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Magma mixing and ascent process of Shinmoedake 2011 eruption from phenocrysts, microlite, vesicle textures

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Shinmoedake 2011 eruption which started on 26th January 2011 showed a characteristic transition of eruption styles.
Two sub-plinian eruptions from 15 h on 26th and from midnight of 27th produced a pumice deposit of 6 cm in thickness at 8 km from the vent. After the sub-plinian phase, the eruption style shifts to vulcanian type which majorly produced volcanic ash with emitting air shock, since an eruption at 15 h on 27th Jan. Among vulcanian eruptions exceeding 10 times until end of Feb, the most intensive eruption on 1st Feb ejected volcanic bombs of 1 m in diameter at 2 km from the vent.

In order to quantify the magma ascent and degassing processes and clarify the governing factors of such an eruption style transition, we carried out the textural and compositional analysis of pumices sampled at 8 km from the vent from 26 and 27, Jan and of bomb sampled at 2.6 km from vent from 1 Feb. We recognize three types of pumices by color: white, gray and brown. White pumices are generally well vesiculated, flake-shaped, 1 to 2 mm in length, and include relatively spherical bubbles (5 to 20 um in diameter) and platy plagioclase (10 to 100 um in length), equant, platy or acicular pyroxene (sub-micron to 10 um) and equant oxide (2 to 10 um) microlites. Gray pumices are generally moderately vesiculated, block-shaped, 2-20 mm in diameter, and include relatively irregular coalesced interconnected bubbles (10 to 100 um in typical scale) and platy plagioclase (10 to 50 um in length), equant, platy or acicular pyroxene (sub-micron to 10 um) and equant oxide (2 to 5 um) microlites. Bomb has a relatively vesiculated inner part (bulk density is 1700kg/m^3) with a rind. The inner part includes two types of vesicles: large irregular shaped (several mili meter in typical scale) and small spherical (10-30 um in diameter), whereas the rind has no small type of vesicle. The bomb includes plagioclase (0.2 to 3 mm in length), clinopyroxene (0.1 to 0.5 mm), orthopyroxene (0.1 to 0.5 mm), olivine (0.2 to 0.5 mm) and magnetite (0.2 to 0.5 mm) as phenocrysts and plagioclase (3 to 100 um in length), clinopyroxene, orthopyroxene (sub-micron to 40 um), and magnetite as microlites. Sulfide minerals of iron and copper are found in inclusion of phenocrysts and groundmass. Plagioclase phenocrysts are largely classified into two types: one has calcic core (An_{90}) with the normal zoning (An_{70} rim) (A-type), the other has sodic core (An_{50}-$_{75}$) with the reverse zoning (An_{70} rim) (B-type). Olivine pheocrysts coexist with A-type plagioclase phenocrysts whereas pyroxene and magnetite phenocrysts coexist with B-type plagioclase phenocrysts. Plagioclase microlites in the bomb are platy to acicular shaped and 10-150 um in length. Larger microlites show a characteristic stepwise zoning structure with calcic core (An_{70}) and sodic rim (An_{58}-$_{60}$). Microlite sodic rims include pyroxene microlites.

From the systematics of the mineral assemblage in glomeroporphyritic phenocrysts and the zoning pattern of two types of plagioclase phenocrysts, it is suggested that the magma mixing process occurred between a basaltic magma and a silicic magma. The chemical composition of An_{70} of plagioclase phenocryst rim and microlite core requires 3.5 wt% of water content in the mixed magma, which approximately corresponds to 1 kbar saturation pressure and 4 km depth. As a result, it is concluded that core of larger pl microlites and rim of pl phenocrysts crystallize under the pressure and water content. From the systematic change in microlite size of white pumice, gray pumice to bomb and the bubble size from white pumice to gray pumice, it is suggested that the decompression rate or water-exsolution rate systematically decrease from white pumice, gray pumice to bomb from the corresponding microlite number density and bubble number density. For more quantitative estimation, we have to develop the method to extract the original signature at the nucleation stage of bubble and microlite.

Keywords: Kirishimayama, magma mixing, eruption style, rock texture, magma ascent