Niobium in Some Alkalic Rocks from Nemuro, Morotsu, and Ponape Island

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Abstract

Nb concentrations for thirty-seven alkalic rocks from Nemuro, Morotsu, and Ponape Island are presented and discussed. There is a gradual increase in the Nb contents and Nb/Ti ratios with an increase in the mafic index. Increasing the concentrations of Nb with an increase in alkali contents is observed in the Morotsu and Ponape rocks. The low concentrations and characteristic trends of Nb in the Nemuro rocks support the view that these rocks were affected by depletion during the deuteric alteration process.

Introduction

There are developed some alkalic rocks in the Nemuro Peninsula of Hokkaido, Morotsu in Saklalin, and Ponape Island in the Western Pacific Ocean.

The rocks of Nemuro and Morotsu districts belong to the alkalic rocks of Japanese Province, whereas those of Ponape to the Intra-Pacific alkalic Province (Yagi, 1959). These rocks have been studied petrographically and petrochemically by Yagi (1953, 1960, 1969) and geochemically by Ishikawa and Yagi (1970) and Ishikawa et al. (1971). They concluded that the alkalic rocks have been formed chiefly by crystallization differentiation from parental olivine basaltic magmas.

This paper presents a summary of the geochemical behavior of Nb in the alkalic rocks from these different petrographic districts. The Nb contents were determined using a neutron activation analysis by E. Campbell of U. S. Geological Survey, Washington, D. C. and M. E. Виktopoba and V. Gladkikh of Institute of Mineralogy, Geochemistry and Crystalchemistry of the Rare Element, Moscow.

Analytical Data and Discussions

Nb concentrations and some element ratios of the Nemuro, Morotsu and Ponape rocks are listed in Tables 1–3 together with those of some major elements quoted from Yagi (1953, 1960, 1969). Average concentrations of Nb for the rocks are also listed in Table 4.

The Morotsu rocks, occur as sheets, laccoliths, and dikes and vary from dolerite, through monzonite to syenite (Yagi, 1953). The concentrations of Nb vary considerably in the same rock types (Table 1). For example, Nb content ranges from 8 to 20 ppm and from 19 to 130 ppm in dolerites and syenites, respectively. Average value of Nb, 16 ppm, for the dolerite of the Morotsu agrees reasonably well with the values, 19 ppm, 16 ppm and 15 ppm,

Table 1. Analytical results for Morotsu rocks

	1	2	3	4	5	6	7	8	9	10	11
Nb (ppm)	20	20	8	35	39	37	19	53	53	130	101
$(Na+K)\times10^3$ (ppm)	33	36	40	67	68	75	69	75	79	91	89
$Nb/Ti\times10^2$	0.13	0.15	0.06	0.32	0.46	0.30	0.39	0.91	0.74	4.04	2.54
$\frac{FeO+Fe_2O_3\times10^2}{MgO+FeO+Fe_2O_3}$	62.3	58.5	64.8	83.2	87.3	75.0	84.8	95.3	94.3	93.8	94.5

1. No. 82, Dolerite
2. No. 605, Dolerite
3. No. 55D, Dolerite
4. No. 902, Monzonite
5. No. 1413, Monzonite
6. No. 1305G, Monzonite
7. No. 55S, Syenite
8. No. 1410, Syenite
9. No. 8023, Syenite
10. No. 1501, Syenite
11. No. 1412, Syenite

Major elements were quoted from K. Yagi (1953); trace elements were determined by E. Campbell (Ishikawa et al., 1971).

estimated by Turekian and Wedepohl (1961), Vinogradov (1962) and Borodin and Gladkikh (1968), respectively, for the basaltic rocks. The average Nb, 71 ppm, for the syenite shows high value compared with the value 35 ppm, estimated by Turekian and Wedepohl (1961) for syenite.

The Ponape rocks, which occur as lava flows, show a wide range of composition from nepheline basalt, through nepheline basanite, olivine basalt, olivine dolerite (picritic basaltic) and trachyandesite to trachyte (Yagi, 1960).

Table 2. Analytical results for Ponape rocks

	1	2	3	4	5	6	7	8	9	10	11	12	13
Nb (ppm)	94	63	92	47	52	58	52	98	77	70	141	108	140
$(Na+K)\times10^3$ (ppm)	20	30	16	23	40	31	32	35	33	43	64	70	86
$Nb/Ti\times10^2$	0.41	0.26	0.51	0.25	0.33	0.26	0.29	0.47	0.41	0.41	1.41	2.70	4.67
$\frac{FeO+Fe_2O_3\times10^2}{MgO+FeO+Fe_2O_3}$	48.4	44.4	46.8	50.2	46.8	60.5	59.9	68.7	68.2	74.2	77.3	89.4	82.6

1. No. 124, Ti-augite-olivine nepheline basalt
2. No. 26, Olivine-nepheline basalt
3. No. 30, Ti-augite-olivine nepheline basalt
4. No. 32, Nepheline dolerite
5. No. 32, Nepheline basanite
6. No. 29, Nepheline basanite
7. No. 1, Olivine basanite
8. No. 19, Olivine basalt
9. No. 8, Olivine basalt
10. No. 2, Ti-augite basalt
11. No. 106, Trachyandesite
12. No. 27, Trachyte
13. No. 23, Trachyte

Major elements were quoted from K. Yagi (1960); trace elements were determined by E. Campbell (Ishikawa et al, 1971) and M. E Bиktopoba and V. Gladkhih.

The nepheline basaltic rock, olivine basalt and Ti-augite basalt of the Ponape have high contents of Nb, 68 ppm, 76 ppm and 70 ppm, respectively. These values agree reasonably with the average Nb, 72 ppm, estimated by Engel et al. (1965). Engel et al. (1965) have noted that the alkali rich basalts from cap submarine and island volcanoes are relatively enriched in Nb. Recently, Kesson (1973) noted that the alkali basalts from the Monaro alkaline volcanics have Nb ranging from 30 to 95 ppm. Winchester and Floyd (1977) also estimated an average content of 48 ppm for alkali olivine basalt. An average Nb, 124 ppm, for the trachyte of the Ponape Island is similar to the average 120 ppm for the trachytes from the Gudalup Islands, East Pacific Rise (Engel and Engel, 1964). Recently, Winchester and Floyd (1977) estimated an average Nb content of 146 ppm for the trachyte.

The Nemuro rocks which occur as differentiated sheet are characterized by association of rock type ranging from picritic dolerite through dolerite and monzonite to syenite, while the undifferentiated sheet is characterized by dolerite showing pillow structure (Yagi, 1969).

The Nemuro rocks have low contents of Nb, an Avg. 3.4 ppm for Hanasaki dolerites and an Aveg. 4.2 ppm for Nosappu dolerites, respectively. The syenite also shows a low value, Avg. 6 ppm, compared with 35 ppm, estimated by Turekian and Wedepohl (1961) for syenite. The characteristic low concentration of Nb of the Nemuro dolerites clearly distinguish them from common alkalic basalts, and these values are rather similar to those for andesite, 4.3 ppm, estimated by Taylor (1968).

The elements such as Ti, Zr, Y, Ce, Ge, Sc and Nb are recognized as immobile during

Table 3. Analytical results for Nemuro rocks

	Nosappu						
	1	2	3	4	5	6	7
Nb (ppm)	4.7	4.2	3.8	5.5	7.1	4.9	3.4
(Na+K)$\times 10^3$ (ppm)	36	41	56	80	94	90	24
Nb/Ti$\times 10^2$	0.04	0.04	0.1	0.1	0.6	0.4	0.07
$\frac{FeO+Fe_2O_3\times 10^2}{MgO+FeO+Fe_2O_3}$	51	51	61	76	63	48	70

Nosappu:
1. No. 3005, Picritic dolerite
2. No. 107A, Picritic dolerite
3. No. 1606, Porphyritic dolerite
4. No. 3009, Monzonite
5. No. 2805, Syenite
6. No. 2803, Syenite

	Hanasaki					
	8	9	10	11	12	13
Nb (ppm)	3.3	3.2	3.6	3.4	4.2	2.7
(Na+K)$\times 10^3$ (ppm)	57	55	50	65	66	68
Nb/Ti$\times 10^2$	0.06	0.06	0.06	0.03	0.04	0.03
$\frac{FeO+Fe_2O_3\times 10^2}{MgO+FeO+Fe_2O_3}$	68	78	69	72	76	73

Hanasaki:
7. No. 204F, Alkali dolerite
8. No. 204C, Alkali dolerite
9. No. 2707D, Trachylite
10. No. 204E, Alkali dolerite
11. No. 2707B, Dolerite
12. No. 2707A, Dolerite
13. No. 2707C, Dolerite

Major elements were quoted from K. Yagi (1969); trace elements were determined by E. Campbell.

Table 4. Average values of Nb (ppm)

	Morotsu			Ponape					Nemuro				
									Nosappu			Hanasaki	
	1	2	3	1	2	3	4	5	1	2	3	1	2
Nb (ppm)	16	40	71	68	76	70	141	124	4.2	5.5	6.0	3.4	3.2

Morotsu:
1. Dolerite
2. Monzonite
3. Syenite

Ponape:
1. Nepheline basaltic rock
2. Olivine basalt
3. Ti-augite basalt
4. Trachy-andesite
5. Trachyte

Nemuro:
(Nosappu)
1. Dolerite
2. Monzonite
3. Syenite

(Hanasaki)
1. Dolerite
2. Trachylite

post-consolidation alteration and metamorphic process by Cann (1970) and others. However, it is indicated that considerable chemical exchange took place when the magma and unconsolidate sediments saturated with sea water during this stage, and the original distribution of trace elements was greatly modified in the Nemuro rocks (Ishikawa et al., 1971). Therefore, the low concentration of Nb in the Nemuro rocks support the view that the rocks were affected by depletion during the deuteric alteration process.

In order to show the variation of the Nb in progressive stages of magmatic differentiation, the Nb data are plotted against the ratio $\frac{FeO+Fe_2O_3}{MgO+FeO+Fe_2O_3}\times 100$, which was devised by Wager and Deer (1939) to represent stages of magmatic fractionation in the Skeargaard intrusion and later designated as the mafic index by Simpson (1954). Gottfreid et al. (1961, 1968) and Bulter and Smith (1962) proved that Nb generally tends to concentrate in the later differentiates. Gottfreid et al. (1968) have also indicated that the Nb/Ti ratio increases toward the late differentiates in the diabase-granopyre suites from Dillsburg, Pennsylvania and Great Lake, Tasmania.

The Nb contents and Nb/Ti ratios generally increase with the function $\frac{FeO+Fe_2O_3}{MgO+FeO+Fe_2O_3}$ ratio rise for the Morotsu and Ponape rock series. In the Nemuro rock series, Nb increases from the early to later members in the Nosappu dolerites, however, the Nb generally remains almost constant in the Hanasaki dolerites.

As mentioned above, Nb content in petrographically distinct rock shows some differences. Fig. 4 shows the relation of Nb content to alkali. There is positive correlation between the contents of Nb and alkali. However, it is difficult to compare the concentrations of Nb in the Nemuro rocks from other districts, because the Nemuro rocks are depleted in Nb by deuteric alteration.

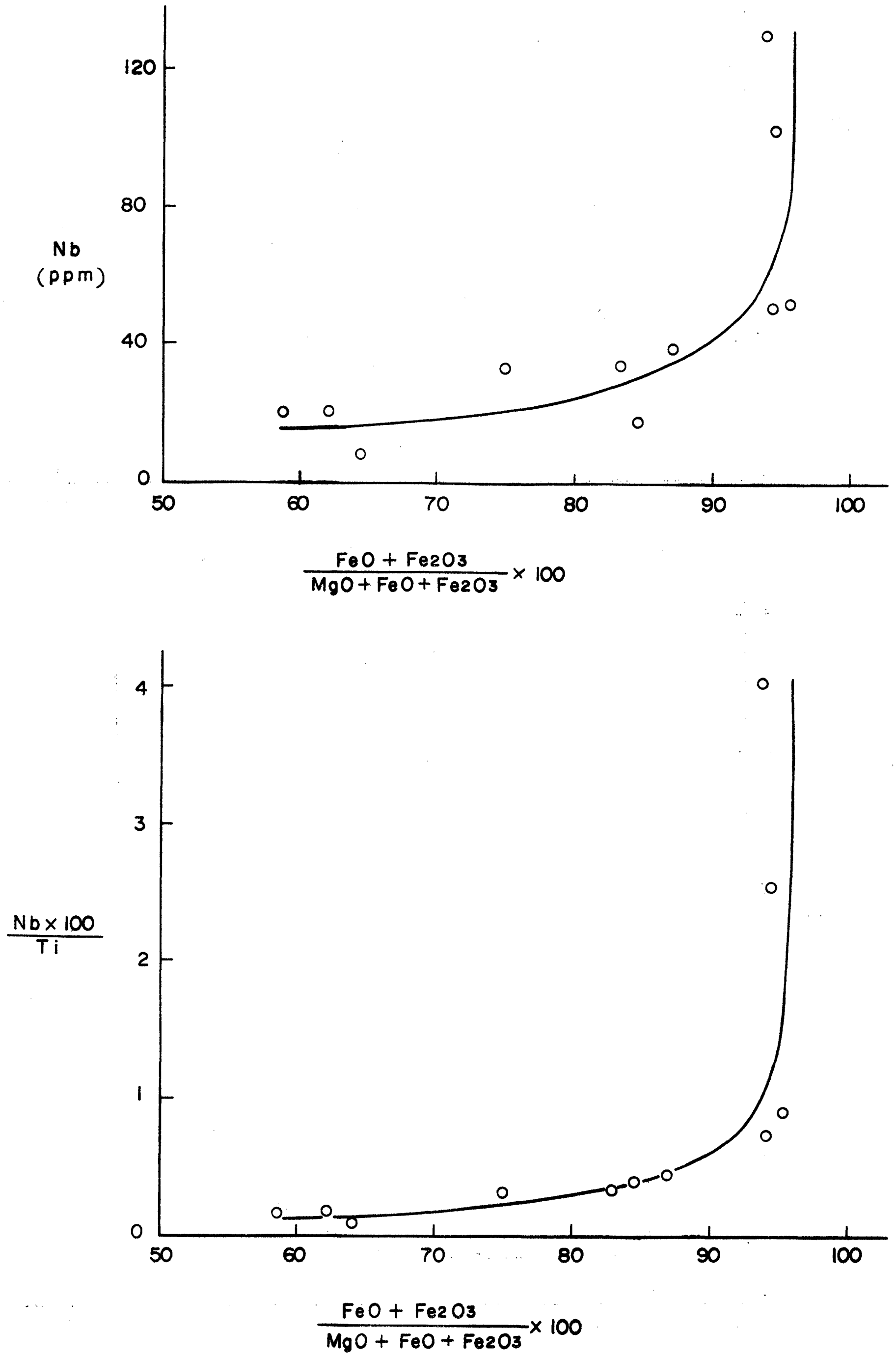

Fig. 1. Variation diagrams showing the distribution of niobium and Nb/Ti ratios in the Morotsu rocks.

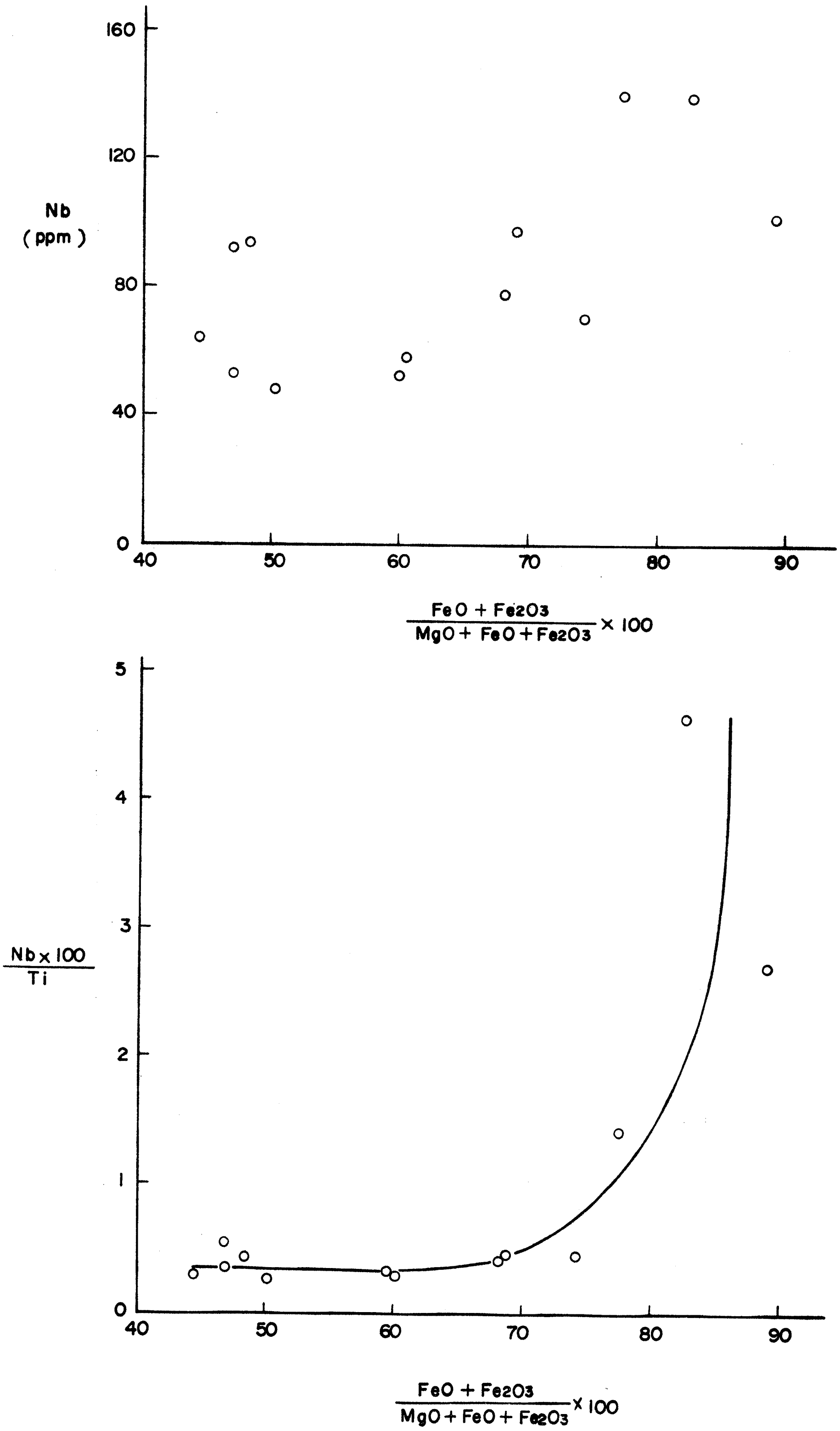

Fig. 2. Variation diagrams showing the distribution of niobium and Nb/Ti ratios in the Ponape rocks.

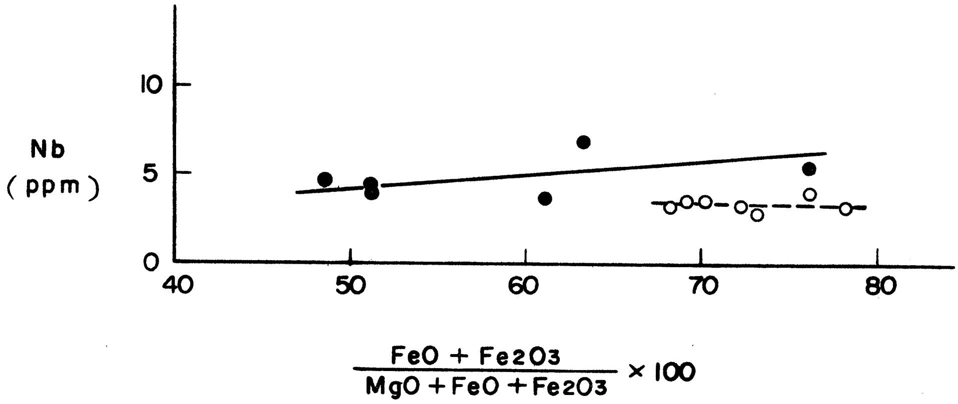

Fig. 3. Variation diagram showing the distribution of niobium in the Nemuro rocks.
open circles: Hanasaki rocks; solid circles: Nosappu rocks

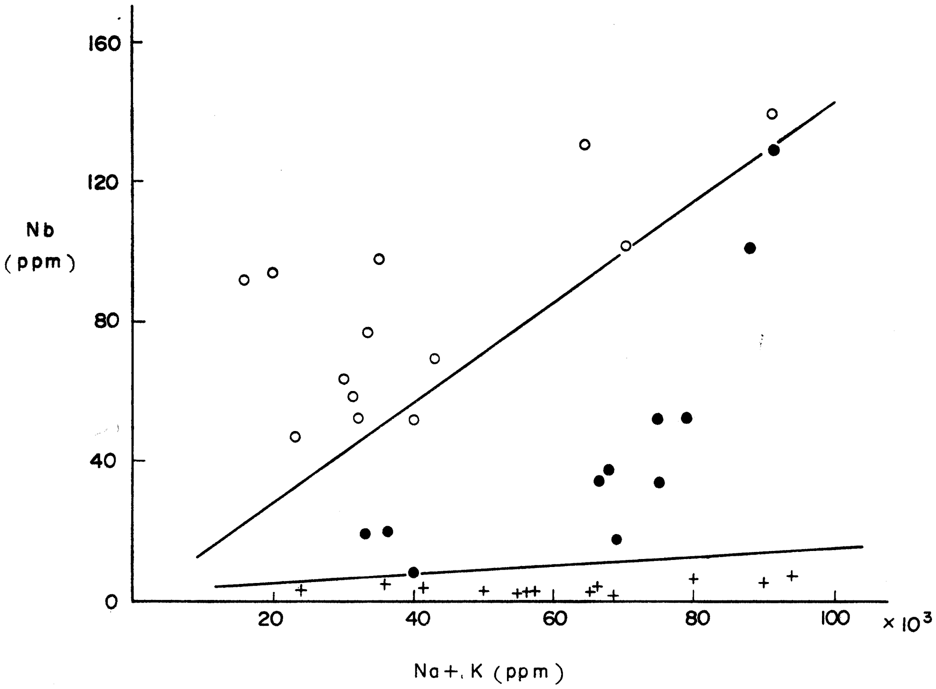

Fig. 4. Relation of Nb content to K+Na.
open circles: Ponape rocks; solid circles: Morotsu rocks; crosses: Nemuro rocks

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