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Rb-Sr Dating of the Gneissic Rocks from the East Coast of Lützow-Holm Bay, Antarctica

By

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Abstract

Rb-Sr age determinations have been carried out on rock samples collected in the area along the east coast of Lützow-Holm Bay, East Antarctica. Two different age groups of 458±10 my. and 1,110 ± 100 my. have been obtained from the biotites and K-feldspars, respectively. The present Rb-Sr age of biotites is in close agreement with the determinations in previous works, indicating that the last metamorphic acitvity occurred in the early Paleozoic age.

The age of 383 my. of the K-feldspar on the rock from the Yamato Mountains differs widely from those of other samples from the east coast of Lützow-Holm Bay.

Introduction

East Antarctica was originally believed to be composed of Precambrian rocks as are most other continental shields. However, results of increasing radiometric age determinations of the rocks in East Antarctica in recent years using various methods reveal ages ranging from 337 my. to 1,792 my. (SHIMA, 1967).

The area along the Lützow-Holm Bay including East Ongul Island on which Syowa Station (69°00′S, 39°35′E) is located, is mostly composed of high-grade metamorphic rocks. Some radiometric datings of these rocks have been carried out and so far almost all the rock samples give ages in a range from 400 my. to 500 my. (NICOLAYSEN *et al.*, 1963).

T. MAEGOYA was a member of the 7 th Japanese Antarctic Research Expedition's Wintering Party, and for the purpose of radiometric dating, collected rock samples from the area along the east coast of Lützow-Holm Bay and from the Yamato Mountains.

This paper is a part of the Rb-Sr age determinations of these rocks now in progress at the Department of Geology and Mineralogy, University of Kyoto.

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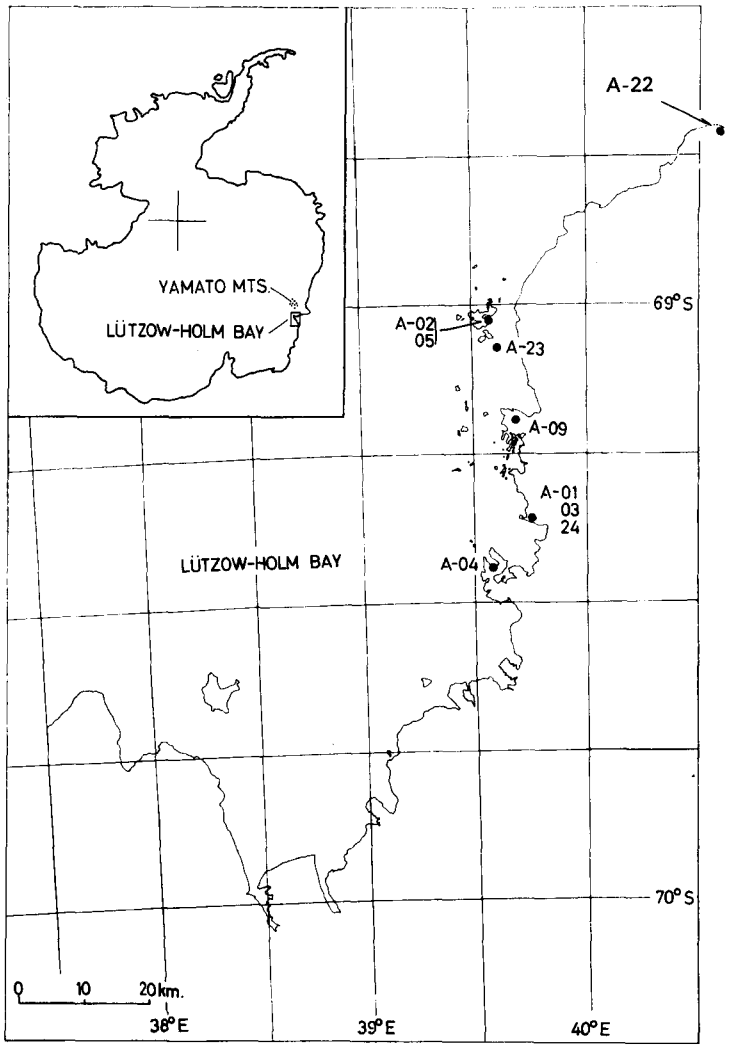

Fig. 1. Index map.

Geological Setting

There are several rocky hills attaining maximum heights of 400 m. to 500 m. along the east coast of Lützow-Holm Bay. Small flat and smooth islands are also scattered along the coast. All these rocky areas show strong evidence of past glaciations by continental ice sheet. Glacial evidence such as polished surfaces, striations, and grooves are found to be more freshly preserved in the coastal regions than those on coastal islands. This suggests a considerable time difference in the periods

of glaciation, probably in the order of several thousand years or more. The effect of isostatic rebound after deglaciation has been also noticed in the raised beaches 15–20 m. above the present sea level, which are observed in many places in this region.

The first geological survey of this area was undertaken by T. TATSUMI and T. KIKUCHI in 1957–1958. A later survey was made by K. KIZAKI in 1960–1961. They classified the rocks exposed and found in the area along the Lützow-Holm Bay into the following nine types.

(1) Metabasites
(2) Marbles and quartzites
(3) Pyroxine gneisses
(4) Hornblende gneisses
(5) Garnet gneisses
(6) Granitic gneisses and granites
(7) Microcline and hornblende pegmatites
(8) Glacial morainic deposits and erratic boulders
(9) Fossil shell-bearing sand and gravel deposits

The trend of gneissosity of these bedrocks has no fixed large scale direction, and varies from place to place. Pyroxine gneisses are comparable to some of the charnockites of the coastal hills of Enderby and Adelie lands.

Detailed studies of the geology and structure of East Ongul Island were carried out on a scale of 1 : 5,000 by K. KIZAKI in 1961. He detects two phases of metamorphism in the area; an earlier granulite facies and a later amphibolite facies.

The Yamato Mountains consist of seven small mountain blocks forming a mountain arc and an inner sub-arc. According to TATSUMI *et al.* (1963), the area is characterized by the predominance of granitic and migmatitic rocks, in contrast to the coastal area along the Lützow-Holm Bay where gneisses of basic to intermediate composition predominate.

As to the isotopic ages of the rocks in the Lützow-Holm Bay, several determinations have been made by Rb-Sr, K-Ar, and U-Pb methods. The results obtained range from 350 my. to 530 my.

Only one single age determination concerning the Yamato Mountains has been reported so far; this by PICCIOTO and COPPEZ (1963) and given as 457 my. using the Rb-Sr method.

Experimental Methods

Rocks are crushed into −60 to +80 meshes, and biotites and K-feldspars are separated by an isodynamic separator and heavy liquid to a concentration of more than 97% in purity. Rb and Sr determinations are made by the stable isotope dilution method on a solid type mass spectrometer with a single focusing 60 sector, a 9

inch radius curvature, and a Cu-Be 12 stage electron multiplier. Details of the analytical method are reported elsewhere (K. ISHIZAKA, 1966). Radiogenic Sr^{87} is obtained using the appropriate initial Sr^{87}/Sr^{86} ratio of 0.7115. The present Sr^{87}/Sr^{86} ratios are calculated from the spiked run.

Table 1. Rb-Sr Ages of Biotites from the East Coast of Lützow-Holm Bay, East Antarcitca.

Sample No.	Rb (ppm)	Common Sr (ppm)	$*Sr^{87}$ (ppm)	$^{87}Rb/Sr^{86}$	Sr^{87}/Sr^{86}	Age (my.)
A-01	907.8	3.903	1.817	673.4	5.092	508
A-02	1008.0	15.17	2.013	192.3	2.069	508
A-03	1043.0	11.23	1.931	268.7	2.469	471
A-05	337.5	3.800	0.6178	257.1	2.373	465
A-09	405.3	9.688	0.8398	121.1	1.597	526
A-10	461.1	12.41	0.9552	107.7	1.499	526
A-22	430.4	9.430	0.7585	132.1	1.534	448
A-24	712.7	10.53	1.454	196.0	2.122	442

Rb^{87} decay constant: 1.39×10^{-11}/year
$*Sr^{87}$ (Radiogenic Sr^{87}) was obtained using the appropriate initial Sr^{87}/Sr^{86} of 0.7115.

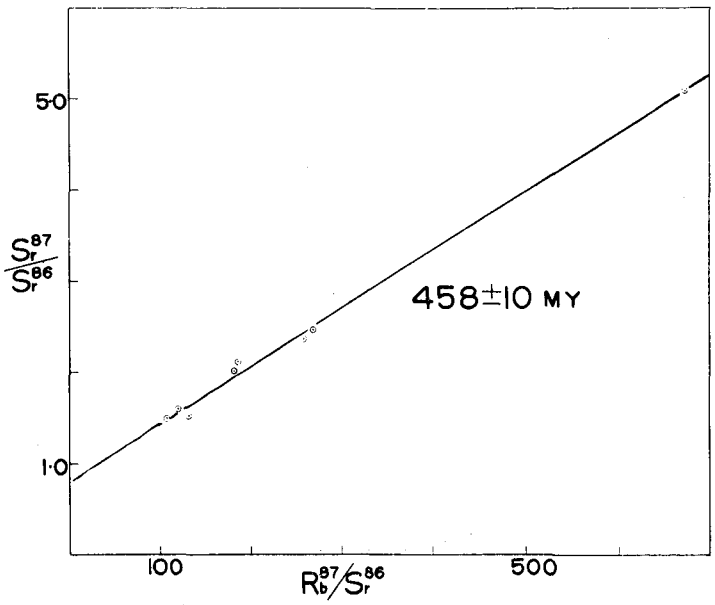

Fig. 2. Rb-Sr isochron of biotites of the gneissic rocks from the east coast of Lützow-Holm Bay, East Antarctica. The displayed age (458±10 my.) and initial Sr^{87}/Sr^{86} ratio (0.793) are determined by the method of least squares.

Results and Discussion

Biotite: Biotites have been separated from eight gneissic rocks collected from the above-mentioned region. The results are listed in Table 1 and displayed in Fig. 2.

Rb/Sr ratios are not high enough to be independent of initial Sr^{87}/Sr^{86} ratio, so that apparent biotite ages range from 442 my. to 526 my., using the initial Sr^{87}/Sr^{86} ratio of 0.7115. But as shown in Fig. 2, plots are well aligned on a single isochron which gives an age of 458 ± 10 my. and an initial Sr^{87}/Sr^{86} ratio of 0.793.

NICOLAYSEN *et al.* (1961) previously reported Rb-Sr datings of biotite in the same region with ages ranging from 500 my. to 530 my. This corresponds with the ages we give. If their data were plotted in an isochron diagram, a result closely agreeing with our isochron in Fig. 2 would be obtained.

U-Pb ages of euxenite in the Skallen district were determined at some 470 my. by SAITO *et al.* (1961). Their data agree with the present Rb-Sr data within the possible analytical errors, with the exception of the Th^{232}-Pb^{208} age (375 ± 27 my.).

K-Ar ages of 350 my. to 421 my. were measured on rocks from East Ongul Island and the Skarvs Nes district by KANEOKA *et al.* (1968). These ages are rather lower than those determined by previous workers. But they suggest that in view of the argon retentivity, the oldest age (421 my.) obtained from the mafic minerals is close to the time when these minerals in the rocks were recrystallized and that the younger ages obtained from whole rock and felsic minerals are essentially due to argon loss from the felsic minerals.

These results suggest that the last metamorphic activity in this region was approximately around 450 my. ago.

K-feldspar: K-feldspars have been separated from seven rock samples. Sample A–08 is the only one collected from the Yamato Mountains, 300 km south-west

Table 2. Rb-Sr ages of K-feldspars from the East Coast of Lützow-Holm Bay, East Antarcitca.

Sample No.	Rb (ppm)	Common Sr (ppm)	$*Sr^{87}$ (ppm)	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}	Age (my.)
A–01	328.0	139.8	1.255	6.790	0.8033	971
A–02	305.0	477.8	0.8718	1.847	0.7301	726
A–04	389.7	635.0	1.143	1.776	0.7299	745
○A–08	184.3	486.0	0.980	3.877	0.7321	383
A–22	174.0	565.6	0.5589	0.8900	0.7216	816
A–23	434.3	166.4	1.732	7.555	0.8177	1,013
A–24	305.9	116.7	1.343	7.586	0.8291	1,116

Rb^{87} decay constant: 1.39×10^{-11}/year

* Sr^{87} (Radiogenic Sr^{87}) was obtained using the appropriate initial Sr^{87}/Sr^{86} of 0.7115.

○ This sample was from the Yamato Mountains, 300 km southwest from Syowa Station.

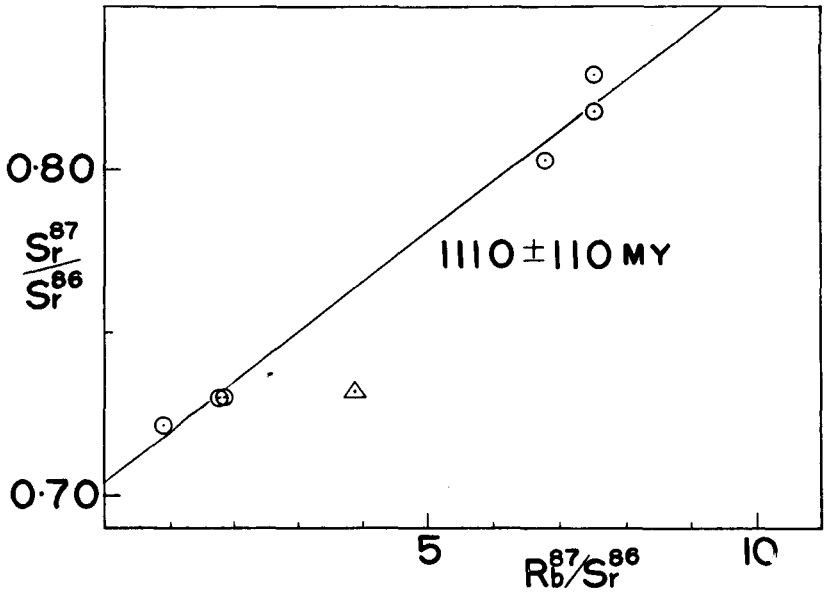

Fig. 3. Rb-Sr isochron of K-feldspars of the gneissic rocks from the east coast of Lützow-Holm Bay, East Antarctica. Sample A–08 from the Yamato Mountains is plotted as triangle, and is not included in the calculation of the displayed age.

of Syowa Station. The results are listed in Table 2 and displayed in Fig. 3.

The apparent age of 383 my. measured on A–08 K-feldspars differs widely from those of other samples collected in the east coast of Lützow-Holm Bay. The geology of the Yamato Mts. is characterized by the development of migmatitic rocks in contrast to the Lützow-Holm Bay area where various gneisses predominate (KIZAKI *et al.*, 1963). Apart from this geological contrast, we have no age datum other than that of PICCIOTTO and COPPEZ (457 my. by Rb-Sr method). More geochronological investigation with reference to the geological structure and the petrographic characteristics of the region is needed before we can reach any conclusion which explains the considerable discrepancy between the biotite age of 457 my. and the K-feldspar age of 383 my.

As shown in Fig. 3, the displayed isochron gives a K-feldspar age of 1,110±110 my. and an initial Sr^{87}/Sr^{86} ratio of 0.704, although the small Rb^{87}/Sr^{86} ratio may result in the low reliability of the ages of the K-feldspar. But considerable differences in the age and initial Sr^{87}/Sr^{86} ratio between the biotite and the K-feldspar seem to be significant. The present Sr^{87}/Sr^{86} ratios of the K-feldspars from samples A–02, A–04, and A–22 are lower than the initial biotite Sr^{87}/Sr^{86} ratio of 0.793. These facts may indicate that the analysed rocks have not maintained a closed

system for Rb and Sr since the preceeding metamorphic events. Abundant age data around 450 my. would correspond to the later phase of the metamorphic event which KIZAKI defined as the amphibolite facies. However, further investigation is needed to determine whether the K-feldspar age obtained in the present study represents an earlier metamorphic episode.

Conclusion

1 Rb-Sr age determinations have been carried out on rock samples collected in the area along the east coast of Lützow-Holm Bay, East Antarctica.
2 Biotites have been separated from seven gneissic rocks in the region. The biotite ages range from 442 my. to 526 my. using the initial Sr^{87}/Sr^{86} ratio of 0.7115. But an isochron gives an age of 458 ± 10 my. and an initial Sr^{87}/Sr^{86} ratio of 0.793.
3 The present Rb-Sr age of biotie given at 458 ± 10 my. is in close agreement with previous measurements, indicating that the last metamorphic activity in this region occurred approximately 450 my. ago.
4 K-feldspars have been separated from six gneissic rocks in the east coast of Lützow-Holm Bay and one sample from the Yamato Mountains. The K-feldspar ages of the rocks from the Lützow-Holm Bay range from 745 my. to 1,116 my. using the initial Sr^{87}/Sr^{86} ratio of 0.7115. But an isochron gives an age of $1,110 \pm 100$ my. and an initial Sr^{87}/Sr^{86} ratio of 0.704.
5 The K-feldspar age of 383 my. on A–08 from the Yamato Mountains differs widely from those of other samples collected in the east coast of Lützow-Holm Bay.
6 A report to be presented after the completion of further measurements will assess the geological significance of the K-feldspar ages.

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