

氏名・(本籍)	キム 金	ユン キュウ 允 圭
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論文審査委員	(主査) 教 授 青 木 謙一郎      教 授 砂 川 一 郎 教 授 田 口 一 雄 教 授 苜 木 浅 彦	

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## 論 文 內 容 要 旨

Ulreung Island is a volcanic island consisting of alkali rock series, and situated off the eastern coast of the Korean peninsula ( $37^{\circ}30'N$ ,  $130^{\circ}50'E$ ). The activity of the volcano probably began in the early Pleistocene and continued until Holocene. The evolutionary history of the island can be divided into five stages on the basis of the mode of activity and nature of the volcanic products. Stage I: a large amount of pyroclastics of trachybasalt has been erupted with some lava flows and dikes, and they formed the basement of the island. Stage II: successive eruptions of trachytic pyroclastic flows and lava flows covered the rocks of stage I, and several dikes intruded. A minor amount of trachyandesite has been erupted as well. Stage III: after a long quiescence, trachytic to phonolitic lavas have been extruded and completed a large stratovolcano of the island. Stage IV: the mode of volcanic activity changed after the completion. A voluminous pumice and ash of trachytic composition and plutonic inclusions were ejected from the central vent and this resulted in formation of a caldera on the northern flank of the volcano. Stage V: a small central cone was formed by the eruption of trachytic pyroclastics and leucite-bearing trachyandesite lava in the caldera.

The petrographic descriptions of the volcanic rocks were presented, and the representative 48 samples, picritic basalt, alkali basalt, trachybasalt, trachyandesite, trachyte and phonolite, were analyzed for major elements. Most of the basic rocks contain abundant olivine, clinopyroxene and plagioclase phenocrysts. Alkali feldspar, kaersutite and biotite phenocrysts appear in the trachyandesite; some trachyandesite contain groundmass leucite. Both trachyte and phonolite are characterized by alkali feldspar phenocryst, and nepheline occurs in the groundmass of the phonolite.

Plutonic inclusions are divided into two types on the basis of the occurrence and texture. Type I consists of alkali gabbro, sodalite-bearing monzonite feldspathoid-bearing alkali feldspar syenite with xenomorphic- to hypidiomorphic-granular or porphyro-granular texture. Type II shows cumulus texture and consists of the various amount of plagioclase, titanite, kaersutite, magnetite and apatite.

The  $SiO_2$  contents of the rocks increase with the evolution of the island; the rocks, however, become more undersaturated in silica. The  $K_2O/Na_2O$

ratios are rather constant and low (ca. 0.5) for the basalts, and rapidly increase to reach 1 for the trachybasalt to phonolite. All the rocks have normative nepheline, except altered or oxidized ones, and which increases from 1 percent basalts up to 16 percent in the phonolite. Although their chemical compositions attribute the rock suite to the potassic alkali rock series, normative leucite is absent.

Trace elements were analyzed for 17 representative volcanic rocks by the photon activation method. The variations of eleven trace elements against Nb contents are summarized as follow: 1) rapid depletion (Ni, Co, Cr, Sc and V), 2) systematic increase throughout the entire sequence (Y, Ce and Zr) and 3) increase to maximum at an intermediate Nb value followed by depletion (Sr, Ba and Bb).

Major and trace elements of type I inclusions show continuous variation trends similar to those of the associated lavas.

Chemical compositions of the rock-forming minerals were analyzed for 17 volcanic rocks and 14 plutonic inclusions with an electron microanalyzer. Systematic compositional variations of the constituent minerals from the alkali basalt to the most evolved phonolite are noticed. Although olivine has a reaction relation with a trachyandesite liquid, olivine and clinopyroxene show a progressive Fe-enrichment from alkali basalt to phonolite. Calcium-rich clinopyroxene is changing in composition from chromian diopside and titanaugite in the alkali basalt, to ferroaugite in the phonolite. Bytownite is a predominant feldspar in the alkali basalt, and labradorite and andesine are abundant in trachybasalt and trachyandesite. Whereas the characteristic feldspar of the trachyte and phonolite is anorthoclase to sodic sanidine. Plagioclase phenocrysts become more sodic from the core to rim. Alkali feldspar phenocrysts show Ca- and Na-enrichments with differentiation of the rocks.

Mineral compositions of type I inclusions show remarkably regular compositional change. Alkali gabbro, sodalite-bearing monzonite and feldspathoid-bearing alkali feldspar syenite form a continuous series with steady Fe-enrichments of mafic minerals. During differentiation the clinopyroxene in type I changed its composition from salite, titansalite to hedenbergite through ferrosalite. The composition of amphiboles also continuously varied from kaersutite, ferrokaersutite to hastingsite through magnesian hastingsite. The chemical compositions of the cumulus minerals in type II are characterized by a narrow compositional

range and very similar to those of the phenocrysts of the trachybasalt. They do not show a compositional change within a grain.

The characteristics of major and trace elements and mineral chemistry of Ulreung volcanic rocks can be accounted for by a simple fractional crystallization of the observed phenocryst phases. A quantitative petrogenetic modelling suggests that the compositional variations observed in the differentiated lavas can be ascribed to an extensive fractional crystallization of a parental alkali basaltic magma. Trachybasalt represents 42 percent of the parental alkali basalt, whereas the phonolite is only 14 percent. The mass balance models indicate that olivine, clinopyroxene, titanomagnetite, plagioclase and alkali feldspar are the dominant fractionated phases. Trace element contents calculated using a Rayleigh equation show a relatively good agreement in all the steps.

Petrogenesis of the plutonic inclusions of type I is explained in terms of differentiation of a parental alkali basaltic magma. The chemical and mineralogical data lead to the conclusion that alkali gabbro might have been crystallized from a moderately undersaturated basaltic melt under hydrous condition at shallow depth. The petrographic and mineralogical characters indicate that type II represents a cumulus phase that initially crystallized from a trachyandesite melt.

## 論文審査の結果の要旨

韓国，鬱陵島は第四紀に活動したピクライト質玄武岩，アルカリ玄武岩，粗面玄武岩，粗面安山岩，粗面岩そしてフォノライト等のアルカリ火山岩類から構成されている。噴出物の量は粗面岩が最も多く，玄武岩，粗面安山岩がそれに次ぐ。本島を構成する岩石は  $\text{SiO}_2$  が 42～62%，全アルカリが 3～14% のポタシク系列に属する典型的なアルカリ岩系列の火山岩である。その珪酸不飽和度は  $\text{SiO}_2$  の増加とともに次第に増加する傾向をもつ。噴出物の組成は，活動とともに次第に珪長質になり，粗面安山岩の噴出で活動が終わっている。

本島の火山岩類は，マグマの分化に伴って斑晶鉱物組合せ・構成鉱物の化学組成・全岩化学組成・微量成分組成の系統的な変化が認められる。火山岩類中の斑晶鉱物はカンラン石，単斜輝石，Ti-磁鉄鉱，斜長石，ケルスート角閃石，黒雲母，アルカリ長石そして燐灰石である。一連のアルカリ火山岩類が示す主成分ならびに微量成分元素組成の変化は，それらが未分化のアルカリカンラン石玄武岩マグマから，その組成を変化させながら晶出する斑晶鉱物を分別することによって形成されたものであることを示している。各種モデル計算に基づき，マグマの分化の早期にはカンラン石，単斜輝石，Ti-磁鉄鉱と斜長石が，中期にはリンカイ石，ケルスート角閃石と黒雲母が，そして末期には主にアルカリ長石の効果的な分別がなされたと結論される。

一方，本火山のカルデラ形成に伴って噴出した降下軽石層には多くの深成岩包有物が含まれている。深成岩包有物はそれを包有する火山岩類とほとんど同じ主成分及び微量成分組成変化を示している。これら包有物は火山岩類を形成したの一連のマグマがマグマ溜り上方の地下深所に貫入し，そこで徐冷，固化して形成され，その後の降下軽石の噴出に伴い地表にもたらされたと考えられる。

以上の研究結果は，アルカリ火山岩類の岩石学的地球化学的研究の分野に大きく貢献するものである。また，これまで公表した論文の内容から判断して，金允圭は自立して研究活動を行なうに必要な高度の研究能力と学識を有していると考えられる。よって，金允圭の提出の論文は理学博士の学位論文として合格と認める。