STRUCTURE OF THE HOROMAN ULTRAMAFIC MASSIF OF THE HIDAKA METAMORPHIC BELT IN HOKKAIDO, JAPAN

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Introduction

The Horoman ultramafic massif (8×10 km) situated at the south-western end of the Hidaka metamorphic belt is considered to be representative of an alpine-type peridotite intrusion. In contrast to many intrusions of this type the rocks of the Horoman massif are fresh and show well-developed layering.

Subsequent to the pioneer works on the general geology of this area by YAMANE (1911), OHDAIRA (1926), and TAKEUCHI (1937), a detailed study of the Horoman massif was carried out by HUNAHASHI (1941), and later by IGI (1953). Both authors describe the general geology and petrography of the massif and commented briefly on its structure. A geologic map including this massif was published by HUNAHASHI and IGI (1956) with an explanatory text ("Horoizumi" sheet, scale 1:50,000). A more detailed geologic map of the southern central part of the massif including some petrographic descriptions is given in HARADA, *et al.* (1960). Petrographic studies on the main rock types of the massif is given by KOMATSU and NOCHI (1966).

Recently, the origin and mode of emplacement of the Horoman massif have been discussed. NAGASAKI (1962, 1966) considered that the Horoman body was formed by successive "hot" intrusions of liquid magma and its crystallization and differentiation *in situ*. His descriptions of the layering, however, are inadequate and contain some errors, as pointed by KOMATSU and NOCHI (1966). Therefore, Nagasaki's conclusions are open

to question. On mineralogical data, ONUKI (1965) suggested that the Horoman massif crystallized under higher temperatures and slightly higher pressures than other alpine-type ultramafic intrusions, but he did not determine whether this massif intruded in a liquid or solid state.

So far, the field relationships and structure of the Horoman massif are incomplete, and further study is required in order to understand the origin and mode of emplacement. Since 1969, the present writer has been engaged in the geologic and structural mapping of the Horoman ultramafic massif and its adjacent area. The present paper gives a structural analysis of the massif on the basis of the field study. Deformational features which are characteristic of the alpine-type ultramafic intrusions will be published at a later date. Petrochemical studies of the massif have been taken by Dr. KOMATSU of Niigata University, and the results will be published elsewhere.

Geologic Setting of the Horoman Ultramafic Massif

Seven major masses of alpine-type peridotite are distributed along the western sides of the Hidaka metamorphic belt for about 140 km. The Horoman ultramafic massif is situated at the southwestern extremity of the Hidaka metamorphic belt (Fig. 1). Apodake (810.6 m) and adjacent areas in the Horoman region are composed of ultramafic rocks, banded biotite gneiss, schistose biotite hornfels, schistose amphibolite, and various kinds of basic plutonics.

The Horoman ultramafic massif crops out over approximately 8×10 km and is more than

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Fig. 1. Map showing distribution of the ultramafic rocks in the Hidaka metamorphic belt.

1. ultramafic rocks, 2. mafic rocks, 3. metamorphic rocks, 4. granitic rocks, Ue; Uenzaru, Pa; Pankenushi, To; Tottabetsu, Po; Poroshiri, Nio; Niobetsu, Horoman, Nik; Nikanbetsu

3,000 m in thickness (Figs. 2, 3, and 6). Conspicuous layers of dunite, lherzolite, plagioclase lherzolite, and a small amount of gabbro and pyroxenite, are well developed.

To the west the Horoman massif is bordered by overthrust fault zone which corresponds to the western margin of the Hidaka metamorphic belt. The overthrust zone contains saussurite gabbro and low-grade metamorphic rocks such as greenschist or blackschist, which are in contact with non-metamorphosed sedimentary rocks of the Pre-Cretaceous Hidaka Super Group (MINATO *et al.*, 1965). The eastern margin of the massif is irregularly bounded by NW-SE striking faults and shear zones. Along the strongest shear zone, near Furukawa, wedge-shaped

masses of banded gneiss and amphibolite occur in a form of "septum" faulted with the ultramafic rocks.

Serpentinization is usually developed at the margin of the massif and along the shear zones. However, the major part of the massif is extremely fresh, though in parts it is weakly serpentinized.

Cataclasis of olivine, involving deformation lamellae, kink bands, and granulation is common. Such cataclastic structures may be explained by assuming that the emplacement of the massif to its present level occurred while the rocks were in a solid state.

Petrography

The ultramafic rocks of the Horoman massif are made up almost entirely of olivine, orthopyroxene, and clinopyroxene. Plagioclase, spinel, and hornblende are important minor constituents. The following rock types are recognized in the Horoman massif based on their mineral assemblage and modal composition.

1. dunite.....Ol+Opx+Cpx+Sp
2. lherzolite.....Ol+Opx+Cpx+Sp
3. plagioclase lherzolite...Ol+Opx+Cpx
Pl+Ho+Sp
4. gabbro (small amount)
5. pyroxenite (very small amount)

In Figure 4, a typical modal composition is given for each of the four rock types, and in Figure 5, a triangular diagram of olivine-orthopyroxene-clinopyroxene is given where 43 modal analyses of rocks are plotted. As shown in Figure 5, a trend of increasing orthopyroxene with olivine can be seen, while clinopyroxene increases when olivine decreases.

DUNITE

Dunite is easily recognizable by its yellowish-brown color due to weathering and most of the constituent minerals are easily distinguishable on the fresh surface, i.e. yellowish-green olivine, yellowish-brown orthopyroxene, light green clinopyroxene, and black spinel. Dunite consists of 90 to 95% (vol. %) olivine, 5 to 8% orthopyroxene, 1 to 3% clinopyroxene, and approximately 1% spinel. Orthopyroxene replaced by bastite is rarely found in some of

Fig. 2

Fig. 2. Geologic map of the Horoman region.

1. dunite, 2. lherzolite, 3. plagioclase lherzolite, 4. gabbro, 5. pegmatite, 6. schistose biotite hornfels, 7. plagioclase porphyroblastic biotite schist, 8. biotite gneiss, 9. schistose amphibolite, 10. greenschist and black schist, 11. diorite, 12. gabbro, 13. saussurite gabbro, 14. Hidaka Super Group, 15. alluvium, 16. thrust fault, 17. fault and shear zone
O; Oomagari-no-sawa, F; Fudo-no-sawa, T; Taki-no-sawa, K; Kage-no-sawa, S; Sarushunai-zawa

Fig. 3. Geologic profile of the Horoman massif. Locations of profiles, S₁-N₁, S₂-N₂, and W-E, are shown in the geologic map (Fig. 2).

1. dunite, 2. lherzolite, 3. plagioclase lherzolite, 4. gabbro, 5. biotite gneiss, 6. schistose biotite hornfels, 7. schistose amphibolite, 8. gabbro, 9. saussurite gabbro, 10. Hidaka Super Group, 11. fault and shear zone

Fig. 4. Modal composition of the four representative rock types of Horoman ultramafic massif.

Fig. 5. Plot of 43 modal analyses on a triangular diagram of olivine-orthopyroxene-clinopyroxene. (dots; dunite, open circles; lherzolite, crosses; plagioclase lherzolite, triangles; gabbro)

the more serpentinized rocks.

At several localities layers of harzburgitic dunite carrying large orthopyroxene crystals are found. Harzburgite lenses, several centimeter in thickness and containing up to 30 % of orthopyroxene, are interlayered with dunite. Spinel-rich dunite layers, about 15 meters in thickness and containing large crystals of spindle shaped brown spinel, are also found in the dunite.

Olivine in the dunite varies in size and shape. Coarse grains, 0.4 to 5.0mm in size, are commonly irregular and have interlocking

grain boundaries. Undulatory extinction and kink bands in the olivine are a characteristic feature and may be due to deformation. Elongation of coarser olivine grains is essentially parallel to the layering. Small grains, less than 0.4 mm in size are commonly and occur in the interstices between the irregular boundaries of the coarse olivine, where they show a mosaic texture.

Orthopyroxene crystals are usually anhedral, and are coarser than olivine and clinopyroxene in the dunite. Aggregates of clinopyroxene or brown spinel form thin layers in a direction parallel to the layering of the dunite. Large, spindle-shaped brown spinels 3—5 mm in size occur commonly as anhedral grains disseminated throughout dunite.

LHERZOLITE

The lherzolite contains 70 to 90% olivine, 10 to 20% orthopyroxene, 5 to 10% clinopyroxene, and about 2% brown spinel. On the weathered surface, the lherzolite is reddish brown in color and its constituent minerals are easily distinguished by their color; greenish-grey olivine, brown orthopyroxene, and emeraldgreen clinopyroxene. Some lherzolite are characterized by brownish-purple seams composed of orthopyroxene, spinel, and clinopyroxene, that are parallel to the layering. These seams, however, are not always contained in the lherzolite.

PLAGIOCLASE LHERZOLITE

Plagioclase lherzolite consists mainly of olivine, orthopyroxene, clinopyroxene, and plagioclase, with accessory green or brown spinel and pale brown hornblende. The amount of plagioclase is commonly less than 15% and that of olivine is less than 80%.

Plagioclase usually occurs as seams associated with spinel and a small amount of clinopyroxene, which are aligned nearly parallel to the layering. Two types of seams are found in the plagioclase lherzolite; one is a small aggregation of fine grained plagioclase and brown spinel (Type I); the other is thicker seam made up of coarse grained plagioclase and green spinel (Type II). The large seams (Type II) pass gradationally into

Table 1. Two types of layered structure in the Horoman massif

	Lower layering type	Upper layering type
Thickness of each rock type	several 10 m — a few 100 m	a few cm — several m
Transition from one to another rock type	gradational	sharp
Main rock types	D, L, and Pl.L	Pl.L and D
Mode of layering	regular; $D \rightarrow L \rightarrow Pl.L \rightarrow L \rightarrow D \rightarrow L \rightarrow Pl.L \rightarrow L \rightarrow \dots$ L lies usually between D and Pl.L rare occurrence of Gb in Pl.L and Py in D and Pl.L is noted	not regular there is no L between D and Pl.L Gb occurs commonly in both of D and Pl.L

D; dunite

L; lherzolite

Pl.L; plagioclase lherzolite

Gb; gabbro

Py; pyroxenite

thin bands of gabbro which rarely occur in the upper part of the Horoman massif.

The plagioclase lherzolite contains a small amount of brown hornblende. The hornblende typically replaces clinopyroxene along its well-developed (100) cleavage. No individual crystals of hornblende are present. The hornblende is pale brown in color with very faint pleochroism.

GABBRO

In the upper part of the Horoman massif, a small amount of gabbro occurs as thin layers several centimeters in thickness, which are aligned parallel to the dunite and plagioclase lherzolite layers. The gabbroic layers are planar and traceable for more than several meters along strike. In the dunite, thick layers of gabbro ranging from 1 to 10 meters in thickness, are rarely found extending for several hundred meters along strike.

There are at least two types of gabbroic rocks which are different in mineralogy and texture. The first type, which is the most common, consists of plagioclase (40 to 60 % in volume), clinopyroxene, olivine, with accessory magnetite and pale brown hornblende, showing coarse texture. The second type is free of olivine, and has fine mosaic texture.

PYROXENITE

Small amounts of orthopyroxenite and clinopyroxenite occur in the Horoman massif as compositional layers a few centimeters in thickness. The former is found only in dunite, while the latter occur in both dunite and plagioclase lherzolite.

Large lenses made up to pure orthopyroxene are rarely found in a dunite layer on the western ridge of Apoi-dake, where a large single crystal of orthopyroxene, about 30 cm in diameter, was collected.

Spinel orthopyroxenite occurs in the dunite layers and consists of up to 50% orthopyroxene, 20 to 30% brown spinel, 10 to 20% olivine, and traces of clinopyroxene, plagioclase, and spinel-pyroxene symplektite.

Layering

As already mentioned, the Horoman ultramafic massif exhibits well-developed compositional layering between dunite, lherzolite, plagioclase lherzolite, and small amount of gabbro and pyroxenite. Two kinds of compositional layering can be distinguished by their megascopic features (Table 1).

The first type, which occurs in the upper part of the Horoman massif, shows well-developed compositional layers ranging from a few centimeters to several meters in thickness (Fig. 6). The second type, which occurs in the lower part of the massif, mainly consists

Fig. 6. Sections showing the sequences of rock types of the Horoman ultramafic massif at the following localities:

1. (O) Oomagari-no-sawa in the northern part of the massif.
2. (W) Western ridge of Apoi-dake.
3. (F) Furukawa-no-sawa in the western part of the Horoman River.
4. (H) Horoman River section, the main part of the southern half of the massif.
5. (T) Taki-no-sawa in the eastern part of Horoman River.
6. (K) Kage-no-sawa in the eastern part of the Horoman River. Locations of these sections are given in Fig. 5.

of massive compositional layers of a few hundred meters in thickness. For convenience, the names of "upper layering type"

for the first type and "lower layering type" for the second type are used in the following descriptions.

In the upper layering type, a rapid transition is generally observed at the contacts between two rock types. On the other hand, in the lower layering type, one rock type is gradationally transformed into another rock type over a vertical interval of several meters. Furthermore, the predominant rocks of each layering type are different. Plagioclase lherzolite and dunite are predominant in the upper layering type. A small amount of gabbro and pyroxenite also occur, but no lherzolite is found. The lower layering type is made up of dunite, lherzolite, and plagioclase lherzolite. Gabbro is typically absent, except for thin gabbroic bands which are rarely found in the plagioclase lherzolite.

The lower layering type is characterized by a well-developed regularity in the layering. Lherzolite usually occurs between the dunite and plagioclase lherzolite layers, and there is a regular repetition of rock types such as dunite→lherzolite→plagioclase lherzolite→lherzolite→... (Fig. 6). Layering of this type is repeated four times in the exposure of the lower layering type rocks, as mentioned by KOMATSU and NOCHI (1966). In the upper layering type, however, such regularity is not recognized. There is an indivisible relation between the dunite and gabbroic layers with the thickness and number of the gabbroic layers increasing with thickening of the dunite layers.

Besides compositional layering, there are a great number of thin mineral layers (seams and aggregations) which are monomineralic or consists of several minerals. These mineral layers are generally aligned parallel to the main layering. The thin mineral layers can be classified as follows;

- 1) aggregation of clinopyroxene in dunite;
- 2) aggregation of spinel in dunite;
- 3) seams of orthopyroxene and spinel in lherzolite; and
- 4) seems of plagioclase and spinel in plagioclase lherzolite.

Fig. 7. Tectonic map of the Horoman ultramafic massif.

1. foliation ($<25^\circ$), 2. foliation ($\geq 25^\circ$), 3. schistosity and gneissosity, 4. lineation ($<20^\circ$), 5. lineation ($\geq 20^\circ, <30^\circ$), 6. lineation ($\geq 30^\circ$), 7. syncline, 8. pegmatite, 9. thrust fault, 10. fault and shear zone, 11. boundary of rock types

Fig. 8. Four subareas of the Horoman massif.
 subarea I; the eastern part of the massif including Bozu-yama.
 subarea II; the main part of the southern half of the massif in the vicinity of the Horoman gorge.
 subarea III; the western part of the semi-dome including Apoi-dake.
 subarea IV; the area north of the syncline.

Structure

A. Megascopic structure of the Horoman massif

The foliation, which is megascopically recognizable in the field, is characterized by two features;

- 1) a boundary plane at the top and bottom of a compositional layer, and
- 2) a plane formed by mineral layers; seams or aggregations of minerals.

Such foliation planes are one of the most important structures in order to understand internal structure and kinematic picture of the Horoman massif.

The tectonic map (Fig. 7) shows that dip direction of layered rocks along the southern half of the massif changes from east on the

eastern side, to west on the western side. The dip of the layers decreases with height as seen at Apoi-dake, Bozu-yama, and other high areas. These dips indicate a dome structure for the southern half of the massif. In a more strict sense, this should be called as a semi-dome structure opening to south, because the southern end of the dome is cut by a WNW-ESE trending fault. The dome structure was first described by HUNAHASHI (1941), and later confirmed by IGI (1953); HARADA *et al.* (1960), and KOMATSU and NOCHI (1966). There is also a small dome structure at Sarushunai in the eastern part of Bozu-yama.

The whole outcrop area of the Horoman massif can be divided into four subareas, I, II, III, and IV, according to their structural characteristics (Fig. 8).

Subarea I occupies the eastern part of the massif including Bazu-yama. The π -diagram (Fig. 9-I) from subarea I shows a high concentration of foliations striking in a NW-SE direction, with some deviations from E-W to N-S, dipping to NE. Subarea II covers the vicinity of the Horoman gorge. The π -diagram (Fig. 9-II) from subarea II shows that the main foliation has the E-W strike and dips moderately to the north. Subarea III includes Apoi-dake and covers the western side of the massif. The foliation in this area is scattered from N-W to NE-SW and gently dips approximately to the west (Fig. 9-III). The existence of a semi-dome structure in the southern half of the massif is clearly shown by the π -diagrams from subareas I, II, and III. It is also shown in the π -diagrams that the western side of this semi-dome plunges to west and the eastern side to east.

The northern half of the massif (subarea IV) displays a nearly monoclinally layered structure striking roughly in an E-W direction and with a moderate dip. As shown in Figure 9-IV, the foliation projection scatters more widely than those of subareas I, II, and III, as a result of disturbance of the layered structure which may have taken place during or after the emplacement of the massif.

The maxima diagram of foliations through-

I. Projection of foliations from subarea I.

III. Projection of foliations from subarea III.

II. Projection of foliations from subarea II.

IV. Projection of foliations from subarea IV.

Fig. 9. π -diagrams for the foliations in each subarea, projected on the lower hemisphere of the Schmidt's net.

Fig. 10. Maxima diagram of foliations showing the maxima for each subarea.

out the massif (Fig. 10) indicates that 1) the main foliation has a nearly E-W strike with a systematic deviation caused by the dome structure in the southern half of the massif, 2) a synclinal structure, with an axis striking about N 70° W, is observed in the central part of the massif near Furukawa.

B. Lineation

In this paper lineation refers to the mineral lineation on the foliation plane, and was measured in the field. The lineation is observed in the elongation of seams of plagioclase+spinel, or orthopyroxene+spinel, and as the linear arrangement of mineral grains such as pyroxene or spinel (Plate I).

More than 60 lineations were measured. The main direction of the lineation trend (Fig. 11) is approximately N 15° E with different dips, although the lineation varies from N 10° W to N 30° E. As shown in the lineation diagram, most of the points are plotted in a well concentrated maximum on a great circle and lineation throughout the massif has a very constant direction in about N 15° E-S 15° W. Near the central part of the massif, there is a large, gentle syncline with the axis of which plunges westward from Furukawa. Therefore, the lineation dips to

Fig. 11. Lineation diagram with 63 projected lineations throughout the Horoman massif on the Schmidt's net.

the north in the southern half of the massif, while it dips to the south in the northern half.

C. Shape of the massif and mode of emplacement

As mentioned above, megascopic structures of the Horoman massif are characterized by synclinal structure with E-W axis at the central part and semi-dome structure at the southern half of the massif. The following evidences may suggest that the massif represents a thick sheet as a summarized shape.

1) Although the massif is bounded by many faults and shear zones, it may be regarded as a continuous body, considering from the same sequences of rock types throughout the whole massif as shown in Figure 6.

2) Typical sheet structures are recognized in the masses of Uenzaru, Pankenushi, Totabetsu, Poroshiri, Niobetsu, and so on, which are composed of the similar rock types to the Horoman massif and occur along the same thrust zone at the western side of the Hidaka metamorphic belt.

3) Lineation throughout the whole massif shows a constant trend, about N 15° E—S 15° W.

The mode of emplacement of the thick sheet is still remains as problem. However, it is probable that the massif went up to the present level along the thrust fault zone (about NW—SE) which passes through the northern side of the Horoman massif to the Nikanbetsu body. Then, the sheet was thrust up to the south-west with very gentle inclination at the present level. As the northern masses of biotite gneiss and amphibolite were continuously rising up, the northern part of the ultramafic sheet was dragged up and dipped to the south. Therefore, the synclinal structure with E—W axis was formed.

Summary

The general characteristics of the structure of the Horoman ultramafic massif are summarized as follows.

1) The Horoman massif represents an ultramafic body in the form of a thick, gently warped sheet. In the southern half of the massif, there is a semi-dome structure that opens to the south, and its western part is dipping to the west as a monoclinical flexure. A synclinal structure with its axis striking N 70° W and plunging west, is recognized at the central part of the massif, so that the northern part of the massif dips to the south and the southern part of the massif dips to the north.

2) The layering in the Horoman massif consists of compositional layers of dunite, lherzolite, plagioclase lherzolite, gabbro, and pyroxenite. Two types of layering are distinguished; one is the upper layering type which has a conspicuous layered structure in the upper part of the massif, and the other is the lower layering type characterized by massive, thick, and gradational compositional layers in the lower part of the massif.

3) In each compositional layer, there are a great number of thin mineral layers (seams or aggregations) consisting of one or more kinds of minerals.

4) The elongated direction of the thin mineral layers and the linear arrangement of their mineral grains are observed on the foliation plane. These lineations have a constant direction of N 15° E—S 15° W throughout the massif.

5) The massif is considered to have been in the form of a thick sheet that was intruded upward along a deep-seated thrust zone. During the final stages of intrusion, the thick sheet was thrust up to southwest, and biotite gneiss and amphibolite were incorporated and folded in its central part.

According to the classification of WYLLIE (1967, 1969), the Horoman ultramafic rocks are an alpine-type peridotite-serpentinite association, and are representative of peridotites and garnet peridotites associated with regionally metamorphosed rocks of upper amphibolite, granulite, or eclogite facies. According to DEN TEX (1969), the Horoman massif belongs to orogenic "root-zone" peridotite bodies occurring as dispersed lenses and tectonic "fish" in the "root-zone" of deeply exhumed orogens.

The Horoman ultramafic massif can be compared with other typical alpine-type peridotites, such as Dun Mountain and Red Hills (LAUDER, 1964; CHALLIS, 1965; WALCOTT, 1968), the Twin Sisters dunite (RAGAN, 1963), the garnet peridotite of Alpe Arami (MÖCKEL, 1969), and the harzburgite and dunite of Burro Mountain (LONEY *et al.*, 1971), in its geologic location, partial serpentinization, and cataclastic structures and textures.

THAYER (1960) discussed some comparative features of alpine-type and truly stratiform peridotite-gabbro complexes. The Horoman massif has a similar form, structure, layering, and rock textures to those of alpine-type peridotites.

In comparison with other alpine-type peridotites in the world, however, it is noted that the Horoman massif has a very conspicuous layered structure, which is an important aspect in considering the origin of the massif.

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References

- CHALLIS, G. A. (1965), The origin of New Zealand ultramafic intrusion. *Jour. Petrol.*, vol. 6, p. 322—364.
- DEN TEX, E. (1969), Origin of ultramafic rocks, their tectonic setting and history. *Tectonophys.*, vol. 7, p. 457—488.
- HARADA, J., HUNAHASHI, M., and KOBAYASHI, H. (1960), Report on the peridotite complex at Apoidake, Hidaka (in Japanese). Hokkaido Development Agency.
- HUNAHASHI, M. (1941), Geology and petrology of the Horoman district, Hidaka (in Japanese). Graduation thesis for Dept. of Geol. & Miner., Hokkaido Univ., no. 90 (manuscript).
- HUNAHASHI, M. and IGI, S. (1956), Explanatory text of the geological map of Japan "Horoizumi" (scale 1 : 50,000) (in Japanese with English abstract). Geol. Surv. Japan.
- IGI, S. (1953), Petrographical studies on the peridotite in the Horoman region at the southern end of the Hidaka mountain range, Hokkaido (in Japanese with English abstract). *Jour. Geol. Soc. Japan.*, vol. 59, p. 111—121.
- KOMATSU, M. and NOCHI, M. (1966), Ultrabasic rocks in Hidaka metamorphic belt, Hokkaido, Japan. I. Mode of occurrence of the Horoman ultrabasic rocks (in Japanese with English abstract). *Earth Science*, vol. 20, p. 99—108.
- LAUDER, W. R. (1965), The geology of Dun Mountain, Nelson, New Zealand. Part 2: The petrology, structure, and origin of the ultrabasic rocks. *New Zeal. Jour. Geol. Geophysics*, vol. 8, p. 475—504.
- LONEY R. A., HIMMERBERG, G. R., and COLEMAN, R. G. (1971), Structure and petrology of the Alpine-type peridotite at Burro Mountain, California, U.S.A. *Jour. Petrol.*, vol. 12, p. 245—309.
- MINATO, M., GORAI, M., and HUNAHASHI, M. ed. (1965), *The geologic developments of the Japanese Islands*. Tsukiji-shokan, Tokyo.
- MÖCKEL, L. R. (1969), The structural petrology of the garnet peridotite of Alpe Arami. *Leid. Geol. Meded.*, vol. 42, p. 61—130.
- NAGASAKI, H. (1962), Ultramafic body from the Horoman district, Hokkaido (abstract) (in Japanese). *Jour. Geol. Soc. Japan.*, vol. 68, p. 406.
- NAGASAKI, H. (1966), A layered ultrabasic complex at Horoman, Hokkaido, Japan. *Jour. Fac. Sci. Tokyo Univ.*, vol. 16, p. 313—346.
- OHDAIRA, Y. (1926), Geological and petrographical study in the Horoizumi district, Hidaka (in Japanese). *Jour. Geol. Soc. Japan*, vol. 35, p. 105—147.
- ONUKE, H. (1956), Petrochemical research on the Horoman and Miyamori ultramafic intrusions, North Japan. *Sci. Rept. Tohoku Univ.*, ser. III, vol. 9, p. 217—276.
- RAGAN, D. M. (1963), Emplacement of the Twin Sisters dunite, Washington, *Amer. Jour. Sci.*, vol. 261, p. 549—565.
- TAKEUCHI, N. (1937), Report of mineral resources in the Horoizumi and Samani district, Hidaka (in Japanese). *Miner. Resource Rept., Hokkaido Indust. Res. Inst.*, no. 67.
- THAYER, T. P. (1960), Some critical differences between Alpine-type and stratiform peridotite-gabbro complexes. *Rept. 21st. Session Intern. Geol. Congr. Copenhagen*, vol. 13, p. 247—259.
- WALCOTT, R. I. (1968), Geology of the Red Hill complex, Nelson, New Zealand. *Trans. Roy. Soc. New Zeal. Earth Sciences*, vol. 7, p. 57—88.
- WYLLIE, P. J. (1967), Petrography and petrology. In: P. J. Wyllie, ed., *Ultramafic and related rocks*. Wiley, New York, p. 403—416.
- (1969), The origin of ultramafic and ultrabasic rocks. *Tectonophys.*, vol. 7, p. 437—455.
- YAMANE, S. (1911), Report of mineral resources in the southern area of Hidaka and the Hiroo district Tokachi, Hokkaido (in Japanese). *Rept. Miner. Resources in Japan.*, Geol. Serv. Japan, no. 4.

幌満超塩基性岩体の構造について

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(要 旨)

幌満超塩基性岩体は日高変成帯の西南端に位置し、古くから顕著な層状構造を有することで知られている。

本論文では、岩体全域の岩相分布および構造について報告する。野外調査にもとづく幌満岩体の巨視的構造のまとめは、次のとおりである。

1) 幌満岩体は、3,000m以上の厚い岩床状の形態をもち、ゆるやかに彎曲している。岩体南部では南方に開いた半ドーム構造をとっており、半ドームの西翼は単傾斜で西に沈んでいる。古川付近からは西方には、東西性の向斜軸が存在し、それより北側では南に傾斜している。

2) 岩体に発達する層状構造の基本は、dunite, lherzolite, plagioclase lherzolite, gabbro, および pyroxenite の各岩石層の累重である。この層状構造の様式には2種類認められ、縞状構造の顕著な岩体上部のものと、塊状で厚い岩石層の積み重なる岩体下部のものとである。前者を“Upper layering type”, 後者を“Lower layering type”と呼ぶ。

3) foliationの面上に、鉱物層の伸びの方向および尖晶石・輝石などの鉱物の線状配列による lineation が認められる。この方向は岩体全域を通じてほぼ一定で、約N15°E—S15°Wに集中している。

4) 侵入機構については、岩体北方に伏在する日高変成帯西縁の衝上断層帯(NW方向)に沿って固体貫入した厚い岩床状岩体のモデルが想定される。岩体全域を通じて一定方向を示す lineation は、岩体固結時の動きの方向を暗示し、侵入の最終段階で、岩体はSW方向につき出したと考えられる。

地	名
Apoi-dake	アポイ岳
Bozu-yama	坊主山
Fudo-no-sawa	不動の沢
Furukawa	古川
Hidaka	日高
Horoman	幌満
Kage-no-sawa	蔭の沢
Oizumi	大泉
Oomagari-no-sawa	大曲の沢
Pinneshiri	ピンネシリ
Sarushunai	サルシュナイ
Schintomigoe	新富越
Taki-no-sawa	滝の沢

Plate I

1. Layered structure of the upper layering type showing alternation of dunite (D) and gabbro (G), —the northern ridge of Apoi-dake. Selective weathering reveals the conspicuous layered structure.
2. Layering between plagioclase lherzolite (PL) and gabbro (G), —the western foot of Apoi-dake.
3. Lineation on an unweathered foliation plane in plagioclase lherzolite, in this shown by elongated seams (light grey) of plagioclase and spinel.