Magma system and processes beneath Baitoushan volcano, during 10th century eruption

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Baitoushan volcano, located at the border of China and North Korea, occurred huge eruption in the 10th century. The eruption was the largest eruption, which was nearly the same as the 1815 eruption Tambora volcano, Indonesia in the past 2000 years (Machida, 1992). Based on stratigraphy, the eruption was divided into two pahses in ascending order; Phase 1, alkali rhyolitic activity; Phase 2, trachytic activity (Miyamoto et al., 2004). We examine the magma system of two phases of the 10th eruption using mineral chemistry and whole-rock chemistry for major and trace elements.

Phase 1 is composed of plinian fall (Unit B) and pyroclastic flow (Unit C). The essential materials of Phase 1 are white and banded pumices. Phase 2 is composed of plinian fall and intra-plinian flow (Unit D), sub-plinian fall (UnitE) and pyroclastic flow (Unit F). The essential materials of Unit D are yellowish-brown pumice and black scoria, whereas those of Unit E and Unit F are gray pumice and black scoria. These ejecta have olivine, orthopyroxene, alkali feldspar and Fe-Ti oxide as major phenocrystic minerals. In addition, plagioclase are also included in Unit B,C,F, quartz are includes in Unit C,F, and the part of Unit B.

Based on whole-rock chemistry, the juvenile materials are defined as alkali rhyolite, trachyte and trchyandesite (SiO2=53-75 wt.%, Na2O + K2O=6-12 wt.%). Most of ejecta of Phase 1 are alkali rhyolite, and they show two different trends, from alkali rhyolitic (SiO2=73wt.%, Na2O+K2O=10wt.%) to low-alkali trachytic (SiO2=60wt.%, Na2O+K2O=10.5wt.%) and to high-alkali trachytic (SiO2=65wt.%, Na2O+K2O=12wt.%) on several Harker diagrams. Part of ejecta of Unit B, which include quartz, shows the different trend from the other ejecta without quartz on Harker diagrams of FeO, Pb, Zn. In Phase 2, most of ejecta of Unit D and -E are trachyte and trachyandesite, and the ejecta of Unit F are trachyte to alkali rhyolite. On Harker diagrams, the ejecta of Unit F show two similar trends, to trends of those of Phase 1, whereas the ejecta of Unit D and -E show the trend combining low-alkali trachytic and high-alkali trachytic ends of trends of Unit F.

Considering compositions of phenocrystic minerals (olivine, orthpyroxene, feldspar), Phase 1 juvenile materials are divided into three types; type I(Fo=0-4, Fs(Wo-En-Fs system)=55, Or(Or-Ab-An system)=35-40An0), type II(Fo=15, Fs=45-50, Or45An5) and type III (Fo=80, Fs=15, Or0An60). Compositional variations for phenocryst minerals in many ejecta are clearly trimodal distribution. In Phase 2, we found two other types of minerals in addition to three types of Phase 1; type IV(Fo=20, Fs=30-35, Or45An5) and type V(Fo=55, Fs=25, Or30-40An10-20). Type I,III,V phenocrysts coexist in Unit D, and all of the types phenocrysts coexist in Unit F. Based on this phenocryst type, it is concluded that type I phenocrysts derived from alkali rhyolite magma, type III phenocrysts derived from trachyandesite magma, type IV phenocrysts derived from trachytic magma, and type II phenocrysts derived from middle composition of alkali rhyolite magma and trachytic magma (type II magma), type V phenocrysts derived from middle composition of trachyandesite magma and trachytic magma (type V magma).

According to variations for whole-rock and mineral chemistry, we assume the magma system of the 10th eruption of Baitoushan as follows. In Phase 1, main alkali ryholite magma mixed with type II and trachyandesite magmas. In the early stage of Phase 2(Unit D and -E), main trachytic magma mixed with both alkali ryholite and trachyandesite magma. In the latest stage of Phase 2 (Unit F), all of five end-member magmas mixed.