Antarctic Research, Vol. 7, No. 2, 94～98, December 1996

A Sm-Nd mineral isochron of mafic granulite from the SΦstrene Island, East Antarctica*

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Received May 12, 1996

Abstract Redetermination of the metamorphic age of the garnet-bearing mafic granulite from the SΦstrene Island, Esat Antarctica has been made and an isochron of whole rock-garnet-pyroxene-plagioclase is obtained, giving an age of [604±28(2σ)] Ma. It is pointed out that this age represents the time of peak granulite facies metamorphism of the area. As to the geological relation of the SΦstrene Island with the Bolingen Islands and the Larsemann Hills to the east, it is deduced from the rock assemblages, metamorphic superposition, spatial changes and metamorphic ages between the above regions that the degree of the superposition of the later low pressure metamorphism is becoming stronger from west to east. While the evolution of the earlier medium pressure to later low pressure implies probably the substages of the same metamorphic cycle.
Key words SΦstrene Island, metamorphic age, East Antarctica, granulite.

1 Introduction

The SΦstrene Island (69°29′S, 75°30′E) is situated at the Prydz Bay, East Antarctica. To the east are the Bolingen Islands and the Larsemann Hills (Fig. 1). In the last decade the high amphibolite-granulite facies event has been assigned to mid-late Proterozoic (Sheraton *et al.*, 1984; Stüwe *et al.*, 1989; Stüwe and Powell, 1989). While the medium pressure granulite facies metamorphism of the SΦstrene Island might occur 1262 Ma, 809～923 Ma ago (Hensen *et al.*, 1992). Whereas the major low pressure granulite facies metamorphism of the Larsemann Hills has been redetermined at *c.* 500 Ma before (Zhao *et al.*, 1993). From the above data it seems that there is no direct relation between the SΦstrene Island and the Larsemann Hills. But if we take the transitional changes of the metamorphic reaction textures of the two areas into consideration, it seems that there is something in common with both of them. Due to the small distance

* The project is supported by the State Antarctic Committee of China and the Foundation for Youth of CAGS, China.

between the Sϕstrene Island and the Larsemann Hills and the possible relations of the metamorphic evolution of the two areas, it is necessary to get the metamorphic age of the Sϕstrene Island.

In the Sϕstrene Island mainly crop out medium-fine grained felsic gneisses, subordinatly with aluminum-rich gneisses. In the central part of the island the felsic gneisses contain strongly deformed hornblende-pyroxene-plagioclase gneiss (Fig. 1). Garnet-bearing assemblage is present locally. Bulk composition of the garnet-pyroxene granulite shows that it is silica-unsaturated (normative olivine) with high contents of Ni (735×10^{-6}) and Cr (1289×10^{-6}) (Stüwe *et al.*, 1989), slight enrichment of LREE (95.43×10^{-6}) over HREE (10.47×10^{-6}), L/H=9.11, δEu=0.88. The garnet-pyroxene granulite is fresh and the minerals are garnet (15% in volume, 0.4～8 mm in diameter), pyroxene (60%), or mostly clinopyroxene(1.5～2 mm), plagioclase (18%, 1～1.5 mm), minor hornblende and opaque minerals (less than 2%, 0.6 mm).

Excellent corona texture of two-stage decompression is developed around garnet (Thost *et al.*, 1991). The garnet core-matrix pyroxene pair gives the equilibrium condition 10×10^2 MPa, 980℃, and the garnet rim-fine-grained corona pair 7×10^2 MPa, 850℃. As to geochronology, the garnet core-whole rock Sm-Nd isochron is 1262 Ma, while the garnet rim-whole rock 809～923 Ma(Hensen *et al.*, 1992). This paper will

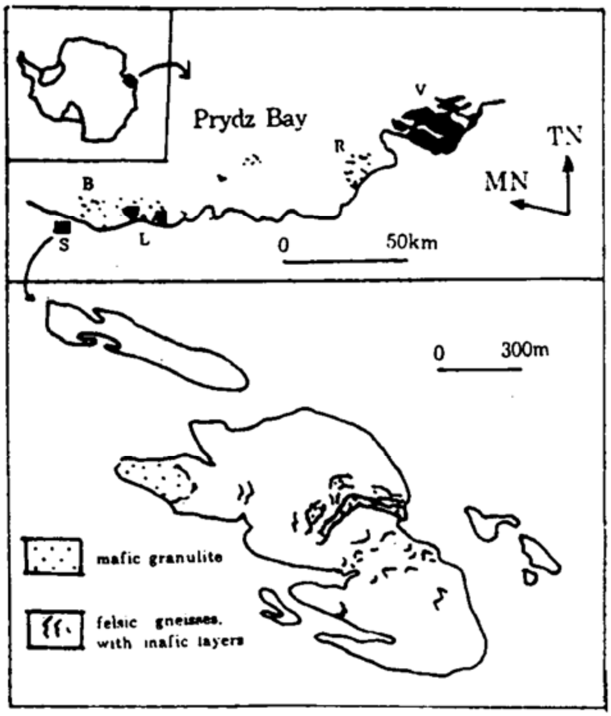

Fig. 1. Schematic map showing the location and lithological units of the Sϕstrene Island, East Antarctica. B-Bolingen Islands, L-Larsemann Hills, R-Rauer Islands, S-Sϕstrene Island, V-Vestfold Hills.

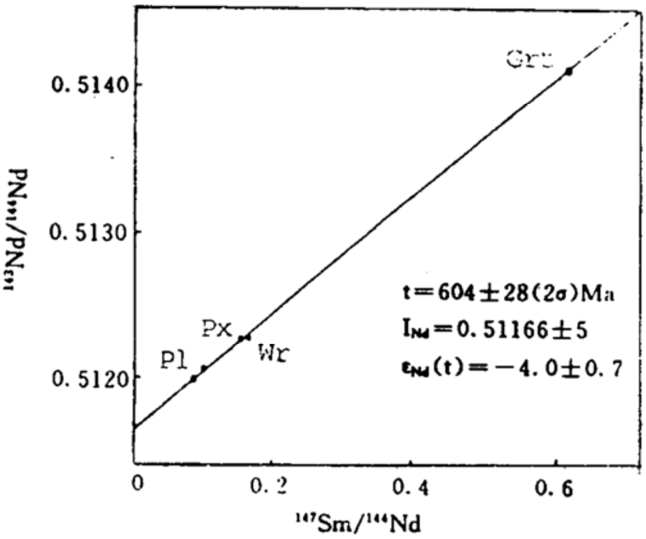

Fig. 2. Sm-Nd isochron diagram of garnet-pyroxene-plagioclase-whole rock of mafic granulite in the Sϕstrene Island, East Antarctica.

present an isochron of garnet-pyroxene-plagioclase (fine grained)-plagioclase (coarse grained)-whole rock of quite different age.

2 Analytical method and results

The method of Zhang and Ye(1987) and Ye and Zhang(1990) for Sm-Nd age determination is adopted here. The Sm, Nd contents are analyzed by isotope dilution method, Nd isotope separation with cation exchange COLUMN (the condition is the same as that of contents analysis), MAT-261 solid isotope mass spectrometer, bi-Re band, M^+ ion pattern, adjustable Faraday tube receiver. Mass fractionation is rectified by $^{146}Nd/^{144}Nd = 0.7219$. Standard measurement result J. M. Nd_2O_3 $^{143}Nd/^{144}Nd = 0.511125 \pm 8 (2\sigma)$, BCR-1 $^{143}Nd/^{144}Nd = 0.512643 \pm 12 (2\sigma)$, the precision of Sm/Nd is less than 0.1%, Sm, Nd blank in process is 5×10^{-11} g, decay constant $\lambda(^{147}Sm) = 6.54 \times 10^{-12}/a$.

By using the above method, we have the analysis result of the granulite from the Sϕstrene Island as in Table 1. The mineral isochron is shown in Fig. 2, giving the isochron age of [$604 \pm 28 (2\sigma)$] Ma, $I_{Nd} = 0.51166 \pm 5 (2\sigma)$, $\varepsilon_{Nd(t)} = -0.4 \pm 0.7$, $t_{DM} =$ 2639 Ma.

Table 1. Sm-Nd isotopic data for the grt-px granulite in the Sϕstrene Island

	$Sm(\times 10^{-6})$	$Nd(\times 10^{-6})$	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$	2σ
Garnet(grt)	2.468	2.423	0.6161	0.514104	8
Pyroxene(px)	8.712	33.075	0.1593	0.51226	8
Plagioclase(f*)	0.687	4.917	0.08455	0.512014	8
Plagioclase(c*)	5.393	33.358	0.09779	0.512014	7
Whole rock(wr)	5.410	20.199	0.1620	0.51225	8

Note* f-fine grained, c-coarse grained. Analysers: Zhang Zongqing and Tang Suohan, Institute of Geology, CAGS.

3 Discussion

As mentioned above, the major minerals of the granulite are distributed essentially along a line with $\varepsilon < 0$ suggesting the event time of isotope resetting. Then what's the implication of this age? what's the relation between the Sϕstrene Island and adjacent Bolingen Islands and the Larsemann Hills? Before answering these questions, let's analyze the possible reason of the difference between the Sm-Nd results about the area.

Generally speaking, the relevant isotope ratio difference between the garnet and whole rock of mafic granulite is large enough to give a reasonable two-point age of a high grade event. But the mafic granulite in the study area is rather heterogeneous and the garnet is very coarse (up to 30 mm in diameter), it is difficult to say a certain sample that really represents the whole rock feature in larger scale. In the method of two-point isochron, derivation of any point away from the real regime will result in directly the low accuracy of the age determination. Whereas the multi-mineral isochron method can deliminate this possible derivation.

What's the geological implication of the age? The closure temperature of the Sm-Nd system in metamorphic garnets is thought to be some 600℃ (Mezger *et al.*, 1992), 700℃ or even granulite facies condition (Basu and Pettingill, 1983). The garnet of the Sϕstrene mafic granulite has undergone more than one episode of granulite facies event (Thost *et al.*, 1991). But the age difference between the garnet core and rim is obvious (Hensen *et al.*, 1992), i. e. isotope homogenization in the garnet grain has not been reached. In other words, the closure temperature of the garnet in this study is well above 600℃. In fact, the factor influencing the resetting of the isotopes is not temperature only. Activity of fluid is also a very important factor. The activities of fluids in the rocks of the Sϕstrene Island overall are very slight, which is in sharp contrast with that of the Larsemann Hills (Stüwe and Powell, 1989). Therefore, the isochron age in this study represents essentially the time of medium pressure granulite facies metamorphism.

Then what's the relation between the Sϕstrene Island and the Larsemann Hills in metamorphism? In lithology, the Sϕstrene Island is dominantly covered with orthogneisses(Stüwe *et al.*, 1989; Thost *et al.*, 1991). To the east the Bolingen Islands, or in the Larsemann Hills paragneisses are increasing in proportion(mainly Al_2O_3-rich and quartzofeldsparthic-rich gneisses). On the other hand, the features of metamorphic superposition and reactions of the three areas are also transitional. The Sϕstrene Island is typical of the earlier medium pressure granulite facies metamorphism (10×10^2 MPa, 980℃) superposed by later thermal event (7×10^2 MPa, 850℃) (Thost *et al.*, 1991); The Bolingen Islands medium pressure event (6.2×10^2 MPa, 810℃) (Wang *et al.*, 1994) was strongly reworked in the decompression event; while the Larsemann Hills to the easternmost are shown only by the relics of the earlier medium pressure assemblages (6.3×10^2 MPa, 750℃) (Wang *et al.*, 1994), the main event is the later low pressure granulite facies metamorphism(4.5×10^2 MPa, 750℃) (Stüwe and Powell, 1989). The internal isochron of pyroxene-hornblende-plagioclase-whole rock of the pyroxene granulite (low pressure assemblage) of Sm-Nd system gives the metamorphic age of (540 ± 75) Ma (Zhao *et al.*, 1993). Hence it seems that the Sϕstrene Island, the Bolingen Islands, the Larsemann Hills, all experienced the earlier (*c.* 600 Ma) medium pressure granulite facies metamorphism, and the later (*c.* 540 Ma) medium-low pressure high grade event is most pronounced in the easternmost Larsemann Hills. As a whole, the earlier medium pressure and later low pressure events might reflect the successive stages of one metamorphic cycle.

Acknowledgment Logistical support was given by the Chinese National Antarctic Research Expedition in the austral summers in 1990/1991 and 1992/1993.

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