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PHLOGOPITE FROM THE HOROMAN ULTRAMAFIC ROCKS

by

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(with 3 Figures and 2 Tables)

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Abstract

Phlogopites from the "alpine-type" peridotite have been rarely reported. A phlogopite vein was found in lherzolite of the Horoman ultramafic massif of the Hidaka metamorphic belt, Hokkaido. The phlogopite from Horoman is characteristically rich in Mg and Ti. The Mg / Mg+Fe ratios (0.916 – 0.924) and TiO₂ contents (5.67 – 6.52 per cent) are distinctly higher than those from crystalline limestones, kimberlites, ultramafic nodules, and other "alpine-type" peridotites, with few exceptions.

Introduction

Phlogopite is typically found in contact-metamorphosed limestones and in ultramafic rocks (Deer et al, 1963). In kimberlite phlogopite occurs as a primary constituent mineral and sometimes displays reaction rims (Williams, 1932; Watson, 1955). Upton and Thomas (1973) reported phlogopite in Precambrian potassic ultramafic rocks from south Greenland. Other characteristic occurrences of phlogopite are in ultramafic nodule of alkali olivine basalt and kimberlite (Kushiro and Aoki, 1968; Dowson et al, 1970; Wilshire and Trask, 1971; Rimsaite, 1971). Oji (1961) reported phlogopitic biotite in druse of trachyandesite from Nokonoshima Island, northern Kyushu.

Phlogopites from the "alpine-type" peridotites have been rarely reported. Recently, Inomata and Tazaki (1974) and Tazaki and Inomata (1974) studied phlogopite-bearing ultramafic rocks from the Mikabu zone in central Japan, and discussed the genesis of phlogopite.

In the Hidaka metamorphic belt, Hokkaido, phlogopite hitherto has not been reported. In the course of the study of the ultramafic rocks, the present writer found phlogopite in the Horoman ultramafic massif, and this paper gives the occurrence and chemical composition of the phlogopite from Horoman.

Occurrence

The Horoman ultramafic massif is situated at the southwestern end of the Hidaka metamorphic belt, and crops out over approximately 8×10 km. Conspicuous layering composed of dunite, lherzolite, plagioclase lherzolite and a small amount of gabbro and pyroxenite, are well developed. The ultramafic rocks of the Horoman massif are made up almost entirely of olivine, orthopyroxene, and clinopyroxene. Plagioclase, spinel, and hornblende are minor constituents.

Detailed petrographic descriptions are given by Harada et al. (1960), Komatsu and Nochi (1966), and Niida (1974).

The locality of phlogopite in the Horoman massif is some 300m up the Horoman river from the junction of the Apei-no-sawa, as shown in Fig. 1. Phlogopite occurs in lherzolite, forming a vein nearly parallel to the foliation plane. The phlogopite vein is up to 1 – 2mm in thickness and extends over 20cm in length.

In the Horoman massif two types of lherzolite are recognized, i.e. lherzolite with brownish purple seams of spinel + orthopyroxene, which is common; and lherzolite without the seams, which occurs in the transitional zone from dunite to lherzolite and from lherzolite to plagioclase lherzolite (Niida, 1974). The phlogopite vein occurs in the lherzolite of the latter type which represents the transitional zone from dunite to lherzolite. No phlogopite has been found in other rock types, but Dr. M. Suzuki of the Geological Survey of Hokkaido found phlogopite in dunite near the lowest part of the Horoman massif (oral communication).

A photomicrograph of phlogopite from Horoman is shown in Fig. 2. The phlogopite is 2.0mm in maximum grain size, and is accompanied by small crystals of brown spinel. The phlogopite shows strong pleochroism from almost colorless to pale brown or reddish brown in thin section, and often exhibits wavy extinction. $2V_x$ is $5^\circ - 9^\circ$, with a concentration between 7° and 8° . Optical properties of the phlogopite are summarized in Table 1.

Chemical Composition

Four grains of phlogopite were analyzed by electronprobe X-ray microanalyser (JXA-5A) at the Geological Survey of Japan. Operating conditions were 15 KV accelerating potential and about $0.03 \mu\text{A}$ specimen current. The electron beam diameter was kept at about 5 microns.

The data were computed into oxide percentages using a correction program by Mr. K. Okumura and Dr. Y. Kawachi of the Geological Survey of Japan for

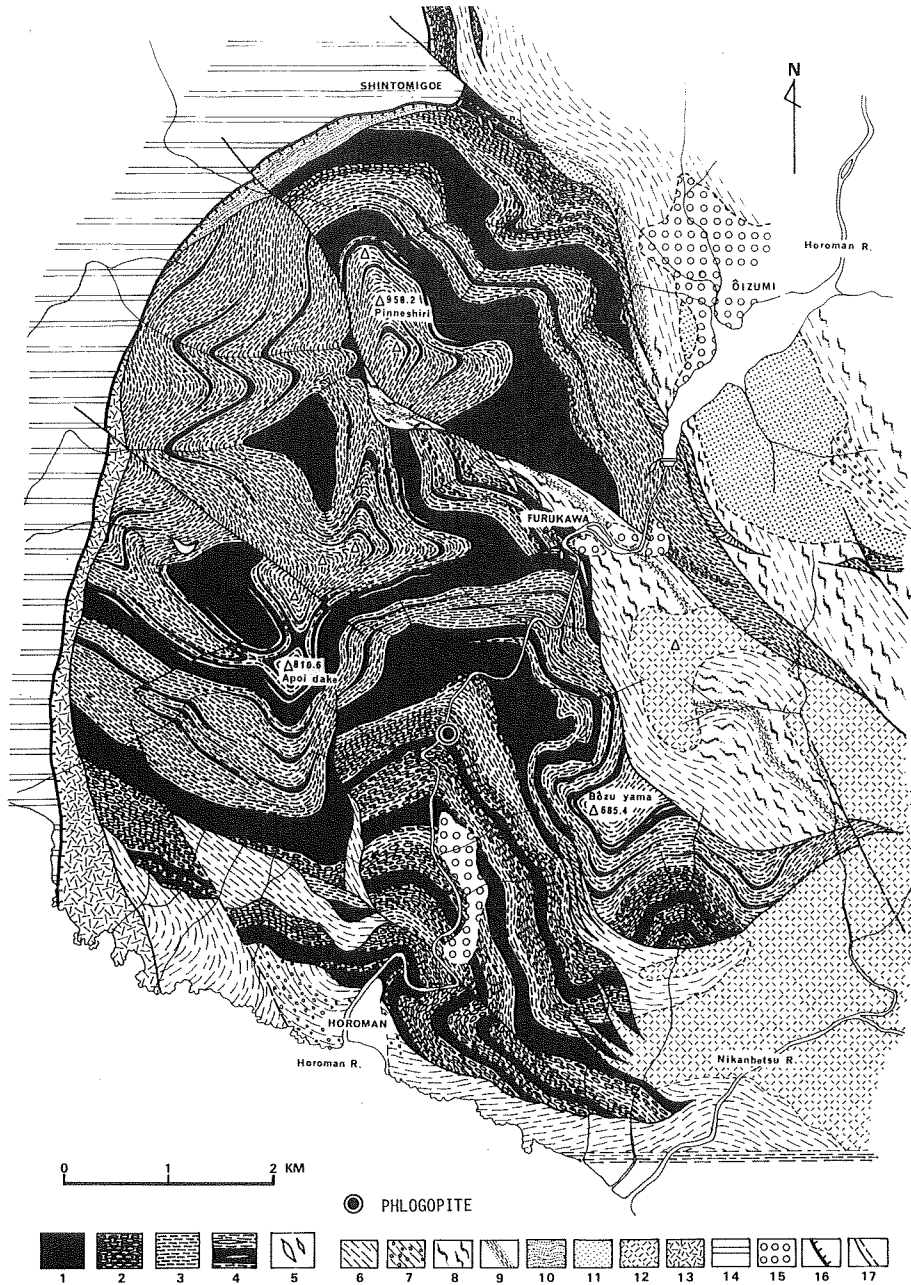


Fig. 1 Locality of phlogopite in the Horoman ultramafic massif. (Geologic map after Niida, 1974)

- | | |
|---|---------------------------------|
| 1. dunite | 9. schistose amphibolite |
| 2. lherzolite | 10. greenschist and blackschist |
| 3. plagioclase lherzolite | 11. diorite |
| 4. gabbro | 12. gabbro |
| 5. pegmatite | 13. saussurite gabbro |
| 6. schistose biotite hornfels | 14. Hidaka Super Group |
| 7. plagioclase porphyroblastic biotite schist | 15. alluvium |
| 8. biotite gneiss | 16. thrust fault |
| | 17. fault and shear zone |

Table 1 Optical properties of phlogopite

α :	—————	<i>Pleochroism</i>
β :	1.612 ± 0.002	X : colorless
γ :	1.615 ± 0.002	Y=Z : pale brown or reddish brown
2Vx :	$5^\circ - 9^\circ$	

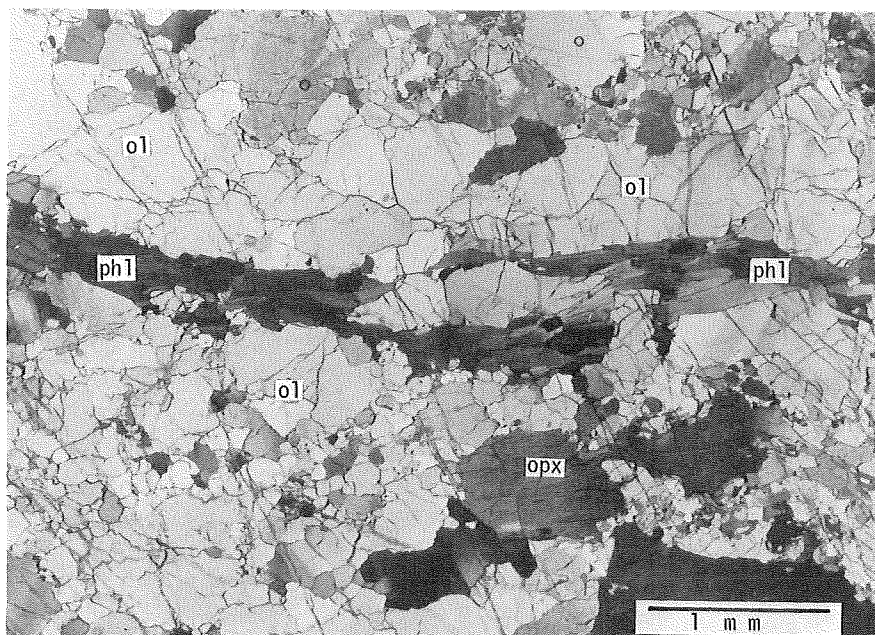


Fig. 2 Photomicrograph of phlogopite in Iherzolite (sample no.72505) from the Horoman ultramafic massif.

phl: phlogopite, ol: olivine, opx: orthopyroxene.

EPMA quantitative analysis, which is essentially the same method as that of Sweatman and Long (1969). Structural formulae of phlogopite were calculated using a program developed by Dr. Y. Kawachi.

Four analyses of phlogopite together with structural formulae calculated on basis of $O = 22$, are listed in Table 2 in order of decreasing Mg : Fe ratio.

MgO contents vary continuously from 20.21 to 21.83 per cent. Fe_2O_3 (total iron) contents range from 3.46 to 3.64 per cent. The Mg / Mg+Fe ratios of the phlogopite (0.916 – 0.924) are distinctly higher than those from kimberlites (0.79 – 0.91), ultramafic nodules (0.73 – 0.90), and ultramafic

Table.2 Microprobe analyses and structural formulae of phlogopite (sample no. 72505 B) from the Horoman ultramafic massif.

	1	2	3	4
SiO ₂	40.64	39.01	39.83	40.29
TiO ₂	6.52	6.45	5.67	6.44
Al ₂ O ₃	16.35	15.64	16.31	16.34
Fe ₂ O ₃ *	3.54	3.46	3.61	3.64
MnO	0.01	0.03	0.02	0.01
MgO	21.83	21.01	21.21	20.21
CaO	0.01	0.02	0.01	0.00
Na ₂ O	1.79	1.95	1.63	1.85
K ₂ O	7.72	8.21	7.96	8.53
Total	98.41	95.78	96.25	97.31

Formulae on basis of O = 22					
Z {	Si	5.48	5.44	5.50	5.52
	Al (IV)	2.52	2.56	2.50	2.48
	Al (VI)	0.08	0.01	0.15	0.16
	Fe **	0.36	0.36	0.38	0.38
Y {	Ti	0.66	0.68	0.59	0.66
	Mn	0.00	0.00	0.00	0.00
	Mg	4.38	4.37	4.36	4.12
	Ca	0.00	0.00	0.00	0.00
X {	Na	0.47	0.53	0.44	0.49
	K	1.33	1.46	1.40	1.49
Z		8.00	8.00	8.00	8.00
Y	°	5.48	5.42	5.48	5.32
X		1.80	1.99	1.84	1.98
Mg/Mg+Fe	**	0.924	0.924	0.920	0.916

* Fe₂O₃ = total iron expressed as Fe₂O₃
 ** Fe = Fe⁺³

rocks in the Mikabu zone (0.76 – 0.87). Compared with other phlogopites, except for those from carbonatite and skarn, the phlogopite from Horoman has the highest value in Mg / Mg+Fe ratio.

Fig. 3 shows the relation between the Mg / Mg+Fe ratio and Ti contents of various phlogopites of different origin. The phlogopite from the Horoman massif has also higher titanium contents, ranging from 5.67 to 6.52 per cent.

Na₂O contents of the phlogopite are also high, varying from 1.63 to 1.95 per cent.

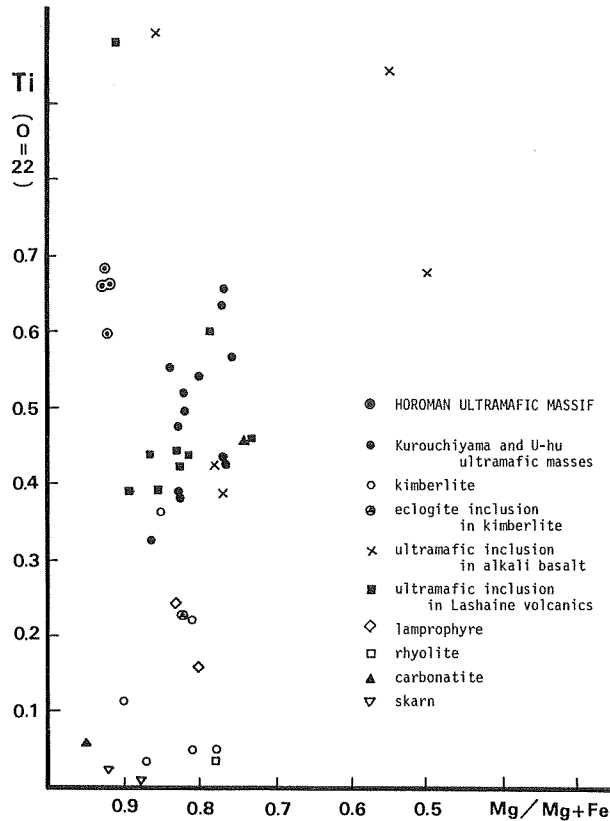


Fig. 3 Plot of phlogopite from Horoman in the diagram Ti vs. Mg / Mg+Fe of Tazaki and Inomata (1974).

Summary

Phlogopite in lherzolite from the Horoman ultramafic massif occurs as a vein nearly parallel to the foliation plane. The phlogopite is characteristically rich in Mg and Ti. The Mg / Mg+Fe ratio and TiO₂ content of the phlogopite are distinctly higher than those from crystalline limestones, kimberlites, ultramafic nodules, and ultramafic rocks in the Mikabu zone, with few exceptions.

The mode of occurrence and the chemistry suggest that the phlogopite crystallized from a fluid rich in Mg, Ti and alkali, subsequent to the solidification of the Horoman massif, though the detailed condition of crystallization remains unsolved.

Recently, phlogopite has attracted special interest in relation to the form and abundance of water and alkalis in the upper mantle. In this connection,

many studies on the stability of phlogopite have been carried out. Kushiro et al. (1967) and Yoder and Kushiro (1969) showed that the stability limit of pure phlogopite is more than about 1,300°C at more than 10 Kb. Allen et al (1972) and Modreski and Boettcher (1972), however, found that the maximum stability limit of phlogopite coexisting with olivine and pyroxene is at a much lower temperature. Such experimental results will be proved by field petrology of ultramafic rocks, such as those of orogenic belts.

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