Petrology of crystal-rich rhyolitic ash-flow tuffs of the Nohi Rhyolite: a preliminary study

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The Nohi Rhyolite is the largest one of the Late Cretaceous ash-flow fields in central Japan (5,000-7,000 km^3). It consists mainly of thick welded ash-flow sheets (a few hundred to more than 1,000 km^3) infilling cauldrons.

Comparing with other large volume (more than 100 km^3) ash-flow tuffs, the Nohi Rhyolite is characterized as 'crystal-rich rhyolites.' Most of their fiammes (essential clasts) has a rhyodacitic to rhyolitic composition with 30-45 vol. %, although minor amounts of them are crystal-poor high-silica rhyolites (less than 20 vol. % phenocrysts). Rhyolitic fiammes contain coarse grains of quartz, alkali feldspar and plagioclase with minor Fe-rich mafic silicates (orthopyroxene, clinopyroxene, hornblende and biotite) and Fe-Ti oxides, whereas rhyodacitic ones are rich in plagioclase with minor pyroxene (opx more than cpx) and Fe-Ti oxides. The Fe-Ti oxides consist of ilmenite and no primary titanomagnetite, which indicates thus that the Nohi Rhyolite belongs to the ilmenite-series. The fiammes generally have no remarkable resorped feldspars and no reverse zoned plagioclase and mafic silicates. These suggest that the phenocrysts derived from primarily silicic magmas and the mixing among mafic and felsic magmas played no important role in the chemical variation of the fiammes.

The mass balance calculation on fiammes of the Setogawa Ash-Flow Sheet (more than 150 km^3) indicates that crystal-rich rhyolites formed mainly by a simple fractional crystallization of plagioclase, orthopyroxene and ilmenite from the rhyodacitic parental magma. Variation of some trace elements also can be explained by the Rayleigh fractional crystallization.

Pre-eruptive condition of the rhyodacitic parental magma is examined using modal, chemical and mineralogical data of the rhyodacitic fiamme of the Gero Ash-Flow Sheet, which is the largest unit (more than 2,200 km^3) of the Nohi Rhyolite. The calculated temperature is about 810-850 degrees centigrade at 1-2 kbar using the pyroxene geothermometer (the QUILF program: Andersen et al., 1993). The rhyodacitic fiamme includes Fe-rich clinopyroxene and ilmenite without primary titanomagnetite and titanite, the assemblage of which implies that the oxygen fugacity of the rhyodacite was under the FMQ oxygen buffer, based on the equilibrium equation by Wones (1989). The water content is estimated using the MELTS program (Ghiorso and Sack, 1995). The most reasonable condition that matches phenocryst content, phenocryst assemblage and temperature is ca. 1 wt. % H_2O content. This result implies that the rhyodacitic parental magma was in a dry condition like the 'crystal-poor rhyolite' type of 'very large volume (more than 1,000 km^3) ignimbrites' (Christiansen, 2005).

When the rhyodacitic parental magma evolves to the rhyolite by fractional crystallization of plagioclase, pyroxene and ilmenite, the rhyolitic magma become more water-rich than the parental. Considering this and the fact that the evolved rhyolitic fiammes have a high phenocryst content, pre-eruptive temperature of the rhyolite must be cooler than the rhyodacite, possibly as low as the 'crystal-rich dacite' type of Christiansen (2005).

References

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