Petrogenetic process controlling explosivity at an intraplate volcano: a case study from Ulleung Island, Republic of Korea

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Ulleung Island represents the top of a 3000 m (from sea floor) intraplate alkali volcanic edifice in the East Sea/Sea of Japan. The emergent section of the volcano consists of a basaltic lava and agglomerate succession intruded and tilted by a younger trachytic core. Younger eruptions at c. 20 ka and 8-5 ka generated thick tephra sequences of phonolitic composition and carried to the surface intrusive syenitic accidental clasts. In major element space, there is a continuous spectrum of compositions from trachyte to phonolite but offset trace element trends exclude a direct relationship between these two end member compositions. Within the phonolitic tephras two subgroups can also be distinguished. The early erupted tephras are considerably enriched in incompatible elements and chondrite normalised rare earth element (REE) patterns display negative Eu anomalies. Later tephras have compositions intermediate between the early tephras and the trachyte/syenite samples and their REE patterns do not have significant Eu anomalies. Petrographic evidence and mineral chemistry suggest a genetic relationship between the syenitic xenoliths and their host phonolitic pumices. The c. 20 ka eruption was fed by a phonolite magma enriched in incompatible elements, possibly by fluids from the crystallizing portion of the hosting shallow magma reservoir; these fluids caused alteration, which gives the lower tephras an orange colour. The subsequent c. 8-5 ka eruption was fed by a new magma batch, which evolved through crystal fractionation but also assimilated parts of the previous reservoir. The phonolite erupted explosively as opposed to the trachytes, which erupted effusively or formed cryptodomes. The differences in eruption style are mainly due to different degrees of fractionation and enrichment in a shallow magma reservoir.