Surface Instability between Mafic and Silicic magmas in the Saga-Futagoyama Volcanic Rocks at Northwest Kyushu, Japan

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The Saga-Futagoyama volcanic rocks lava is a composite lava formed by the mixing between the basalt and the rhyolite magmas. Morphological asymmetries are observed between the mafic rock and the silicic rock. The mafic rock has blunt shapes against the silicic rock. The silicic rock has sharp cusp shapes against the mafic rock. Three dimensionally isolated silicic fragments in the mafic rock suggest that these morphological asymmetries were caused by the surface instability when they interacted as magmas. The comparison with fluid mechanical experiments (Snyder and Tait, 1995) indicates that the surface ignitability is the Saffman-Taylor instability which develops when a viscous fluid is driven forwards by the pressure of the less viscous fluid (Saffman and Taylor 1958).

Based on a petrological evidence such as a disequilibrium phenocryst mineral assemblage, it has been a common sense that mixing between magmas different in compositions occurs in a magma chamber among authors. Especially, mixing of mafic and felsic magmas is considered to play a principal role to calc-alkaline andesite magma generation. However, mechanical processes through which hybrid magma homogeneous in the microscopic scale generates from endmember magmas very different in temperature, density and viscosity has not been well understood. Authors has discussed this issue on the basis of fluid dynamic experiments in laboratories. Field and microscopic observations, however, has not been reported enough to constrain the processes.

The lava of the Saga-Futagoyama volcanic rocks is a composite lava ranging from basalt to low-Si rhyolite in composition. The composite lava is considered formed by mixing of the basalt and the rhyolite endmember magmas based on lines of petrological evidences as follow: (1) a disequilibrium relationship between hole rock compositions and mineral compositions of plagioclase phenocrysts in intermediate andesite samples; (2) straight liner relationships between major elements. The composite lava is composed of the mafic rock ranging in composition from basalt to andesite and the felsic rock ranging in composition dacite to rhyolite. There is a gap of compositon between the mafic rock and the silicic rock. Although the mafic rock contains felsic rocks as inclusions, the most part of the mafic rock is a hybrid rock which is homogeneous even in the microscopic scale . The felsic rock is a mingling rock containing many mafic rocks as inclusions. At the outcrop, the mafic rock include the felsic rock.

Morphological asymmetries are observed between the mafic and the silicic rocks. When the mafic rock contacts with the silicic rock, the mafic rock has spheric island or blunt peninsula shapes against the silicic rock. The silicic rock has sharp cusp shapes against the mafic rock. Three dimensionally isolated silicic inclusions suggests that these morphological asymmetries generated when the mafic rock and the silicic rock interacted as magmas.

Snyder and Tait (1995) reported fluid dynamic experiments that are designed to investigate mechanical interactions between two fluids different in viscosity when less viscous one injects into more viscous one. The injections developed a low-front instability. The less-viscous fluid formed blunt finger shapes against the more-viscous fluid. The more-viscous fluid had sharp cusps shapes against the less-viscous fluid. Snyder and Tait (1995) discussed that the flow -front instability is caused by the Saffman-Taylor instability which develops when a viscous fluid is driven forwards by the pressure of the less viscous fluid (Saffman and Taylor 1958; Saffman 1986; Manickam and Homsy 1995; Casademunt and Magdaleno, 2000). The morphological features of the results of their experiments are very analogous to those of the Saga-Futagoyama volcanic rocks. The similarity suggest that the morphological asymmetries between the mafic rock and the silicic rock was generated by the Saffman-Taylor type surface instability when they interacted as magmas.

The Surface instability observed in the Saga-Futagoyama volcanic rocks decreases surface areas of the mafic magma and increases those of the silicic magma. This feature promotes the silicic magma entrainment by the mafic magma and prevents mafic magma entrainment by the silicic magma. Therefore, the surface instability between the mafic and the silicic magma is considered to play a principal role for the generation of hybrid calc-alkaline andesite magma and gap of hole rock composition which is observed in many volcanos.