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PRELIMINARY RESULT FOR THE Rb-Sr MINERAL ISOCHRON AGES OF GRANITIC ROCKS FROM CAPE OMEGA AND OKU-IWA ROCK, PRINCE OLAV COAST, EAST ANTARCTICA

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Abstract: The granitic rocks of the Cape Omega, and Oku-iwa Rock, yield the age of 439.0±12.3 Ma with an initial Sr isotope ratio of 0.70609±0.00014 and 417.9±2.2 Ma with an initial Sr isotope ratio of 0.70646±0.00002, respectively. These ages represent the time when these granitic rocks cooled down to the closure temperature of biotite and are consistent with previous reported K-Ar biotite ages (339–449 Ma) of granitic rocks in the Lützow-Holm Complex.

Calculated cooling rates of the Cape Omega and the Oku-iwa Rock areas are 5.3–4.1°C/Ma and 3.8–3.6°C/Ma, respectively. These results are consistent with cooling rates for the amphibolite facies terrain of the Lützow-Holm Complex previously reported.

key words: Rb-Sr mineral age, cooling rate, Cape Omega, Oku-iwa Rock, Lützow-Holm Complex

1. Introduction

Early Paleozoic granitic rocks are widely distributed throughout the Lützow-Holm Complex (LHC) (SUZUKI and MORIWAKI, 1979; YANAI *et al.*, 1974a, b; ISHIKAWA *et al.*, 1976; YOSHIDA *et al.*, 1976; NAKAI *et al.*, 1981; SHIRAISHI and YOSHIDA, 1987; ISHIKAWA *et al.*, 1994) which is a Cambrian high-grade metamorphic terrain, East Antarctica (SHIRAISHI *et al.*, 1994). Most of the K-Ar and Rb-Sr mineral ages for metamorphic rocks in the Complex cluster around 500 Ma, which have been interpreted to be the time of cooling after the regional metamorphism and/or granite intrusions (SHIBATA *et al.*, 1985). Recently, SHIRAISHI *et al.* (1994) obtained U-Pb zircon ages of 520–550 Ma from several samples of different metamorphic grade within the LHC and interpreted these zircon ages as the time of granulite facies metamorphism.

On the other hand, the Rb-Sr mineral age of hornblende biotite gneissose granite from the East Ongul Island have been dated at 482.5±9.5 Ma (SHIBATA *et al.*, 1985), and K-Ar biotite ages of gneissose granites from the West Ongul Island and the Austhovde have been dated at 399 Ma and 449 Ma, respectively (YANAI and UEDA, 1974; FRASER and MCDOUGALL, 1995). Most recently, the Rb-Sr whole-rock isochron age for the migmatites and the peraluminous granites from Breidvågnipa have also been measured to be 570±46 Ma (SHIMURA *et al.*, 1998). These ages are obtained from the granitic rocks in the granulite-facies zone of the LHC. Most granitic rocks in other metamorphic zones (transitional zone and amphibolite-facies zone) of the Complex have not been dated yet so that are do not yet have enough data to discuss relationships between petrological characteristics of the granitic rocks and high-grade metamorphism. In this paper, the authors report the modes of occurrence of the granitic rocks from the Cape Omega and Oku-iwa Rock in the transitional zone of the LHC, and present their Rb-Sr mineral isochron ages.

2. Description of Samples

Cape Omega is located about 80 km away from Syowa Station, East Ongul Island and is composed of three main ice-free areas: Omega-nisi, Omega-naka and Omega-higasi (SUZUKI and MORIWAKI, 1979). It is located in the transitional zone in the LHC (Fig. 1), and is underlain by hornblende gneiss, clinopyroxene gneiss, biotite gneiss, garnet biotite gneiss, metabasite, gneissose granite, pink granite and pegmatite.

The pink granite has a close association with metamorphic rocks. The structure of the granitic body coincides with folded structures of the surrounding metamorphic rocks (SUZUKI and MORIWAKI, 1979). The granite shows contacts with surrounding gneissose rocks which are generally concordant, but in some places cross-cuts the gneissic fabric (Fig. 2A, B). The rock is fine- to medium-grained and massive in appearance. Analyzed sample collected from the Omega-nisi Rock (Fig. 3B) is mainly composed of quartz (47.3 modal%), K-feldspar (26.5%), plagioclase (20.1%) and biotite (3.4%). They have a

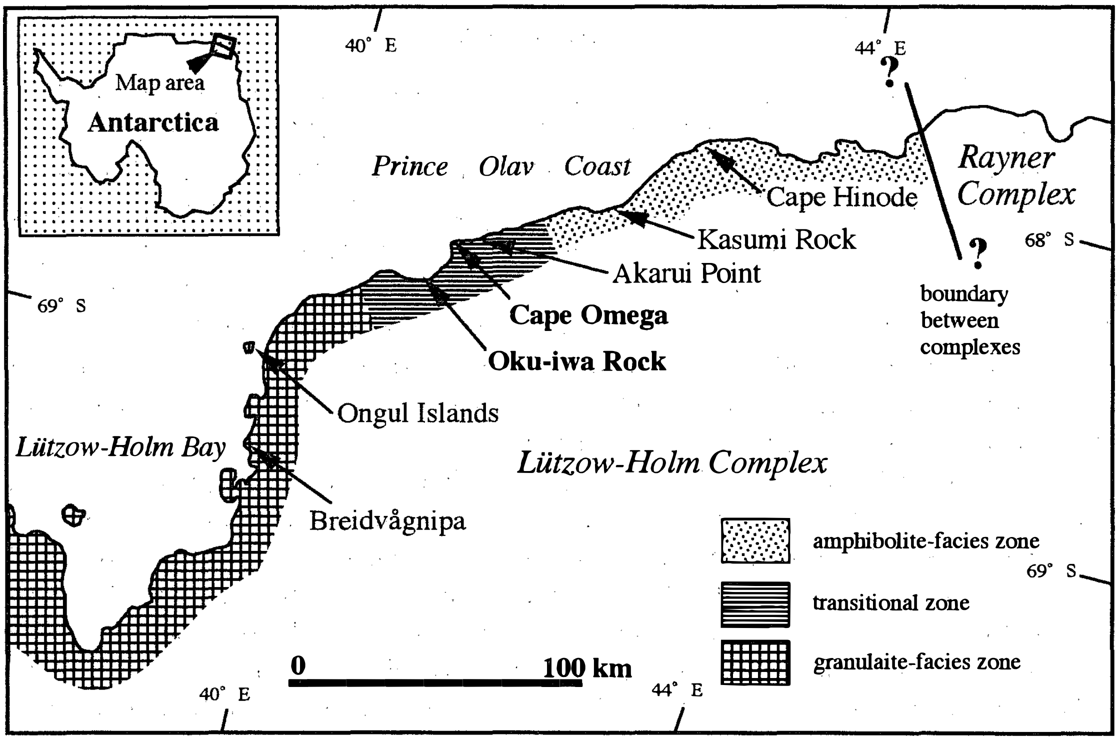

Fig. 1. Locality map of the study area. Metamorphic facies boundaries are after HIROI et al. (1991).

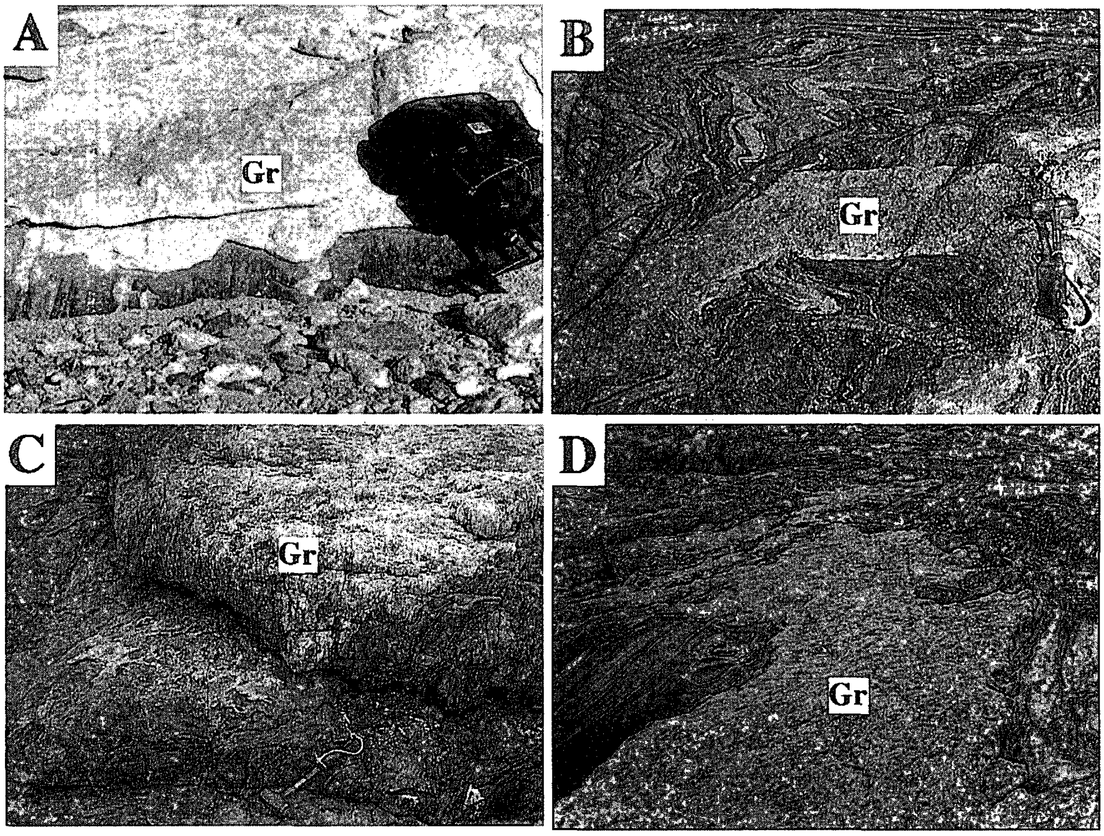

Fig. 2. Field occurrences of the granitic rocks. Gr, granitic rock. (A) Massive granitic rock in the Omega-nishi Rock. (B) Granitic rock cross-cuts the gneissic fabric in the Omega-nishi Rock. (C) Occurrence of the massive granitic rock in the Oku-iwa Rock. (D) Granitic rock cross-cuts the gneissic fabric (middle part of photograph) in Oku-iwa Rock.

general grain size of around 1 mm in diameter and exhibit equigranular texture (Fig. 4A, B). Apatite, hornblende and ilmenite occur as accessory minerals (2.7%), and muscovite and chlorite as secondary minerals. Quartz crystals are subhedral to anhedral grains that usually exhibit weak undulatory extinction. Perthite and antiperthite are common in K-feldspars. Subhedral plagioclases are partly corroded grains; some of them show myrmekite with quartzes. Some subhedral to anhedral biotites have been partly altered to secondary chlorites.

Oku-iwa Rock is located 58 km northeast of Syowa Station and is also situated in the transitional zone (Fig. 1). The main exposed basement rocks are composed of biotite gneiss, biotite hornblende gneiss, pink granite, aplite and pegmatite (NAKAI *et al.*, 1981).

The pink granite occurs as a small discordant mass on the northeast seashore of this area and shows remarkable folded structures (NAKAI *et al.*, 1981). It has no chilled margins and cross-cuts the gneissic fabric in some places (Fig. 2C, D). A xenolith of the biotite hornblende gneiss and migmatitic occurrence are observed. The rock (Fig. 3A) is medium- to coarse-grained and fresh in hand specimen. It shows granitic texture without distinctive foliation (Fig. 4C, D). Main constituent minerals are K-feldspar (52.1%), quartz (32.5%), plagioclase (13.3%) and biotite (1.8%). They have a dominant grain size of around 3 mm diameter. Sphene, magnetite and ilmenite occur as accessory minerals

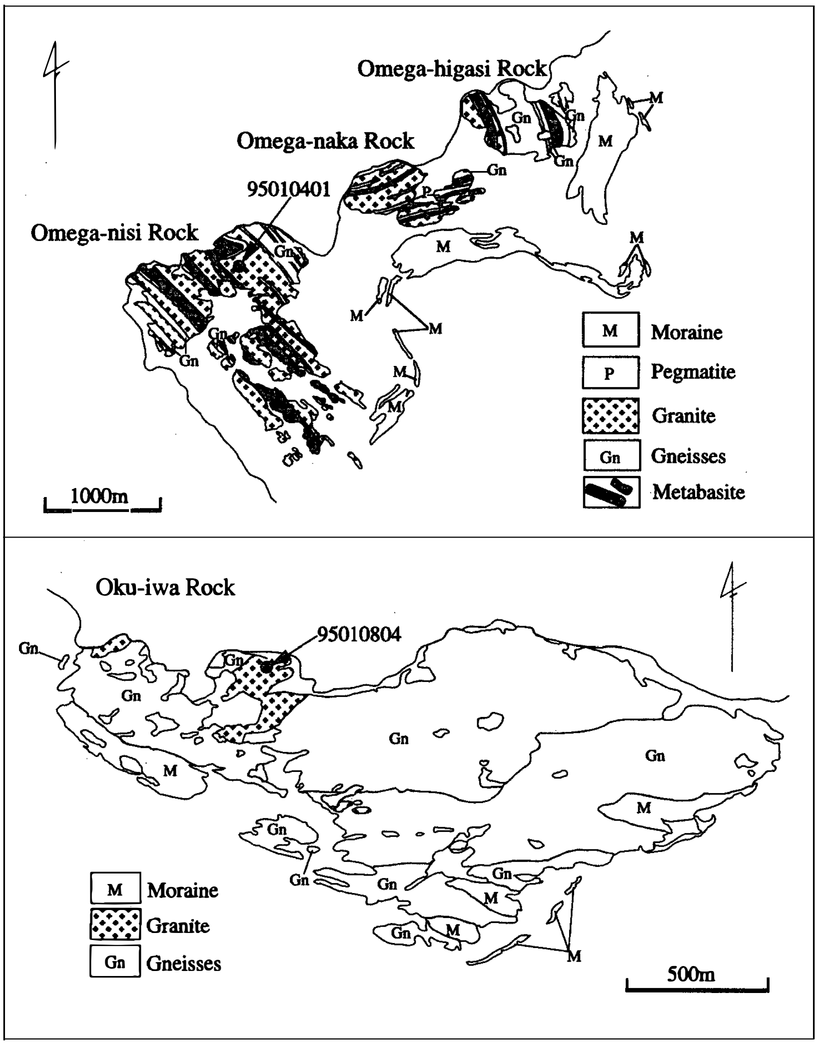

Fig. 3. Sample localities in Cape Omega (simplified from SUZUKI and MORIWAKI, 1979) and Oku-iwa Rock (simplified from NAKAI et al., 1981).

(0.3%). Perthite and antiperthite are very common. Quartz crystals are subhedral to anhedral shaped and usually exhibit weak undulatory extinction. Corroded plagioclases are common in thin section. Biotites are subhedral to anhedral shaped and show brown to dark brown.

As mentioned above, the granitic rocks have a close association with the metamorphic rocks and show folded structures. Furthermore, they show contacts with surrounding gneissose rocks which are generally concordant. From these field observations, the granitic rocks in both areas are inferred to have intruded at the latest metamorphic stage.

3. Analytical Procedures

Plagioclase, K-feldspar and biotite were separated from the rock samples by flotation, isodynamic separation and hand picking. Isotopic analyses were performed on a MAT261-type (modified from MAT260) mass spectrometer at the Graduate School of

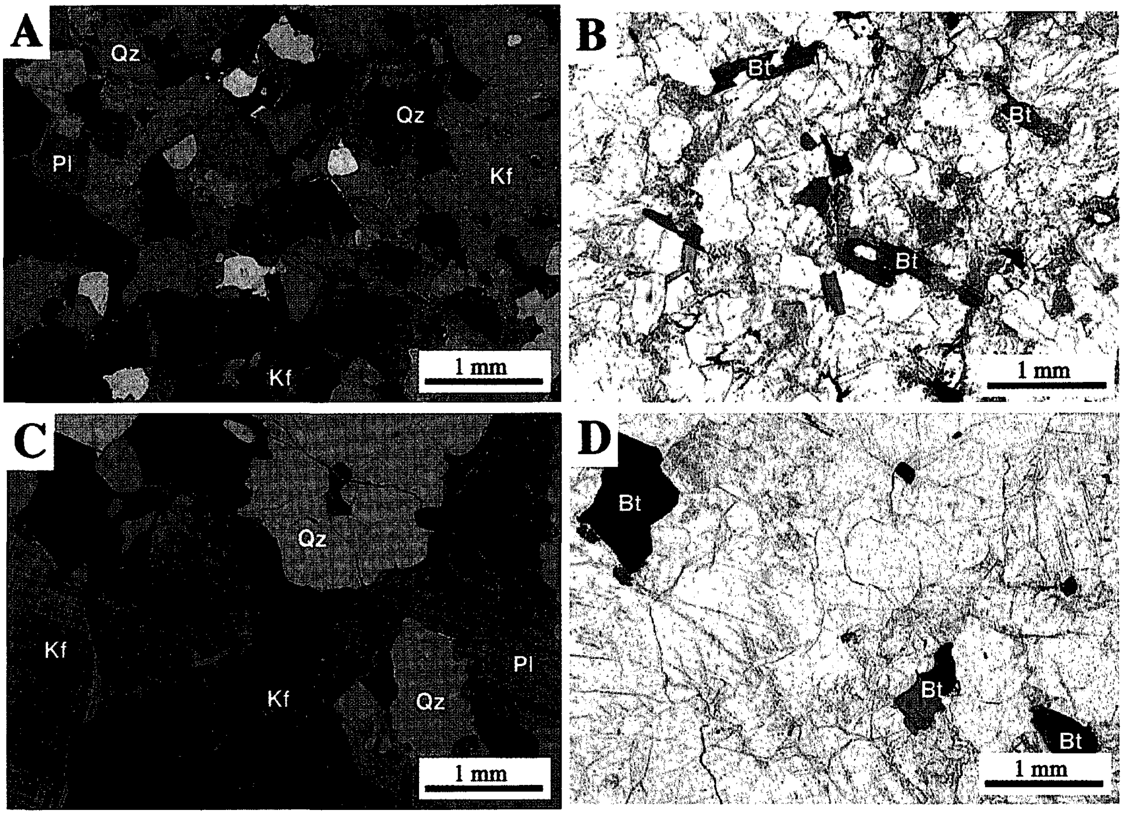

Fig. 4. Photomicrographs of the granitic rocks. Qz, quartz; Pl, plagioclase; Kf, K-feldspar; Bt, biotite. (A) Photomicrographs of granitic rock (95010401) from the Cape Omega. Crossed polars. (B) Same A. Plane polarized light. (C) Photomicrographs of granitic rock (95010804) from the Oku-iwa Rock. Crossed polars. (D) Same C. Plane polarized light.

Science and Technology, Niigata University equipped with five Faraday cups. The $^{87}Sr/^{86}Sr$ ratios were normalized to $^{86}Sr/^{88}Sr=0.1194$. The blanks for the procedures were <0.09 ng of Rb and <0.70 ng of Sr and the $^{87}Sr/^{86}Sr$ ratio measured for NBS987 was 0.710218±0.000015 (n=11). In addition, the Sr isotopic ratios of GSJ (Geological Survey of Japan) rock reference samples were 0.704054±0.000014 (JB-1a), 0.704022±0.000014 (JB-1b), 0.710753±0.000014 (JG-1a) and 0.709243±0.000013 (JGb-2). Rb and Sr concentrations were determined by isotope dilution using ^{87}Rb-^{84}Sr mixed spike. The ages and initial $^{87}Sr/^{86}Sr$ ratios were calculated by the computer program of KAWANO (1994) using the equation of YORK (1966) and the decay constant $\lambda^{87}Rb=1.42\times10^{-11}/y$ (STEIGER and JÄGER, 1977). The estimated relative errors in the calculation of $^{87}Rb/^{86}Sr$ and $^{87}Sr/^{86}Sr$ ratios are ±1% (1σ) and ±0.01% (1σ), respectively.

4. Results and Discussion

The analytical results are listed in Table 1. The Rb-Sr mineral isochron plot for granite from Cape Omega is shown in Fig. 5. Biotite, K-feldspar, plagioclase and whole-rock points define an isochron age of 439.0±12.3 Ma with an initial Sr isotope ratio of 0.70609±0.00014 and MSWD of 2.11. The Rb-Sr data for granite from Oku-iwa Rock

Table 1. Rb and Sr concentrations and Sr isotopic data of the granitic rocks from Cape Omega and Oku-iwa Rock.

Sample Name		Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
<Cape Omega>					
401PL	Plagioclase	23.7	951	0.072	0.70648 (1)
401KF	K-feldspar	194	978	0.574	0.70981 (1)
401BK	Whole-rock	80.7	650	0.359	0.70828 (1)
401Bio	Biotite	525	127	12.0	0.78058 (2)
<Oku-iwa Rock>					
804PL	Plagioclase	82.4	3181	0.075	0.70689 (1)
804KF	K-feldspar	170	2682	0.184	0.70757 (1)
804BK	Whole-rock	135	2099	0.186	0.70757 (2)
804Bio	Biotite	485	577	2.43	0.72093 (2)

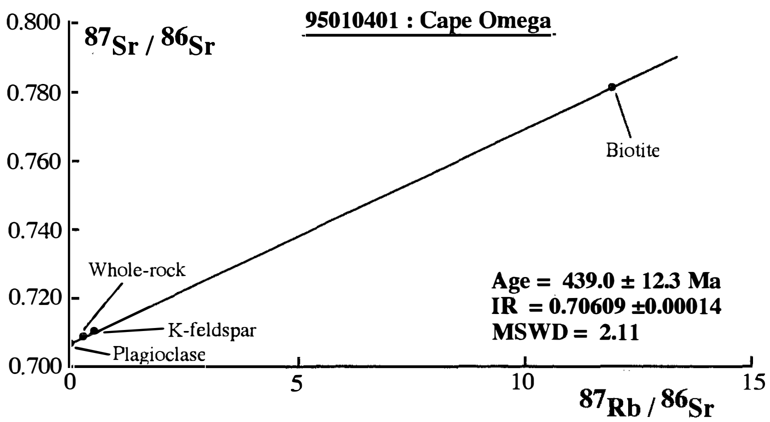

Fig. 5. Rb-Sr mineral isochron diagram for the granitic rock of the Cape Omega.

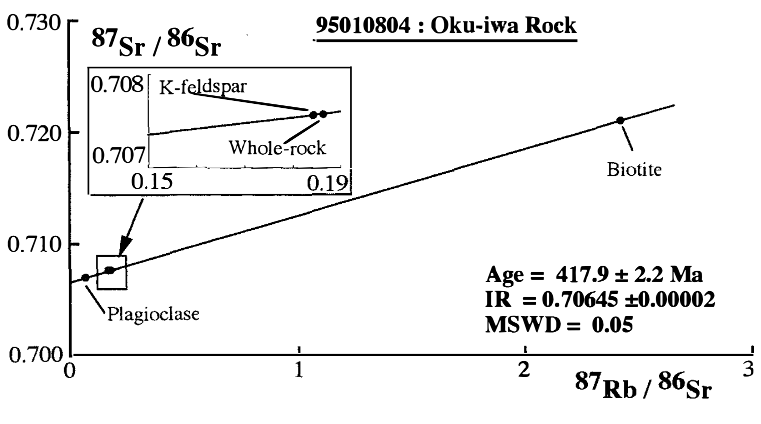

Fig. 6. Rb-Sr mineral isochron diagram for the granitic rock of the Oku-iwa Rock.

are plotted in Fig. 6. Biotite, K-feldspar, plagioclase and whole-rock points define a well-correlated isochron age of 417.9±2.2 Ma with an initial Sr isotope ratio of 0.70646±0.00002 and MSWD of 0.05. The MSWD of the former is larger than that of the latter and the former biotite point lay slightly below the isochron. It might have been caused by chloritization of the biotites.

The obtained Rb-Sr mineral isochron ages appear to indicate the time when these granitic rocks cooled down to the closure temperature of biotite, because these isochrons are controlled by biotite compositions (Figs. 5 and 6). Furthermore, both isochron ages are consistent with K-Ar biotite ages (339–449 Ma) of the granitic rocks from the LHC (YANAI and UEDA, 1974; FRASER and MCDOUGALL, 1995).

MAEGOYA *et al.* (1968) reported whole-rock isochron ages of ~1100 Ma for the metamorphic rocks from the LHC. SHIMURA *et al.* (1998) suggested that these ages do not represent the time of metamorphism as the samples were collected from a very wide area, and are unlikely to have isotopically homogenized even during granulite-facies metamorphism. The biotite–K-feldspar mineral isochron age for the metamorphic rocks from Oku-iwa Rock was recalculated using the data of MAEGOYA *et al.* (1968), which yields an age of 434.7±22.0 Ma for sample A-22. The recalculated age is in good agreement with the mineral isochron age obtained in this study.

FRASER and MCDOUGALL (1995) reported cooling rates of the metamorphic rocks from the amphibolite- and granulite-facies zones in the LHC using the K-Ar and ^{40}Ar-^{39}Ar mineral ages combined with the U-Pb zircon ages. Then, we calculate cooling rates for the study areas in the transitional zone using obtained isochron and previous U-Pb zircon ages. We assume that the closure temperature of the mineral isochron age controlled by biotite is ~300±30°C (MCDOUGALL and HARRISON, 1988) and average metamorphism temperature of the transitional zone is 715°C (SUZUKI, 1984; HIROI *et al.*, 1983). The U-Pb zircon age (529±17 Ma) for the garnet-biotite gneiss from Akarui Point (Fig. 1) in the transitional zone is cited from SHIRAISHI (1996). Calculated cooling rates

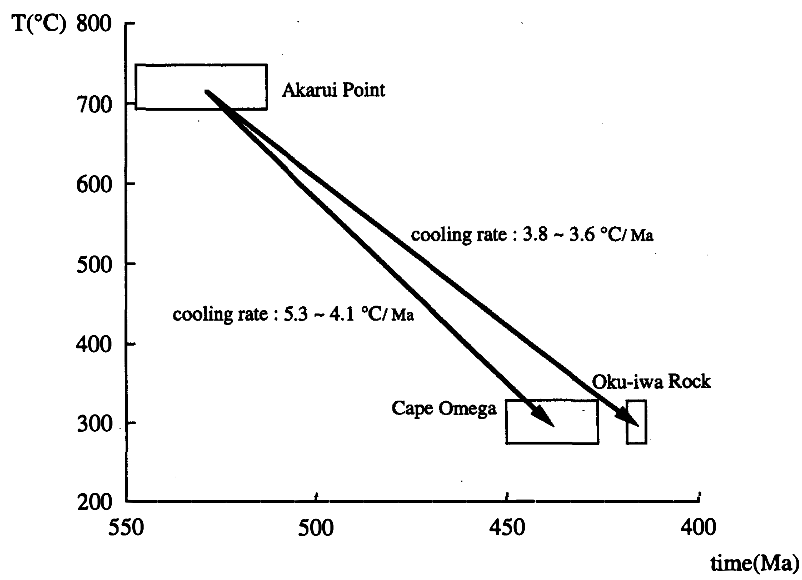

Fig. 7. Temperature versus time cooling curves for the both study areas.

of the Cape Omega and Oku-iwa Rock areas are 5.3–4.1°C/Ma and 3.8–3.6°C/Ma, respectively (Fig. 7). These results are consistent with cooling rates for the metamorphic rocks in Cape Hinode and Kasumi Rock of the amphibolite facies terrain (6.6–4°C/Ma) mentioned by FRASER and MCDOUGALL (1995).

5. Summary

The granitic rocks from Cape Omega and Oku-iwa Rock in the LHC gave Rb-Sr mineral isochron ages of 439 and 418 Ma, which represent the time when these granitic rocks cooled down to the closure temperature of biotite. Calculated cooling rates of both areas are consistent with previous reported cooling rates for the amphibolite facies terrain of the LHC.

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