GEOCHRONOLOGY AND GEOCHEMISTRY OF THE IGNEOUS ROCKS FROM BARTON AND FILDES PENINSULAS, KING GEORGE ISLAND: A REVIEW

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Abstract: Igneous rocks in Barton and Fildes Peninsulas show isotopic age of Early Cenozoic. The apparent K-Ar whole-rock ages of the Barton volcanic rocks are younger than those from Fildes Peninsula. However, since the ages of the Barton Peninsula volcanics are assumed to have been reset by reheating during granitic intrusions, their true ages may be older than the apparent ages and be similar to those of the Fildes Peninsula volcanics. The volcanic rocks in the Barton and Fildes areas generally represent the tholeiitic characteristics. The granitic rocks in the Barton area exclusively show the calc-alkaline natures. The volcanic magmas erupted on the areas were probably generated at the upper mantle, but the granitic magmas intruded into the Barton Peninsula area were originated by the partial melting of lower crust or by the mixing of the magma with crustal material.

Keywords: K-Ar age, Cenozoic magmatism, tholeiitic, calc-alkaline, King George Island

Introduction

King George Island (KGI) is located at the northeastern part of the South Shetland Islands (SSI), a magmatic island-arc of Jurassic - Quaternary. The forming of KGI is a Late Cretaceous - Tertiary representative of the magmatism along the Pacific side of the northern Antarctic Peninsula (Pankhurst and Smellie, 1983; Smellie et al., 1984). After the comprehensive study of the magmatism around KGI by Smellie et al. (1984), new data on the igneous rocks in Barton and Fildes Peninsulas in terms of age and geochemistry have been reported by Korea Antarctic Research Program since 1989 (Kang and Jin, 1989; Park, 1989; Jin and Jwa, 1990; Jwa, 1991; Park and Jwa, 1991). Here, the results of these works are reviewed by comparing K-Ar radiometric age and geochemical nature of the volcano-plutonic rocks in the area.

Geological Setting

Barton as well as Fildes Peninsula situates in the western part of KGI. The igneous rocks there consist mainly of lava and pyroclastic flows, subvolcanic rocks and granitic rocks (Fig. 1). Widespread propylitic and argillic alterations are prevalent in the area (Park, 1991). The lithostratigraphical division of KGI is slightly different in each study. Smellie et

Fig. 1. Simplified geologic map of the western King George Island. 1, lava and pyroclastic flows; 2, subvolcanic rocks; 3, granitic rocks; 4, fault; K, King George Island; N, Nelson Island; R, Robert Island; G, Greenwich Island; L, Livingston Island; D, Deception Island; S, Snow Island; GP, Gemel Peaks; C, Chilean Station.

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al. (1984) divided the stratigraphy of KGI into two formations - lower Fildes Formation and upper Hennequin Formation - from the lithological characteristics. According to their division, the rocks occurred in the western part of KGI belong to the Fildes Formation. By contrast, Birkenmajer (1983) separated the Barton and Weaver Peninsula area (Barton Horst) from the Fildes Peninsula (Fildes Block) and Potter Peninsula (Warszawa Block) areas with large scale strike-slip faults. The Barton Horst consists mainly of Palaeogene volcanic-sedimentary complex, whereas the Fildes Block, downthrown with respect to the Barton Horst, consists of Palaeocene - Eocene volcanics and sediments, equivalent to the Palaeogene part of the Warszawa Block suite (Birkenmajer et al., 1990). Recently a new stratigraphical division has been proposed for Fildes Peninsula by Chinese geologists (Zheng and Liu, 1990; Li and Liu, 1991). They distinguished four distinct volcanic stratigraphical members and subdivided the strata in Fildes Peninsula into lower Great Wall Formation and upper Fossil Formation. The Great Wall Formation is distributed in the western and southern parts of the peninsula, whereas the Fossil Formation in the eastern and northern parts. Both formations were intruded by subvolcanic rocks which occur as sporadic outcrops.

In the western part of KGI, the outcrops of granitic intrusives of quartz-diorite and granodiorite are observed exclusively in Barton Peninsula. Though the boundaries between the intrusives and volcanic strata are mainly of fault contact, it seems that the granitic rocks intruded into the volcanic strata, judging from the volcanic enclaves such as basalt and basaltic andesite within the granitic body.

**Age Relationships**

Table 1 represents the result of K-Ar whole-rock analysis which was reported recently in KGI (Park, 1989; Park and Jwa, 1991). The Fildes Peninsula volcanic rocks show the ages of 53 to 61 Ma (Paleocene - Eocene). The age of basaltic andesite from the lower Great Wall Formation (No. 1 in Table 1) is about 60 Ma and those from the upper Fossil Formation (Nos. 2 and 3) show 56 and 61 Ma. Subvolcanic basalts (Nos. 4 and 5) which intruded into both formations show the ages of 53 Ma. This result is in general agreed with Chinese lithostratigraphical divisions. On the other hand, the Barton Peninsula volcano-plutonic rocks have ages of 36 to 49 Ma (Eocene - Early Oligocene). It is understood that the apparent ages of the Fildes Peninsula volcanic rocks are older than those of the Barton Peninsula volcano-plutonic rocks. However, since the K-Ar ages of the volcanic rocks in Barton Peninsula are assumed to have been reset by reheating process during granitic intrusions (Birkenmajer, 1989), the true ages of the volcanic rocks can be older than the apparent ages.

In Fig. 2, the K-Ar ages of the volcanic and plutonic rocks in Fildes and Barton Peninsulas are selected from the published data to show the range and median of the ages (Grikurov et al., 1970; Watts, 1982; Smellie et al., 1984; Kang and Jin, 1989; Park, 1989; Zheng and Liu, 1990; Park and Jwa, 1991). As a whole, the data indicate the Early Cenozoic igneous activity in the area. For the Fildes Peninsula area, the age range and median of the Great Wall and Fossil Formation volcanics (GWF and FF) are compared with each other. The GWF (57 Ma of median) is slightly older than the FF (49 Ma). From the areal distribution of the GWF and FF in Fildes Peninsula, it can be deduced that the magmatic activities moved toward the north and the east over time. This kind of migration can be interpreted that it follows a general trend of northeastward migration of magmatism in the SSI reported by Smellie et al. (1984). The range and median age of the Barton Peninsula granitoids (BG) is similar to those of the FF, whereas the Barton Peninsula volcanics (BV) shows younger age. If the K-Ar ages of the volcanics on Barton Peninsula were reset due to the granitic intrusion, the initiation of volcanism in the peninsula should have anteceded the stage of intrusion (about 60–40 Ma). This indicates that the volcanism in Barton Peninsula is not so different in its stage from that in Fildes Peninsula. Hence,

**Table 1. Analytical data of K-Ar whole-rock method.**

<table>
<thead>
<tr>
<th>Rock</th>
<th>%K</th>
<th>%Ar (rad nl/g)</th>
<th>%Ar (atmos.)</th>
<th>Age (Ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fildes Peninsula</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. basaltic andesite</td>
<td>0.337</td>
<td>1.411</td>
<td>55.7</td>
<td>59.5±3.0</td>
</tr>
<tr>
<td>2. basaltic andesite</td>
<td>0.749</td>
<td>3.238</td>
<td>68.4</td>
<td>61.4±2.4</td>
</tr>
<tr>
<td>3. basaltic andesite</td>
<td>0.400</td>
<td>1.581</td>
<td>79.3</td>
<td>56.2±2.7</td>
</tr>
<tr>
<td>4. basalt</td>
<td>0.452</td>
<td>1.691</td>
<td>41.6</td>
<td>53.2±2.5</td>
</tr>
<tr>
<td>5. basalt</td>
<td>0.293</td>
<td>1.096</td>
<td>75.7</td>
<td>53.2±3.0</td>
</tr>
<tr>
<td>Barton Peninsula</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. andesite</td>
<td>0.204</td>
<td>0.696</td>
<td>82.2</td>
<td>48.5±4.0</td>
</tr>
<tr>
<td>7. basaltic andesite</td>
<td>0.233</td>
<td>0.577</td>
<td>88.8</td>
<td>35.5±3.4</td>
</tr>
<tr>
<td>8. lapilli tuff</td>
<td>0.614</td>
<td>1.906</td>
<td>70.7</td>
<td>44.2±2.4</td>
</tr>
<tr>
<td>9. granodiorite</td>
<td>2.501</td>
<td>7.929</td>
<td>32.3</td>
<td>45.2±1.9</td>
</tr>
<tr>
<td>10. granodiorite</td>
<td>2.070</td>
<td>6.117</td>
<td>29.1</td>
<td>42.1±1.9</td>
</tr>
<tr>
<td>11. quartz-diorite</td>
<td>0.736</td>
<td>2.334</td>
<td>58.4</td>
<td>45.2±2.4</td>
</tr>
</tbody>
</table>

Data sources: Park (1989) for Barton Peninsula; Park and Jwa (1991) for Fildes Peninsula.
Fig. 2. A box plot showing the ranges of K-Ar whole-rock ages of the volcanic and plutonic rocks in Fildes and Barton Peninsulas. Data sources: for Fildes Peninsula (GWF and FF), Zheng and Liu (1990) and Park and Jwa (1991); for Barton Peninsula (BG and BV), Grikurov et al. (1970), Watts (1982), Smellie et al. (1984), Kang and Jin (1989) and Park (1989).

it is assumed that the displacement of the Barton Horst with respect to the Fildes Block was not great.

Geochemical Relationships
For the comparison of geochemical characteristics of the volcanic and plutonic rocks in Fildes and Barton Peninsulas, the data of major and rare earth elements were cited from Jin and Jwa (1990) and Jwa (1991). For the genetic consideration of the igneous rocks, a FeO*/(total iron as FeO)/MgO vs. SiO₂ diagram from Miyashiro (1974) was used (Fig. 3). Since hydrothermal alteration is widespread in the areas (Park, 1991), the discrimination diagrams of using alkaline contents that show strong mobility during alteration process can not be applied. The Great Wall Formation volcanics (GWF) in Fildes Peninsula entirely exhibit tholeiitic nature, whereas the Fossil Formation (FF) and Barton Peninsula volcanics (BV) straddle between tholeiitic and calc-alkaline natures. The Barton Peninsula granitic rocks (BG) almost enter into the field of calc-alkaline series.

In Fig. 4, the geochemical variations are considered by using REE patterns. The existence of Eu anomaly and the ratio between light rare earth elements (LREE) and heavy rare earth elements (HREE) are the useful keys to identify the tholeiitic and calc-alkaline natures. For the tholeiitic rocks, the REE pattern generally shows relatively positive Eu anomaly and low LREE/HREE ratio. On the other hand, the pattern for calc-alkaline rocks exhibits relatively negative Eu anomaly and high LREE/HREE ratio. The GWF shows typical tholeiitic patterns, whereas the FF exhibits both tholeiitic and calc-alkaline patterns. The BV shows both patterns, whereas the BG exhibits calc-alkaline patterns.

In Figs. 3 and 4, it is understood that the volcanic rocks in Barton and Fildes Peninsulas generally show tholeiitic natures, whereas the granitic ones in Barton Peninsula exhibit calc-alkaline. This may come from the compositional differences between the volcanic and granitic magmas. From the

Fig. 3. A plot of FeO*/ (total iron as FeO)/MgO versus SiO₂ variation for the volcanic rocks in the western King George Island. The boundary between tholeiitic (TH) and calc-alkaline (CA) fields is from Miyashiro (1974). Symbols: crossed square, Great Wall Formation; solid square, Fossil Formation; solid circle, Barton Peninsula volcanics; open circle, Barton Peninsula granitic rocks.

Fig. 4. Chondrite-normalized REE patterns for the volcanic and plutonic rocks from Fildes and Barton Peninsulas. GWF, Great Wall Formation; FF, Fossil Formation.

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previous studies on Sr isotopic ratios, the volcanic rocks in
Fildes Peninsula represent a narrow Sr initial range of
0.7032 - 0.7038 (Smelie et al., 1984; Li and Liu, 1991). This
indicates that the magmas were generated from partial melts
at the upper mantle. However, the granitic magmas in
Barton Peninsula showing Sr initial ratio of 0.70671 (Kang
and Jin, 1989) were originated by partial melting of the
lower crust or by mixing of the magma generated at the
upper mantle with crustal material.

Conclusion
From the geochronological review of the volcano-plutonic
rocks in the Barton and Fildes Peninsula areas, it is recog-
nized that the magmatism occurred in the Early Cenozoic
time. Considering the time resetting due to the granitic
intrusion, the true K-Ar ages of the volcanic rocks on Barton
Peninsula are probably older than its apparent ages and the
stage of volcanism seems likely to be similar to that occurred
in Fildes Peninsula.

The geochemical natures of the volcanic rocks generally
show the tholeitic trend. Different from the volcanics, the
granitic rocks in Barton Peninsula show exclusively calc-
alkaline nature. The volcanic magmas erupted in the Barton
and Fildes areas were probably generated at the upper
mantle, but the granitic magmas intruded into the Barton
area were generated by the partial melting of the lower crust
or by the mixing of magma with crustal material.

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