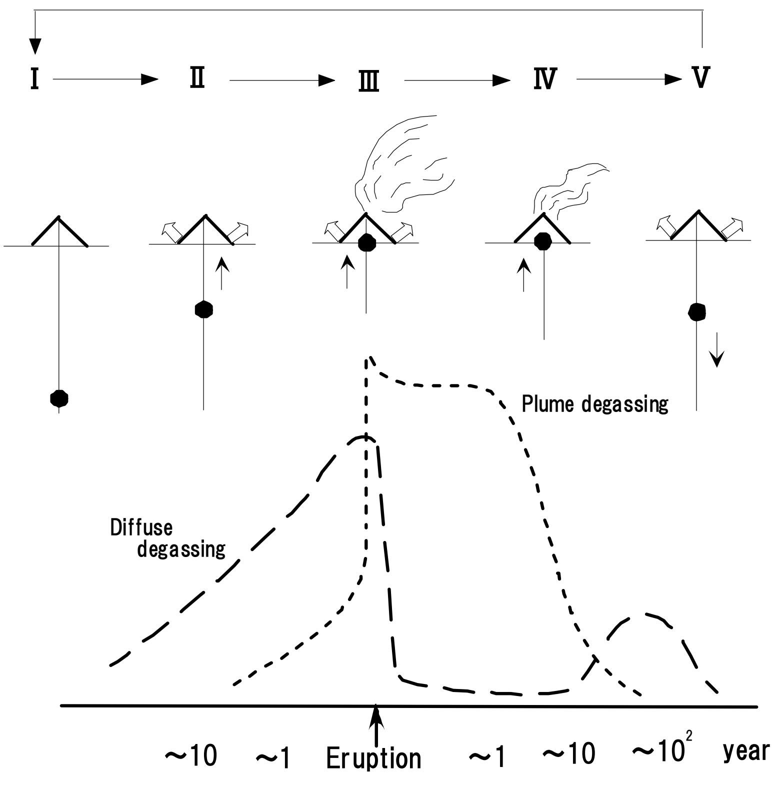

Figure 1. Schematic illustration showing an evolutionary model of gas release from volcanoes. (Notsu et al., 2006).

Solid circle is magma rising and descending along the vent. Emission patterns of both diffuse and plume degassing are roughly illustrated as two broken lines. Time scale of horizontal axis is tentatively indicated in case that the recurrence time of eruptions is 10^2~10^3 years.