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XRF analyses of Sanbagawa pelitic schists in central Shikoku, Japan

By

Atsushi GOTO[*1,*2], Toshio HIGASHINO[*3] and Chihiro SAKAI[*1,*4]

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Abstract

This paper lists the XRF major and trace element (Rb, Sr, Y, Zr, Nb, Ba, Th, Pb, and Ni) analyses of 198 Sanbagawa pelitic schists along with their mineral assemblages. These data give the following average composition of the Sanbagawa pelitic schist (1 σ of standard deviations in parentheses): Major element in weight percent; SiO_2, 68.94 (3.17); TiO_2, 0.55 (0.10); Al_2O_3, 15.12 (1.22); Fe_2O_3, 4.49 (1.07); MnO, 0.14 (0.08); MgO, 1.68 (0.51); CaO, 0.99 (0.75); Na_2O, 2.47 (0.83); K_2O, 3.02 (0.55); P_2O_5 0.11 (0.02); loss of ignition, 2.14 (0.62); Trace element in ppm; Rb, 119 (21); Sr, 129 (60); Y, 21.1 (4.7); Zr, 144 (17); Nb, 9.6 (1.4); Ba, 486 (103); Th, 12.7 (2.1); Pb, 18.7 (5.7); Ni, 15.7 (11.0). The Sanbagawa pelitic schists are characterized geochemically by the narrow *mg*-value (=molar MgO/(MgO+FeO)) of 0.422 (0.031), K/Rb weight ratio of 211 (15), and K/Ba weight ratio of 52.3 (6.5).

Introduction

A pelitic schist is a common rock-type in most metamorphic belts. The term "pelitic" is used loosely to signify all slaty or schistose rocks with a high proportion of micas or other phyllosilicates (YARDLEY, 1989), and involves no geochemical definition at all. Thus, there is a considerable variation in bulk chemical composition of pelitic rocks in different metamorphic areas. The geochemical characterization of pelitic rocks in each metamorphic belt needs the determination of their bulk chemical composition.

The bulk chemical composition and also metamorphic conditions are basic factors controlling phase equilibria of metamorphic rocks. Hence, we must evaluate the effect of bulk chemical composition on pressure and temperature estimation of metamorphic rocks for better understanding of metamorphic evolution. The variation causes the diversity in the paragenetic relation of rocks concerned, and its full understanding requires the determination of the bulk chemical composition.

*1 Department of Geology and Mineralogy, Faculty of Science, Kyoto University. Kyoto, 606.
*2 Present address; Department of Geology, Himeji Institute of Technology. Shosha, Himeji, Hyogo, 671-22.
*3 Hakusan Nature Conservation Center. Yoshinodani-mura, Ishikawa 920-24.
*4 Present address; Materials Characterization Group, NSG Techno-Research Co., Ltd. Itami, Hyogo, 664.

The pelitic schist is the most dominant rock-type in the Sanbagawa metamorphic belt. They have been extensively studied from phase petrological point of view, as BANNO and SAKAI (1989) reviewed. Recently, an important progress has been made in the radiometric dating of Sanbagawa metamorphic rocks (ITAYA and TAKASUGI, 1988; ISOZAKI and ITAYA, 1990; TAKASU and DALLMEYER, 1990, 1992; SHINJOE and TAGAMI, 1994). As a result, we can draw pressure-temperature-time paths of the Sanbagawa metamorphism fairly quantitatively (e.g., TAKASU *et al.*, 1994). Some authors have reported major element analyses (BANNO, 1964; ERNST *et al.*, 1970; KURATA and BANNO, 1974) and Na_2O, K_2O, Fe_2O_3 and MnO partial analyses (BANNO, 1961) of the Sanbagawa pelitic and basic schists. Little is, however, known about bulk rock chemistry, in particular trace element chemistry, of Sanbagawa pelitic schists.

This paper lists the bulk chemical compositions of about 200 pelitic schists with their mineral assemblages in the Sanbagawa metamorphic belt, and summarizes them to understand the geochemical feature. It also presents the average composition as the mean Sanbagawa pelitic schist. Through this work, GOTO undertook XRF analyses and HIGASHINO and SAKAI to collect rock samples and determine their mineral assemblages. Abbreviations of mineral names are, unless otherwise stated, after KRETZ (1983).

Outline of geology, metamorphic zonation, and sample localities

The Sanbagawa metamorphic belt belongs to the high-pressure intermediate type of metamorphism (MIYASHIRO, 1961). It stretches from eastern Kyushu through Shikoku Island to the Kanto Mountains for a distance of about 800 km and a width less than 30 km (Fig. 1).

The Sanbagawa metamorphic rocks are composed mainly of pelitic and basic schists, but also contain some psammitic and siliceous schists, and a rare calcareous schist. Mappable to hand specimen sizes, metagabbro, peridotite, serpentinite, and actinolite rocks occur as exotic rocks, particularly in higher structural levels (KUNUGIZA *et al.*, 1986; HIGASHINO, 1990a, b).

The parageneses of pelitic and basic schists have defined several metamorphic zones of the Sanbagawa belt in central Shikoku (e.g., BANNO and SAKAI, 1989). HIGASHINO (1990a, b) has given a mineral zone map in a wide area of central Shikoku using the first appearance of garnet, biotite, and oligoclase, which appear successively in the Sanbagawa pelitic schist during prograde metamorphism. ENAMI (1983) and ENAMI *et al.* (1994) have estimated the maximum pressure and temperature conditions for each mineral zone; the chlorite zone, 550–650 MPa and <360°C; the garnet zone, 700–850 MPa and 440 ± 15°C, the albite-biotite zone, 800–950 MPa and 520 ± 25°C; the oligoclase-biotite zone, 900–1100 MPa and 610 ± 25°C, in the Asemi-gawa and Besshi (Bessi) regions. OTSUKI and BANNO (1990) have discussed the paragenesis of hematite-bearing basic

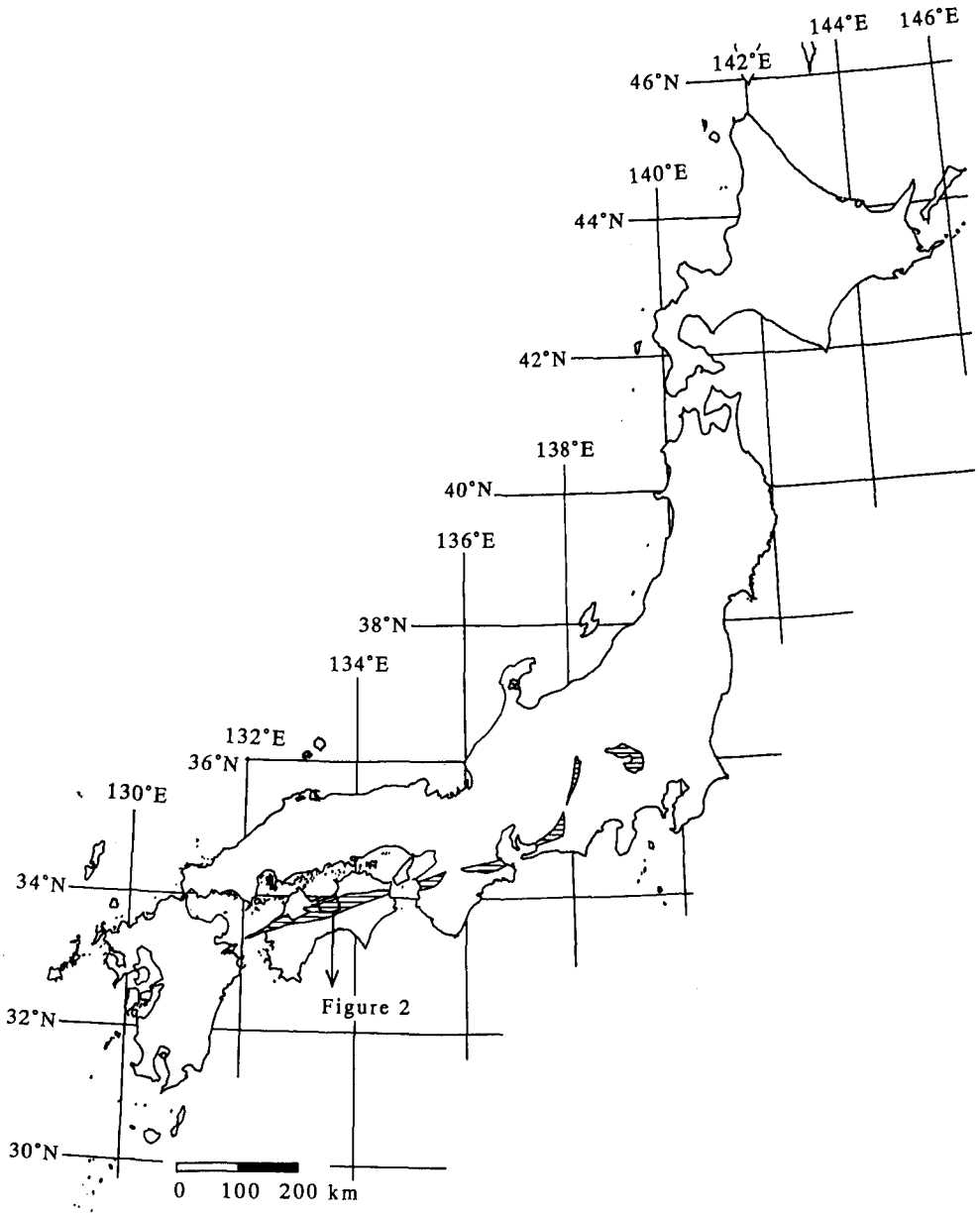
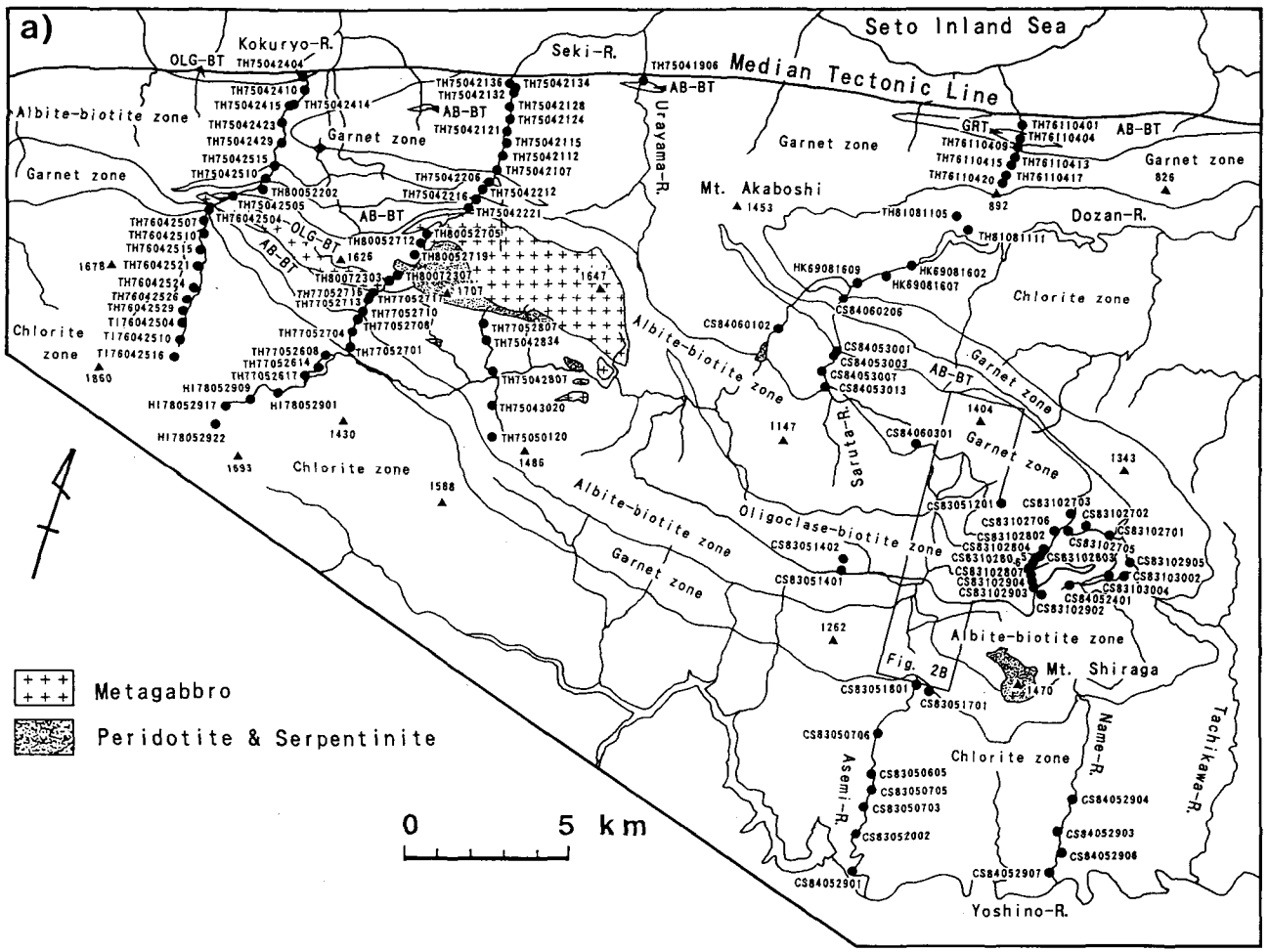


Figure 1. Distribution map of the Sanbagawa metamorphic rocks.


a)
Seto Inland Sea
Kokuryo-R.
Seki-R.
Median Tectonic Line
OLG-BT
AB-BT
GRT
Albite-biotite zone
Garnet zone
Chlorite zone
Oligoclase-biotite zone
Uryama-R.
Mt. Akaboshi
1453
Dozan-R.
Mt. Shiraga
1470
Fig. 2B
Saruta-R.
Asemi-R.
Name-R.
Tachikawa-R.
Yoshino-R.
Metagabbro
Peridotite & Serpentinite
0 5 km

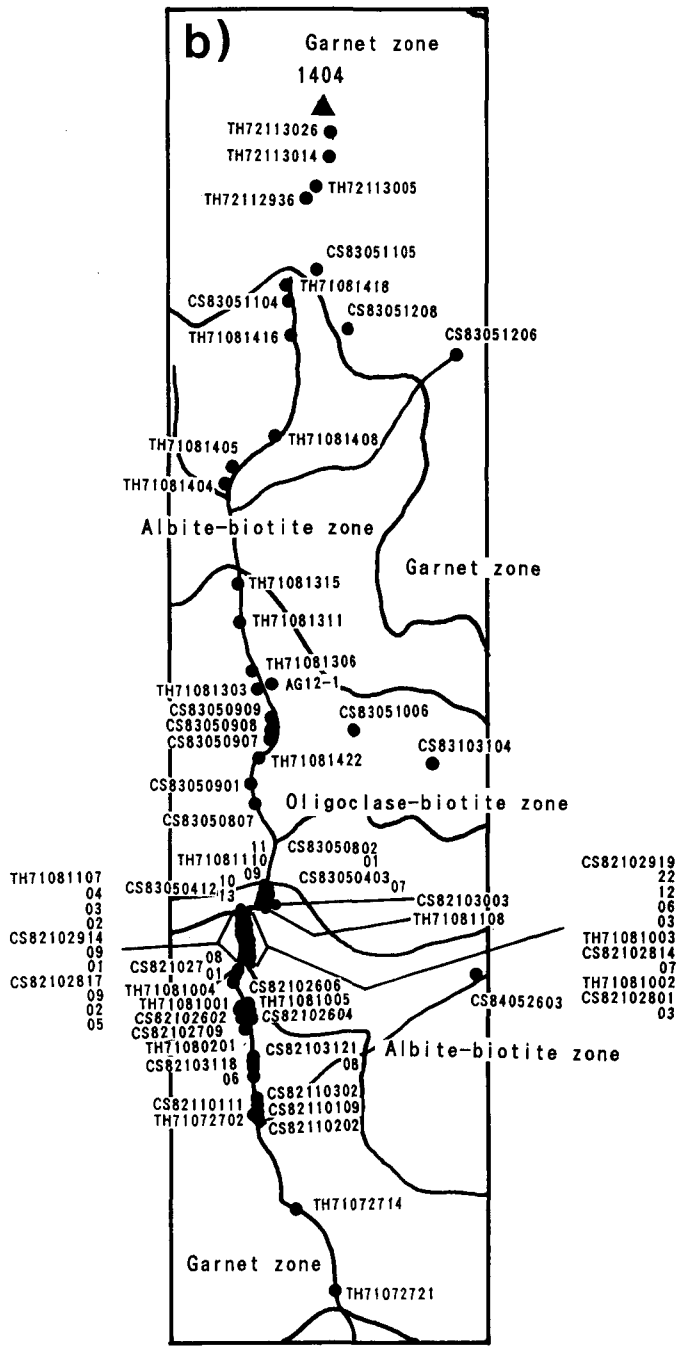


Figure 2. Locality map with boundaries of metamorphic zones that are after HIGASHINO (1990a). a; Central Shikoku area. b; Metamorphic zones above and at the garnet zone of the Asemi-river area.

schists.

Figure 2 is a locality map of the analyzed samples with boundaries of metamorphic zones in central Shikoku (HIGASHINO, 1990a). Sanbagawa pelitic schists also occur as clasts in conglomerates from the Kuma Group of middle Eocene age (NAGAI, 1972; HIROTA, 1990; YOKOYAMA and ITAYA, 1990; TAKASU and DALLMEYER, 1992). Three pelitic schist clasts were also analyzed. Two (118996 and K-1) of them belong to the oligoclase-biotite zone grade and one (K-8) of them to the garnet zone grade (YOKOYAMA, personal communication).

Table 1 lists mineral assemblages of the analyzed samples. All minerals present in the samples are listed in Table 1 whether all of them are equilibrium or not. As Table 1 shows, quartz, albite, muscovite, and graphite (carbonaceous matter) are principal minerals in the Sanbagawa pelitic schist. Further, clinozoisite occurs in about 89% (171/192) of the pelitic schist. Although ilmenite occurs as a TiO_2 accessory mineral in pelitic schists of the biotite zone (ITAYA and BANNO, 1980), "Ore" in Table 1 may include it.

Analytical procedure and results

Bulk chemical compositions of 198 pelitic schists were determined by X-ray fluoresc-

Table 1. Mineral assemblages of the analyzed pelitic schist samples. All minerals present in the samples are listed whether all of them are equilibrium or not. Mineral abbreviations are after KRETZ (1983) except CM (carbonaceous matter) and Ores (ore minerals).

Chlorite zone pelitic schists																	
Sample No.	Locality	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
TH76042507	Kokuryo	+	+	+	+				+	+	+		+	+	+	+	
TH76042510	Kokuryo	+	+	+	+				+		+		+	+	+	+	
TH76042515	Kokuryo	+	+	+	+				+		+		+	+	+	+	Aln
TH76042521	Kokuryo	+	+	+	+				+	+	+		+	+	+	+	Aln
TH76042524	Kokuryo	+	+	+	+				+		+		+	+	+	+	Aln, Stp
TH76042526	Kokuryo	+	+	+	+				+	+	+		+	+	+	+	Stp
TH76042529	Kokuryo	thin section absent															
TI76042504	Kokuryo	+	+	+	+				+	+			+	+	+	+	
TI76042510	Kokuryo	+	+	+	+				+		+		+	+	+	+	
TI76042516	Kokuryo	+	+	+	+				+	+	+		+	+	+	+	
TH77052608	Hiura	+	+	+	+				+	+	+		+	+	+	+	Aln
TH77052614	Hiura	+	+	+	+				+		+		+	+	+	+	Aln
TH77052617	Hiura	+	+	+	+				+		+		+	+	+	+	
HI78052901	Hiura	thin section absent															
HI78052909	Hiura	thin section absent															
HI78052917	Hiura	thin section absent															
HI78052922	Hiura	thin section absent															
HK69081602	Dozan	+	+	+	+				+		+		+	+	+	+	
HK69081607	Dozan	+	+	+	+						+		+	+	+	+	
HK69081609	Dozan	+	+	+	+				+				+	+	+	+	
TH81081105	Mishima	+	+	+	+				+	+	+		+	+	+	+	
TH81081111	Mishima	+	+	+	+				+	+	+		+	+	+	+	
CS83050605	Asemi	+	+	+	+				+	+	+				+	+	Aln, Fl
CS83050703	Asemi	+	+	+	+				+	+	+		+		+	+	Lws, Kfs
CS83050705	Asemi	+	+	+	+				+		+				+	+	Lws, Aln, Kfs

Table 1. Chlorite zone pelitic schists (continued.)

Sample No.	Locality	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
CS83050706	Asemi	+	+	+	+				+	+	+		+		+	+	Lws, Aln, Pmp
CS83051701	Asemi	+	+	+	+						+		+	+	+	+	
CS83051801	Asemi	+	+	+	+	?					+		+		+	+	
CS83052002	Asemi	+	+	+	+						+				+	+	
CS84052901	Asemi	+	+	+	+				?	+	+				+	+	
CS84052903	Name	+	+	+	+						+		+		+	+	Lws
CS84052904	Name	+	+	+	+				+		+			+	+	+	
CS84052906	Name	+	+	+	+						+				+	+	
CS84052907	Name	+	+	+	+						+				+	+	
CS84052505	Tachi	+	+	+	+				+		+		+	+	+	+	

Garnet zone pelitic schists

Sample No.	Locality	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
TH75042107	Seki	+	+	+	+	+			+		+		+	+	+	+	
TH75042112	Seki	+	+	+	+	+			+		+		+	+	+	+	Aln
TH75042115	Seki	+	+	+	+	+			+		+		+	+	+	+	Aln
TH75042121	Seki	+	+	+	+	+			+	+	+		+	+	+	+	Aln
TH75042124	Seki	+	+	+	+	+			+		+		+	+	+	+	
TH75042128	Seki	+	+	+	+	+			+		+		+	+	+	+	Aln
TH75042132	Seki	+	+	+	+				+		+		+		+	+	
TH75042134	Seki	+	+	+	+	+			+		+		+	+	+	+	
TH75042136	Seki	+	+	+	+	+			+		+		+	+	+	+	
TH75042212	Seki	+	+	+	+	+			+	+	+		+	+	+	+	
TH75042510	Kokuryo	+	+	+	+	+			+		+		+	+	+	+	
TH75042515	Kokuryo	+	+	+	+	+			+	+	+		+	+	+	+	
TH76042504	Kokuryo	+	+	+	+	+			+		+		+	+	+	+	
TH77052701	Hiura	+	+	+	+	+			+	+	+		+	+	+	+	
TH77052704	Hiura	+	+	+	+	+			+		+		+	+	+	+	
TH77052708	Hiura	+	+	+	+	+			+	+	+		+	+	+	+	
TH75041906	Urayama	+	+	+	+	+			+	+	+		+	+	+	+	Stp

Table 1. Garnet zone pelitic schists (continued.)

Sample No.	Locality	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
TH76110404	Mishima	+	+	+	+	+			+	+	+		+	+	+	+	Aln
TH76110413	Mishima	+	+	+	+	+			+		+		+	+	+	+	
TH76110415	Mishima	+	+	+	+	+			+		+		+	+	+	+	
TH76110417	Mishima	+	+	+	+	+				+	+		+	+	+	+	
TH76110420	Mishima	+	+	+	+	+			+		+		+	+	+	+	
TH71072702	Asemi	+	+	+	+	+			+		+		+	+	+	+	Aln
TH71072714	Asemi	+	+	+	+	+			+		+		+	+	+	+	
TH71072721	Asemi	+	+	+	+				+	+	+	+	+	+	+	+	Aln
TH71080201	Asemi	+	+	+	+	+			+		+	+		+	+	+	
TH71081001	Asemi	+	+	+	+	+			+		+		+	+	+	+	Aln
TH71081004	Asemi	+	+	+	+	+			+		+	+	+	+	+	+	
TH71081005	Asemi	+	+	+	+	+			+		+		+	+	+	+	
TH72112936	Asemi	+	+	+	+	+			+		+		+	+	+	+	Aln
TH72113005	Asemi	+	+	+	+	+			+		+		+	+	+	+	Aln, Stp
TH72113014	Asemi	+	+	+	+	+			+		+		+	+	+	+	Aln
TH72113026	Asemi	no thin section															
CS82102602	Asemi	+	+	+	+	+			+		+	+	+	+	+	+	Aln
CS82102604	Asemi	+	+	+	+	+			+		+		+		+	+	
CS82102606	Asemi	+	+	+	+	+			+		+		+	+	+	+	
CS82102701	Asemi	+	+	+	+	+			+		+		+	+	+	+	
CS82102708	Asemi	+	+	+	+	+			+		+	+	+	+	+	+	Aln
CS82102709	Asemi	+	+	+	+	+			+		+		+	+	+	+	Aln
CS82103106	Asemi	+	+	+	+	+		+	+	+	+				+	+	Aln
CS82103108	Asemi	+	+	+	+	+			+	+	+		+	+	+	+	Zrn
CS82103118	Asemi	+	+	+	+	+			+	+	+		+	+	+	+	
CS82103121	Asemi	+	+	+	+	+			+		+		+	+	+	+	
CS82110109	Asemi	+	+	+	+	+			+	+	+				+	+	
CS82110111	Asemi	+	+	+	+	+			+	+	+		+	+	+	+	Aln
CS82110202	Asemi	+	+	+	+	+			+		+		+		+	+	Aln
CS82110302	Asemi	+	+	+	+	+				+	+		+	+	+	+	
CS83051105	Asemi	+	+	+	+	+			+	+	+	+	+	+	+	+	Aln

Table 1. Garnet zone pelitic schists (continued.)

Sample No.	Locality	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
CS83051201	Asemi	+	+	+	+	+			+		+		+	+	+	+	Aln
CS83051206	Asemi	+	+	+	+	+			+		+		+	+	+	+	Aln
CS83051208	Asemi	+	+	+	+	+			+	+	+	?	+	+	+	+	
CS84060301	Asemi	+	+	+	+	+					+			+	+	+	
CS83102703	Tachi	+	+	+	+	+			+		+	+	+		+	+	
CS83102706	Tachi	+	+	+	+	+				+	+		+	+	+	+	
CS83102802	Tachi	+	+	+	+	+			+	+	+		+		+	+	
CS83102905	Tachi	+	+	+	+	+					+		+	+	+	+	
CS83103002	Tachi	+	+	+	+	+			+		+		+	+	+	+	
CS83103004	Tachi	+	+	+	+	+			+		+		+	+	+	+	
CS84052504	Tachi	+	+	+	+	+			+		+		+	+	+	+	
CS84053001	Saruta	+	+	+	+	+			+		+		+		+	+	
CS84053003	Saruta	+	+	+	+	+			+		+				+	+	
CS84053007	Saruta	+	+	+	+				+	+	+		+	+	+	+	Aln
CS84053013	Saruta	+	+	+	+	+			+		+		+	+	+	+	
CS84060102	Saruta	+	+	+	+				+		+				+	+	Aln
CS84060206	Saruta	+	+	+	+	+			+		+		+	+	+	+	

Albite-biotite zone pelitic schists

Sample No.	Locality	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
TH75042206	Seki	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
TH75042216	Seki	+	+	+	+	+			+		+		+	+	+	+	
TH75042221	Seki	+	+	+	+	+		+	+	+	+		+	+	+	+	
TH75042410	Kokuryo	+	+	+	+	+	+		+		+	+	+	+	+	+	
TH75042414	Kokuryo	+	+	+	+	+	+		+		+		+	+	+	+	
TH75042415	Kokuryo	+	+	+	+	+	+		+		+		+	+	+	+	
TH75042423	Kokuryo	+	+	+	+	+			+		+		+	+	+	+	
TH75042429	Kokuryo	+	+	+	+	+			+		+		+	+	+	+	Aln
TH80052202	Kokuryo	+	+	+	+	+			+		+		+	+	+	+	
TH75042807	Tokonabe	+	+	+	+	+	+		+	+	+		+	+	+	+	

Table 1. Albite-biotite zone pelitic schists (continued.)

Sample No.	Locality	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
TH75042834	Tokonabe	+	+	+	+	+	+	+	+		+		+	+	+	+	
TH75043020	Tokonabe	+	+	+	+	+			+	+	+	+	+	+	+	+	
TH75050120	Tokonabe	+	+	+	+	+	+	+	+		+			+	+	+	Aln
TH77052807	Tokonabe	+	+	+	+	+		+	+		+	+		+	+	+	
TH77052710	Hiura	+	+	+	+	+	+		+	+	+		+	+	+	+	
TH77052713	Hiura	+	+	+	+	+	+		+	+	+		+	+	+	+	Aln
TH77052716	Hiura	+	+	+	+	+	+	+	+	+	+		+	+	+	+	
TH77052717	Hiura	+	+	+	+	+	+		+	+	+	+	+	+	+	+	
TH76110401	Mishima	+	+	+	+	+	+		+		+	+	+	+	+	+	
TH76110409	Mishima	+	+	+	+	+	+		+		+		+	+	+	+	
TH71081002	Asemi	+	+	+	+	+	+		+		+		+	+	+	+	
TH71081003	Asemi	+	+	+	+	+	+		+		+		+	+	+	+	
TH71081102	Asemi	+	+	+	+	+	+		+	+	+	+	+	+	+	+	Aln
TH71081103	Asemi	+	+	+	+	+	+		+		+		+	+	+	+	Aln
TH71081104	Asemi	+	+	+	+	+	+		+		+		+	+	+	+	Aln
TH71081107	Asemi	+	+	+	+	+	+		+		+	+	+	+	+	+	
TH71081108	Asemi	+	+	+	+	+		+	+	+	+	+	+	+	+	+	
TH71081109	Asemi	+	+	+	+	+	+		+		+		+	+	+	+	
TH71081110	Asemi	+	+	+	+	+	+		+	+	+		+	+	+	+	
TH71081111	Asemi	+	+	+	+	+		+	+		+	+	+	+	+	+	Aln
TH71081404	Asemi	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	Aln
TH71081405	Asemi	+	+	+	+	+		+	+	+	+	+	+	+	+	+	Aln
TH71081408	Asemi	+	+	+	+	+	+	+	+		+	+	+	+	+	+	Aln
TH71081416	Asemi	+	+	+	+	+	+	+	+		+	+	+	+	+	+	Aln
TH71081418	Asemi	+	+	+	+	+		+	+		+		+	+	+	+	
CS82102801	Asemi	+	+	+	+	+	+		+	+	+		+		+	+	
CS82102802	Asemi	+	+	+	+	+	+		+	+	+		+	+	+	+	
CS82102803	Asemi	+	+	+	+	+			+		+		+	+	+	+	
CS82102805	Asemi	+	+	+	+	+			+		+		+	+	+	+	
CS82102807	Asemi	+	+	+	+	+	+			+	+	?	+	+	+	+	
CS82102809	Asemi	+	+	+	+	+			+		+	+		+	+	+	

Table 1. Albite-biotite zone pelitic schists (continued.)

Sample No.	Locality	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
CS82102814	Asemi	+	+	+	+	+		+	+		+		+	+	+	+	Aln
CS82102817	Asemi	+	+	+	+	+			+		+		+	+	+	+	
CS82102901	Asemi	+	+	+	+	+			+	+	+		+	+	+	+	
CS82102903	*Asemi*	+	+	+	+	+			+		+		+		+	+	Lws (?)
CS82102906	Asemi	+	+	+	+	+			+		+		+	+	+	+	
CS82102909	Asemi	+	+	+	+	+			+	+	+		+	+	+	+	
CS82102912	Asemi	+	+	+	+	+			+	+	+			+	+	+	
CS82102914	Asemi	+	+	+	+	+	?		+		+		+	+	+	+	
CS82102919	Asemi	+	+	+	+	+	+		+		+	?		+	+	+	Aln
CS82102922	Asemi	+	+	+	+	+	+		+		+			+	+	+	
CS82103003	Asemi	+	+	+	+	+			+		+		+	+	+	+	
CS83050403	Asemi	+	+	+	+	+	+		+	+	+		+	+	+	+	
CS83050407	Asemi	+	+	+	+	+			+	+	+		+		+	+	
CS83050410	Asemi	+	+	+	+	+			+	+	+		+	+	+	+	
CS83050412	Asemi	+	+	+	+	+	+		+	+	+		+	+	+	+	
CS83050413	Asemi	+	+	+	+	+			+	+	+		+	+	+	+	
CS83050801	Asemi	+	+	+	+	+					+		+		+	+	
CS83050802	Asemi	+	+	+	+	+	+				+	?	+	+	+	+	
CS83051104	Asemi	+	+	+	+	+	+	+	+		+		+	+	+	+	
CS84052603	Asemi	+	+	+	+	+	+		+		+			+	+	+	
CS83102701	Tachi	+	+	+	+	+	+			+	+		+	+	+	+	
CS83102702	Tachi	+	+	+	+	+	+	+	+		+	+	+	+	+	+	Aln
CS83102705	Tachi	+	+	+	+	+	+	+	+	+	+	+	+		+	+	
CS83102803	Tachi	+	+	+	+	+	+	+		+	+		+		+	+	
CS83102804	Tachi	+	+	+	+	+	+			+	+	+	+		+	+	Stp
CS83102805	Tachi	+	+	+	+	+	+	+		+		+	+		+	+	
CS83102806	Tachi	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
CS83102902	Tachi	+	+	+	+	+	+		+			+	+	+	+	+	
CS84052401	Tachi	+	+	+	+	+	+		+		+	+	+		+	+	

Table 1 (continued.). Oligoclase-biotite zone pelitic schists

Sample No.	Locality	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
TH75042404	Kokuryo	+	+	+	+	+			+		+	+	+	+	+	+	Aln
TH75042505	Kokuryo	+	+	+	+	+	+	+	+		+	+		+	+	+	
TH80052705	Seki	+	+	+	+	+	+	+	+		+	+		+	+	+	
TH80052712	Seki	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	Dol
TH80052719	Seki	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
TH80072303	Hiura	+	+	+	+	+	+	+	+		+	+		+	+	+	
TH80072307	Hiura	+	+	+	+	+		+	+	+	+	+		+	+	+	
TH71081303	Asemi	+	+	+	+	+	+	+	+		+	+	+	+	+	+	
TH71081306	Asemi	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
TH71081311	Asemi	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
TH71081315	Asemi	+	+	+	+	+	+	+	+		+	+	+	+	+	+	
TH71081422	Asemi	+	+	+	+	+	+		+	+	+	+	+	+	+	+	Aln
CS83050807	Asemi	+	+	+	+	+	+	+	+		+	+		+	+	+	
CS83050901	Asemi	+	+	+	+	+	+		+		+			+	+	+	
CS83050907	Asemi	+	+	+	+	+	+		+	+	+		+	+	+	+	
CS83050908	Asemi	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
CS83050909	Asemi	+	+	+	+	+	+	+			+	+	+		+	+	
CS83051006	Asemi	+	+	+	+	+	+	+	+		+	+	+	+	+	+	
CS83051401	Asemi	+	+	+	+	+	+		+	+	+		+	+	+	+	
CS83051402	Asemi	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
CS83103104	Asemi	+	+	+	+	+	+		+	+	+	+	+	+	+	+	
AG12-1	*Asemi*	+	+	+	+	+	+	+	+		+	+	+	+	+	+	
CS83102807	Tachi	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
CS83102903	Tachi	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
CS83102904	Tachi	+	+	+	+	+	+	+	+	+	+	+		+	+	+	

Pelitic schist clasts in conglomerate from the Kuma Group

Sample No.	Qtz	Pl	Ms	Chl	Grt	Bt	Hbl	Ep	Cal	Spn	Rt	Tur	Ap	CM	Ores	others
K-8	+	+	+	+	+			+			+	+	+	+	+	Zrn
118996	+	+	+	+		+		+		+		+	+		+	
K-1	+	+	+		+	+	+	+	+				+		+	Dol

ence spectroscopy; major elements by Rigaku model Simultix-3530 and trace elements (Rb, Sr, Y, Zr, Nb, Ba, Th, Pb, and Ni) by Rigaku model 3370. The analytical procedures are identical to those by GOTO and TATSUMI (1991, 1992). The loss of ignition of samples was also measured gravimetrically. In the following tables, total iron is represented as Fe_2O_3.

Table 2 lists XRF major and trace element compositions of pelitic schists. In Table 2, the data with an asterisk (*) are lower in concentration than the minimum of the standards and those with double asterisks (**) higher than the maximum one. Table 3 presents the average values with 1 σ of standard deviations and the compositional range of analyzed samples, representing the mean bulk chemical composition of Sanbagawa pelitic schists. The compositional variation is conspicuous, and the narrow *mg*-value (molar MgO/(MgO+FeO)) of 0.422 ± 0.031 (1σ) (Figure 3), K/Rb weight ratio of 211 ± 15 (Figure 4), and K/Ba weight ratio of 52.3 ± 6.5 (Figure 5), being characteristic of the Sanbagawa pelitic schist geochemically.

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Table 2. XRF major and trace element analyses of Sanbagawa pelitic schists.

	Chlorite zone pelitic schist															
Sample No.	TH7604 2507	TH7604 2510	TH7604 2515	TH7604 2521	TH7604 2524	TH7604 2526	TH7604 2529	TI7604 2504	TI7604 2510	TI7604 2516	TH7705 2608	TH7705 2614	TH7705 2617	HI7805 2901	HI7805 2909	HI7805 2917
(wt. %)																
SiO_2	67.88	73.21	70.82	74.21	73.34	73.30	72.80	68.56	67.83	74.41	72.05	66.69	67.09	73.06	69.33	68.08
TiO_2	0.58	0.40	0.50	0.37	0.43	0.38	0.46	0.53	0.54	0.39	0.42	0.59	0.47	0.39	0.53	0.56
Al_2O_3	15.21	13.86	14.13	13.42	13.71	13.09	13.08	14.66	13.92	13.35	14.22	15.98	16.79	13.32	15.00	16.14
Fe_2O_3#	4.98	3.18	4.43	3.15	2.69	2.62	3.05	4.43	4.40	3.10	3.60	5.01	3.97	2.90	4.37	4.29
MnO	0.20	0.07	0.12	0.08	0.03	0.04	0.06	0.11	0.04	0.04	0.06	0.15	0.10	0.05	0.09	0.09
MgO	1.77	1.08	1.65	0.93	0.82	0.76	0.80	1.58	1.48	1.02	1.12	1.81	1.48	0.97	1.42	1.52
CaO	0.46*	0.17*	0.22*	0.15*	0.54	2.04	1.54	0.97	0.23*	0.10*	0.20*	0.65	0.68	1.31	0.62	0.11*
Na_2O	2.37	3.11	3.20	3.27	2.97	3.27	4.12	2.55	0.60	3.09	2.85	2.30	3.07	3.20	2.51	3.13
K_2O	3.41	2.57	2.29	2.57	3.19	2.46	1.94	3.32	4.53	2.37	3.17	3.36	3.90	2.82	3.30	3.13
P_2O_5	0.11	0.08*	0.09*	0.07*	0.09*	0.09*	0.08*	0.11	0.10*	0.08*	0.08*	0.12	0.10*	0.08*	0.09*	0.11
LOI	1.83	1.79	1.95	1.66	1.37	1.13	1.35	2.80	5.58	2.16	1.87	2.79	2.21	1.90	2.02	2.71
Total	98.80	99.52	99.40	99.88	99.18	99.18	99.28	99.62	99.25	100.11	99.64	99.45	99.86	100.00	99.28	99.87
(ppm)																
Rb	129	105	93.8	105	117	84.1	72.6	130	160	97.9	135	135	148	101	133	131
Sr	49.5	40.0	50.9	32.3	147	290	198	88.9	35.4	33.4	22.0	78.4	98.4	142	76.4	44.6
Y	23.5	18.9	17.8	22.2	17.2	16.0	16.6	22.6	25.7	22.9	17.9	22.9	26.0	18.5	25.5	18.9
Zr	142	146	133	144	162	142	175	150	171	150	143	152	164	134	146	168
Nb	10.2	8.7	8.9	8.3	7.9	6.0	6.3	9.2	10.1	8.5	8.6	10.4	8.8	6.5	10.5	10.8
Ba	480	437	375	475	497	454	350	577	713	381	486	545	564	526	517	551
Th	12.7	11.0	11.6	12.2	11.4	8.2	8.9	12.8	13.2	12.0	13.1	13.2	14.1	8.2	14.1	11.7
Pb	18.6	12.3	16.3	28.8	18.6	15.5	16.0	21.3	20.4	20.6	21.2	17.3	12.7	18.3	15.9	11.1
Ni	20.9*	7.2*	10.4*	6.7*	1.1*	1.9*	8.2*	16.0*	14.1*	7.9*	6.2*	14.8*	9.6*	4.4*	14.6*	9.6*
mg-value	0.413	0.402	0.425	0.369	0.376	0.365	0.342	0.414	0.400	0.395	0.381	0.417	0.425	0.399	0.392	0.412
Mn-ratio	2.58	1.46	1.72	1.77	0.78	1.08	1.44	1.61	0.61	0.87	1.15	1.93	1.60	1.15	1.39	1.37
K/Rb	219	203	203	204	227	243	222	213	235	201	196	206	218	232	206	198
K/Ba	59.0	48.9	50.7	44.9	53.3	44.9	46.1	47.7	52.7	51.7	54.1	51.1	57.4	44.5	53.0	47.2

Fe_2O_3# = total iron as Fe_2O_3. LOI; loss of ignition
mg-value; molar MgO/(MgO+FeO)
Mn-ratio; percent molar MnO/(MgO+FeO+MnO)
K/Rb and K/Ba; weight ratios

Table 2 (continued.)

	Chlorite zone pelitic schists															
Sample No.	HI7805 2922	HK6908 1602	HK6908 1607	HK6908 1609	TH8108 1105	TH8108 1111	CS8305 0605	CS8305 0703	CS8305 0705	CS8305 0706	CS8305 1701	CS6305 1801	CS8305 2002	CS8405 2901	CS8405 2903	CS8405 2904
(wt.%)																
SiO_2	66.12	71.88	71.33	70.32	71.15	64.87	67.28	69.02	67.65	69.47	69.29	69.98	64.38	59.63	62.21	69.91
TiO_2	0.60	0.45	0.46	0.51	0.47	0.60	0.56	0.48	0.46	0.59	0.55	0.56	0.63	0.75	0.69	0.59
Al_2O_3	17.25	14.25	14.98	14.41	14.37	17.25	15.07	15.26	16.55	15.58	14.60	14.37	16.20	18.41	16.91	14.22
Fe_2O_3#	4.20	3.78	3.93	4.54	3.68	5.27	4.95	3.09	3.04	4.59	4.71	4.67	6.91	7.80	6.16	4.73
MnO	0.09	0.05	0.11	0.08	0.05	0.11	0.09	0.05	0.05	0.08	0.17	0.15	0.28	0.30	0.21	0.10
MgO	1.36	1.29	1.60	1.48	0.95	1.62	1.87	1.25	1.22	1.80	1.81	1.71	2.34	2.96	2.23	1.57
CaO	0.32*	0.07*	0.10*	0.13*	0.25*	0.56	1.48	2.00	1.63	0.38*	0.50	0.43*	0.37*	0.66	1.32	0.50
Na_2O	3.32	2.92	1.09	3.24	3.75	2.98	2.74	4.85	5.52	2.85	2.73	2.15	2.75	2.41	1.81	3.53
K_2O	3.43	2.75	4.09	2.35	2.35	3.65	2.63	1.76	1.61	2.58	2.76	2.82	2.59	3.43	3.73	1.84
P_2O_5	0.11	0.08*	0.08*	0.11	0.09*	0.10*	0.12	0.12	0.10*	0.12	0.10*	0.10*	0.10*	0.11	0.14	0.12
LOI	2.65	2.34	2.33	2.30	3.03	3.00	2.95	1.99	1.61	2.43	2.48	2.78	2.97	3.15	3.60	2.22
Total	99.45	99.86	100.10	99.47	100.14	100.01	99.74	99.87	99.44	100.47	99.70	99.72	99.52	99.61	99.01	99.33
(ppm)																
Rb	136	111	155	99.0	91.1	142	103	68.2	62.2	107	114	121	109	135	153	76.7
Sr	104	34.7	22.9*	57.6	46.3	71.9	143	260	182	48.1	55.5	63.5	53.5	52.4	113	65.0
Y	20.3	9.3	14.8	18.6	25.9	11.7	18.5	15.5	15.2	19.4	23.1	17.1	18.4	21.5	18.8	17.3
Zr	155	136	142	138	135	166	137	187	177	150	138	120	124	147	136	137
Nb	11.2	9.6	10.2	9.6	10.0	10.2	8.9	6.8	6.7	9.7	9.7	9.1	9.1	10.9	10.1	9.5
Ba	567	394	696	416	340	641	438	361	334	415	541	494	320	538	623	286
Th	16.4	13.8	15.7	12.8	13.5	14.6	10.8	8.3	8.6	12.5	13.2	12.1	13.3	15.8	12.4	11.5
Pb	18.6	18.7	12.7	17.7	30.1	22.1	23.0	17.5	20.2	18.5	15.8	17.0	34.1**	21.3	10.8	20.3
Ni	8.0*	0.6*	16.4*	10.5*	8.8*	12.6*	19.1*	9.8*	7.1*	20.4*	15.0*	17.6*	29.9*	40.6*	29.2*	13.3*
mg-value	0.391	0.403	0.446	0.392	0.338	0.378	0.428	0.445	0.443	0.437	0.432	0.420	0.401	0.429	0.418	0.397
Mn-ratio	1.45	0.88	1.71	1.19	1.00	1.44	1.16	1.00	1.02	1.09	2.25	2.05	2.66	2.41	2.19	1.42
K/Rb	209	206	219	197	214	214	212	214	215	199	202	194	198	211	203	199
K/Ba	50.3	57.9	48.8	46.9	57.4	47.3	49.8	40.4	40.0	51.6	42.3	47.4	67.2	53.0	49.7	53.4

Table 2 (continued.)

	Chlorite zone pelite	Garnet zone pelitic schists														
Sample No.	CS8405 2906	CS8405 2907	CS8405 2505	TH7504 2107	TH7504 2112	TH7504 2115	TH7504 2121	TH7504 2124	TH7504 2128	TH7504 2132	TH7504 2134	TH7504 2136	TH7504 2212	TH7504 2510	TH7504 2515	TH7604 2504
(wt.%)																
SiO_2	61.04	64.81	69.35	71.03	71.69	66.91	72.56	69.42	70.39	69.65	70.63	66.31	66.28	68.76	67.39	65.89
TiO_2	0.76	0.66	0.57	0.51	0.35	0.58	0.37	0.58	0.48	0.31	0.50	0.64	0.64	0.56	0.61	0.63
Al_2O_3	18.23	16.74	15.24	14.04	15.49	15.34	14.65	14.47	13.65	17.07	14.98	16.65	15.51	15.17	15.11	16.86
Fe_2O_3#	6.49	5.43	4.76	3.65	2.47	5.27	2.48	4.52	4.79	2.70	3.43	4.30	5.08	5.16	5.16	5.11
MnO	0.14	0.10	0.13	0.13	0.08	0.37	0.05	0.18	0.06	0.03	0.07	0.08	0.08	0.23	0.21	0.11
MgO	2.31	2.02	1.76	1.35	1.01	2.30	0.93	1.93	1.66	0.90	1.50	1.66	2.02	1.70	2.03	1.85
CaO	0.62	0.79	0.32*	0.53	0.44*	0.66	0.56	0.53	0.94	0.05*	0.21*	1.19	0.58	0.50	1.30	0.53
Na_2O	2.52	2.65	2.08	2.43	3.98	1.13	3.45	1.24	2.65	3.54	2.11	2.16	1.40	1.84	2.06	2.82
K_2O	3.59	3.34	2.84	2.89	2.68	3.84	2.73	3.50	2.21	3.40	3.47	3.56	4.25	3.37	3.24	3.26
P_2O_5	0.14	0.16	0.15	0.10*	0.07*	0.11	0.05*	0.10*	0.13	0.05*	0.10*	0.13	0.13	0.12	0.12	0.13
LOI	3.31	2.51	2.28	2.16	1.46	2.40	1.64	2.82	2.20	2.05	2.49	2.83	2.64	2.90	2.17	2.76
Total	99.15	99.21	99.48	98.82	99.72	98.91	99.47	99.29	99.16	99.75	99.49	99.51	98.61	100.31	99.40	99.95
(ppm)																
Rb	138	125	115	118	110	142	110	144	91.5	136	136	136	144	137	128	125
Sr	74.9	87.4	74.8	102	133	73.4	135	80.0	110	67.6	55.6	199	36.3	99.1	128	152
Y	24.2	22.8	50.3**	19.1	26.8**	22.8	22.6	18.4	21.8	36.8**	19.8	28.4**	19.9	26.2**	22.7	17.5
Zr	176	175	142	136	180	138	151	123	128	143	128	165	138	162	140	158
Nb	12.4	11.0	10.0	9.1	10.2	10.3	8.4	10.0	7.8	9.8	8.8	10.6	10.0	10.8	9.7	9.6
Ba	543	521	448	432	502	685	445	538	396	564	505	602	547	513	479	481
Th	15.1	13.4	13.7	12.1	16.2	13.9	12.8	13.8	9.9	15.0	13.5	14.4	11.4	13.1	13.1	13.0
Pb	22.5	20.1	17.8	16.7	30.1	55.8**	15.3	16.3	15.2	17.8	15.5	19.7	9.4	19.7	21.6	17.1
Ni	24.4*	20.7*	5.3*	7.0*	1.8*	25.6*	9.9*	17.3*	13.6*	10.9*	4.6*	10.8*	17.9*	11.0*	26.9*	6.2*
mg-value	0.414	0.424	0.423	0.423	0.448	0.464	0.426	0.458	0.407	0.398	0.464	0.433	0.441	0.395	0.438	0.418
Mn-ratio	1.40	1.18	1.74	2.26	1.97	4.07	1.29	2.37	0.83	0.75	1.22	1.17	0.98	2.95	2.51	1.39
K/Rb	215	221	206	203	203	224	207	202	200	207	211	217	245	204	210	217
K/Ba	54.9	53.2	52.7	55.5	44.3	46.5	51.0	54.0	46.4	50.0	57.0	49.1	64.5	54.5	56.1	56.3

Table 2 (continued.)

	Garnet zone pelitic schists															
Sample No.	TH7705 2701	TH7705 2704	TH7705 2708	TH7504 1906	TH7611 0404	TH7611 0413	TH7611 0415	TH7611 0417	TH7611 0420	TH7107 2702	TH7107 2714	TH7107 2721	TH7108 0201	TH7108 1001	TH7108 1004	TH7108 1005
(wt. %)																
SiO_2	69.07	63.55	68.02	66.84	68.39	70.89	65.79	70.26	68.51	74.32	67.28	69.81	71.10	73.73	72.21	74.01
TiO_2	0.54	0.69	0.59	0.57	0.54	0.59	0.61	0.55	0.64	0.40	0.60	0.59	0.50	0.49	0.55	0.41
Al_2O_3	13.29	17.60	15.31	16.32	14.78	14.96	17.44	16.18	15.31	13.60	16.02	14.82	15.01	13.16	13.48	13.87
Fe_2O_3#	4.75	5.89	5.13	4.56	4.45	3.10	4.73	2.67	4.79	2.84	5.06	4.39	3.61	3.87	4.98	2.78
MnO	0.16	0.29	0.20	0.13	0.12	0.05	0.08	0.02	0.11	0.06	0.19	0.07	0.09	0.12	0.17	0.05
MgO	2.99	2.12	1.93	1.51	1.59	1.35	1.58	1.22	1.96	1.11	1.94	1.77	1.41	1.51	1.71	0.98
CaO	1.23	0.62	0.62	0.24*	1.47	1.06	0.20*	0.10*	0.17*	0.51	0.54	0.40*	0.40*	0.64	0.72	0.59
Na_2O	1.85	3.44	2.38	2.69	2.22	0.85	2.58	1.88	1.60	3.16	2.01	2.55	2.74	2.24	2.06	3.96
K_2O	2.71	3.08	3.12	3.27	3.24	4.26	3.91	4.19	3.62	2.57	3.53	2.90	2.83	2.67	2.61	2.12
P_2O_5	0.11	0.11	0.12	0.11	0.11	0.07*	0.16	0.09*	0.09*	0.08*	0.10*	0.09*	0.09*	0.09*	0.10*	0.07*
LOI	2.53	2.58	2.07	3.57	2.02	2.38	2.71	3.43	2.81	1.46	2.20	2.34	1.68	1.68	1.37	1.15
Total	99.23	99.97	99.49	99.81	98.93	99.56	99.79	100.59	99.61	100.11	99.47	99.73	99.46	100.20	99.96	99.99
(ppm)																
Rb	110	125	126	n.d.	125	161	150	165	145	104	144	118	123	112	112	88.5
Sr	107	133	72.5	n.d.	102	177	68.9	51.7	49.5	109	112	77.0	97.1	109	73.0	118
Y	20.0	31.6**	21.2	n.d.	23.1	20.0	24.4	5.0*	7.0*	18.4	22.0	20.8	16.0	18.3	19.3	17.6
Zr	131	163	145	n.d.	140	128	165	135	127	137	137	146	131	115	139	132
Nb	9.3	12.4	10.9	n.d.	9.8	10.6	9.5	10.8	10.7	6.8	10.3	9.3	9.3	8.6	9.5	7.1
Ba	429	468	483	n.d.	470	778	667	639	570	426	579	461	437	448	471	393
Th	10.3	15.8	13.5	n.d.	13.1	12.6	17.2	15.9	14.5	10.3	14.1	13.2	12.1	11.8	11.2	10.7
Pb	25.8	14.0	15.0	n.d.	21.6	14.3	17.1	14.3	19.3	14.6	19.2	12.6	22.8	20.1	11.0	12.7
Ni	50.0	25.5*	23.8*	n.d.	15.5*	3.4*	4.2*	0.0*	7.0*	4.5*	11.1*	15.0*	11.1*	7.0*	24.4*	7.5*
mg-value	0.555	0.416	0.427	0.396	0.414	0.463	0.398	0.475	0.448	0.436	0.432	0.444	0.436	0.436	0.405	0.411
Mn-ratio	1.66	3.13	2.45	1.90	1.75	0.97	1.13	0.44	1.41	1.32	2.35	0.99	1.56	1.93	2.24	1.18
K/Rb	204	204	206		216	220	216	211	207	206	203	204	192	199	194	199
K/Ba	52.4	54.6	53.6		57.2	45.5	48.7	54.4	52.7	50.1	50.6	52.3	53.7	49.5	46.0	44.7

n.d. = not determined.

Table 2 (continued.)

	Garnet zone pelitic schists															
Sample No.	TH7211 2936	TH7211 3005	TH7211 3014	TH7211 3026	CS8210 2602	CS8210 2604	CS8210 2606	CS8210 2701	CS8210 2708	CS8210 2709	CS8210 3106	CS8210 3108	CS8210 3118	CS8210 3121	CS8211 0109	CS8211 0111
(wt. %)																
SiO_2	74.64	77.48	72.89	70.65	73.39	68.82	70.06	71.80	68.22	70.66	72.21	69.71	62.63	74.94	67.53	66.84
TiO_2	0.35	0.31	0.53	0.49	0.46	0.59	0.55	0.54	0.58	0.53	0.39	0.52	0.74	0.30	0.53	0.55
Al_2O_3	14.12	12.01	13.74	15.18	13.81	16.20	14.63	14.31	15.43	14.74	12.48	14.43	17.36	13.55	15.81	14.62
Fe_2O_3#	2.14	1.99	3.43	3.75	3.12	4.83	4.68	4.57	5.31	4.31	3.33	4.78	6.25	2.46	5.51	4.74
MnO	0.05	0.06	0.06	0.05	0.06	0.18	0.22	0.20	0.23	0.19	0.16	0.27	0.12	0.05	0.35	0.23
MgO	0.81	0.63	1.22	1.43	1.04	1.79	1.66	1.78	2.03	1.69	1.20	1.88	2.61	0.64	2.02	1.84
CaO	0.42*	0.72	0.73	0.63	0.73	0.59	0.62	0.68	0.87	0.50	2.23	1.06	1.19	0.59	0.77	2.83
Na_2O	2.67	3.28	3.69	3.74	3.51	2.29	2.27	1.66	2.02	2.29	2.27	1.89	2.58	4.36	2.04	2.88
K_2O	3.34	2.24	2.09	2.42	2.36	3.29	2.92	3.19	3.32	3.04	2.82	2.81	3.10	1.84	3.21	2.23
P_2O_5	0.07*	0.06*	0.09*	0.10*	0.08*	0.12	0.11	0.10*	0.12	0.10*	0.12	0.13	0.15	0.07*	0.10*	0.12
LOI	1.07	1.23	1.35	1.27	1.44	1.96	2.04	1.66	2.09	2.14	2.27	2.72	2.83	1.31	2.09	3.16
Total	99.68	100.01	99.82	99.71	100.00	100.66	99.76	100.49	100.22	100.19	99.48	100.20	99.56	100.11	99.96	100.04
(ppm)																
Rb	130	n.d.	85.3	98.2	95.9	139	123	134	131	124	103	121	121	71.0	134	89.6
Sr	93.0	n.d.	121	142	121	101	93.0	70.6	121	86.9	139	129	210	174	93.0	195
Y	22.3	n.d.	16.4	17.4	20.8	24.2	24.4	17.6	19.9	21.7	17.1	20.2	21.6	19.7	23.9	18.6
Zr	147	n.d.	156	133	140	155	136	130	134	137	101	114	145	141	124	123
Nb	7.6	n.d.	7.5	7.5	8.6	10.3	10.2	9.6	9.0	9.5	7.0	9.3	10.1	6.9	9.4	8.9
Ba	691	n.d.	394	436	415	563	444	469	619	461	431	354	501	383	512	337
Th	13.0	n.d.	9.5	9.6	10.7	14.9	12.6	12.7	15.0	12.9	9.7	11.3	13.3	12.9	15.1	11.5
Pb	18.8	n.d.	12.9	14.2	13.5	18.2	21.1	12.2	13.9	22.3	18.2	26.2	14.4	10.7	10.7	37.7**
Ni	6.4*	n.d.	12.1*	10.9*	10.4*	15.1*	14.6*	17.7*	11.3*	15.7*	8.3*	20.6*	7.7*	0.2*	25.3*	21.0*
mg-value	0.429	0.385	0.413	0.430	0.398	0.423	0.413	0.436	0.431	0.437	0.417	0.438	0.453	0.340	0.421	0.435
Mn-ratio	1.48	2.04	1.14	0.85	1.29	2.36	3.01	2.71	2.70	2.72	3.06	3.45	1.17	1.49	3.98	2.99
K/Rb	213		203	205	204	197	197	198	210	204	227	193	212	215	200	207
K/Ba	40.2		44.1	46.1	47.2	48.6	54.6	56.5	44.5	54.7	54.3	65.9	51.4	39.9	52.0	55.0

Table 2 (continued.)

	Garnet zone pelitic schists															
Sample No.	CS8211 0202	CS8211 0302	CS8305 1105	CS8305 1201	CS8305 1206	CS8305 1208	CS8406 0301	CS8310 2703	CS8310 2706	CS8310 2802	CS8310 2905	CS8310 3002	CS8310 3004	CS8405 2504	CS8405 3001	CS8405 3003
(wt.%)																
SiO_2	68.81	64.55	70.31	68.00	68.82	67.29	63.76	69.70	69.97	70.97	72.48	68.87	67.19	62.82	66.15	72.62
TiO_2	0.58	0.66	0.51	0.55	0.58	0.54	0.70	0.57	0.49	0.44	0.50	0.55	0.60	0.75	0.61	0.51
Al_2O_3	15.30	15.97	14.29	15.05	15.29	14.95	18.18	15.03	14.55	14.41	13.03	14.75	16.40	16.70	15.84	13.07
Fe_2O_3#	4.86	5.40	4.69	4.54	4.54	4.67	5.77	3.86	4.23	3.43	4.76	5.04	5.13	6.75	5.62	4.34
MnO	0.22	0.21	0.20	0.16	0.13	0.16	0.20	0.07	0.18	0.10	0.26	0.25	0.33	0.28	0.23	0.22
MgO	1.73	2.24	1.71	1.81	1.81	1.69	2.13	1.39	1.38	1.14	1.82	1.85	1.84	3.07	1.58	1.54
CaO	0.66	1.24	0.99	1.72	0.71	1.64	0.29*	0.76	1.58	1.22	0.53	0.41*	0.62	0.64	1.08	0.60
Na_2O	2.24	2.33	1.28	1.72	1.97	2.39	2.45	2.82	1.84	3.27	1.48	2.13	1.89	2.12	3.54	2.03
K_2O	3.16	3.22	3.22	3.35	3.26	3.05	3.87	2.59	3.11	2.76	2.69	2.92	3.68	3.36	2.22	2.63
P_2O_5	0.11	0.12	0.11	0.11	0.11	0.12	0.13	0.07*	0.09*	0.09*	0.11	0.11	0.13	0.13	0.10*	0.09*
LOI	2.51	3.38	2.66	2.43	2.32	2.64	2.91	1.95	2.31	1.17	1.99	1.94	1.81	2.50	2.36	1.73
Total	100.18	99.32	99.97	99.44	99.54	99.14	100.39	98.81	99.73	99.00	99.65	98.82	99.62	99.12	99.33	99.38
(ppm)																
Rb	128	131	133	129	131	119	152	106	130	114	114	120	156	128	91.7	106
Sr	132	142	110	191	130	155	80.6	188	176	127	57.3	54.9	122	112	162	94.7
Y	22.8	21.3	20.5	19.2	22.3	22.3	24.9	32.5**	23.8	22.3	21.8	14.2	26.8**	25.0	22.2	16.9
Zr	147	148	122	134	142	142	170	158	137	146	116	127	168	151	119	110
Nb	10.4	10.3	10.7	9.2	10.4	9.5	12.0	10.8	10.3	9.0	8.8	9.9	11.7	10.5	9.5	8.9
Ba	479	485	474	517	553	537	641	380	655	501	449	402	535	463	427	410
Th	13.9	13.7	11.7	11.5	14.0	12.7	15.4	15.2	13.7	12.2	11.1	13.3	17.7	13.1	13.1	11.2
Pb	12.4	8.7	20.3	14.0	13.8	13.7	15.7	16.7	19.5	18.6	14.4	20.1	18.4	29.0	12.5	19.7
Ni	14.1*	28.0*	10.3*	13.9*	4.6*	16.4*	24.0*	–	12.1*	5.1*	22.2*	11.9*	24.2*	52.0	19.2*	10.2*
mg-value	0.414	0.451	0.419	0.441	0.441	0.418	0.422	0.416	0.393	0.397	0.431	0.421	0.415	0.474	0.358	0.413
Mn-ratio	2.90	2.35	2.71	2.17	1.77	2.20	2.20	1.18	2.83	1.94	3.38	3.13	4.06	2.40	2.87	3.24
K/Rb	206	205	202	216	207	213	211	202	198	202	196	202	196	218	201	205
K/Ba	54.8	55.1	56.4	53.8	48.9	47.2	50.1	56.5	39.4	45.7	49.7	60.3	57.1	60.3	43.2	53.2

Table 2 (continued.)

	Garnet zone pelitic schists				Albite-biotite zone pelitic schists											
Sample No.	CS8405 3007	CS8405 3013	CS8406 0102	CS8406 0206	TH7504 2206	TH7504 2216	TH7504 2221	TH7504 2410	TH7504 2414	TH7504 2415	TH7504 2423	TH7504 2429	TH8005 2202	TH7504 2807	TH7504 2834	TH7504 3020
(wt.%)																
SiO_2	69.66	68.78	72.79	73.96	68.44	67.14	64.25	70.03	71.82	72.83	70.38	67.35	68.82	71.84	65.13	67.21
TiO_2	0.52	0.54	0.39	0.43	0.56	0.70	0.62	0.57	0.51	0.45	0.52	0.57	0.56	0.39	0.63	0.60
Al_2O_3	14.52	15.99	14.64	13.61	14.93	15.99	16.38	15.01	14.67	13.75	14.69	16.28	15.66	13.45	16.63	15.05
Fe_2O_3#	3.99	4.38	2.45	3.77	4.65	5.41	4.37	4.72	3.40	3.71	4.52	5.03	4.66	2.79	5.39	5.92
MnO	0.06	0.18	0.03	0.12	0.15	0.17	0.18	0.12	0.10	0.17	0.09	0.14	0.22	0.06	0.20	0.31
MgO	1.63	1.62	0.84	1.42	1.62	1.92	1.75	1.68	1.21	1.31	1.42	1.66	1.81	0.98	1.83	2.19
CaO	0.92	1.06	1.34	0.33*	1.13	0.25*	2.22	0.34*	0.46*	0.40*	0.28*	0.31*	0.46*	1.95	0.83	0.85
Na_2O	3.88	2.47	2.92	2.15	1.84	1.07	2.59	0.88	2.70	3.53	2.78	2.63	2.18	2.91	2.15	2.08
K_2O	1.94	3.49	3.29	2.81	3.39	3.93	3.37	3.99	2.83	2.03	2.83	3.32	3.35	2.78	3.75	2.61
P_2O_5	0.12	0.11	0.08*	0.09*	0.12	0.11	0.14	0.10*	0.11	0.10*	0.11	0.14	0.10*	0.11	0.11	0.11
LOI	1.50	1.70	1.60	1.80	1.81	2.57	3.11	2.73	2.38	1.60	2.45	2.69	2.14	1.26	2.29	2.29
Total	98.74	100.32	100.37	100.49	98.64	99.26	98.98	100.17	100.19	99.88	100.07	100.12	99.96	98.52	98.94	99.22
(ppm)																
Rb	71.9	132	114	118	131	157	135	157	116	82.3	112	128	133	106	149	113
Sr	186	155	292	72.3	136	85.9	240	77.2	113	116	90.9	81.3	102	190	121	123
Y	16.3	25.5	21.0	20.7	21.9	20.3	22.3	20.8	14.4	16.8	17.2	23.4	23.3	19.2	23.5	21.7
Zr	151	153	166	123	137	145	158	131	194	147	144	143	156	150	153	130
Nb	7.6	10.6	7.8	8.4	9.2	13.7	12.0	10.7	12.0	8.7	9.2	10.0	11.2	8.5	11.9	9.9
Ba	369	571	559	434	589	565	459	632	463	281	489	453	511	450	514	334
Th	8.3	16.5	11.0	12.1	12.4	13.1	11.1	13.0	12.4	12.0	12.7	14.0	15.9	11.2	15.2	13.2
Pb	22.8	11.4	21.2	20.7	21.1	14.7	19.5	12.6	40.0**	15.0	24.4	26.8	22.4	12.3	17.9	28.4
Ni	6.3*	2.9*	1.2*	12.6*	15.6*	11.1*	12.8*	14.6*	7.3*	4.4*	13.6*	10.6*	24.7*	2.6*	9.9*	23.0*
mg-value	0.447	0.423	0.404	0.427	0.408	0.413	0.442	0.414	0.413	0.412	0.384	0.395	0.435	0.410	0.402	0.423
Mn-ratio	0.93	2.60	0.81	2.01	2.10	2.03	2.52	1.65	1.90	2.95	1.36	1.86	2.92	1.41	2.44	3.29
K/Rb	224	220	240	198	215	208	207	210	203	205	210	215	209	218	210	192
K/Ba	43.7	50.7	48.8	53.7	47.8	57.7	60.9	52.4	50.8	59.9	48.0	60.9	54.4	51.3	60.5	64.8

Table 2 (continued.)

	Albite-biotite zone pelitic schists															
Sample No.	TH7505 0120	TH7705 2807	TH7705 2710	TH7705 2713	TH7705 2716	TH7705 2717	TH7611 0401	TH7611 0409	TH7108 1002	TH7108 1003	TH7108 1102	TH7108 1103	TH7108 1104	TH7108 1107	TH7108 1108	TH7108 1109
(wt. %)																
SiO_2	72.39	67.14	68.13	73.72	71.56	64.81	67.94	69.23	72.57	70.15	63.48	68.31	69.89	71.90	64.72	66.74
TiO_2	0.49	0.56	0.53	0.42	0.43	0.65	0.58	0.50	0.48	0.53	0.72	0.65	0.55	0.45	0.69	0.61
Al_2O_3	13.83	15.99	14.35	13.48	13.90	16.68	16.18	15.63	13.70	15.16	16.40	15.99	14.63	14.83	16.00	16.16
Fe_2O_3#	2.80	4.38	3.82	2.89	3.24	6.29	4.33	3.77	4.25	4.14	7.96	4.55	4.43	3.20	5.67	5.90
MnO	0.02	0.05	0.10	0.05	0.06	0.27	0.14	0.05	0.13	0.10	0.34	0.09	0.19	0.05	0.16	0.31
MgO	0.89	1.60	1.75	1.04	1.12	2.37	1.58	1.23	1.61	1.40	2.65	1.59	1.68	1.08	2.34	2.22
CaO	0.59	3.47	2.36	1.04	1.32	0.86	0.59	0.78	0.51	0.61	1.03	0.88	0.84	0.92	1.85	0.83
Na_2O	2.58	0.47	2.80	3.64	3.04	1.77	2.10	0.63	1.60	3.24	2.08	2.86	0.88	2.88	2.59	2.02
K_2O	3.13	3.61	2.81	2.10	2.73	3.44	3.68	4.92	3.09	2.76	2.87	3.19	4.12	3.31	2.91	3.38
P_2O_5	0.09*	0.16	0.12	0.08*	0.08*	0.14	0.11	0.08*	0.11	0.15	0.11	0.12	0.09*	0.08*	0.12	0.10*
LOI	2.11	1.88	3.02	1.21	1.66	2.14	1.85	2.40	1.96	1.35	2.36	1.70	1.55	1.32	2.32	1.82
Total	98.92	99.31	99.79	99.67	99.14	99.42	99.08	99.22	100.01	99.59	100.00	99.93	98.85	100.02	99.37	100.09
(ppm)																
Rb	110	115	107	76.1	98.8	142	142	181	127	111	113	125	156	130	111	134
Sr	109	440	174	113	110	118	109	134	81.5	127	121	184	116	149	186	98.9
Y	15.1	17.0	16.2	19.4	19.1	20.6	17.5	23.2	24.2	20.4	25.0	22.3	20.5	26.7**	20.9	17.7
Zr	150	166	148	129	128	129	150	125	139	168	133	184	135	165	141	134
Nb	9.1	7.1	7.6	7.8	8.4	9.7	10.2	10.1	13.6	8.8	12.2	9.5	9.7	11.8	9.3	9.8
Ba	426	751	456	323	469	412	663	916	484	497	455	587	627	523	507	471
Th	9.8	10.6	9.2	10.9	10.1	13.2	13.9	14.0	13.1	13.2	12.9	12.0	12.9	15.6	10.6	15.1
Pb	12.1	19.7	15.2	12.3	17.4	23.0	17.8	21.4	14.4	21.3	11.1	17.3	12.2	18.4	16.9	15.4
Ni	7.2*	2.9*	10.6*	11.0*	7.4*	28.0*	6.2*	13.6*	16.1*	18.5*	24.4*	16.9*	23.1*	2.6*	29.4*	15.5*
mg-value	0.386	0.420	0.476	0.416	0.406	0.427	0.420	0.393	0.429	0.401	0.397	0.409	0.429	0.401	0.450	0.427
Mn-ratio	0.49	0.74	1.52	1.12	1.22	2.69	2.07	0.90	1.93	1.60	2.82	1.30	2.68	1.04	1.72	3.28
K/Rb	237	260	219	229	229	201	216	225	202	207	211	212	219	211	217	209
K/Ba	60.9	39.9	51.1	54.0	48.4	69.4	46.1	44.6	53.0	46.1	52.4	45.1	54.6	52.5	47.7	59.5

Table 2 (continued.)

	Albite-biotite zone pelitic schists															
Sample No.	TH7108 1110	TH7108 1111	TH7108 1404	TH7108 1405	TH7108 1408	TH7108 1416	TH7108 1418	CS8210 2801	CS8210 2802	CS8210 2803	CS8210 2805	CS8210 2807	CS8210 2809	CS8210 2814	CS8210 2817	CS8210 2901
(wt. %)																
SiO_2	68.55	71.79	72.10	70.19	70.66	69.22	68.23	70.64	70.60	72.15	69.72	68.60	64.67	67.41	66.95	72.94
TiO_2	0.57	0.48	0.49	0.53	0.56	0.59	0.58	0.43	0.50	0.54	0.56	0.55	0.68	0.59	0.62	0.37
Al_2O_3	15.41	14.37	14.20	15.52	14.77	15.20	15.47	15.35	14.52	14.27	15.04	15.31	16.86	15.05	16.00	13.28
Fe_2O_3#	4.99	3.48	3.33	3.79	4.47	5.00	4.73	3.96	4.26	4.71	5.04	4.25	6.08	5.70	6.15	2.80
MnO	0.19	0.06	0.09	0.11	0.14	0.21	0.12	0.10	0.12	0.21	0.16	0.08	0.26	0.25	0.33	0.06
MgO	1.83	1.39	1.26	1.36	1.52	1.77	1.68	1.33	1.64	1.89	1.97	1.26	2.27	2.31	2.25	0.92
CaO	0.98	0.43*	0.85	0.78	0.89	0.73	1.11	0.49	1.00	0.19*	0.77	0.60	0.98	0.88	0.43*	1.97
Na_2O	1.96	2.99	5.15	3.34	1.52	2.09	2.06	2.87	2.64	0.67	0.60	2.84	2.27	2.17	2.04	2.81
K_2O	3.30	2.79	1.42	2.80	3.52	3.15	3.43	3.03	2.84	3.22	4.15	3.21	3.29	2.77	2.89	2.48
P_2O_5	0.11	0.07*	0.10*	0.09*	0.11	0.09*	0.11	0.09*	0.11	0.12	0.11	0.10*	0.13	0.10*	0.12	0.10*
LOI	2.16	1.85	1.08	1.92	1.96	1.85	2.07	2.00	1.86	2.17	1.88	2.83	2.54	2.08	2.47	1.64
Total	100.05	99.70	100.07	100.43	100.12	99.90	99.59	100.29	100.09	100.14	100.00	99.63	100.03	99.31	100.25	99.37
(ppm)																
Rb	134	118	62.4	112	141	130	132	134	121	130	140	130	133	103	120	96.8
Sr	115	143	129	155	155	122	234	101	129	84.9	56.4	87.2	129	70.2	113	201
Y	21.0	16.1	20.5	22.4	22.5	19.6	21.2	23.5	17.2	12.8	25.3	19.5	27.0**	18.5	19.6	25.0
Zr	136	136	149	156	140	124	150	129	125	115	128	152	139	139	128	134
Nb	9.8	8.0	8.2	8.3	9.3	9.5	8.4	9.9	8.2	8.7	9.4	9.7	11.6	9.9	10.0	9.3
Ba	523	441	252	436	564	560	733	537	521	373	599	460	477	359	394	393
Th	12.8	11.6	12.2	12.8	12.5	13.4	12.2	16.7	11.9	13.1	12.4	12.6	13.6	12.4	11.4	12.7
Pb	19.5	25.1	21.0	23.0	18.8	16.4	18.1	15.6	27.8	17.6	10.3	16.1	29.0	17.1	27.4	13.4
Ni	27.4*	4.6*	15.9*	17.8*	14.0*	20.8*	11.4*	10.9*	22.2*	14.4*	20.3*	11.2*	29.2*	27.2*	24.2*	3.7*
mg-value	0.421	0.442	0.428	0.415	0.402	0.412	0.413	0.400	0.433	0.443	0.436	0.370	0.425	0.445	0.420	0.394
Mn-ratio	2.42	1.07	1.71	1.87	2.06	2.70	1.65	1.68	1.77	2.72	1.97	1.32	2.69	2.67	3.38	1.44
K/Rb	204	196	189	208	207	202	216	188	194	206	245	205	205	224	201	213
K/Ba	52.4	52.5	46.8	53.3	51.8	46.7	38.9	46.8	45.2	71.6	57.5	57.9	57.3	64.1	60.9	52.4

Table 2 (continued.)

	Albite-biotite zone pelitic schists															
Sample No.	CS8210 2903	CS8210 2906	CS8210 2909	CS8210 2912	CS8210 2914	CS8210 2919	CS8210 2922	CS8210 3003	CS8305 0403	CS8305 0407	CS8305 0410	CS8305 0412	CS8305 0413	CS8305 0801	CS8305 0802	CS8305 1104
(wt.%)																
SiO_2	71.49	67.22	70.02	67.31	67.31	74.67	69.73	64.36	69.33	64.65	68.71	66.98	65.63	68.27	68.89	72.72
TiO_2	0.51	0.64	0.53	0.60	0.62	0.18	0.42	0.69	0.53	0.67	0.57	0.59	0.65	0.61	0.56	0.48
Al_2O_3	14.45	15.69	14.21	15.44	15.62	14.01	14.72	17.14	14.74	15.96	14.59	15.69	16.42	16.06	15.43	14.05
Fe_2O_3#	3.76	5.93	4.69	5.44	5.06	1.99	3.70	5.85	3.93	5.35	5.20	4.89	5.76	5.66	4.96	3.11
MnO	0.06	0.40	0.17	0.22	0.17	0.06	0.06	0.25	0.07	0.12	0.23	0.17	0.24	0.32	0.18	0.07
MgO	1.31	1.88	1.78	2.21	1.99	0.58	1.20	2.07	1.51	2.44	1.96	1.91	2.29	2.07	1.78	1.12
CaO	0.65	0.77	0.95	0.84	0.95	0.47	0.93	0.66	1.77	2.25	0.68	1.55	0.94	0.82	0.72	0.93
Na_2O	3.56	2.36	1.27	1.92	2.19	4.55	2.46	2.07	2.75	2.16	1.98	2.39	1.98	1.52	2.09	3.56
K_2O	2.39	2.68	3.51	3.23	3.43	2.33	3.93	3.74	2.60	2.89	2.95	3.01	3.32	3.26	3.16	2.34
P_2O_5	0.11	0.12	0.10*	0.12	0.12	0.06*	0.09*	0.12	0.11	0.12	0.11	0.12	0.12	0.10*	0.11	0.09*
LOI	1.70	2.18	2.75	2.63	2.29	0.99	1.76	2.85	2.41	2.66	2.66	2.22	2.65	2.34	2.16	1.35
Total	99.99	99.87	99.98	99.96	99.75	99.89	99.00	99.80	99.75	99.27	99.64	99.52	100.00	101.03	100.04	99.82
(ppm)																
Rb	94.4	110	137	128	134	94.6	159	153	103	112	128	121	140	131	128	88.8
Sr	145	117	116	106	104	114	138	119	224	203	120	162	136	30.5	114	158
Y	21.6	28.5**	19.9	20.3	19.2	40.3**	29.3**	23.9	15.7	21.1	21.4	18.0	19.5	20.3	18.8	17.0
Zr	165	133	112	131	141	110	159	149	148	142	122	137	144	136	137	160
Nb	9.1	10.6	9.3	9.5	9.5	12.7	12.8	11.4	8.8	9.6	9.8	9.3	10.1	10.2	10.2	8.4
Ba	348	407	540	421	484	337	491	533	399	466	442	497	470	418	514	354
Th	11.6	12.4	11.4	12.8	12.6	25.0	17.0	15.5	10.9	12.0	12.4	12.5	12.7	14.6	13.1	10.4
Pb	16.0	27.9	16.4	20.9	9.8	24.3	21.7	20.7	17.8	22.8	21.7	13.7	21.4	22.7	15.1	15.2
Ni	11.7*	38.8*	18.5*	26.4*	17.8*	2.5*	6.8*	11.8*	14.9*	28.9*	24.0*	20.3*	31.3*	10.9*	10.1*	3.3*
mg-value	0.408	0.386	0.429	0.446	0.438	0.366	0.391	0.412	0.432	0.475	0.427	0.436	0.441	0.420	0.416	0.416
Mn-ratio	1.05	4.46	2.28	2.46	2.08	2.11	1.10	2.75	1.13	1.31	2.77	2.16	2.56	3.56	2.33	1.46
K/Rb	210	203	212	209	213	204	206	203	210	214	192	206	197	207	204	219
K/Ba	57.0	54.7	53.9	63.6	58.9	57.4	66.4	58.2	54.1	51.5	55.4	50.2	58.7	64.7	51.1	54.9

Table 2 (continued.)

	Albite-biotite zone pelitic schists									Oligoclase-biotite zone pelitic schists					
Sample No.	CS8405 2603	CS8310 2701	CS8310 2702	CS8310 2705	CS8310 2803	CS8310 2804	CS8310 2805	CS8310 2806	CS8310 2902	CS8405 2401	TH7504 2404	TH7504 2505	TH8005 2705	TH8005 2712	TH8005 2719	TH8007 2303
(wt.%)																
SiO_2	72.54	70.27	65.80	65.05	63.54	63.63	68.83	64.54	71.94	69.11	67.80	66.44	66.77	63.83	68.47	67.47
TiO_2	0.43	0.43	0.64	0.70	0.72	0.67	0.58	0.65	0.51	0.59	0.56	0.65	0.72	0.73	0.75	0.66
Al_2O_3	14.02	14.63	16.11	16.00	17.11	17.22	14.52	16.93	13.76	15.35	15.99	16.01	15.78	15.61	12.46	16.16
Fe_2O_3#	2.83	3.16	5.50	5.72	6.02	5.46	5.22	5.04	4.80	4.94	4.73	4.98	5.92	5.94	5.46	5.05
MnO	0.04	0.06	0.23	0.20	0.12	0.12	0.15	0.13	0.25	0.24	0.21	0.09	0.22	0.12	0.19	0.09
MgO	1.10	1.12	2.05	2.14	2.03	2.00	1.60	1.87	1.87	1.72	1.77	2.19	2.37	3.01	2.54	1.78
CaO	0.99	1.24	1.31	1.82	1.87	0.79	1.62	1.72	0.67	0.79	0.44*	2.02	2.39	2.96	3.75	1.16
Na_2O	3.03	3.45	2.10	2.49	3.38	2.64	2.12	2.39	1.38	2.16	3.06	1.73	1.48	1.83	1.36	1.83
K_2O	2.72	2.61	3.21	3.09	2.73	4.11	2.83	3.46	2.86	3.12	3.00	2.94	2.52	3.08	2.28	3.22
P_2O_5	0.08*	0.09*	0.12	0.14	0.13	0.10*	0.18	0.13	0.12	0.12	0.10*	0.13	0.14	0.15	0.16	0.12
LOI	1.57	1.40	1.75	2.44	1.72	1.95	1.89	2.31	1.44	1.32	2.43	1.92	1.48	1.87	1.37	2.20
Total	99.35	98.46	98.82	99.79	99.37	98.69	99.54	99.17	99.60	99.46	100.09	99.10	99.79	99.13	98.79	99.75
(ppm)																
Rb	100	94.7	127	123	106	128	117	133	124	135	114	82.8	78.6	113	83.6	115
Sr	137	159	167	160	214	177	172	204	96.0	125	76.2	247	254	165	182	171
Y	22.5	17.7	22.9	22.6	22.9	21.3	25.2	22.1	19.0	25.3	21.1	22.3	22.8	23.7	20.7	22.9
Zr	133	130	146	165	162	157	146	164	119	165	152	155	142	146	119	164
Nb	8.1	8.2	10.2	10.5	9.7	8.0	9.7	10.7	7.9	11.1	11.5	9.8	9.5	10.6	10.6	11.7
Ba	445	404	455	481	498	963	504	517	408	445	419	587	475	446	371	468
Th	11.1	11.2	13.2	14.4	13.8	14.3	12.0	13.7	11.9	15.1	12.8	11.7	11.9	12.0	9.6	14.3
Pb	15.5	18.5	22.4	21.8	20.1	15.0	17.1	22.8	22.9	19.7	22.5	19.1	17.8	14.3	14.4	16.0
Ni	5.0*	3.3*	21.6*	22.5*	18.9*	17.4*	12.6*	14.2*	22.9*	22.7*	15.1*	22.4*	22.9*	48.2	23.2*	46.3*
mg-value	0.435	0.412	0.425	0.426	0.400	0.420	0.378	0.424	0.436	0.408	0.426	0.466	0.442	0.501	0.480	0.411
Mn-ratio	0.89	1.24	2.64	2.21	1.33	1.41	1.97	1.65	3.20	3.13	2.79	1.08	2.28	1.12	2.00	1.17
K/Rb	225	229	209	208	214	267	201	216	192	192	218	295	266	226	226	233
K/Ba	50.7	53.6	58.6	53.4	45.5	35.4	46.6	55.5	58.2	58.2	59.4	41.6	44.0	57.4	51.0	57.2

Table 2 (continued.)

	Oligoclase-biotite zone pelitic schists															
Sample No.	TH8007 2307	TH7108 1303	TH7108 1306	TH7108 1311	TH7108 1315	TH7108 1422	CS8305 0807	CS8305 0901	CS8305 0907	CS8305 0908	CS8305 0909	CS8305 1006	CS8305 1401	CS8305 1402	CS8310 3104	AG12-1
(wt. %)																
SiO_2	65.95	70.78	64.47	63.85	67.74	70.69	62.65	73.85	71.31	66.75	67.66	68.30	71.14	73.78	73.51	69.42
TiO_2	0.60	0.50	0.59	0.68	0.57	0.49	0.71	0.31	0.43	0.67	0.60	0.60	0.49	0.47	0.43	0.58
Al_2O_3	15.90	14.37	15.15	16.59	15.32	14.80	16.88	14.83	14.95	16.31	15.18	15.44	13.85	13.00	11.57	15.21
Fe_2O_3#	4.41	4.67	4.91	5.59	5.04	4.00	5.82	2.83	3.44	5.37	4.83	4.76	3.49	3.58	4.36	5.10
MnO	0.13	0.18	0.20	0.18	0.14	0.24	0.13	0.11	0.09	0.08	0.13	0.16	0.06	0.10	0.15	0.20
MgO	2.24	1.78	1.56	1.94	1.70	1.73	2.96	0.93	1.18	1.85	1.83	1.75	1.25	1.31	1.60	1.94
CaO	3.81	0.92	3.74	1.99	1.19	1.13	2.90	0.67	0.72	0.95	1.69	1.52	1.69	1.36	1.46	0.83
Na_2O	1.18	1.88	2.83	2.89	3.38	1.81	2.58	1.74	2.81	2.42	2.26	2.23	2.84	1.98	1.78	2.16
K_2O	3.14	2.92	2.73	3.05	2.71	3.41	3.02	3.23	3.09	2.90	2.98	2.96	2.73	2.61	2.64	2.84
P_2O_5	0.13	0.12	0.13	0.12	0.09*	0.09*	0.14	0.08*	0.08*	0.14	0.10*	0.12	0.08*	0.19	0.10*	0.11
LOI	2.04	1.26	2.44	2.54	1.61	2.06	1.85	1.22	1.55	2.63	2.10	1.73	2.08	1.39	1.37	2.01
Total	99.53	99.38	98.75	99.42	99.49	100.45	99.64	99.80	99.65	100.07	99.36	99.57	99.70	99.68	99.06	100.40
(ppm)																
Rb	103	126	103	117	117	133	99.2	125	120	117	115	117	102	106	115	120
Sr	277	149	288	208	164	108	211	145	123	153	198	178	164	193	112	128
Y	19.3	16.9	21.8	23.5	21.7	23.3	21.2	27.1**	24.5	20.3	17.3	21.5	19.3	16.8	24.6	23.5
Zr	153	129	143	162	132	121	151	146	149	159	145	145	134	146	104	141
Nb	8.3	7.8	13.7	9.8	6.3	8.6	10.0	9.7	9.1	9.4	8.8	10.3	8.3	8.6	7.6	9.8
Ba	606	537	479	531	466	414	577	597	406	421	433	464	431	375	354	420
Th	11.2	12.8	10.6	14.1	13.8	13.7	13.3	18.2	13.2	12.5	11.0	12.1	10.5	8.3	9.1	12.0
Pb	18.0	22.4	23.0	24.7	29.9	25.3	14.1	24.5	19.3	19.2	19.4	20.4	16.6	16.3	14.7	20.5
Ni	8.8*	26.2*	13.0*	21.7*	20.1*	16.1*	49.9	8.3*	6.9*	11.0*	16.1*	13.4*	9.8*	5.3*	12.1*	20.4*
mg-value	0.502	0.430	0.386	0.407	0.401	0.461	0.502	0.394	0.405	0.406	0.429	0.421	0.415	0.420	0.421	0.430
Mn-ratio	1.63	2.41	2.74	2.10	1.84	3.51	1.24	2.58	1.72	0.99	1.70	2.14	1.12	1.79	2.19	2.46
K/Rb	253	192	220	216	193	213	253	214	213	205	216	210	223	205	191	196
K/Ba	43.0	45.1	47.3	47.7	48.3	68.4	43.4	44.9	63.2	57.2	57.2	52.9	52.6	57.7	61.8	56.1

Table 2 (continued.)

	Ol.-bt. zone pelites			Pelitic schist clasts		
Sample No.	CS8310 2807	CS8310 2903	CS8310 2904	K-8	118996	K-1
(wt. %)						
SiO_2	68.64	70.70	70.50	65.31	60.47	63.30
TiO_2	0.58	0.54	0.54	0.74	0.82	0.66
Al_2O_3	15.09	14.75	14.29	16.87	17.77	13.97
Fe_2O_3*	4.39	3.81	4.25	5.49	6.11	5.36
MnO	0.10	0.15	0.12	0.08	0.11	0.16
MgO	1.50	1.42	1.59	1.94	3.68	3.41
CaO	1.87	1.43	1.59	1.76	1.73	4.97
Na_2O	2.71	2.76	1.81	4.00	2.34	2.87
K_2O	2.77	2.60	3.01	2.05	3.56	2.20
P_2O_5	0.10*	0.09*	0.11	0.17	0.17	0.13
LOI	1.63	1.01	1.41	1.94	3.57	3.38
Total	99.38	99.26	99.22	100.35	100.33	100.41
(ppm)						
Rb	108	102	115	90.2	122	79.1
Sr	215	191	178	183	199	245
Y	20.9	18.9	17.7	25.6	24.0	20.3
Zr	149	173	147	186	173	123
Nb	9.5	9.6	8.3	13.7	10.7	7.6
Ba	404	375	450	328	559	569
Th	10.7	11.3	11.5	17.7	12.7	9.3
Pb	19.2	19.7	17.4	21.7	10.7	15.1
Ni	11.7*	7.7*	10.5*	27.5*	67.7	70.5
mg-value	0.404	0.425	0.426	0.412	0.544	0.558
Mn-ratio	1.51	2.48	1.79	0.96	0.92	1.46
K/Rb	214	212	218	189	243	231
K/Ba	56.9	57.6	55.6	51.9	52.9	32.1
	metamorphic grade			Grt	Ol-Bt	Ol-Bt

Table 3. Average, standard deviation (1 σ) and range for bulk chemical compositions of Sanbagawa pelitic schists

	Average	1σ	Maximum	Minimum
(wt. %)				
SiO_2	68.94	3.17	77.48	59.63
TiO_2	0.55	0.10	0.82	0.18
Al_2O_3	15.12	1.22	18.41	11.57
Fe_2O_3#	4.49	1.07	7.96	1.99
MnO	0.14	0.08	0.40	0.02
MgO	1.68	0.51	3.68	0.58
CaO	0.99	0.75	4.97	0.05
Na_2O	2.47	0.83	5.52	0.47
K_2O	3.02	0.55	4.92	1.42
P_2O_5	0.11	0.02	0.19	0.05
LOI	2.14	0.62	5.58	0.99
(ppm)				
Rb	119	21	181	62.2
Sr	129	60	440	22.0
Y	21.1	4.7	50.3	5.0
Zr	144	17	194	101
Nb	9.6	1.4	13.7	6.0
Ba	486	103	963	252
Th	12.7	2.1	25.0	8.2
Pb	18.7	5.7	55.8	8.7
Ni	15.7	11.0	70.5	0.0
mg-value	0.422	0.031	0.558	0.338
Mn-ratio	1.92	0.79	4.46	0.44
K/Rb	211	14.9	295	188
K/Ba	52.3	6.5	71.6	32.1

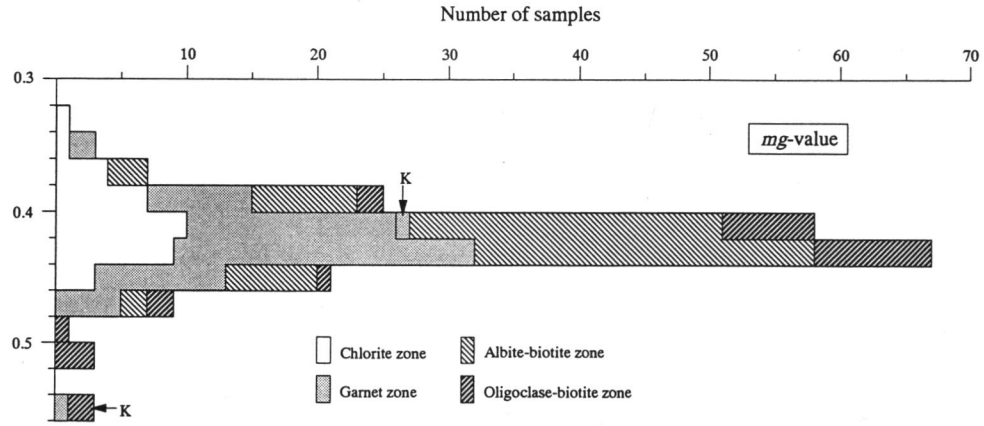

Figure 3. Frequency distribution for *mg*-value. Boxes labelled by "K" are the data of pelitic schist clasts from the Kuma Group.

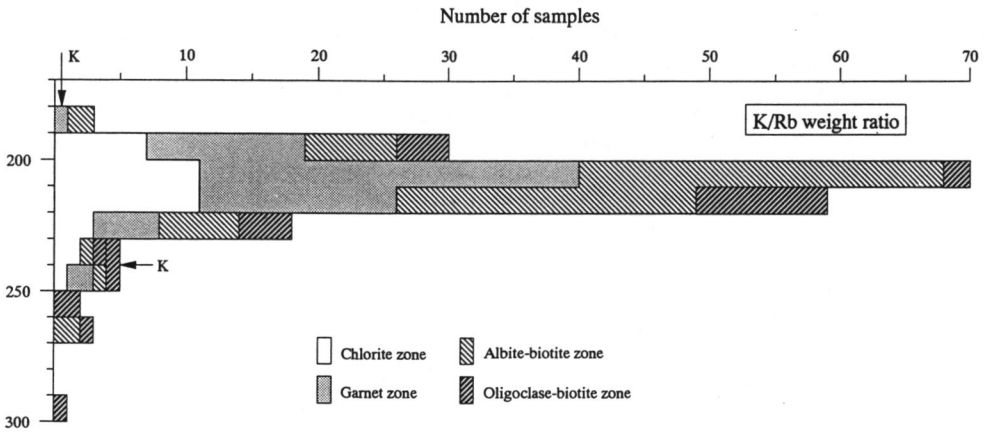

Figure 4. Frequency distribution for K/Rb weight ratio. Boxes labelled by "K" are the data of pelitic schist clasts from the Kuma Group.

cent analysis, and Dr. Kazumi YOKOYAMA, who provided him three pelitic schist clasts in conglomerates from the Kuma Group. He also thanks Rigaku Corporation and Dr. Mamoru MURATA for providing him the opportunity of using the XRF spectrometers. This study was sponsored by Grants-in-Aid (01790351 and 03740419) from the Ministry of Education, Science and Culture of Japan to AG.

References

BANNO, S. (1961): On the so-called "soda-metasomatism" of the Sanbagawa schists in the Bessi district.

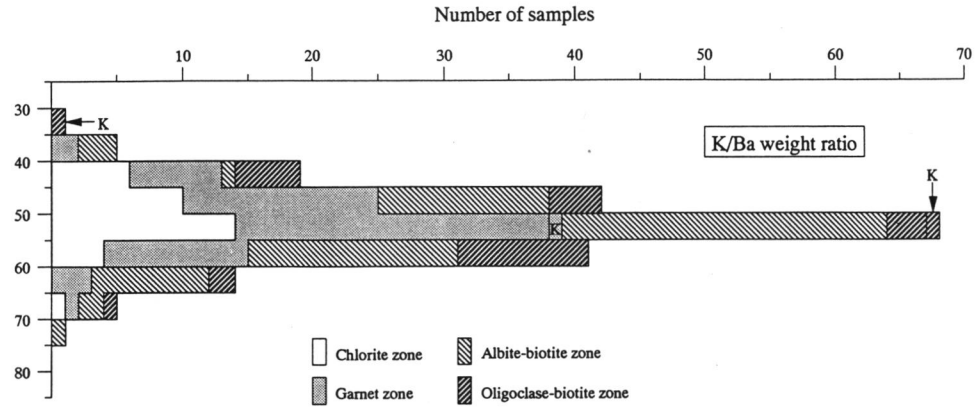

Figure 5. Frequency distribution for K/Ba weight ratio. Boxes labelled by "K" are the data of pelitic schist clasts from the Kuma Group.

Jour. Geol. Soc. Jpn., **67**, 515–525 (in Japanese with English abstract).

BANNO, S. (1964): Petrologic studies on Sanbagawa crystalline schists in the Bessi-Ino district, central Shikoku, Japan. *Jour. Fac. Sci. Univ. Tokyo, Sec. II*, **15**, 203–319.

BANNO, S. and SAKAI, C. (1989): Geology and metamorphic evolution of the Sanbagawa metamorphic belt, Japan. In J. S. DALY, R. A. CLIFF and B. W. D. YARDLEY (eds) *Evolution of metamorphic belts*, Geological Society Special Publication No. 43, pp 519–532.

ENAMI, M. (1983): Petrology of pelitic schists in the oligoclase-biotite zone of the Sanbagawa metamorphic terrain, Japan: phase equilibria in the highest grade zone of a high-pressure intermediate type of metamorphic belt. *Jour. metamor. Geol.*, **1**, 141–161.

ENAMI, M., WALLIS, S. R. and BANNO, Y. (1994): Paragenesis of sodic pyroxene-bearing quartz schists: implications for the P-T history of the Sanbagawa belt. *Contrib. Mineral. Petrol.*, **116**, 182–198.

ERNST, W. G., SEKI, Y., ONUKI, H. and GILBERT, M. C. (1970): Comparative study of low-grade metamorphism in the California Coast Range and the outer metamorphic belt of Japan. *Mem. Geol. Soc. Amer.*, **124**, 276 pp.

GOTO, A. and TATSUMI, Y. (1991): Quantitative analysis of rock samples by an X-ray fluorescence spectrometer (I). *Rigaku-Denki Journal*, **22**, 28–44 (in Japanese).

GOTO, A. and TATSUMI, Y. (1992): Quantitative analysis of rock samples by an X-ray fluorescence spectrometer (II). *Rigaku-Denki Journal*, **23**, 50–69 (in Japanese).

HIGASHINO, T. (1990a): Metamorphic zones of the Sambagawa metamorphic belt in central Shikoku, Japan. *Jour. Geol. Soc. Jpn.*, **96**, 703–718 (in Japanese with English abstract).

HIGASHINO, T. (1990b): The higher grade metamorphic zonation of the Sambagawa metamorphic belt in central Shikoku, Japan. *Jour. metamor. Geol.*, **8**, 413–423.

HIROTA, Y. (1990): Clasts of metamorphic rocks within the Eocene Kuma Group in the Kamegamori area, western Shikoku, Japan. *Geol. Rep. Shimane Univ.*, **9**, 37–49 (in Japanese).

ISOZAKI, Y. and ITAYA, T. (1990): Chronology of Sanbagawa metamorphism. *Jour. metamor. Geol.*, **8**, 401–411.

ITAYA, T. and BANNO, S. (1980): Paragenesis of titanium-bearing accessories in pelitic schists of the Sanbagawa metamorphic belt, central Shikoku, Japan. *Contrib. Mineral. Petrol.*, **73**, 267–276.

ITAYA, T. and TAKASUGI, H. (1988): Muscovite K-Ar ages of the Sanbagawa schists, Japan and argon depletion during cooling and deformation. *Contrib. Mineral. Petrol.*, **100**, 281–290.

KRETZ, R. (1983): Symbols for rock-forming minerals. *Amer. Mineral.*, **68**, 277–279.

KUNUGIZA, K., TAKASU, A. and BANNO, S. (1986): The origin and metamorphic history of the ultramafic

and metagabbro bodies in the Sanbagawa metamorphic belt. *Mem. Geol. Soc. Amer.*, **164**, 375–385.

KURATA, H. and BANNO, S. (1974): Low-grade progressive metamorphism of pelitic schists of the Sazare area, Sanbagawa metamorphic terrain in central Shikoku, Japan. *Jour. Petrol.*, **15**, 361–382.

MIYASHIRO, A. (1961): Evolution of metamorphic belts. *Jour. Petrol.*, **2**, 277–311.

NAGAI, K. (1972): The Eocene Kuma Group, Shikoku, Japan. *Mem. Ehime Univ. Science Series, D*, **7**, 1–7 (in Japanese with English abstract).

OTSUKI, M. and BANNO, S. (1990): Prograde and retrograde metamorphism of hematite-bearing basic schists in the Sanbagawa belt in central Shikoku. *Jour. metamor. Geol.*, **8**, 425–439.

SHINJOE, H. and TAGAMI, T. (1994): Cooling history of the Sanbagawa metamorphic belt inferred from fission track zircon ages. *Tectonophys.*, **239**, 73–79.

TAKASU, A. and DALLMEYER, R. D. (1990): $^{40}Ar/^{39}Ar$ mineral age constraints for the tectonothermal evolution of the Sambagawa metamorphic belt, central Shikoku, Japan: a Cretaceous accretionary prism. *Tectonophys.*, **185**, 111–139.

TAKASU, A. and DALLMEYER, R. D. (1992): $^{40}Ar/^{39}Ar$ mineral ages within metamorphic clasts from the Kuma Group (Eocene), central Shikoku, Japan: Implications for tectonic development of the Sambagawa accretionary prism. *Lithos*, **28**, 69–84.

TAKASU, A., WALLIS, S. R., BANNO, S. and DALLMEYER, R. D. (1994): Evolution of the Sambagawa metamorphic belt, Japan. *Lithos*, **33**, 119–133.

YARDLEY, B. W. D. (1989): *An introduction to metamorphic petrology*. Longman, Harlow, 248 pp.

YOKOYAMA, K. and ITAYA, T. (1990): Clasts of high-grade Sanbagawa schist in Middle Eocene conglomerates from the Kuma Group, central Shikoku, south-west Japan. *Jour. metamor. Geol.*, **8**, 467–474.