

The eruption styles and grain compositions of deposits from the 2011 eruption of Shinmoedake, Kirishima volcano, Japan

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We determined the grain and chemical compositions of ash fall deposits emitted from the 2011 eruption series of Shinmoedake, Kirishima volcano. As the main result, we found that the products from both eruption types, sub-plinian and vulcanian, have similar grain and chemical compositions. This suggests that all eruptions were fed by a homogeneous magma and driven by similar magma ascent processes.

Shinmoedake, one of the eruptive centers of Kirishima volcanoes located in southern Kyushu, Japan, repeated eruptions from January to September 2011. The eruption series started by a phreato-magmatic explosion in January 19, followed by sub-plinian eruptions on January 26-27, extrusion of lava that filled the summit crater, vulcanian eruptions since the end of January, and minor ash emissions. We collected on-site ash samples for each event, thus derived from all types of eruptions. This provides a rare chance to investigate the mechanisms controlling the eruption style, from the viewpoint of characteristics of the eruptive products through time and possible correlations with the eruption type.

We observed color, shape, and vesicularity of the grains in the size range 0.25-0.50 mm, using the optical stereoscopic microscope and SEM. We regarded grains with fresh morphology as juvenile materials. We distinguished five types of juvenile grains based on their vesicularity and color: P (light-colored pumice), S (dark-colored scoria), WG (white glassy dense block), GG (gray glassy dense block), and BG (black glassy dense block). For each eruption, we counted the number of grains of each type among an original population of 200 grains.

The proportion of highly-vesicular grains (sum of P and S types) goes from 14%, corresponding to the phreato-magmatic explosion of January 19, to 26.5%, corresponding to the sub-plinian eruption of January 26. The proportion then fluctuated between 2-25.5% during the subsequent vulcanian eruptions and/or minor ash emissions that occurred from February to August. This means that despite the change in the eruption style, highly-vesicular grains were always present in every ash sample. The proportion of dense grains (sum of WG, GG and BG types) ranges between 35 and 70.5 %, and the three types are found in every ash sample.

The groundmass of the juvenile grains from all eruptions has chemical compositions that lie around 65 wt% SiO₂, despite the variation in color, shape, and vesicularity of the grains. There are some grains with a differentiated groundmass (70 to 75 wt% SiO₂), but they belong to the same differentiation trend as all other grains.

We conclude that the constituents and chemical compositions of all types of grains are similar, despite of the great variability in the eruption style (phreato-magmatic explosion, sub-plinian eruptions, vulcanian eruptions, and minor ash emissions), and thus eruption intensity. In particular, highly-vesicular grains are ubiquitous in all ash samples, although their proportion is varying. This suggests that fresh magma fed every eruption of the 2011 series. As a consequence, vulcanian eruptions are not the results of lava dome and/or cap-rock destruction, but likely the results of input of fresh magma in the shallow conduit system, which is comparable in a certain extent to what occurs for sub-plinian eruptions.

Keywords: Kirishima volcano, Shinmoedake, 2011 eruption series, ash deposit, grain composition, eruption style