Pan-African adakitic rocks from the Sør Rondane Mountains, East Antarctica

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Abstract: The Sør Rondane Mountains (22°E–28°E) are located in eastern Dronning Maud Land, East Antarctica, and consist of amphibolite to granulite facies metamorphic rocks and various intrusive rocks. Peak metamorphism took place during the Pan-African event. Considering the mode of occurrence and previously reported age data, felsic magma activity started at the waning stage of the metamorphism. In this study, we report on the petrogenesis of discordantly intruding post-tectonic pyroxene tonalite (Px tonalite) with adakitic composition. In addition, the petrogenesis of post-tectonic biotite granite (Bt granite), of which the geochemical features are similar to high-K adakite in the collision zone, are reevaluated with reference to the Px granite. The initial Sr isotopic ratios (SrI) corrected to 525 Ma of Px tonalite and Bt granite represent limited values (0.7037–0.7052) that are included within the SrI of the Proterozoic metatonalite corrected to the same age (525 Ma). These Sr isotopic signatures combined with geochemical modeling suggest that chemical variation of Px tonalite and Bt granite can be explained by partial melting of the Proterozoic metatonalite with various degrees of melting, leaving garnet as a residual phase, subsequent to fractional crystallization and/or accumulation of specific phases. Taking the tectonic situation and geochemical signature into account, Px tonalite and Bt granite from the Sør Rondane Mountains are correlated to the collision zone adakite and represent the post-collision magmatism in the suture zone during the Gondwana formation of the Pan-African event.

key words: Dronning Maud Land, the Sør Rondane Mountains, Pan-African, collision zone, adakitic rock

1. Introduction

Adakite and adakitic rocks are generally exposed in subduction zones (Defant and Drummond, 1990; Atherton and Petford, 1993; Martin, 1999; Martin *et al.*, 2005). Recent study, however, reveals that adakite occurs in continent–continent collision zones in north and south Tibet (Chung *et al.*, 2003; Wang *et al.*, 2005). Adakite magma is potentially produced by partial melting of eclogite (Defant and Drummond, 1990; Rapp *et al.*, 1991; Sen and Dunn, 1994). Therefore, if the crustal thickness is sufficient for eclogite formation, the adakitic magma can be produced by partial melting

of such a thickened lower crust (Atherton and Petford, 1993).

The Sør Rondane Mountains (22°E–28°E) are located in eastern Dronning Maud Land, East Antarctica, within the East Africa–Antarctic Orogen (EAAO), which is considered to be the continental collision zone between West Gondwana and East Gondwana during the Pan-African event (Jacobs *et al*., 2003). The Sør Rondane Mountains consist mainly of metamorphic rocks and various felsic intrusive rocks. Most granitic rocks in the Sør Rondane Mountains possess a geochemical signature with peralkaline composition (Sakiyama *et al*., 1988; Tainosho *et al*., 1992; Li *et al*., 2001, 2003, 2005). However, if partial melting has taken place in the thickened crust that has undergone eclogite facies metamorphism due to continent–continent collision, it could be expected to have produced adakite in the Sør Rondane Mountains.

In this paper, we describe adakitic rocks from the Sør Rondane Mountains and discuss the petrogenesis of the adakitic magma in the collision zone. This is the first report on Pan-African adakitic rocks from Dronning Maud Land, East Antarctica.

2.   Geological outline of the Sør Rondane Mountains

The Sør Rondane Mountains are occupied by metamorphic rocks and various kinds of intrusive rocks. The metamorphic rocks comprise intermediate to felsic gneiss with minor amounts of mafic and pelitic gneisses (Fig. 1). The main structural features of the metamorphic rocks are controlled by the E-W trend of foliations and fold axes (Toyoshima *et al*., 1995). The Main Shear Zone (MSZ) and Sør Rondane Suture (SRS) are considered to be the dominant tectonic boundaries in the mountains (Shiraishi *et al*.,
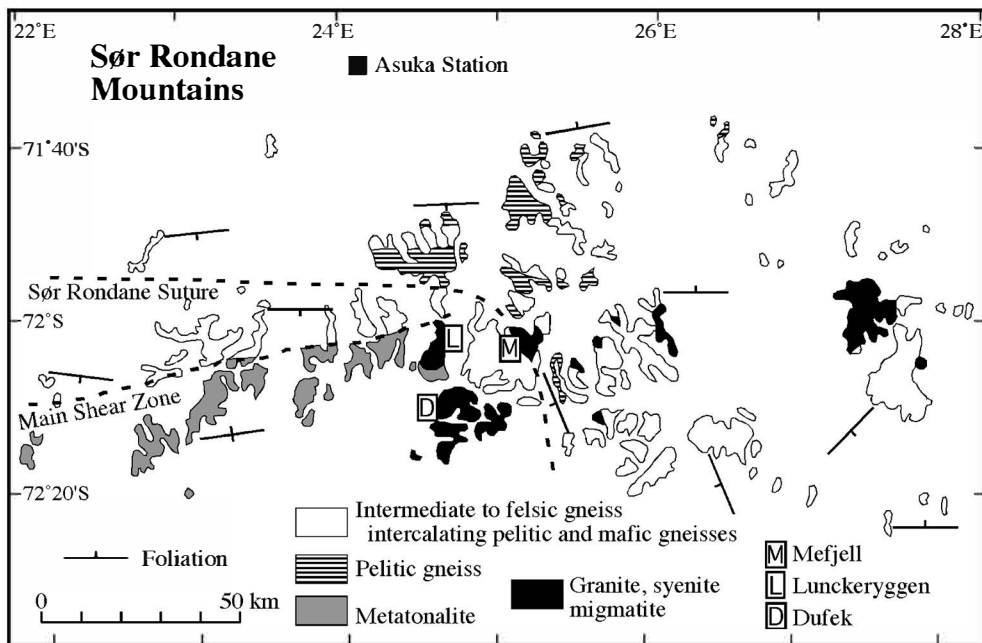

Fig. 1.   Geological sketch map of the Sør Rondane Mountains.

1991; Osanai *et al*., 1992). Metatonalite with intermediate to felsic compositions is exposed in the southern part of the MSZ, whereas metamorphic rocks and various intrusive rocks crop out of the northern part of the MSZ (Fig. 1; Shiraishi *et al*., 1991). The SRS divides the region into granulite facies metamorphic rocks in the north and amphibolite to greenschist facies metamorphic rocks in the south (Fig. 1; Osanai *et al*., 1992).

The Rb-Sr whole rock isochron study reveals that the protolith of the metatonalite in the southwestern part of the Sør Rondane Mountains was emplaced in the Middle-Proterozoic (*ca*. 960 Ma) (Fig. 1; Takahashi *et al*., 1990). The protolith age of an orthogneiss (charnockitic gneiss) in the north of the SRS indicates *ca*. 1000 Ma determined with Rb-Sr and Sm-Nd whole-rock isochron methods (Shiraishi and Kagami, 1992). The granulite facies metamorphism occurred at *ca*. 530 Ma in terms of monazite and zircon chemical isochron method (CHIME) ages (Asami *et al*., 2005). The felsic intrusive rocks occurring as stocks in the central part of the Sør Rondane Mountains are dated between 530 and 500 Ma by Rb-Sr and Sm-Nd whole rock isochron methods (Takahashi *et al*., 1990; Tainosho *et al*., 1992; Arakawa *et al*., 1994). Therefore, the timing of the granulite facies metamorphism and the felsic magma activities in the Sør Rondane Mountains corresponds to the Pan-African age. Mafic dikes (lamprophyre and dolerite) intrude the metamorphic rocks but are cut in places by the younger veins of pegmatite (Shiraishi *et al*., 1988). The radiogenic ages (K-Ar and Ar-Ar whole-rock methods) of the mafic dikes indicate 434–488 Ma (Takigami *et al*., 1987; Takigami and Funaki, 1991). These activities occurred at a few tens of millions of years after major orogenic events (Shiraishi *et al*., 1988; Arima and Shiraishi, 1993).

The felsic intrusive rocks are divided into four groups in terms of mode of occurrence: post-tectonic Group I granite, syn-tectonic Group II granite, Lunckeryggen syenite, and the Mefjell plutonic complex (Li *et al*., 2003). Group I granite occurs as stocks with massive or weakly foliated structure and discordantly intrudes into the host gneisses, whereas Group II granite appears as sheets or lenses possessing foliations parallel to the pervasive foliation with concordant intrusions for the host metamorphic rocks (Li *et al*., 2003). In the central part of the Sør Rondane Mountains, granites in Dufek and Lunckeryggen belong to Group I granite. Both granitic suites lithologically represent biotite granite (Bt granite) with massive to weakly foliated structure. Bt granite has been studied by numerous researchers with respect to petrology, geochemistry and geochronology (Sakiyama *et al*., 1988; Takahashi *et al*., 1990; Tainosho *et al*., 1992; Arakawa *et al*., 1994; Li *et al*., 2001, 2003). Bt granite represents evolved alkaligranite with high-K composition. Rb-Sr whole-rock isochron ages of Bt granites in Dufek and Lunckeryggen are 528±31 Ma and 535±32 Ma, respectively. The Lunckeryggen syenite has high-K composition similar to the Yamato syenite (Li *et al*., 2003, 2005). The Mefjell plutonic complex consists mainly of granite and quartz syenite (Li *et al*., 2003). The granite has strong foliations and locally shows migmatitic structure; the quartz syenite locally includes Fe-rich olivine (Tainosho *et al*., 1992). The chemical compositions of the Mefjell plutonic complex are similar to those of the charnockite-syenite suites from central Dronning Maud Land (Li *et al*., 2003, 2005). Diorite dikes and pyroxene tonalite (Px tonalite) appear in the Mefjell plutonic complex (Shiraishi *et al*., 1997; Fig. 2).

3.   Geology and petrography of Px tonalite in Mefjell

Px tonalite occurs as small stocks on the northeastern part of Mefjell (Fig. 2). Figure 3 shows the mode of occurrence of Px tonalite that includes the mafic granulites of host rocks.   In addition to the granulite xenoliths, Px tonalite is locally accompanied by fine-grained mafic inclusions.   Field relationships between Px tonalite and other
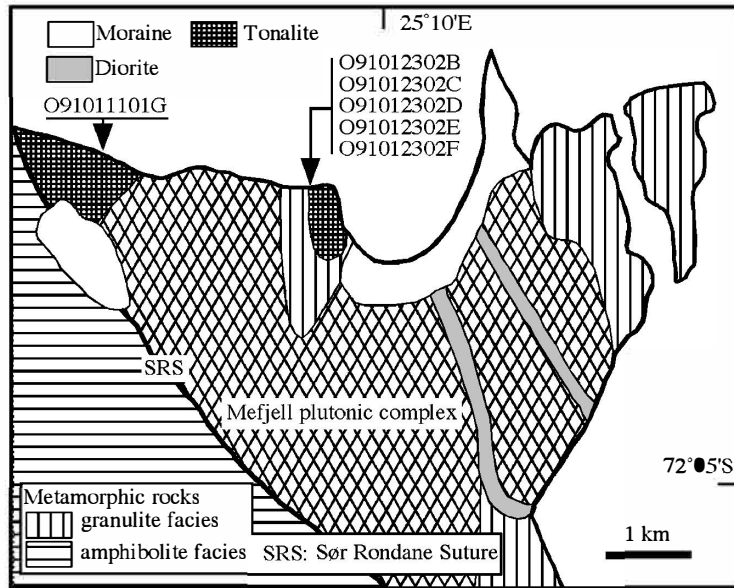

Fig. 2.   *Geological sketch map of the northeastern part of the Mefjell (Shiraishi et al., 1997).*

Fig. 3.   *Mode of field occurrence of Px tonalite.*

plutonic rocks of the Mefjell plutonic complex are not clearly understood.

Px tonalite shows gray to pale gray color with medium grain size and comprises plagioclase, quartz, clinopyroxene, orthopyroxene, hornblende and biotite with traces of K-feldspar. Opaque minerals and apatite are present as accessory minerals. Px tonalite locally shows foliation defined by alignment of mafic minerals such as planar biotite and elongated hornblende. Considering the mode of field occurrence and petrography, Px tonalite could belong to Group I granite.

4. Major and trace element geochemistry

The analyses of major and some trace elements in Px tonalite were determined using XRF (RIX-3000) at the Center for Instrumental Analyses, Yamaguchi University. Some trace elements and REE analyses were also performed using an ICP-MS at Actlabs Ltd., Canada. Analytical results are shown in Table 1. Figure 2 shows sampling sites of Px tonalite.

Variation diagrams of Px tonalite are shown in Fig. 4. The chemical compositions of Bt granite (Lunckeryggen granite and Dufek granite) (Li *et al.*, 2001) are also plotted. SiO_2 contents of Px tonalite range between 58–69 wt%. On the other hand, those of Bt granite consist of more than 70 wt% SiO_2. The chemical compositions of Px tonalite form smooth trends; however, these trends are different from the chemical trends of Bt granite. For instance, K_2O contents of Px tonalite decrease from 1.37 to 0.62 wt% with increasing SiO_2 from 59 to 69 wt%, whereas K_2O contents of Bt granite increase with enhancing SiO_2 (Fig. 4). Although the chemical compositions of Px tonalite and Bt granite form different chemical trends in the variation diagrams, both rocks are characterized by high concentration of Sr (Fig. 4). Figure 5 represents Sr/Y–Y (ppm) for Px tonalite and Bt granite with compositional field of adakite and island arc andesite–dacite–rhyolite (Defant and Drummond, 1990). The chemical compositions of Px tonalite and Bt granite are mostly plotted within the adakite field (Fig. 5). The chondrite-normalized REE patterns for Px tonalite show enrichment of light-REE (LREE) and depletion of heavy-REE (HREE) with weak presence of the negative Eu anomalies (Fig. 6). Figure 6 also represents the REE patterns of Bt granite as a shaded field. The REE pattern of Bt granite almost resemble that of Px tonalite; however, Bt granite possesses large La/Yb ratios rather than those of Px tonalite and they show no to positive Eu anomalies (Fig. 6).

5. Sr isotope geochemistry

5.1. Analytical procedure

Isotopic analyses were performed at Okayama University using the experimental procedure of Kagami *et al.* (1987). The thermal ionization mass spectrometer (MAT 261) equipped with multi-faraday cups at Okayama University measured isotopic compositions of samples. $^{87}Sr/^{86}Sr$ ratios were normalized to $^{86}Sr/^{86}Sr = 0.1194$. The normalized $^{87}Sr/^{86}Sr$ ratios were corrected using the NBS-987 standard of $^{87}Sr/^{86}Sr = 0.710241$. Rb and Sr concentrations were determined with XRF. Analytical errors for $^{87}Rb/^{86}Sr$ and $^{87}Sr/^{86}Sr$ were 5% (1σ) and 0.01% (1σ), respectively.

Table 1. Major and trace elements analysis of Px tonalite.

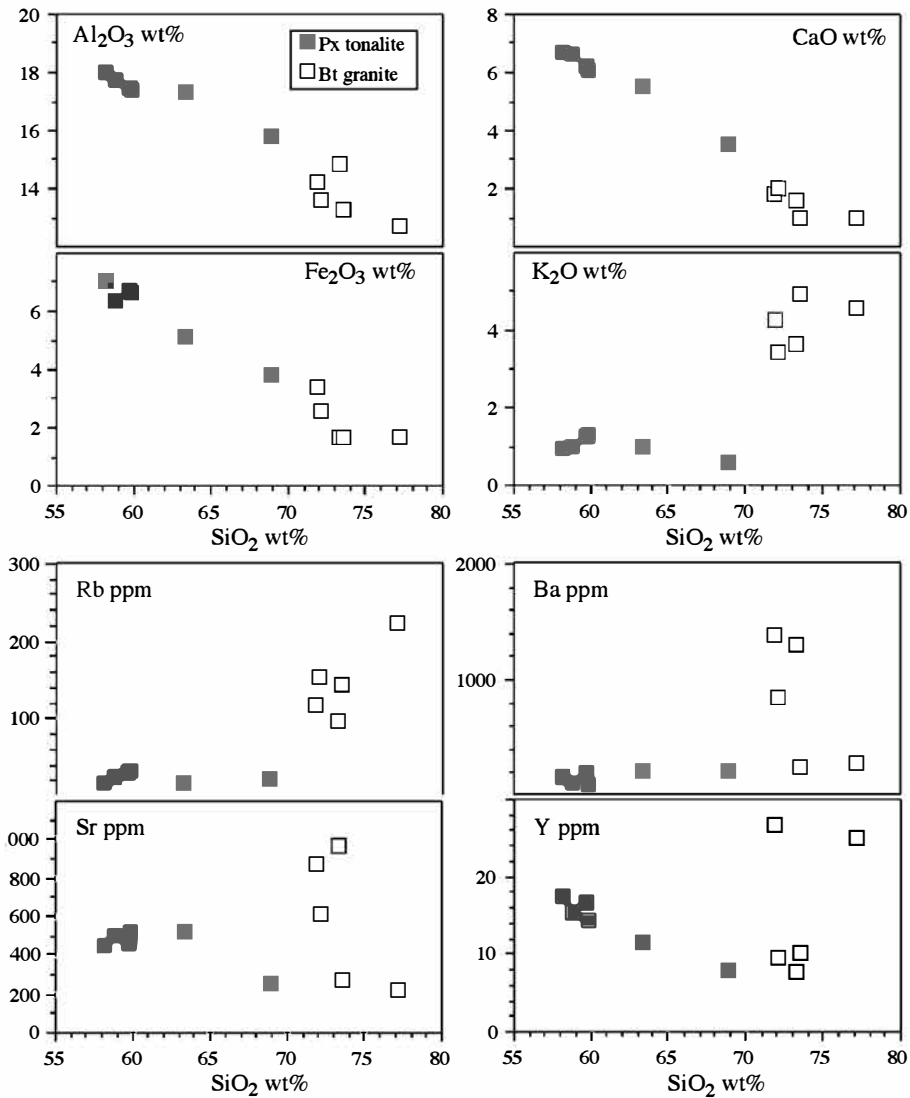*: Data are determined with ICP-MS. Other data are analyzed by XRF. **: Total Fe as Fe_2O_3.

Fig. 4.   Variation diagrams of Px tonalite (this study) and Bt granite (Li et al., 2001).

5.2. Results

Analytical results are listed in Table 2; and the isochron diagram for Px tonalite and Bt granite (Lunckeryggen granite, Takahashi *et al*., 1990 and Dufek granite, Tainosho *et al*., 1992) is shown in Fig. 7.   Strontium isotopic data of the Proterozoic metatonalites corrected to 525 Ma are also plotted in the isochron diagram (Fig. 7). The isotopic composition of Px tonalite cannot define an isochron because of the small variation of $^{87}Rb/^{86}Sr$ ratios; however, these data are plotted along the 525 Ma reference isochron.   Sr initial (SrI) ratios corrected to 525 Ma are 0.7042 to 0.7045 and range within those for Bt granite (Fig. 7).   SrI ratios of Px tonalite are relatively low rather
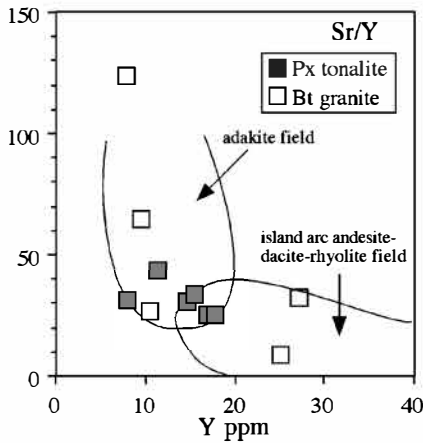
Fig. 5. *Sr/Y–Y ppm diagram of Px tonalite (this study) and Bt granite (Li et al., 2001). Compositional fields for adakites and island arc andesite–dacite–rhyolite are quoted from Defant and Drummond (1990).*
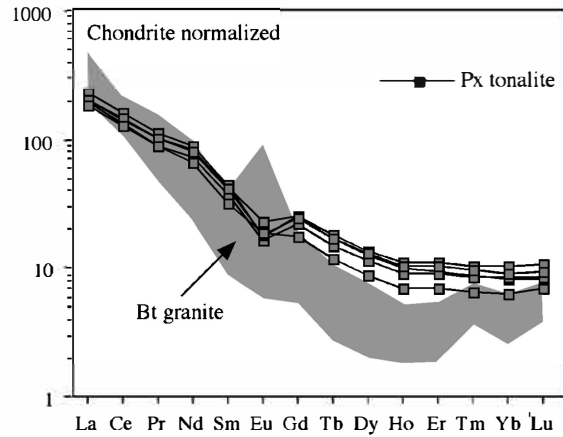

Fig. 6. *Chondrite-normalized REE patterns of Px tonalite and Bt granite. Data for Bt granite are quoted from Li et al. (2003). Normalized values are taken from Sun and McDonough (1989).*

Table 2. *Sr isotopic compositions of Px tonalite and Proterozoic metatonalite.*

	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	(2σ)	SrI (525 Ma)
Mefjell pyroxene tonalite						
O091012302B	15	514	0.0844	0.70516	(1)	0.70453
O091012302C	25	526	0.1375	0.70555	(1)	0.70452
O091012302D	31	488	0.1838	0.70580	(1)	0.70442
O091012302E	27	456	0.1713	0.70552	(1)	0.70424
O091012302F	18	521	0.0999	0.70499	(1)	0.70424
Proterozoic metatonalite						
O091010802C	9	262	0.0994	0.70471	(1)	0.70397
O091010802C'	11	297	0.1071	0.70470	(1)	0.70390
O091010802D	28	109	0.7436	0.71265	(1)	0.70709

than those of the mafic dikes from the Sør Rondane Mountains (SrI=0.7049–0.7062, corrected to 525 Ma: Ikeda *et al.*, 1995). The Proterozoic metatonalites possess variable SiO_2 contents but limited SrI ratios (Takahashi *et al.*, 1990). The Sr isotopic ratios corrected to 525 Ma for the metatonalites cover the SrI ratios for Px tonalite and Bt granite (Fig. 7).
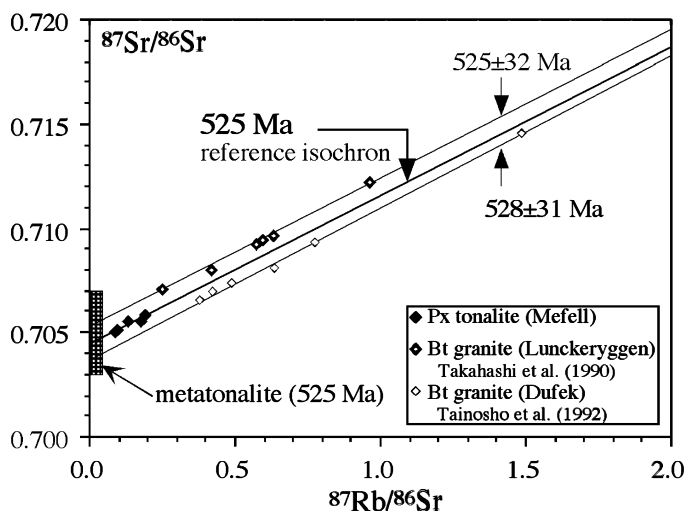
Fig. 7. Isochron diagram of Px tonalite and Bt granite. Note: analytical data of Px tonalite are plotted closely on the 525 Ma reference isochron. Sr initial ratios of Px tonalite and Bt granite appear in the range of those of Proterozoic metatonalite.

6. Discussion

6.1. Origin of adakitic magma in the Sør Rondane Mountains

The chemical compositions of Bt granite in Lunckeryggen and Dufek are characterized by high concentrations of K_2O and Sr. The SrI ratios corrected to 525 Ma for Bt granite in Lunckeryggen and Dufek indicate 0.7049–0.7062 and 0.7033–0.7041, respectively. Fractionation or partial melting of high-K basalts may be an important process in the origin of high-K granites (Mungall and Martin, 1995). Bt granite in Lunckeryggen has SrI ratios similar to the mafic dikes, whereas SrI ratios of Bt granite in Dufek are lower than those of the mafic dikes. In addition, the magma activities of the mafic dikes took place a few tens of millions of years after the intrusion of the felsic magma in the Sør Rondane Mountains (Shiraishi *et al.*, 1988; Arima and Shiraishi, 1993). Therefore, it is unlikely that there are genetic relationships between Bt granite and the high-K mafic dikes.

The chemical compositions of Px tonalite and Bt granite are similar to those of adakite in the Sr/Y–Y (ppm) diagram (Fig. 5); however Bt granite is characterized by high concentration of K_2O compared to the adakite. The major element chemistry of Px tonalite shows high Al_2O_3 and low K_2O/Na_2O ratios. In comparison with Bt granite, these geochemical signatures of Px tonalite are similar to those of adakite except for negative Eu anomalies. In general, adakite magma is derived from partial melting of subducting oceanic crust with basaltic compositions (Defant and Drummond, 1990; Martin, 1999). Melting experiments for basaltic rocks reveal that the chemical compositions of synthetic melt are low-K_2O regardless of any pressure conditions (Beard and Lofgren, 1991; Sen and Dunn, 1994; Springer and Seck, 1997). Therefore, the Bt granite magma is unlikely originated from basaltic compositions such as a subducting

basaltic slab.

The SrI ratios of Bt granite in Lunckeryggen and Dufek overlap those of the Proterozoic metatonalite (SrI = 0.7030–0.7077) (Fig. 7), thereby suggesting that the Proterozoic metatonalite is a candidate for the source material of Bt granite (Arakawa *et al.*, 1994).   The granitic magma can be produced by partial melting of intermediate to felsic rocks under various pressure conditions based on experimental study (Conrad *et al.*, 1988; Beard and Lofgren, 1991; Singh and Johannes, 1996; Patiño Douce, 1997, 2005) and geochemical investigation for the natural rocks (Kamei, 2002).

Px tonalite possesses low SrI values (0.7042–0.7045), which is completely plotted within the SrI values of Bt granite and the Proterozoic metatonalite (Fig. 7).   Chondrite-normalized REE patterns of Px tonalite and Bt granite show enrichment of LREE and depletion of HREE.   The chemical compositions of Px tonalite show low LIL and REE contents compared to those of Bt granite (Figs. 4 and 6).

As mentioned above, the inferred source rocks of Px tonalite and Bt granite have Sr isotope compositions similar to Proterozoic metatonalite.   In addition, the chondrite-normalized REE patterns of Px tonalite and Bt granite suggest that the source rocks have left garnet as a residual phase coexisting with granitic melts.   Therefore, it is reasonable that the Px tonalite and Bt granite magmas are derived from the same source and the chemical compositions of Px tonalite and Bt granite reflect the difference of degree of melting.

In order to verify the above hypothesis, we performed geochemical modeling to produce the Px tonalite and Bt granite magmas originated from the Proterozoic metatonalite as a source rock.   The formulation utilized the batch melting calculation and partition coefficient for elements listed in Table 3.   We used an average composition of the Proterozoic metatonalite as a source rock (Table 3).   The assemblages and propor-

Table 3.   *Partitioning coefficients and proportion of residual minerals for geochemical modeling.*

	Pl[1,4]	Cpx[1,3]	Grt[1,3]	Opx[2,3]	source compositions	
Ba	0.308	0.131	0.017	0.003	Ba	140 ppm
Rb	0.041	0.032	0.009	0.003	Rb	16 ppm
Sr	4.44	0.516	0.015	0.009	Sr	369 ppm
La	0.19	0.047	0.026	0.031	La	17.2 ppm
Yb	0.041	1.3	11.5	0.860	Yb	1.77 ppm

modal proportions

Model a Grt:Cpx:Opx:Pl:Qtz=5:40:20:20:15

Model b Grt:Cpx:Qtz=15:70:15

Model c Cpx:Opx:Pl:Qtz=20:30:30:20

1: Arth (1976), 2: Pearce and Norry (1979), 3: Rollinson (1993), 4: Fujimaki *et al.* (1984).   Source compositions used in the models are of average compositions for the Proterozoic metatonalite quoted from Tainosho *et al.* (1992), Ikeda and Shiraishi (1998), and this study.
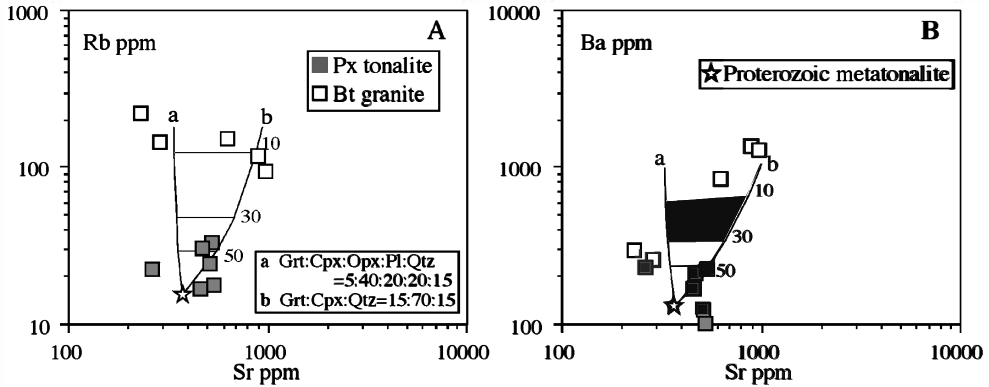
Fig. 8.   Geochemical modeling for the petrogenesis of Px tonalite and Bt granite.   (A) Sr ppm–Rb ppm,
(B) Sr ppm–Ba ppm diagrams.   Models a and b represent the melting calculations of plagioclase-
bearing and plagioclase-free residues, respectively.   Both models include garnet as a residual phase.
Partial melting curves and numbered tick marks indicate the fusion percent.   Stars represent the
compositions of the source material.   Proportion of the residual phases refers to the experimental
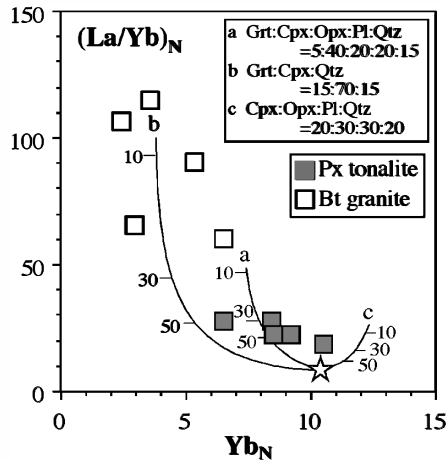results of Patiño Douce (2005).

Fig. 9.   Chondrite-normalized $(La/Yb)_N$–Yb_N diagram showing geochemical modeling for
the petrogenesis of Px tonalite and Bt granite.   Normalized values are the same as
Fig. 6.   Model c indicates the melting curve without garnet in the residue.   Partial
melting curves, numbered tick marks and the star are as the same Fig. 8.

tion of residual phases for each model (Models a to c) refer to experimental results using
tonalite as a starting material (Patiño Douce, 2005).   The results of geochemical mod-
eling are shown in Rb (ppm)–Sr (ppm), Ba (ppm)–Sr (ppm) diagrams (Fig. 8) and a
chondrite-normalized $(La/Yb)_N$–Yb_N diagram (Fig. 9).   The proportion of residual
phases of Models a, b and c is also drawn in Figs. 8 and 9 and Table 3.
   Some samples of Px tonalite are plotted on the model compositions between Models

a and b with degree of melting around 50%, whereas the chemical composition of Bt granite is partly identical to the model composition ca. 10% degree of melting (Fig. 8). In the $(La/Yb)_N$–Yb_N diagram, most of the Px tonalites are plotted around the Model a curve, whereas Bt granite appears around the Model b curve (Fig. 9). Both Px tonalite and Bt granite don't fit on the Model c curve (Fig. 9). The residual phases of Models a and b correspond to the mineral assemblage of high-pressure granulite and eclogite. On the other hand, the mineral assemblages of residual phases in Model c indicate low-pressure granulite. Therefore, the geochemical signature of Px tonalite and Bt granite can be produced basically by partial melting of the Proterozoic metatonalite under high-pressure conditions with different degrees of melting and assemblages; however, garnet should be contained as a residual phase.

Garnet and plagioclase are important minerals as indicators of pressure under dry conditions when partial melting takes place in the crust. In tonalitic compositions, garnet appears above 10 kbar at temperature $\leq 750°C$ coexisting with granite to granodiorite melt (Singh and Johannes, 1996); however, the segregation of large-volume granitoid magmas from tonalitic orthogneisses requires temperatures greater than 950°C (Rutter and Wyllie, 1988). It is known that garnet disappears at temperature above 950°C at 10 kbar (Rutter and Wyllie, 1988). According to results of a recent melting experiment, garnet and plagioclase are stable under pressure greater than 15 kbar and plagioclase disappears above 18 kbar when temperature is greater than 950°C during vapor-absent melting (Patiño Douce, 2005). Based on the results of melting experiments, the formation of the Px tonalite and Bt granite magmas would have taken place under pressure greater than 15 kbar.

Px tonalite shows monotonous trends in the variation diagrams (Fig. 4). Fe_2O_3 and CaO contents of Px tonalite decrease with increasing SiO_2, thereby suggesting that mafic minerals such as clinopyroxene, orthopyroxene and hornblende should be subtracted from the parental magma. Moreover, as K_2O contents decrease with increase of more than 59 wt% in SiO_2, biotite is potentially fractionated from the melt. Plagioclase has behaved as an accumulation phase in the Bt granite magma because chondrite-normalized REE patterns of Bt granite show no to positive Eu anomalies (Fig. 6). These geochemical signatures suggest that fractional crystallization and/or accumulation of specific phases may play an important role in the respective chemical variations for Px tonalite and Bt granite.

6.2. *Tectonic significance of adakitic magma during the Pan-African age*

Both Px tonalite and Bt granite intrude the host gneisses (Fig. 3). The granulite facies metamorphism took place at ca. 530 Ma (Asami *et al*., 2005). Rb-Sr whole rock isochrons for two Bt granites bodies give ages of 525 ± 32 Ma (Takahashi *et al*., 1990) and 528 ± 31 Ma (Tainosho *et al*., 1992), respectively. The Sr isotope compositions of Px tonalite are plotted around the 525 Ma-reference isochron (Fig. 7). In addition, these granitic rocks clearly cut the pervasive metamorphic foliation and give thermal effect to the host gneisses (Asami *et al*., 1992). Considering the occurrence and age dating for both granitic and metamorphic rocks, the intrusion of Px tonalite and Bt granite took place apparently after the peak metamorphic stage.

The *P-T* evolution of the metamorphic rocks that occur in the northern part of the

SRS shows a clockwise path (Asami *et al.*, 1992). Similar metamorphic evolution is reported from central Dronning Maud Land (Engvik and Elvevold, 2004), *ca.* 700 km west of the Sør Rondane Mountains. In that area, the peak metamorphic event occurs at 550–530 Ma related to the Pan-African event, which is generally accepted as a waning stage of the continental collision between east and west Gondwana (Paech, 1997; Jacobs *et al.*, 1998, 2003). Taking metamorphic processes and age dating into account, the Sør Rondane Mountains should be located in the collision zone between west and east Gondwana during the Pan-African event.

Adakite and high-K adakite crop out in south and north Tibet, respectively (Chung *et al.*, 2003; Wang *et al.*, 2005). Figure 10 shows SiO_2 and Mg-numbers ($100 \times Mg/(Fe+Mg)$; mole ratio) for Px tonalite and Bt granite. In Fig. 10, the values for Tibetan adakite and high-K adakite are also plotted in order to compare with granitic rocks in the Sør Rondane Mountains. Tibetan adakite and high-K adakite indicate low-Mg-numbers regardless of SiO_2 content and are mostly plotted within the field of synthetic melt compositions derived from the melting experiment on mafic rocks (Condie, 2005). On the other hand, subduction related Cenozoic adakite possesses high Mg-number (Fig. 10) because the subduction related adakitic magma elevates the Mg-number due to interaction with the wedge mantle (Stern and Kilian, 1996; Rapp *et al.*, 1999; Smithies, 2000; Condie, 2005). Since Tibetan adakite and high-K adakite magmas are derived from thickened lower crust caused by continent–continent collision, they cannot interact with wedge mantle. Chemical compositions of Px tonalite and Bt granite from the Sør Rondane Mountains show low Mg-number as well as adakite and high-K adakite from the collision zones in Tibet (Fig. 10). Considering the tectonic setting and geochemical signature, Px tonalite and Bt granite of the Sør Rondane Moun-
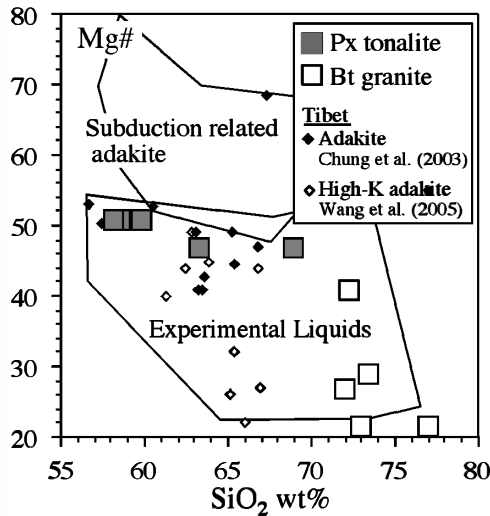

Fig. 10. *Mg#–SiO₂ wt% diagram of Px tonalite and Bt granite comparing with adakite and high-K adakite from Tibetan collision zones. Compositional fields of both synthetic liquids and Cenozoic adakite are quoted from Condie (2005).*

tains are correlated to collision zone adakite. Therefore, Px tonalite and Bt granite represent post-collision type magmatism in the suture zone of Gondwana formation during the Pan-African event.

Acknowledgments

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