Petrology of Peridotite and Chromitite in Wakamatsu Mine of the Tari-Misaka Ultramafic Complex, Western Japan

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Abstract: Peridotite and chromitite in Wakamatsu mine, a large chromite mine, at the Tari-Misaka ultramafic complex are described in order to understand the genesis of podiform chromitite. Rocks in and around the Wakamatsu mine are thermally metamorphosed by granite and the main silicate mineralogy and zonal structure of relic spinel are controlled by the thermal metamorphic temperatures dependent on the distance from the granite. The primary lithologies, however, can be determined by relic textures. Dunite is relatively predominant at Wakamatsu mine area, and chromitite occurs as pods within the dunite. Primary peridotites are variable in textural and chemical characteristics of chromian spinel dependent on the distance from the chromitite pod. Harzburgite far from chromitite, typically exposed at Misaka, has low-Ti (< 0.2 wt% of TiO₂) and highly anhedral spinel. Harzburgite close to the boundary with dunite has less anhedral and more Ti-rich (up to 0.5 wt% of TiO₂) spinel. Dunite also has relatively Ti-rich (up to 0.5 wt% of TiO₂) spinel, which tends to be more abundant and euhedral towards chromitite. Chromitite has rather constant mineralogy irrespective of spinel modal amount, with up to 0.7 (mostly 0.2 to 0.4) wt% of TiO₂. Cr# (=Cr/(Cr+Al) atomic ratio) of spinel in all lithologies is confined in a narrow range, from 0.4 to 0.6. These characteristics possibly indicate that a melt/harzburgite interaction controlled the genesis of the podiform chromitite and enclosing peridotites. The low-Ti harzburgite was passed by a relatively Ti-rich melt to leave dunite-chromitite and harzburgite envelope with relatively high-Ti mineralogy.

1. Introduction

Wakamatsu mine is located in the Tari-Misaka ultramafic complex, which is distributed around the boundary area of Tottori, Shimane, Okayama and Hiroshima Prefectures, Chugoku district, western Japan (Fig. 1). It has been the largest chromite mine in Japan, producing Al-rich refractory-grade chrome ores (e.g., BAMBA, 1963), and provides us a good field for research of chromitite genesis.

The Tari-Misaka ultramafic complex (ARAI, 1980) has been very famous for a large chromite field, having been paid attention by many researchers, especially by ore geologists. Among them KITAHARA (1958, 1959ab, 1962ab) described various rocks and minerals from the chromite mines of this complex. BAMBA (1963) made pioneering works on ultramafic rocks of the Tari-Misaka complex. IGI and ABE (1969) and Research Group of Peridotite Intrusion (1967) summarized petrographical characteristics of peridotites in compilation of peridotite complexes of Chugoku district and Japan, respectively. ARAI (1975) discussed the contact-metamorphic petrogenesis of ultramafic rocks of the Tari-Misaka complex for the first time. HIRANO et al. (1978) successfully discriminated the primary lithologies of contact metamorphosed peridotites and recognized that dunite is relatively predominant in the northern part of the Tari-Misaka complex, to which Wakamatsu mine belongs. ARAI (1980) established the essential igneous petrological characteristics of the Tari-Misaka peridotite. There have been only few...

In this article we describe petrography and mineral chemistry of chromitites and associated rocks in the Wakamatsu mine to make genetic relationship between chromitite and associated peridotite much clearer. As in the previous works (Arai and Yurimoto, 1994; Matsumoto et al., 1997) we focused on chromian spinel because its chemistry and texture are often preserved to be primary, the compositions of olivine and other minerals are not reliable for the primary ones (Arai, 1975). This article is complementary to ever published works (Arai, 1980; Arai and Yurimoto, 1994; Matsumoto et al., 1997) and also provides a background for discussion on the genesis of chromitite pods of Wakamatsu mine, the largest chromite concentration in Japan.

2. Geological background

The Tari-Misaka ultramafic complex is one of the largest of many ultramafic complexes (Fig. 2) in the Sangun metamorphic belt, which is of intermediate high-pressure type (Miyashiro, 1973). Most of them were suffered from thermal metamorphism by Cretaceous granitic intrusions (Arai, 1975). The Sangun ultramafic complexes are mostly composed of massive harzburgite and dunite with or without small amount of podiform chromitite (e.g., Arai, 1980; Matsumoto et al., 1995). One exception is the Ochiasi-Hokubo complex which is composed of layered harzburgite-herzolite-dunite-wrhlite (e.g., Arai et al., 1988).

The Tari-Misaka ultramafic complex is emplaced into the Paleozoic sediments (mainly slates) and is covered with Cretaceous rhyolitic welded tuff and Tertiary sediments. The complex is intruded by two granite to granodiorite masses of Cretaceous age (Arai, 1975). The Tsudoko tunnel of Hirose mine, another large chromite mine in the complex, penetrated through the peridotite from west to east into the granodiorite mass at its eastern end. Granodiorite phorphyry dikes are frequently observed in Wakamatsu mine. The thermal metamorphism was after some serpentinization, and transformed the ultramafic rocks into deserpentinized peridotites (Arai, 1975). Five metamorphic mineral zones are recognized from the contact with granite to the center of the complex (Arai, 1975; Matsumoto et al., 1995): (1) chrysotile/lizardite (Zone I, thermally unmetamorphosed), (2) antigorite (Zone II), (3) olivine-talc (Zone
III), (4) olivine-anthophyllite (Zone IV), and (5) olivine-orthopyroxene (Zone V). The primary lithology, dunite or harzburgite, can be completely discriminated in Zones I and II, where primary minerals and/or textures are often preserved. As described below in more detail chromian spinel is characteristically euhedral in dunite and anhedral or even vermicular in harzburgite there. Dunite and harzburgite can be usually distinguished even for highly metamorphosed peridotites, which preserve primary textures, especially pseudomorphs of orthopyroxene and chromian spinel (Hirano et al., 1978).

Harzburgite is generally dominant over dunite in the Tari-Misaka ultramafic complex as in almost all complexes in the Sangun zone (Matsumoto et al., 1995). However, dunite is relatively predominant in the northern part of the complex where some chromite mines including Wakamatsu mine are present (Hirano et al., 1978; Matsumoto et al., 1995). Gabbroic to dioritic rocks are frequently observed as irregular-shaped blocks or dikes with chilled margins. Pyroxenites are characteristically rare.

3. Wakamatsu Mine

Chromitite (chromite ore or chrome ore) was discovered in 1897 in this area, and the Wakamatsu mine is the oldest mine for the chromitite. There were several chromite mines in the northern part of the Tari-Misaka complex (Bamba, 1963). Wakamatsu and Hirose mines are the largest of them. The Hirose mine, for which the work of Arai (1975) was mainly done, was closed several years ago (in 1984) because of shortage of the reserve. Wakamatsu mine had been the only working chromite mine in Japan for many years but stopped to work a few years ago (in 1994). The chromite ore in this mine contains about 31 wt% of Cr₂O₃ on average, and is of refractory grade for making firebricks.

Many chromitite pods are distributed in the mining area; main deposits (pods) are, from north to south, North 7th (Kita-Nana-go) pod, North 5th (Kita-Go-go) pod and South 5th (Minami-Go-go) orebody which is subdivided into six smaller pods (South 51st to South 56th) (Fig. 3). The North 7th pod, striking southeast and dipping 30° south, is the largest chromite orebody in Japan, 20 to 30 m thick, 30 to 50 m wide and 200 m long in size. The North 5th pod has a lenticular shape, with a long axis of 50 m, a short axis of 25 m and average thickness of 15 m. The main tunnel (= Chubu-ko) connects the North 7th pod to the north with the South 5th pods to the south. In addition to the large pods, at least three small pods are found in the Chubu-ko tunnel.

4. Sampling

Samples used in this study were mainly collected at the Wakamatsu mine and its surrounding area. Samples from the Misaka area, where harzburgite is noticeably predominant over dunite, were also examined for comparison.

All over the Chubu-ko tunnel, which connects main pods, was sampled at every 10 m to check the relationship between chromitite pods and wall-rock peridotites (Fig. 3). Short tunnels which connect the North 7th and South 55th pods with the Chubu-ko tunnel were also sampled at every 10 m to examine the mode of occurrence of chromitite in more detail. The chromitite samples were collected at the North 7th, North 5th and South 5th pods as well as at small pods at the Chubu-ko tunnel.

All samples from the Misaka area were supplied from Metal Mining Agency of Japan (MMAJ). They were collected in the investigation in the storage condition of rare metal mineral resources by MMAJ.

5. Petrography

5.1 Peridotites

The rocks from the Misaka area belong to Zone I or Zone II in terms of metamorphic mineralogy. They usually preserve the primary textures and often partially preserve primary minerals, olivine, orthopyroxene, clinopyroxene and chromian spinel. We can, therefore, clearly discriminate primary lithologies there. Harzburgite, which is predominant, of the Misaka area has the
protogranular texture. Orthopyroxene is usually severely altered into bastitic pseudomorph. Olivine and orthopyroxene are sometimes kinked. Chromian spinel, which is highly anhedral (vermicular) to subhedral, is brownish under the microscope. The vermicular spinel is usually intergrown with pyroxenes. Dunite has euhedral chromian spinel and rarely has pyroxenes.

The rocks from the Wakamatsu mine and adjacent area, on the other hand, are thermally metamorphosed to have mineral assemblages of Zones III to V (ARAI, 1975). Their primary mineralogies are not evidently determined. There are two kinds of metaperidotites; one has irregular-shaped chromian spinel and clots of metamorphic orthopyroxene or talc dependent on the metamorphic grade, and the other has euhedral chromian spinel and small amount of the Si-rich mineral clots. The protoliths are harzburgite for the former and dunite for the latter, based on the comparison with the primary lithologies from the Misaka area. Chromian spinel is partially or wholly altered into opaque ferrrichromite or magnetite. The clots of the Si-rich minerals (orthopyroxene or talc) are most probably pseudomorphs of primary orthopyroxene.

Based on this classification we can estimate the primary lithologies even in the Wakamatsu mine area (Fig. 4). It was confirmed that chromitites pods are always enclosed by dunite (ARAI and YURIMOTO, 1994) as for other chromitite pods ever documented (e.g., THAYER, 1964). The strongly anhedral (vermicular) chromian spinel tends to be more abundant in peridotites with an increase of the distance from the pods.

Petrographical characteristics of the thermally metamorphosed peridotites were extensively described by ARAI (1975). Secondary metamorphic olivine is usually fine-grained and sometimes has a dusty appearance due to abundance of minute inclusions of magnetite and sulfides. Talc forms clots sometimes with trails of fine euhedral magnetite, which may trace original cleavage of primary orthopyroxene. Metamorphic orthopyroxene, which is totally free of deformation and exsolution of clinopyroxene, usually forms radial aggregates. Zone IV, which is characterized by appearance of acicular anthophyllite, is characteristically very narrow and roughly coincides with the Chubu-ko tunnel (Fig. 10a).

5.2 Modal variations of chromian spinel in peridotites

Modal amounts of chromian spinel are distinctly different between harzburgite and dunite as first described by ARAI (1980) (Fig. 5a). Dunite contains 1 to 11 volume % (most frequently around 3 %) of chromian spinel, whereas harzburgite has less than 3 volume % (mostly 1 to 2 %) of spinel (Fig. 5b). It is noteworthy that the morphological change of spinel is also distinctive as mentioned above; euhedral spinel surpasses anhedral one in dunite and vice versa in harzburgite (Fig. 5a).

The variation of modal amounts of chromian spinel in peridotites in the northern part of the Chubu-ko tunnel is especially noteworthy (Fig. 4). As mentioned above the peridotites exposed at this part of the Chubu-ko tunnel are wall of the North 7th chromitite pod to the north (Fig. 3).
In addition a small chromitite pod is found between sampling points 11 and 12 of Fig. 4. The spinel mode distinctly increases around the chromitite pods: for example, it increases both from No. 6 to No. 1 towards the North 7th pod and from 9 to 12 towards the small pod (Fig. 4).

5.3 Chromitites
Chromitites are composed of chromian spinel and silicate matrix with various proportions. There is a gap for the chromian spinel mode, between 10 and 20 volume % (ARAI, 1980), and the rocks with more than 20 volume % of chromian spinel are named “chromitite” in this article. Chromian spinel in the chromitite is most frequently between 40 and 90 volume % in mode. Chromitite with high content of chromian spinel exhibits so-called foam texture, an aggregation of rounded chromian spinel. Nodular and anti-nodular textures are rarely found especially in the South 5th pods, but orbicular texture is not found. Chromian spinel is sometimes fractured or even brecciated and is reddish brown in thin section. The silicate matrix is totally composed of hydrous minerals, serpentine, chlorite, and talc in most cases. Olivine, orthopyroxene, cordierite and others are also found depending on the metamorphic grade and degree of alteration. Ti-rich minerals, rutile and ilmenite, are characteristically found in chromitites (ARAI, 1980). Rutile frequently encloses ilmenite and they altogether fill the crack of chromian spinel. Rutile also rarely occurs as a discrete grain within silicate matrix. Native copper, chalcopyrite, pentlandite and millerite are found in trace amount.

6. Mineral chemistry
Chemical compositions of chromian spinel and other minerals were determined by the SEM (Akashi alpha-30A)-EDAX system with an energy dispersive X-ray spectrometer at Kanazawa University. Fe²⁺ and Fe³⁺ in chromian spinel were calculated assuming spinel stoichiometry. In the calculation all Ti in spinel was combined with Fe²⁺ to form...
ulvöspinel component. Chromian spinel was carefully analyzed at its fresh core for the primary composition in case of chromian spinel partly altered. Selected analyses are listed in Tables 1 and 2.

6.1 Chromian spinel

Trivalent cation ratios of chromian spinel in harzburgite demonstrate a systematic variation dependent on mode of occurrence, especially on the distance from chromitite pods (Fig. 6). Chromian spinel in harzburgite from Misaka area, where chromitites are absent, is rather confined in composition, relatively low in Cr# (= Cr/(Cr+Al) atomic ratio), around 0.5, and Fe3+ ratio (Fig. 6). On the other hand the harzburgite close to the boundary with dunite from Wakamatsu mine has spinel distinctively higher both in Cr#, around 0.6, and Fe3+ ratio than the Misaka harzburgite (Fig. 6). Spinel in the harzburgite far from dunite, that is also far from chromitite, has an intermediate spinel (Fig. 6). Chromian spinel is also variable in dunite; spinel is higher in Cr# in the dunite directly enclosing chromitite pod (around 0.6) than in other dunites (0.5 to 0.6) (Fig. 6). Mg# (= Mg/(Mg+Fe2+) atomic ratio) of spinel is basically variable inversely with Cr# (Fig. 7). These chemical tendencies can be also recognized through the lithologies in the Chubu-ko tunnel (Fig. 8).

Chromian spinel in chromitite pods is not largely different in Cr# from that in peridotites (Figs. 6 and 7). It is noteworthy, however, that spinel from major pods is relatively low in Cr#, 0.4 to 0.5, whereas spinel from a small but highly spinel-concentrated

Table 1 Selected microprobe analyses of chromian spinel in rocks from Wakamatsu mine and adjacent area.

<table>
<thead>
<tr>
<th>sample</th>
<th>CR0109</th>
<th>CR0901</th>
<th>CE1101</th>
<th>CR4501</th>
<th>CR5107</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr</td>
<td>0.60</td>
<td>0.56</td>
<td>0.59</td>
<td>0.63</td>
<td>0.53</td>
</tr>
<tr>
<td>Mg#</td>
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<td>0.54</td>
<td>0.54</td>
<td>0.50</td>
<td>0.56</td>
</tr>
<tr>
<td>Cr</td>
<td>0.55</td>
<td>0.55</td>
<td>0.56</td>
<td>0.54</td>
<td>0.49</td>
</tr>
<tr>
<td>Al</td>
<td>0.37</td>
<td>0.43</td>
<td>0.39</td>
<td>0.36</td>
<td>0.45</td>
</tr>
<tr>
<td>Fe</td>
<td>0.08</td>
<td>0.09</td>
<td>0.05</td>
<td>0.10</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Table 1: Selected microprobe analyses of chromian spinel in rocks from Wakamatsu mine and adjacent area.

Legend

- Dunite
- Harzburgite in Wakamatsu Mine
- Misaka Harzburgite
- Chromitite Pod
- Small Chromite Pod

Fig. 6 Ratios of trivalent cations of chromian spinel in rocks from Wakamatsu mine and adjacent area.
Table 2 Selected microprobe analyses of Ti-rich minerals in chromitite from Wakamatsu mine.

<table>
<thead>
<tr>
<th>Sample</th>
<th>BR002</th>
<th>DR004</th>
<th>FR004</th>
<th>FR005</th>
<th>RO002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oxide %</td>
<td>Oxide %</td>
<td>Oxide %</td>
<td>Oxide %</td>
<td>Oxide %</td>
</tr>
<tr>
<td></td>
<td>ATNo.</td>
<td>ATNo.</td>
<td>ATMol.</td>
<td>ATNo.</td>
<td>ATNo.</td>
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<tr>
<td>Si</td>
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<td>0.15</td>
<td>0.30</td>
<td>0.38</td>
<td>0.45</td>
</tr>
<tr>
<td>Ti</td>
<td>96.98</td>
<td>98.26</td>
<td>95.73</td>
<td>95.26</td>
<td>95.24</td>
</tr>
<tr>
<td>Al</td>
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<td>0.14</td>
<td>0.24</td>
<td>0.72</td>
<td>0.25</td>
</tr>
<tr>
<td>Cr</td>
<td>1.93</td>
<td>0.94</td>
<td>1.88</td>
<td>2.70</td>
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</tr>
<tr>
<td>Fe</td>
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<td>0.28</td>
<td>1.30</td>
<td>0.65</td>
<td>1.93</td>
</tr>
<tr>
<td>Mn</td>
<td>0.09</td>
<td>0.04</td>
<td>0.16</td>
<td>0.00</td>
<td>0.18</td>
</tr>
<tr>
<td>Mg</td>
<td>0.00</td>
<td>0.13</td>
<td>0.80</td>
<td>0.34</td>
<td>1.27</td>
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<tr>
<td>Ca</td>
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<td>0.00</td>
<td>0.17</td>
<td>0.04</td>
<td>0.00</td>
</tr>
<tr>
<td>Na</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>K</td>
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<td>0.04</td>
<td>0.08</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>P</td>
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<td>0.02</td>
<td>0.08</td>
<td>0.17</td>
<td>0.00</td>
</tr>
<tr>
<td>Ni</td>
<td>0.19</td>
<td>0.02</td>
<td>0.11</td>
<td>0.08</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Total: 100.12 1.010 1.007 1.006 1.009 1.024 1.003 1.017 1.029

Fig. 7. Mg#-Cr# relationships of chromian spinel in rocks from Wakamatsu mine and adjacent area.

Note that primary spinel in chromitite should have had slightly higher TiO₂ content because Ti-rich minerals were precipitated at subsolidus as described above. The essentially similar relationship for Ti content in spinel, that is higher in chromitite than in dunite, is also recognized in Oman and Troodos ophiolites (AUGE, 1987; ARAI and YURIMOTO, 1994).
Fig. 8 Compositional variations of chromian spinel in peridotites along the Chubu-ko tunnel of Wakamatsu mine. (a) Along the Chubu-ko tunnel with small chromitite. (b) Along the tunnel from the north 7th orebody.

Fig. 9 Cr#-TiO2 relationships of chromian spinel in rocks of Wakamatsu mine and adjacent area.

Fig. 10 Difference in compositional zoning of chromian spinel dependent on contact metamorphic temperature along the Chubu-ko tunnel of Wakamatsu mine. (a) Cr-Al-Fe3+ cationic ratio of chromian spinel. (b) Plan of Chubu-ko tunnel. Metamorphic zone are also indicated.

An spinel has been altered into ferritchromite or magnetite along the rim or crack in all lithologies without an exception. Observed by reflected light under the microscope the spinel core with low reflectivity gradually changes into more reflective rim in peridotites from Zone V (olivine-enstatite zone). Chemical analysis reveals that the low-Fe3+ chromian spinel at the core gradual changes into Al-free ferritchromite or chromian magnetite (Fig. 10). For spinel in rocks from Zone III (olivine-talc zone), on the other hand, there is a sharp optical boundary or a compositional gap between the core and the rim (Fig. 10).
6. 2 Ti-rich minerals

Ti-rich minerals usually occur as fine-grained aggregates within spinel. Rutile rarely occurs as a discrete grain within serpentine mineral(s) as described above. In the former ilmenite encloses rutile. Rutile is almost pure TiO$_2$ (Table 2). Ilmenite is very Mg-rich; the Mg$\#$ is around 0.68. As rutile and ilmenite usually fill cracks of spinel they are secondary subsolidus minerals. This indicates that spinel in chromitite initially had some higher contents of TiO$_2$, although the effect of their precipitation is actually very low because of their extremely low modal amount (<< 0.1%).

7. Discussion

The data mentioned above for chromitite of Wakamatsu mine are concordant to field observations for podiform chromitites (THAYER, 1964; CASSARD et al., 1983) and also to recent interpretations for the origin of podiform chromitite (LAGO et al., 1982; ARAI, 1992, 1997; ARAI and YURIMOTO, 1992, 1994; ZHOU et al., 1994). They interpreted that the dunite envelope around podiform chromitite is essentially "the discordant dunite" (KELEMEN, 1990) which is an interaction product between melt and wall harzburgite. The melt counterpart should be enriched with Si due to contribution from decomposition of orthopyroxene in harzburgite combined with precipitation of olivine. The details of the melt/peridotite interpretation were described in KELEMEN (1990) and ARAI et al. (1994). It is highly possible that the secondary relatively Si-rich melt meets and is mixed with subsequently supplied relatively primitive melt within a conduit (e.g., NOLLER and CARTER, 1986; PAKTUNC, 1990; ARAI and YURIMOTO, 1994; ZHOU et al., 1994). The mixed melt should be oversaturated with chromian spinel to solely precipitate chromian spinel (= to form spinel-rich cumulates) (IRVINE, 1975, 1977).

For the Tari-Misaka case, relatively Ti-rich melt was supplied from deeper parts through cracks into Ti-poor harzburgite (= Misaka-type) (Fig. 11). The melt reacted the wall harzburgite to leave discordant dunite which has relatively Ti-rich spinel (Fig. 11). The subhedral character of spinel in the dunite near the boundary with harzburgite is inherited from the vermicular shape of the Misaka-type harzburgite. This type of dunite with subhedral spinel is of replacive origin from harzburgite due to decomposition of orthopyroxene (MATSUMOTO, 1996). The harzburgite adjacent to the melt conduit was metasomatized to have also similarly Ti-rich spinel (= Wakamatsu-type) (Fig. 11). The spinel in the Wakamatsu-type harzburgite is less vermicular than that in the Misaka-type and is thus chemically and morphologically modified equivalent to the latter one. The dunite sometimes low-Ti spinel possibly due to the dilution effect of orthopyroxene, which is very low in Ti,
involved with the interaction. The almost uniform chemical composition, especially for Cr# and TiO₂ content, throughout the interaction product (chromitite, dunite and Wakamatsu-type harzburgite) may indicate that fractional crystallization did not control the process (e.g., Arai and Yurimoto, 1994). It is possible instead that the minerals including chromian spinel were finally re-equilibrated with each other through a melt during the interaction (cf., Arai, 1980).

Spinel chemistry is changeable from the initial igneous one during the subsolidus stage, depending on both the modal amount and metamorphic temperature. The relatively large variation of Mg# of spinel in peridotites from Wakamatsu mine is possibly due to the thermal metamorphism; Mg# of spinel was lowered through Mg-Fe redistribution with olivine at 450 to 600°C during the metamorphism. The Mg# of spinel in the Misaka harzburgite is uniform because the rock is basically unmetamorphosed and the equilibrium temperature should be the same in the Misaka area (Arai, 1975). The compositional gap of spinel in peridotites from the Chubu-ko tunnel (Fig. 10) is possibly equal to a miscibility gap because the metamorphic temperature by the granitic intrusions is definitely lower in Zone III than Zone V (Arai, 1975). This clearly means that the enclosed chromitites have different thermal histories dependent on the distance from the granite. The zonal structure of chromian spinel is thus a good guide to the metamorphic temperature or thermal history of ultramafic rocks in the Tari-Misaka complex.

Acknowledgements: This paper is based on the Master's thesis of K. M. at the Kanazawa University, which was supervised by Prof. T. Matsumoto and Prof. K. Kihara. We are very grateful to the stuff of Wakamatsu mine for approving us to research the mine, and especially to Mr. T. Yamane (the then Chief Exploration Engineer) for his continuing help and hospitality in everything we have done at the mine. We are very much indebted to Dr. I. Matsumoto for his discussion and assistance in preparation of this paper. We wish to express our thanks to Metal Mining Agency of Japan for encouragement and lending us the important samples from Misaka area.

References


若松鉱山のかんらん岩およびクロム鉱鉱岩の岩石学的研究

三宅一弘・荒井章司・奥野正幸

要旨：多里ー三坂超苦銹岩質体中の若松鉱山のかんらん岩をクロミタイトを編、ボディフォーム型クロム鉱鉱床の成因について考察した。若松鉱山の坑内および周辺の岩石は花崗岩により熱変成を受けているが、岩石の初生構造は岩石組織の違いにより判別できる。ダナイトは鉱山周辺で多く見られ、クロミタイトはダナイト中にボッ-
ド状に出現する。これらのかんらん岩はクロマイト・ボッ-
ドからの距離により、クロミアントスピンネルの組成や化学組成が変化している。クロマイト鉱鉱から十分離れ
ている三坂地域のハルツバージャイト中のスピネルは、
Ti含有量が低く（<0.2 wt%）、複雑な他形の形態を呈して
いる。ダナイトとの境界に近いハルツバージャイト中の
スピネルは、他形のものが少なくなりややTiに富む(0.5
wt%)。ダナイト中のスピネルもTiに富み（0.5 wt%）、クロ
ミタイトにかけてTi含有量は増加し、自形度の高いス
ピネルが多く見られる。一方、クロミタイトはそのスピ
ネルのモード組成分に関わらずむしろ均質な鉱物組成を持
ち、0.7 wt% に達するTi含有量（多くは0.2–0.4）を示す。
すべての岩相において、Cr#（=Cr/Cr+Al）、原子比）は0.4–
0.6の狭い範囲に収まる。

このような特性は、ボディフォーム型クロミタイトと
それを取り巻く鉱脈岩の成因を支配する。クロマイト
をハルツバージャイト相互反応の存在を示唆する。つまり、低
いTi含有量を持つハルツバージャイトから、Tiに富む
クレートの通過によって、Tiに富むダナイトークロミタイト
およびそれを取り巻くハルツバージャイトが形成され
たと考えられる。

日本語表記
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