On the Petrochemical Character of the Pelitic Gneiss from the Southwestern Part in the Hida Metamorphic Belt, Central Japan

By

Morihisa Suzuki

with 4 Tables and 6. Text-figures

(Received April 30, 1975)

Abstract: In the Hida Metamorphic Belt, metapelites develop in a small amount, in contrast to wide development of basic and calcareous metamorphites. The metapelites in the district have been clarified to be higher in CaO, FeO and MgO contents while lower in Al-excess as compared to the usual metapelite. Judged from the petrochemical characteristics and the mode of occurrence, it is probable that the metapelites in question should not be derived from rocks of "miogeosynclinal" character of higher maturity, but from those intermingled with basic volcanic materials. Also have been discussed the similarity and the difference between the metapelites from other high T-low P type metamorphic belts in Japan along with the Precambrian metapelites from the Kamiaso conglomerate.

Contents

I. Introduction

In order to investigate the specific characters of the metamorphism in the Hida Metamorphic Belt, it is of great importance to clarify not only the metamorphic processes but also the nature of the original rocks of the metamorphites. Concerning to the former, one of the most annoying problems is the time and spatial relationship of some metamorphic episodes. As for the latter, unsolved problem is to determine types of the original rocks reflecting the provenance environments.

In the Hida Metamorphic Belt, there distribute different kinds of gneisses derived from various kinds of original rocks. For example, complicatedly intermingled are amphibolite or hornblende gneiss of basic rock origin, marble and limesilicate gneiss of calcareous rock origin and biotite gneiss of pelitic rock origin, associated with vast amounts of granitic rocks.

It is characteristic in the Hida Metamorphic Belt that pelitic gneiss has a small share in the metamorphites, in contrast to the cases in the other high T-low P type metamorphic belts in Japan. Moreover, also curious is the scarce occurrence of aluminium silicate minerals in metapelites in the Hida terrain, undoubtedly subjected to the metamorphic condition of amphibolite facies.

Consequently, if the mode of occurrence, and petrochemical and mineralogical characters of the minority in the Belt could be clarified, it gives the one step to understand the foundamental character of the Hida Metamorphic Belt.

In this paper, the author wishes to treat on pelitic gneisses from the southwestern area of the Hida Metamorphic Belt, to give a key to solve the problem on the Pre-metamorphic Hida Belt.

Acknowledgement: The author wishes to express his sincere thanks to Professor George KOJIMA of the Hiroshima University for his invaluable advice and continuous encouragement. He is also indebted to Dr. Kiyoshi ISHIBASHI of the Kyushu University, who kindly makes chemical analyses. His hearty thanks are due to Mr. Asao MINAMI of the Hiroshima University for a chemical analysis. The present study is partly supported by the Grant in Aid for Scientific Researches of the Ministry of Education.

II. GEOLOGICAL SETTING AND METAMORPHISM

The investigated area is located in the southwestern part of the Hida Metamorphic Belt. The field is divided into two parts by the Atotsugawa Fault running along the Odori-River (Fig. 1). In the northern half of the area, widely developed are hornblende-clinopyroxene gneiss (hornblende-clinopyroxene-potassium feldspar-plagioclase-quartz) and clacareous gneiss (crystalline limestone and lime-silicate gneiss with scapolite, wollastonite, and diopside). In the northernmost part, there also distribute calcareous gneiss and hornblende-clinopyroxene gneiss, permeated by migmatitic granite.

The southern half consists mainly of basic migmatite (hornblende-biotite-potassium feldspar-plagioclase-quartz), tectonically contacted by potassium feldspar porphyritic granite.

Pelitic gneiss is also distributed in the area, but the mode of occurrence varies place to place. Namely sometimes it occurs as a thick bed of some ten meters, but in another occasion it appears as an intercalation with basic or calcareous gneiss. Details will be mentioned in the following section.

Generally speaking, rocks in the area represent the metamorphic condition of amphibolite facies or lower as many authors have sofar suggested. It is notable, however, that there occur some interesting rocks to suggest the higher grade metamorphic condition, probably granulite facies. Among them, potassium feldspar corundum gneiss (potassium feldspar-corundum-plagioclase-biotite-rutile) and "eclogitic rock" (almandine-ferroaugite-quartz) are found and described by the author (SUZUKI and KOJIMA, 1970, and SUZUKI, 1973). Besides them, two pyroxene gneiss, which is characterized by the stable association of two pyroxene, associated with brown hornblende and almandine, is also found to suggest the higher grade metamorphic condition. So-called "syenitic rock" of the Inishi type, with the assemblage of wollastonite-clinopyroxene-plagioclase, can also be consistent with those rocks formed under the granulite facies metamorphism.

The granulite facies rocks occur sporadically in the amphibolite facies metamorphic terrain and it is impossible to construct the simple thermal structure, progressively grading

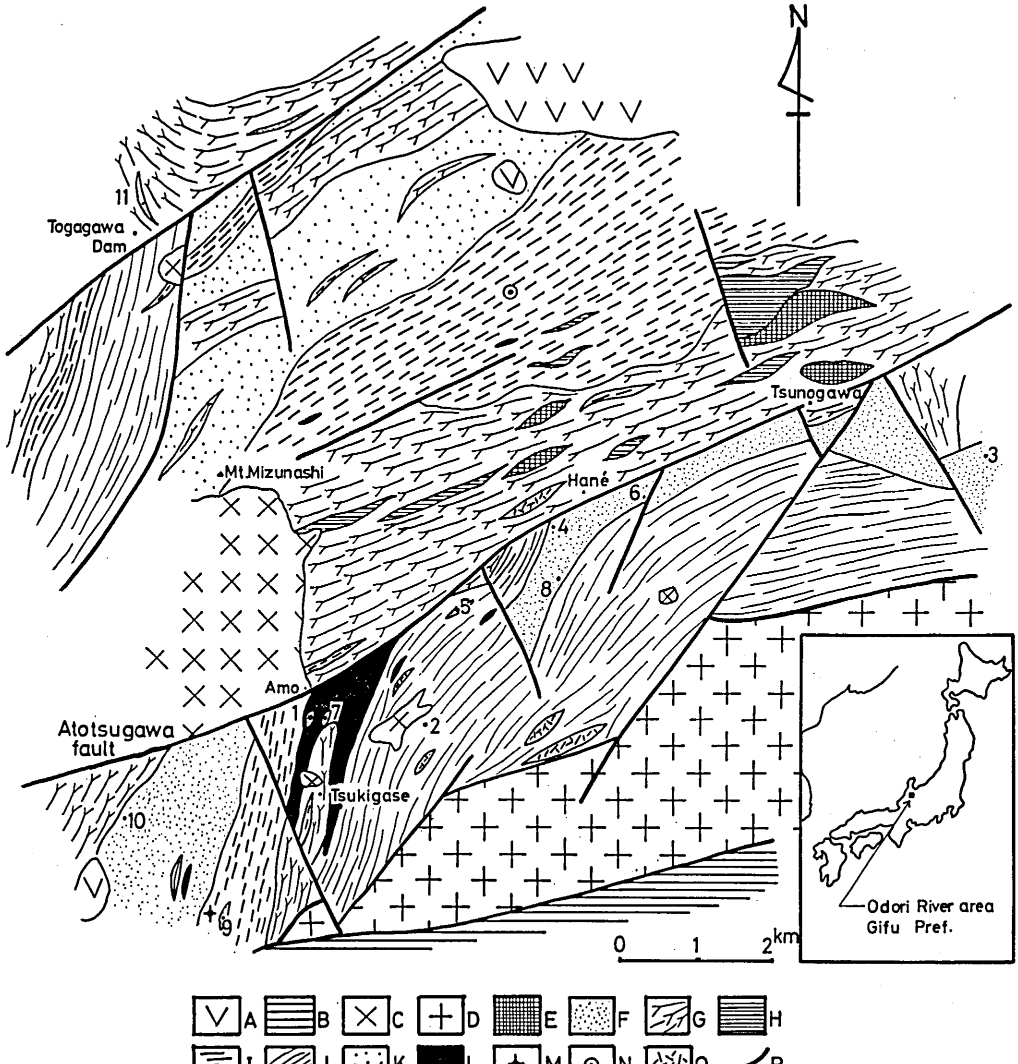

FIG. 1. Geological map of the Odori-River district, Gifu Prefecture. Numbers on the map indicate localities of studied metapelites, being consistent with the column numbers in Tables 1 and 2. A; Cenozoic volcanic rocks, B; Tetori Series (Mesozoic), C; Funatsu type granite, D; Potassium feldspar porphyritic granite, E; Gabbro, F; Biotite gneiss, G; Crystalline limestone, H; Lime silicate gneiss I; Hornblende-clinopyroxene gneiss, J; Basic migmatite K; Migmatitic granite, L; Pyroxene gneiss, M; "Eclogitic rock", N; Potassium feldspar corundum gneiss, O; "Syenitic rock" of the Inishi type, P; Fault.

into the higher grade part towards the granulite facies rocks. Concerning to this point, it must also be notable that the metamorphosed basic dyke is found in the Tsukigase area, intruding after the formation of gneissosity of surrounding gneisses including the "eclogitic rock" of the granulite facies, and after that the dyke is suffered by the metamorphism under the amphibolite facies condition, as well as the surroundings. Accordingly, polymetamorphism, at least of two phases, must be actualized in the area (SUZUKI, 1973 and 1974).

In this connection, special attention should be paid to appearance of gray granite. It is one of the most characteristic granites in the Hida Belt, occurring not as a large body but frequently as a sheet or a dyke. Namely in one occasion, it "intrudes" parallel to the gneissosity of the gneisses, but sometimes cleanly cuts across the gneissosity.

The author has the opinion that gray granite is the "pruduct" of the granulite facies metamorphism. Since the P–T condition under the granulite facies metamorphism, possibly exceeding to the higher temperature side of the Q–Ab–Or melting curve, must cause the partial melting of the granitic materials from the surrounding gneisses.

III. MODE OF OCCURRENCE OF METAPELITES

The pelitic gneiss with characteristic assemblage of biotite and garnet shows various mode of occurrence. The most common type is the intercalation within hornblende-clinopyroxene gneiss and basic migmatite, both of which are derived originally from basic rocks. In the southern half of the area, however, there distribute thick beds of pelitic gneiss. Eleven samples of metapelites are selected to be chemically analysed, as shown in Fig. 1. Their mode of occurrence are summerized as follows:

1) intercalated with pyroxene gneiss, which may be derived from graywacke sandstone ——— Nos. 1 and 7
2) intercalated with hornblende gneiss or basic migmatite ——— Nos. 2, 5, 9 and 11
3) independent thick bed ——— Nos. 3, 4, 6, 8 and 10

The modal composition of metamorphic minerals for each sample are given in Table 1.

TABLE 1. MODAL ANALYSES OF PELITIC GNEISSES IN THE ODORI-RIVER DISTRICT.

	1	2	3	4	5	6	7	8	9	10	11
Quartz	25.7	5.3	22.5	36.3	24.9	27.7	32.2	53.6	16.9	3.1	36.0
Plagioclase	43.5	64.4	47.9	19.6	56.3	24.2	44.5	15.2	55.1	49.7	33.5
K-feldspar	1.9	7.2	3.1	24.1	1.5	21.5	2.7	3.6	0.6	2.9	2.5
Biotite	19.1	14.1	24.4	19.8	16.9	22.7	11.4	16.5	25.2	28.3	17.3
Muscovite	0.7	8.7	—	0.1	tr.	0.6	0.7	—	—	1.8	0.1
Sillimanite	—	—	—	—	—	—	—	—	—	0.3	0.5
Garnet	2.6	0.2	0.4	—	0.3	2.8	4.4	5.7	0.4	7.8	8.0
Titanite	1.5	0.1	—	0.1	0.1	—	0.1	tr.	—	0.1	0.1
Hornblende	—	—	1.7	—	—	—	0.1	5.3	—	—	—
Clinopyroxene	—	—	—	—	—	—	—	—	0.8	—	—
Graphite	2.4	0.1	0.1	—	—	—	3.6	—	0.1	5.7	0.5
Ore	—	—	—	0.1	tr.	0.6	0.3	0.1	1.0	0.4	0.5
Others	2.6	—	—	—	—	—	—	—	—	—	1.1
Total	100.0	100.1	100.1	100.1	100.0	100.1	100.0	100.0	100.1	100.1	100.1

1. 67 V 2408, 2. 67 V 1922, 3. 67 IV 2902, 4. 67 V 0601, 5, 67 V 1811,
6. 67 V 2701, 7. 67 V 2335, 8. 68 VII 1802, 9. 69 X 0402, 10. 70 VI 0609
11. 71 IX 1112.

Quartz, potassium feldspar, plagioclase and biotite are universally distributed, although with some variations of frequency. Whereas it is of great interests that aluminium silicate minerals occur very scarcely* but always as sillimanite. It is also notable that some samples contain greenish brown hornblende and as much clinopyroxene.

It may be doubtful that rocks with these unusual mineral assemblage can belong to the category of the pelitic origin metamorphites in the strict sense. But the main constituent minerals are biotite, feldspars and/or garnet. Hence they are wholly included in the members of metapelites.

It seems that in the district correlation between mode of occurrence and mineral composition cannot be observed.

IV. Petrochemical Character and Its Bearings

Chemical analytical data of metapelites in the area are given in Table 2, as well as the values of C. I. P. W. norms. Published chemical data of metapelites from the Hida Metamorphic Belt are summerized in Table 3. C. I. P. W. norms are calculated by the author.

In table 4, for comparison, average chemical compositions of metamorphic pelites from Ryoké and Abukuma Metamorphic Belts and of pelitic rocks from Palaeozoic geosynclinal sediments in Japan, as well as the data of Precambrian metapelites from Kamiaso conglomerate (Miyashiro and Haramura, 1966 and Adachi, 1973). In this case, the analyses with more than 70% SiO_2 contents are excluded, because these rocks could not be regarded as pelitic rock in the strict sense.

Generally speaking, metapelites in the Hida Metamorphic Belt are characterized by the lower value of SiO_2 and the higher values of FeO, MgO and CaO than the affinities of the other high T-low P type metamorphic belts in Japan, also than the Palaeozoic pelites and Precambrian metapelites.

The author has plotted on AKF diagram pelitic gneisses from the Hida Metamorphic Belt as well as the affinities from other localities in Japan (Fig. 2). Hida metamorphites are concentrated in the vicinity of the apex of F, reflecting the enrichment of FeO and MgO contents. In Fig. 3, the characteristic feature of Hida metapelites of mafic-rich can be seen cleanly.

Nextly, analysed data are plotted on the CaO-alkalies diagram (Fig. 4). Samples from the Hida Metamorphic Belt are maldistributed in the CaO richer area.

In conclusion, metapelites from the Hida Metamorphic Belt is characterized by the characteristics are directly reflecting the mineralogy as follows:

i) occasional occurrence of hornblende or clinopyroxene.

ii) plagioclase has much higher content of CaO, and garnet, more or less almandinous, has rather higher content of CaO for those in a usual pelitic gneiss (Suzuki, 1975).

As for the mineralogical characters, details will be discussed in the another paper soon later.

As previously mentioned, aluminium silicate appears rarely in the Hida metapelites. The reason is also explained on the view point of the chemical characters of the original rocks. Winchester (1974) has proposed the diagram, showing exactly the compositional

* In thin sections of metapelites from this area, only 3.2% of them contain aluminium silicate.

Table 2. CHEMICAL COMPOSITIONS AND C. I. P. W. NORMS OF PELITIC

		1	2	3	4	5	6
Wt%	SiO_2	59.91	50.92	60.51	67.76	58.76	60.11
	TiO_2	0.61_6	0.89_4	0.73_3	0.43_9	0.59_8	0.64_0
	Al_2O_3	17.61	22.98	17.93	15.44	18.43	17.83
	Fe_2O_3	1.22	0.77	0.63	0.02	0.44	2.28
	FeO	4.95	4.88	5.72	3.10	5.58	4.54
	MnO	0.13_2	0.04_9	0.08_3	0.04_6	0.11_8	0.13_6
	MgO	3.53	1.72	1.86	1.29	2.04	1.22
	CaO	4.24	6.73	5.52	1.13	5.42	2.63
	Na_2O	2.63	4.51	3.82	2.11	3.76	0.97
	K_2O	1.91	2.52	1.89	7.91	2.23	7.52
	H_2O (−)	0.19	0.21	0.16	0.14	0.22	0.45
	H_2O (+)	2.36	3.38	0.70	0.62	1.90	1.21
	P_2O_5	0.18_7	0.38_2	0.24_2	0.15_7	0.19_3	0.21_3
	CO_2	—	0.15	0.03	0.02	—	—
	C	0.38	—	—	—	—	—
	S	—	—	—	—	—	—
	Total	99.86_5	100.09_5	99.82_8	100.18_2	99.68_9	99.74_9
mol. ratio	$\frac{K_2O}{Na_2O+K_2O}$	0.32	0.27	0.25	0.72	0.28	0.84
	$\frac{Al_2O_3}{Na_2O+K_2O+CaO}$	1.25	1.03	0.98	1.28	1.00	1.23
Wt%	$Fe_2O_3+FeO+MnO+MgO$	9.83_2	7.41_9	8.29_3	4.45_6	8.17_8	8.17_6
				Norms (CIPW)			
	Q	20.11	—	13.01	19.00	10.09	16.21
	c	3.89	1.37	0.03	1.67	0.36	3.73
	or	11.29	14.90	11.18	46.76	13.18	44.42
	ab	22.22	35.42	32.28	17.82	31.75	8.17
	an	19.96	31.22	26.05	4.67	25.80	11.87
	ne	—	1.45	—	—	—	—
	di wo	—	—	—	—	—	—
	di en	—	—	—	—	—	—
	di fs	—	—	—	—	—	—
	hy en	8.82	—	4.64	3.22	5.09	3.04
	hy fs	7.29	—	8.91	5.04	9.09	5.65
	ol fo	—	3.00	—	—	—	—
	ol fa	—	5.36	—	—	—	—
	mt	1.76	1.11	0.90	0.02	0.63	3.29
	hm	—	—	—	—	—	—
	il	1.17	1.69	1.38	0.82	1.12	1.20
	ap	0.44	0.87	0.54	0.37	0.44	0.47

GNEISS IN THE DISTRICT.

7	8	9	10	11
59.54	68.41	56.41	48.19	59.40
0.70_8	0.42_5	0.55_3	0.82_4	1.38
17.47	13.29	19.70	24.99	20.86
2.50	0.64	1.16	—	0.33
3.12	4.86	5.85	7.77*	10.38
0.14_4	0.15_9	0.18_3	0.22_2	0.17
1.74	1.63	2.54	7.19	1.70
6.49	4.22	5.56	2.45	1.32
2.76	0.60	3.67	4.19	1.36
1.69	3.54	1.63	1.88	1.90
0.17	0.27	0.19	0.17	0.25
3.18	1.62	2.54	1.62	1.58
0.17_8	0.16_2	0.20_0	0.15_4	0.04
—	—	—	—	n.d.
0.21	—	—	0.47	n.d.
—	—	—	0.08	n.d.
99.90_0	99.82_6	100.18_6	100.20_0	100.67
0.29	0.80	0.23	0.23	0.48
0.96	1.06	1.10	1.86	3.11
7.50_4	7.28_9	9.73_3	15.18_2	12.58
19.96	36.71	9.52	—	31.31
—	1.12	2.21	11.91	14.23
9.95	20.91	9.62	11.06	11.23
23.32	5.03	30.97	35.37	11.48
30.25	20.02	26.41	11.31	6.37
—	—	—	—	—
0.39	—	—	—	—
4.34	—	—	—	—
2.75	—	—	—	—
—	4.07	6.34	7.31	4.24
—	7.97	9.20	5.41	16.79
—	—	—	7.46	—
—	—	—	6.08	—
3.62	0.90	1.67	—	0.46
—	—	—	—	—
1.34	0.81	1.03	1.55	2.61
0.40	0.37	0.47	0.34	0.07

Analyst: 1 to 10; K. ISHIBASHI, 11; A. MINAMI.

* This sample contains sulfide, so the iron content is determined in terms of total Fe as FeO.

TABLE 3. CHARACTERISTIC MINERAL ASSEMBLAGES, CHEMICAL FROM THE HIDA METAMORPHIC BELT.

	Characteristic mineral association	sillimanite +biotite		garnet+biotite				
		a	b	c	d	e	f	g
	Locality	Senno-tani	Wada-gawa	Koshi-mizu	Nagato-gawa	Wada-gawa	Wada-gawa	Wada-gawa
	Reference	1	2	3	2	1	1	2
	Analyst	YAMADA	*	YAMA-SHITA	*	OMORI	OMORI	*
Wt %	SiO_2	60.58	53.85	56.24	57.24	62.06	54.98	50.50
	TiO_2	1.09	0.97	0.88	0.77	0.51	0.93	1.00
	Al_2O_3	23.64	25.81	20.72	23.81	18.06	19.05	25.27
	Fe_2O_3	0.21	1.24	2.06	0.34	1.44	1.16	0.41
	FeO	3.16	5.13	5.79	5.60	4.01	6.27	6.83
	MnO	0.11	0.17	—	0.14	0.19	0.15	0.13
	MgO	0.40	1.95	3.07	1.04	1.55	3.38	3.33
	CaO	0.14	3.82	8.85	5.40	4.45	5.95	6.63
	Na_2O	0.52	2.85	1.61	3.88	4.05	2.97	3.15
	K_2O	0.75	1.26	0.94	0.89	1.33	2.25	1.59
	H_2O (−)	0.53	0.37	—	0.24	0.40	0.12	0.48
	H_2O (+)	6.31	1.71	—	0.86	1.44	1.80	1.50
	P_2O_5	—	0.16	—	0.28	0.24	0.29	0.23
	S	—	0.46	—	0.14	—	—	0.04
	Total	97.44	99.39	100.16	100.31	99.73	99.30	100.61
mol. ratio	$\frac{K_2O}{Na_2O+K_2O}$	0.49	0.23	0.28	0.13	0.18	0.33	0.25
	$\frac{Al_2O_3}{Na_2O+K_2O+CaO}$	12.27	1.99	1.05	1.39	1.12	1.05	1.33
Wt %	Fe_2O_3+FeO +MnO+MgO	3.88	8.49	10.92	7.12	7.19	10.96	10.76
	Norms (CIPW)							
	Q	52.04	18.56	16.39	14.84	19.62	7.82	2.61
	c	21.74	13.14	0.95	7.22	2.35	1.50	6.78
	or	4.39	7.45	5.50	5.23	7.84	13.29	9.40
	ab	4.35	24.05	13.57	32.75	34.22	25.10	26.62
	an	0.67	18.04	43.92	25.21	20.74	27.86	31.55
	ne	—	—	—	—	—	—	—
	di wo	—	—	—	—	—	—	—
	di en	—	—	—	—	—	—	—
	di fs	—	—	—	—	—	—	—
	hy en	0.99	4.87	7.67	2.59	3.87	8.44	8.32
	hy fs	4.01	7.09	7.48	8.96	5.68	9.28	10.78
	ol fo	—	—	—	—	—	—	—
	ol fa	—	—	—	—	—	—	—
	mt	0.30	1.79	2.97	0.49	2.06	1.67	0.58
	hm	—	—	—	—	—	—	—
	il	2.07	1.84	1.66	1.46	0.96	1.76	1.88
	ap	—	0.37	—	0.64	0.54	0.67	0.54

Norms are calculated by the author.

References: 1. NOZAWA *et al* (1960), 2. SOMA (1975), 3. KOBAYASHI (1954), 4. AOKI (1964), 5. SATO (1968).

* : Analyses are made by the Metallic Minerals Exploration Agency of Japan.

COMPOSITIONS AND C. I. P. W. NORMS OF PELITIC GNEISSES

biotite			hornblende+biotite			clinopyroxene+biotite		
h	i	j	k	l	m	n	o	p
Onagatani -gawa	Wada-gawa	Wada-gawa	Wadagawa	Onagatani -gawa	Futatsu-ya	Fuji-bashi	Wada-gawa	Wada-gawa
4	2	2	1	4	5	1	2	2
AOKI	*	*	YAMADA	AOKI	SHIBATA	OMORI	*	*
66.90	58.58	57.32	47.98	66.34	65.30	51.52	54.18	45.70
0.41	0.96	1.08	1.51	0.03	0.66	0.99	1.64	1.16
17.99	22.22	23.92	19.15	16.55	17.79	16.47	19.75	18.85
0.12	0.51	0.06	2.05	1.34	0.94	0.96	0.83	3.35
2.29	3.88	3.16	8.48	2.72	2.99	7.34	7.04	5.32
0.03	0.08	0.04	0.11	0.03	—	0.17	0.14	0.10
0.66	2.29	1.69	5.11	1.15	1.15	6.77	3.23	6.91
2.95	4.66	4.66	7.82	3.62	1.86	5.00	5.56	8.34
4.36	3.33	4.39	3.08	3.55	4.85	3.25	3.50	3.34
3.52	1.36	1.98	2.15	3.62	1.85	3.28	1.90	1.45
0.22	0.36	0.33	0.46	0.34	0.32	0.32	0.26	0.26
1.03	1.30	0.93	1.43	0.99	1.89	1.65	1.37	2.26
0.02	0.14	0.30	0.42	0.30	0.02	0.32	0.28	0.25
—	—	0.02	—	—	—	—	0.11	2.66
100.50	100.51	99.55	99.75	100.58	99.62	98.04	99.53	99.64
0.35	0.21	0.23	0.31	0.40	0.20	0.40	0.26	0.22
1.10	1.44	1.34	0.89	1.01	1.44	0.92	1.10	0.85
3.10	6.76	4.95	15.75	5.24	5.08	15.24	11.24	15.68
Norms (CIPW)								
19.28	18.58	10.67	—	21.40	22.77	—	6.09	—
1.66	7.06	6.71	—	0.84	4.46	—	2.40	—
20.79	8.01	11.68	12.68	21.41	10.90	19.35	11.23	8.56
36.84	28.14	37.10	25.99	29.97	40.98	27.46	29.55	25.68
14.54	22.38	21.38	32.05	16.21	9.15	20.63	25.99	32.14
—	—	—	—	—	—	—	—	1.36
—	—	—	1.81	—	—	0.97	—	3.27
—	—	—	1.34	—	2.87	6.76	—	—
—	—	—	1.21	—	3.63	4.53	—	—
1.64	5.72	4.22	—	2.87	—	—	8.07	—
3.49	5.27	4.04	—	3.89	—	—	9.78	—
—	—	—	7.99	—	—	7.11	—	12.09
—	—	—	7.99	—	—	5.26	—	4.07
0.16	0.72	0.07	2.97	1.93	1.35	1.37	1.18	—
—	—	—	—	—	—	—	—	4.85
0.78	1.81	2.04	2.86	0.05	1.25	1.87	3.10	2.19
0.03	0.30	0.71	0.97	0.71	0.03	0.74	0.64	0.57

TABLE 4. AVERAGED COMPOSITIONS AND C. I. P. W. NORMS OF PELITES FROM JAPAN.

	Symbols	K	A	R	N	S
	No. of analyses	6	10	30	31	12
Wt %	SiO_2	64.09	65.03	62.92	65.31	66.16
	TiO_2	0.40	0.55	0.71	0.63	0.59
	Al_2O_3	15.96	15.53	18.16	15.81	15.37
	Fe_2O_3	1.93	2.23	1.02	1.83	1.48
	FeO	3.52	4.49	4.64	3.25	3.30
	MnO	1.28	—	0.08	0.08	0.11
	MgO	2.08	2.54	2.37	2.08	1.84
	CaO	1.51	2.73	1.19	0.34	0.49
	Na_2O	2.31	2.31	2.04	2.09	2.95
	K_2O	4.40	1.77	4.01	3.84	3.28
	H_2O (−)	2.79	2.20 (H₂O (−) + H₂O (+))	0.24	0.61	0.73
	H_2O (+)	0.37		2.37	3.36	2.88
	P_2O_5	0.07	—	0.13	0.10	0.12
	C	—	—	—	0.76	0.67
	Total	100.71	99.38	99.88	100.09	99.97
Mol. ratio	$\frac{K_2O}{Na_2O+K_2O}$	0.56	0.34	0.56	0.55	0.42
	$\frac{Al_2O_3}{Na_2O+K_2O+CaO}$	1.41	1.45	1.84	1.93	1.66
Wt %	Fe_2O_3+FeO+MnO+MgO	8.81	9.26	8.11	7.24	6.73
	Norms (CIPW)					
	Q	24.65	32.72	26.94	33.28	31.17
	c	4.76	4.85	8.57	7.80	6.32
	or	26.02	10.45	23.69	22.68	19.35
	ab	19.49	19.49	17.24	17.66	24.89
	an	7.14	13.54	5.14	1.08	1.75
	ne	—	—	—	—	—
	di wo	—	—	—	—	—
	di en	—	—	—	—	—
	di fs	—	—	—	—	—
	hy en	5.19	6.34	5.92	5.19	4.59
	hy fs	6.59	5.49	6.65	3.56	4.07
	ol fo	—	—	—	—	—
	ol fa	—	—	—	—	—
	mt	2.78	3.22	1.46	2.64	2.13
	hm	—	—	—	—	—
	il	0.74	1.03	1.34	1.19	1.11
	ap	0.13	—	0.30	0.24	0.27

Norms are calculated by the author.

K: Precambrian pelitic metamorphites of the Kamiaso conglomerate (Data from ADACHI, 1973), A: Pelitic schists of the southern Abukuma Plateau and the eastern half of central Abukuma Plateau (Data from MIYASHIRO and HARAMURA, 1966), R: Pelitic rocks of the Dando area and Kiso-Komagane area, Ryoké Metamorphic Belt (*ditto*), N: Practically or nearly unmetamorphosed Palaeozoic slates for zone N (*ditto*), S: Practically or nearly unmetamorphosed Palaeozoic slates for zone S (*ditto*).

limits of stability field of the aluminium silicate minerals under the amphibolite facies condition expressed in terms of the CaO against Al_2O_3 contents of analysed pelites. In Fig. 5 the curve A–A′ can be drawn dividing pelitic rocks lacking aluminium silicate associated with muscovite from those with aluminium silicate. The curve A–B may divide the rocks which contain aluminium silicate but lack muscovite or retain only a trace of it, from aluminium silicate free rocks. C–C′ curve may drown the boundary between pelitic rocks and amphibilite or lime-silicate rocks (WINCHESTER, 1974). Samples with sillimanite (Nos. 10 and 11) are plotted in the field of Al-richer side than the curve A–A′, whereas the rests lacking of aluminium silicate in the opposite side. Plotted points of the Hida metapelites on the diagram can explain the scarce occurrences of aluminium silicate minerals in the area, none the less subjected by the amphibolite facies metamorphism or higher than that. Namely, as mentioned above, the metamorphic grade is commonly said to be the amphibolite facies, and in the district thermal gradient towards the higher grade part can not be supposed, because of complicated overlapping of some metamorphic episodes. Consequently, it is impossible to consider that the scarce appearance of aluminium silicate is depending on the dissatisfaction of physical condition. Under the microscope, rarely found are such evidence suggesting the preexistence of aluminium silicate as aggregates of muscovite. Hence, it is also impossible to consider that aluminium silicate could disappear in the progress of metamorphic events.

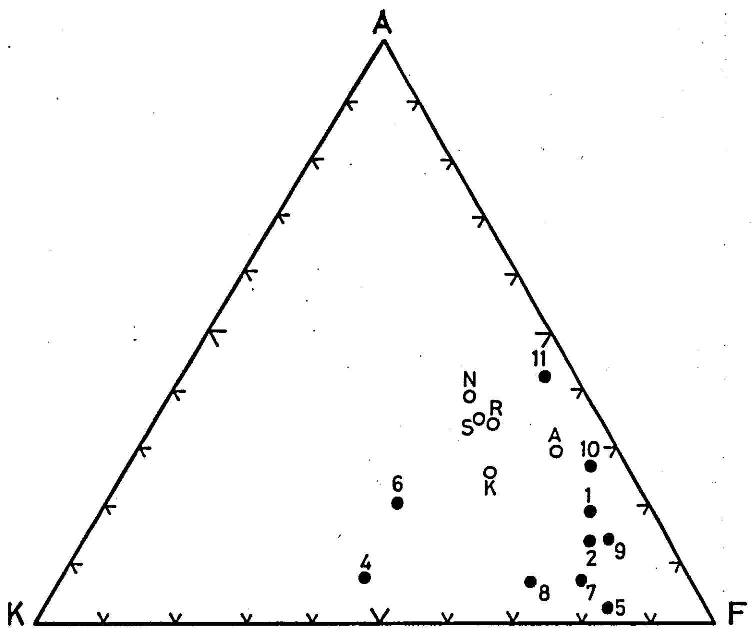

FIG. 2. AKF plots of pelitic rocks in Japan.
Solid circles: Hida metapelites. The numbers attached to individual symbols refer to the column numbers in Tables 1 and 2, except for NO. 3 which can not be plotted on the diagram because of too lower value of excess alumina. Open circles: Averaged values of pelites from Kamiaso conglomerate (K), Abukuma Metamorphic Belt (A), Ryoké Metamorphic Belt (R), Palaeozoic from zone N (N) and Palaeozoic from zone S (S). Abbreviations for open circles as in Table 4.

All are considered, unusual occurrence of aluminium silicate can explained in connection with the dependence on the bulk rock chemistry.

In view of the above results it is found to be difficult to avoid the conclusion that mineralogical character of the metapelites from the Hida Metamorphic Belt is seriously depending on bulk rock chemistry.

The most troublesome problem, however, is whether this chemical character of present metapelites can certainly and directly reflect those of the original rocks. In this connection, it is fortunate that none of analysed samples show abnormally high or low contents of alkalies, which must be one of the most easily mobile components. Consequently, there happens no remarkable alkali addition or subtraction through the metamorphic processes. It may be probable to suppose that in the progress of metamorphism the reaction could be advanced under more or less isochemical condition.

Generally speaking, the more the pelites have been decomposed to take the character of high maturity, the higher the ratio of K_2O/Na_2O+K_2O, and excess alumina (Al_2O_3/

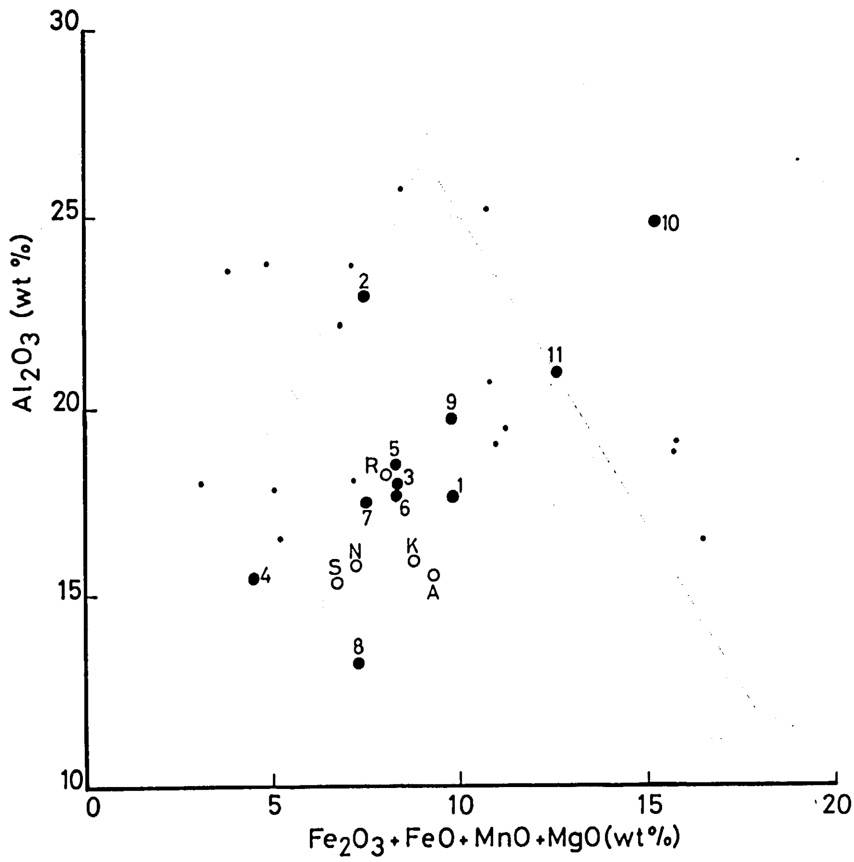

FIG. 3. Al_2O_3 plotted against Fe_2O_3+FeO+MnO+MgO for pelites. Small solid circles are plots of published data for metapelites from the Hida Metamorphic Belt, their chemical composition being shown in Table 3. Other abbreviations as in Fig. 2.

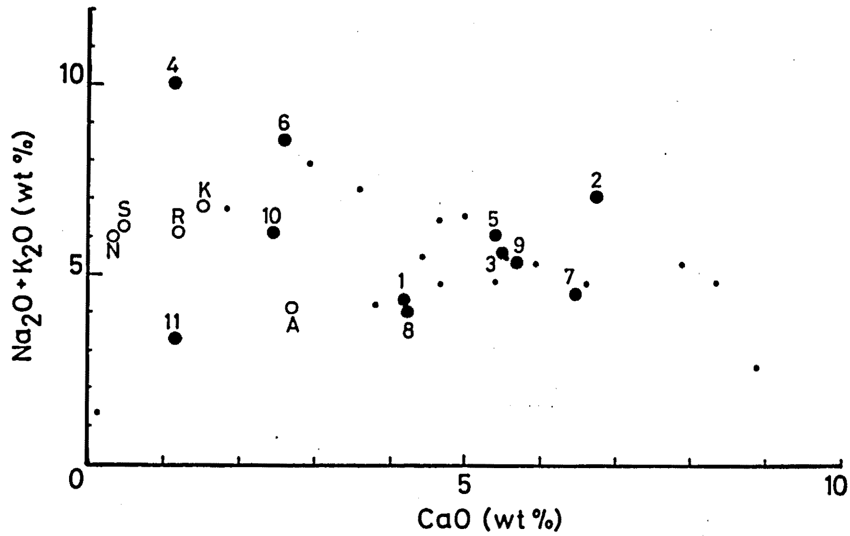

FIG. 4. Total alkalies and CaO contents of pelites. Abbreviations as in Fig. 3.

Na_2O+K_2O+CaO) (MIYASHIRO and HARAMURA, 1962 and 1966). These values for pelites are given in Table 2, 3 and 4 with the chemical analytical data. Fig. 6 represents the relationship between alkali ratios and the values of Al-excess of pelitic rocks, metamorphosed and unmetamorphosed in Japan. It is to be noted from the figure that most samples from the Hida Metamorphic Belt are plotted in the area of lower values of not only alkali ratios but alumina-excess, than the affinities from other localities in Japan.

As may readily be seen, the enrichment of CaO, FeO and MgO is the characteristic to Hida metapelites suggesting the mechanical mixing of basic volcanic materials into pelites.

All are concerned, it may be concluded that sedimentary environments of Hida pelites is not miogeosynclinal but rather "eugeosynclinal", where mixed sediments of pelitic rock with basic volcanic provenance can be accumulated. The point is one of the most distinguishable character of the Hida Metamorphic Belt among the similar type metamorphic belts in Japan.

Based on his detailed petrological studies on the Precambrian metamorphic pebbles in the Permian (to Triassic?) Kamiaso conglomerate, ADACHI (1973) has come to the conclusion that metamorphites are derived from the Precambrian land including the present Hida terrain. KANO (1972) also noted the similarity of composition and zoning pattern in garnets from Kamiaso Precambrian gneiss and Hida metapelites.

The author, however, has the opinion that the petrochemical and mineralogical characteristics of the metapelites from the present Hida terrain could not be similar to gneisses from the Kamiaso conglomerate. The original rocks of the former must be accumulated in the sedimentary environments of mixing of basic volcanics into pelites. The latter, however, must be derived from pelite of high maturity. This difference may suggest the distinction of sedimentary environments of original rocks. Precambrian metapelites in the Kamiaso conglomerate may be derived from the more innerside (near to the Sino-Korea platform) than the present Hida terrain, where through the Palaeozoic age to

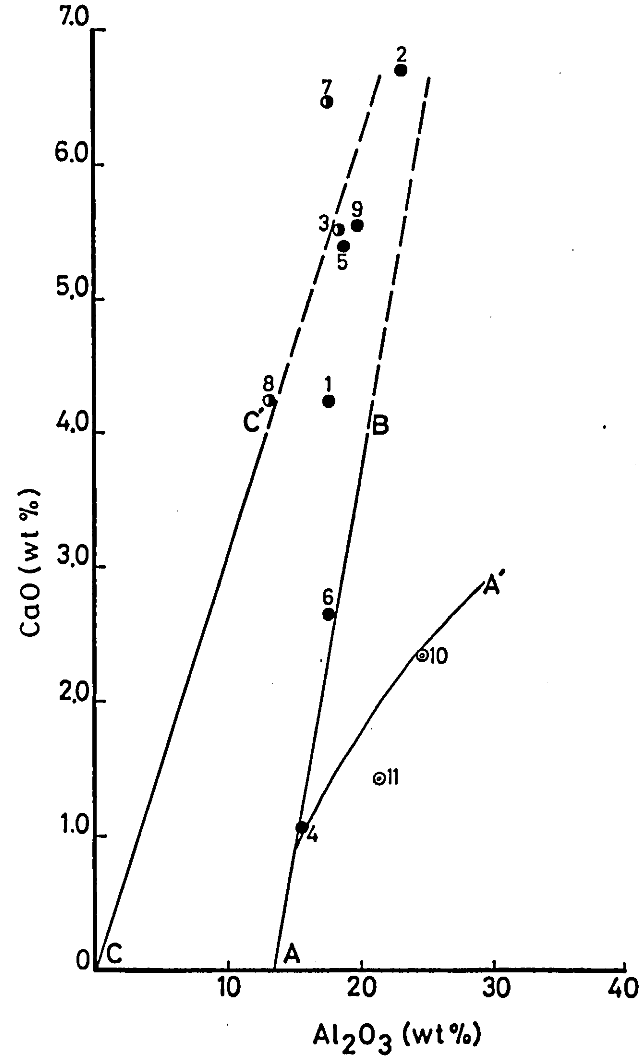

FIG. 5. The compositional distribution of metapelites in the Odori-River district. Double circles: sillimanite present, solid circles: no aluminium silicates (almost with muscovite), half open circles: hornblende or clinopyroxene present. The numbers attached to circles refer to the column numbers in Tables 1 and 2. The explanation for the curves is presented in the text. Dashed lines are extended by the author.

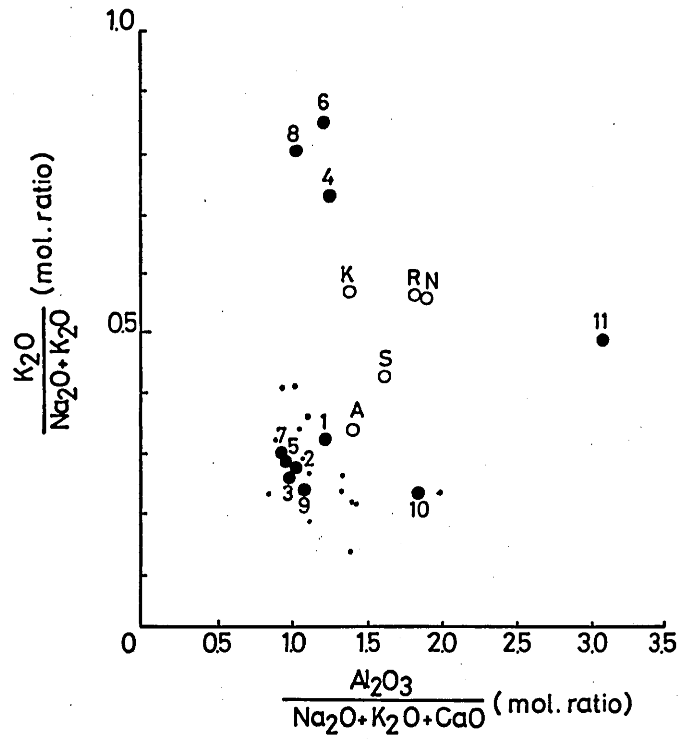

FIG. 6. Alkali ratios and excess alumina of pelites. Abbreviations as in Fig. 3. A sample (column a in Table 3.) is omitted because of its exceptionally high value of excess alumina.

Mesozoic age, some metamorphic episodes have overlapped. Namely, not all of the Hida metamorphites are Precambrian but a part of them are composed of those which had been firstly metamorphosed in the Precambrian age to form hinterland as well as the basement of the Japanese Palaeozoic geosyncline.

V. CONCLUSIONS

On the stand point of his petrological studies on metapelites from the Hida Metamorphic Belt, the author has come to the following conclusions.

i) Pelitic gneisses from the southwestern part of the Hida Metamorphic Belt are clarified to have such chemical characteristics as having comparatively high contents of FeO, MgO and CaO, with low values of alkali ratios and alumina excess. This is the common characters of metapelites through the Hida Metamorphic Belt.

ii) The occasional appearance of hornblende or clinopyroxene in contrast to the scarce appearance of aluminium silicate in metapelites can be explained by the dependence on bulk rock chemistry.

iii) In comparison with petrochemical character of the affinities from other high T and low P type metamorphic belts and Palaeozoic slates from Japan, as well as Precambrian metapelites of Kamiaso conglomerate, it could well be said that the original pelites of the Hida Metamorphic Belt had not been derived from miogeosynclinal sediments of high maturity, but from pelites with mixing of basic volcanic materials. This is one of the most distinguishable character of the Hida Metamorphic Belt.

REFERENCES

ADACHI, M. (1973): Pelitic and quartzo-feldspathic gneisses in the Kamiaso conglomerate — A study of Precambrian geology in Japan and East Asia —. *Jour. Geol. Soc. Japan*, **79**, 3, 181–203.

AOKI, H. (1964): Regional metamorphism and granitization in the Ioridani-Otani district, northeastern Hida Metamorphic region. (Part II). *Chikyu Kagaku* (*Earth Sci.*), 75, 16–28.

KANO, H. (1972): Precambrian basement rocks in Japanese Islands (in Japanese). *NIHONKAI* (*Japan Sea*), 7, 47–54.

KOBAYASHI, H. (1954): On the cummingtonite plagioclase rock of the Koshimizu district, Toyama Prefecture *Jour. Fac. Sci., Hokkaido Univ.* Ser IV., **8**, 4, 407–418.

MIYASHIRO, A. and HARAMURA, H. (1962): Chemical composition of Paleozoic slates, part IV (in Japanese). *Jour. Geol. Soc. Japan*, **68**, 797, 75–82.

——— and ——— (1966): Sedimentation and regional metamorphism in the Paleozoic geosynclinal pile of Japan. *Proc. Symp. Tectonics, in Bull. Indian Geophy. Union*, 3, 45–55.

NOZAWA, T. and SAKAMOTO, T. (1960): Explanatory text book of the geological map of Japan, scale 1: 50000, Gohyakkoku, (in Japanese). *Geol. Surv. Japan.*

SATO, S. (1968): Precambrian-Variscan polymetamorphism in the Hida Massif, basement of the Japanese Islands. *Sci. Rept. Tokyo Univ. Education* Sect. C, **10**, 95, 15–129.

SOMA, T. (1975): Hida Metamorphic Belt (in Japanese). *Bull. Geol. Geograph. Research Toyama Pref.*, 6, 187–222.

SUZUKI, M. and KOJIMA, G. (1970): On the association of potassium feldspar and corundum found in the Hida Metamorphic Belt. *Jour. Japan. Assoc. Min. Pet. Econ. Geol.* **63**, 6, 266–274.

——— (1973): An occurrence of "eclogitic rock" in the Hida Metamorphic Belt. *Jour. Japan. Assoc. Min. Pet. Geol.* **68**, 12, 372–382.

——— (1974): Polymetamorphism in the western part of the Hida Metamorphic Belt (in Japanese). *TOKOKIBAN* (*Basement of the island arc*), 1, 15–21

——— (1975): Garnets in pelitic gneisses from the western part of the Hida Metamorphic Belt (in Japanese). *Abst. Program, 1975 Annual Meet. Geol. Soc. Japan*, 258.

WINCHESTER, J. A. (1974): The control of the whole-rock content of CaO and Al_2O_3 on the occurrence of the aluminium silicate polymorphs in amphibolite facies pelites. *Geol. Mag.*, **111**, 3. 205–211.

INSTITUTE OF GEOLOGY AND MINERALOGY
FACULTY OF SCIENCE,
HIROSHIMA UNIVERSITY
HIROSHIMA, JAPAN