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GENESIS OF CHROMITITE FROM THE MITCHELL RANGE, CENTRAL BRITISH COLUMBIA

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ABSTRACT

Allochthonous serpentinized peridotite in the Mitchell Range, British Columbia, contains numerous occurrences of chromitite in which the aluminian chromite usually contains more than 55% Cr_2O_3. Two groups of podiform chromitite have been recognized. In one group, the chromite is similar in composition to that in layered, net- and occluded-silicate-textured chromitite; such rocks are interpreted to have equilibrated with magma during initial partial melting. This group originated by deformation of chromitite layers and segregations, first in the upper mantle and then during obduction. The second type of podiform chromitite occurs as massive pods without relation to preexisting layers. Inclusions in chromite consist of coexisting platinum-group minerals and Fe-Ni sulfide phases. Pargasitic amphibole with abundant primary and secondary fluid-inclusions occurs in the chromite grains, thus supporting the possibility that a sodium-bearing fluid phase was present during chromite precipitation.

Keywords: Chromitite, peridotite, podiform, genesis, Mitchell Range, British Columbia.

SOMMAIRE

La péridotite serpentinisée allochtone du chaînon Mitchell, en Colombie-britannique, contient plusieurs venues de chromitite à chromite alumineuse, contenant généralement plus de 55% de Cr_2O_3. On y reconnaît deux groupes de chromitite podiforme. Dans un de ces groupes, la chromite ressemble en composition à celle des chromitites rubanées, à texture réticulaire ou à silicate interstitiel. On interprète ces roches comme résultant d'un équilibre avec le magma pendant la fusion partielle initiale. Ce groupe résulterait de la déformation des couches et des ségrégations de chromitite, d'abord dans le manteau supérieur et ensuite en cours d'obduction. Le second type de chromitite podiforme se présente sous forme de lentilles massives sans relation avec les couches préexistantes. Les inclusions dans la chromite consistent en minéraux du groupe du platine et phases de sulfures Fe-Ni. L'amphibole pargasitique, qui se présente dans les grains de chromite avec d'abondantes inclusions fluides primaires et secondaires, étaye l'hypothèse de la présence d'une phase fluide sodique au cours de la précipitation de la chromite.

(Traduit par la Rédaction)

Mots-clés: chromitite, péridotite, podiforme, genèse, chaînon Mitchell, Colombie-britannique.

INTRODUCTION

Chromite occurrences define a linear, north-northeast-trending band in allochthonous ultramafic rocks of the Mitchell Range, 240 km northwest of Prince George, British Columbia and 160 km northwest of Fort St. James (Fig. 1). Allochthonous rocks of the Mitchell Range are primarily harzburgite tectonite with minor dunite, gabbro and chromitite (Whittaker 1982). Obduction in Late Triassic time (Paterson 1977, Monger & Price 1979) brought rocks of the upper mantle into contact with Late Pennsylvanian to Middle Permian carbonate rocks of the lower Cache Creek Group (Armstrong 1949). The southeast-trending Stuart Lake Belt of the Cache Creek Group is openly folded, with north-trending fold axes that plunge 10 to 30° northward. This reflects east - west compression related to an east-dipping, Late Jurassic to Early Cretaceous subduction zone (Monger & Price 1979).

Textures and structures of chromite concentrations similar to those observed in the Mitchell Range are also seen in smaller obducted slivers of serpentinite in rocks of the Cache Creek Group at Murray Ridge, near Fort St. James, at Scottie Creek, 30 km north of Cache Creek, and in the Cameo Lake (Nicola) deposit, 60 km northwest of Kelowna (Whittaker & Watkinson 1981). In the Osoyoos area, two chromite deposits occur in Anarchist Series rocks, possibly time-equivalent to the Cache Creek Group (Monger & Price 1979). These are the Anarchist deposit, enclosed by recrystallized micritic limestone, and the Bridon deposit, enclosed by serpentinite (James 1958, Whittaker & Watkinson 1981).

The purpose of this paper is to present field, petrographic and chemical characteristics of chromite occurrences in ultramafic rocks of the Mitchell Range. This locality is presented as a type area because of the abundance and variety of the concentrations of chromite in these allochthonous ultramafic rocks.

DISTRIBUTION OF CHROMITE OCCURRENCES

Penetrative mylonitic foliation throughout harzburgite of the Mitchell Range has a north-northwesterly trend, typical of the fabric of this ultramafic massif. Chromite occurrences are concentrated in a

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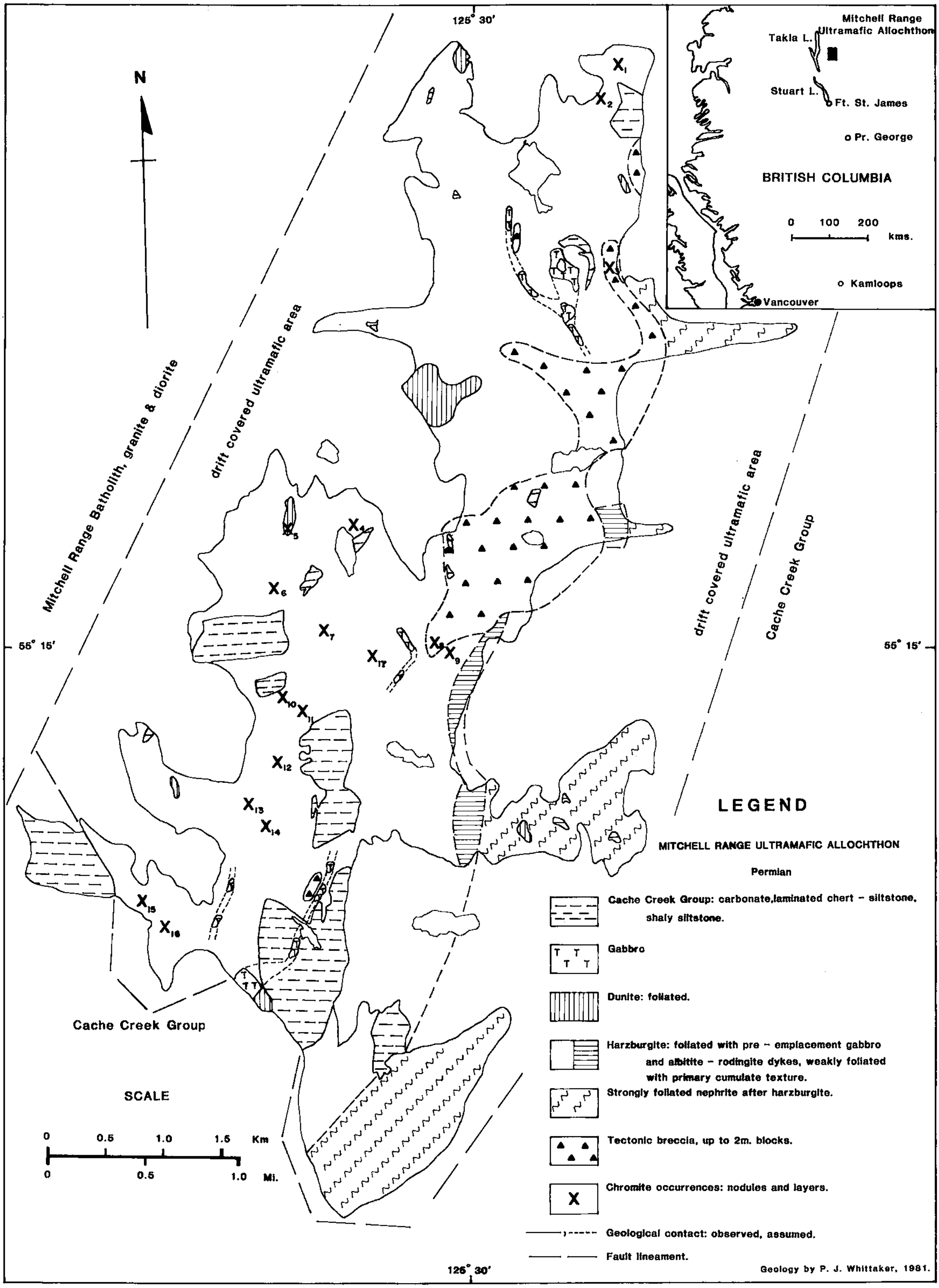

FIG. 1. Geology of the Mitchell Range ultramafic allochthon.

horizon that is conformable to this trend (Fig. 1). The distribution of chromite in this horizon may result from a tectonic concentration or orientation process (Cassard *et al.* 1981) or represent a primary magmatic chromitiferous horizon in harzburgite of the upper mantle. Chromite occurs primarily in harz-

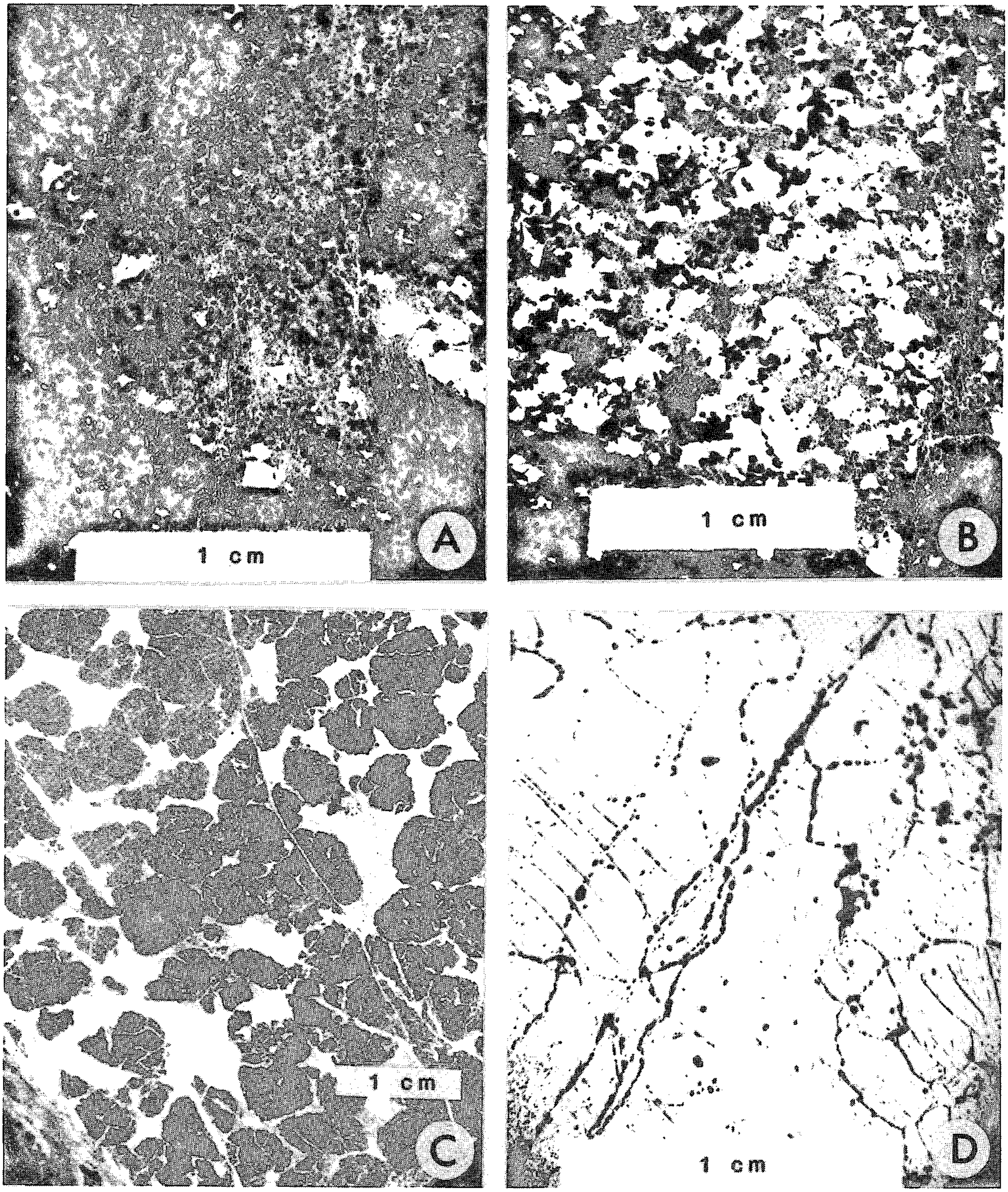

FIG. 2. Photographs of chromite textures. A. Disseminated chromite. B. Disseminated chromite forming occluded-silicate texture in a chromitite layer; black dots within chromite grains are primary silicate inclusions. C. Nodular chromitite from a 0.75-m-thick layer. D. Massive chromitite from a pod; chains of black dots represent silicate inclusions along annealed fractures. Photos A, B and D are prints directly from polished thin sections, in which chromite appears white and silicates black.

burgite; some horizons are sheathed by a 1-to-3-cm-thick mantle of fine-grained dunite. The absence of a dunite mantle around most chromitite occurrences distinguishes the Mitchell range from other ophiolites, such as at Troodos (Greenbaum 1977) and New Caledonia (Cassard *et al.* 1981), where dunite sheaths are common.

Gabbroic dykes in harzburgite tectonite predate all deformation. Both the layered and podiform chromitite occur in the gabbro–harzburgite zone that

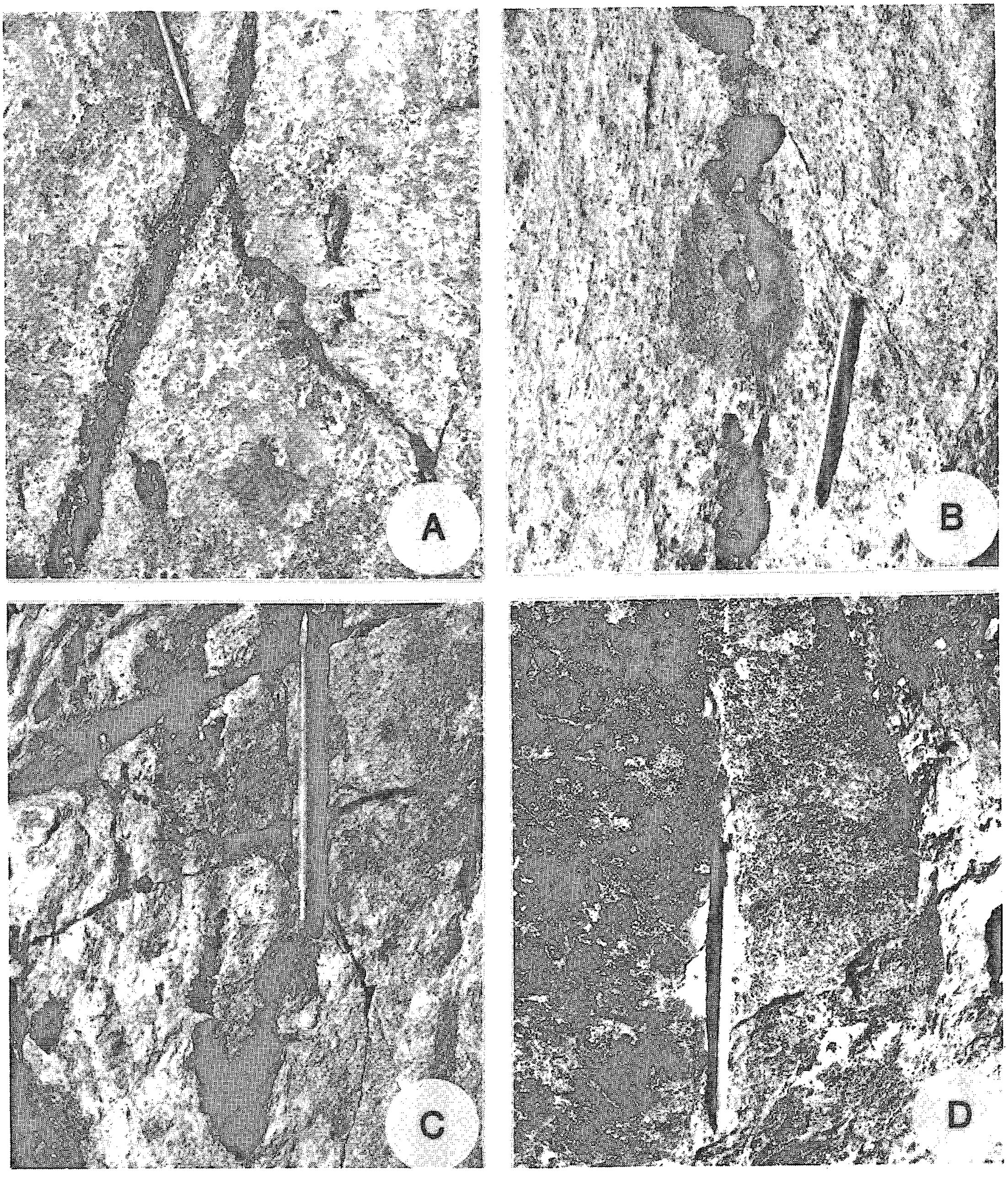

FIG. 3. Photographs of chromitite in outcrop. A. Planar aggregate to massive chromitite layer with thinner parallel chromitite seams. B. Chromitite layer with rounded pull-apart structures; pencil parallels trace of foliation. C. Isoclinally folded chromitite pod with thickened nose of fold; limbs and pencil parallel trace of foliation. D. Compound podiform chromitite; massive core left of pencil, aggregate rim right of pencil.

forms the central and southwestern part of the massif. In the area of chromitite occurrences X_{12} and X_{13} (Fig. 1), as much as 25% of the outcrop area consists of gabbroic dykes. The area intruded by these preobduction dykes, some of which are adjacent to chromitite pods, is interpreted to be an upper level of the mantle where segregated partial melt moved into tensional fractures. Gabbroic intrusive bodies are sparsely distributed or absent elsewhere in the ultramafic massif; their absence possibly in-

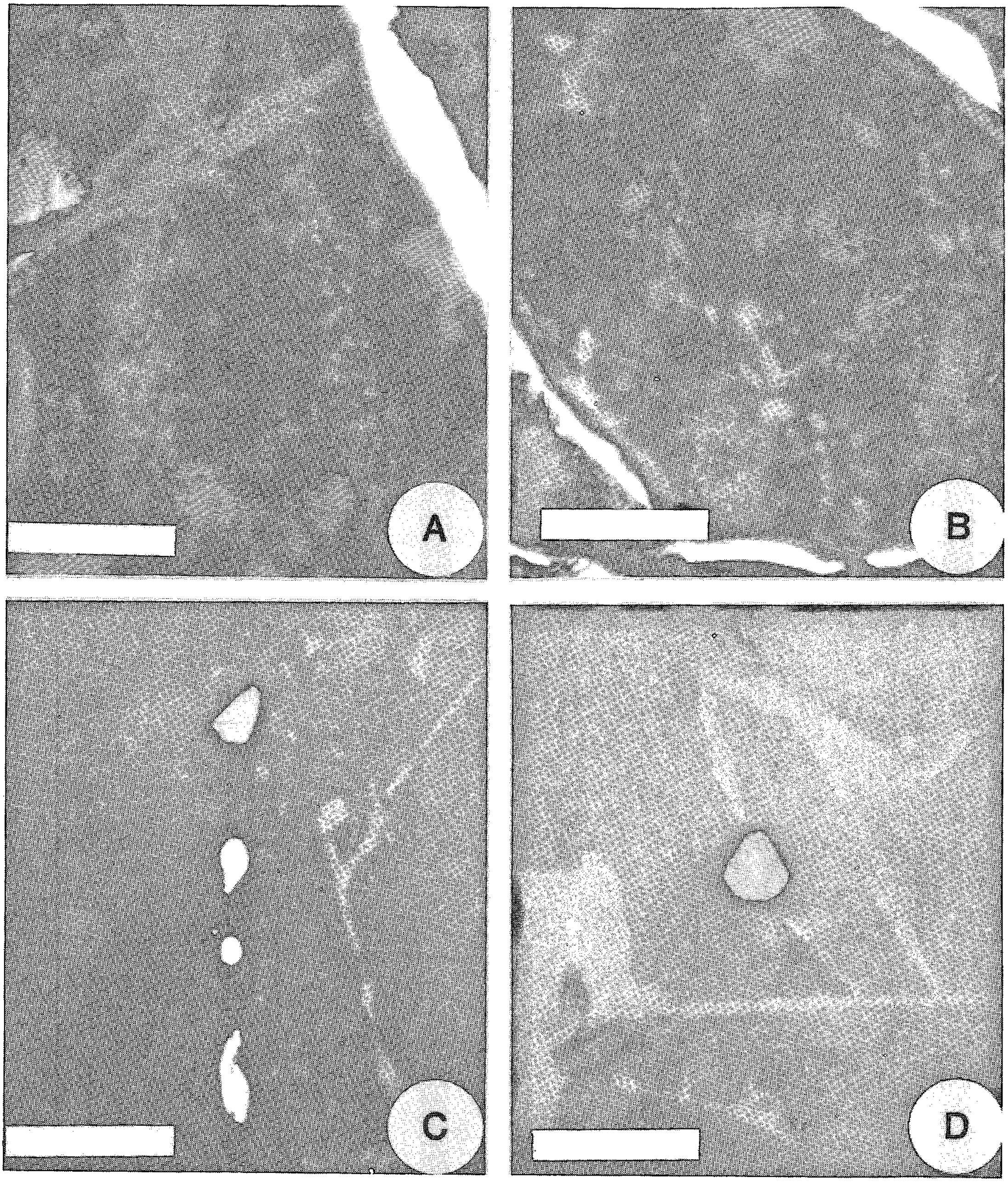

FIG. 4. Photomicrographs of fluid and sulfide inclusions. A. Subparallel planar swarms of spherical to tubular fluid inclusions. B. Larger fluid inclusions with dark ends and bright cores. C. Inclusion train of Fe - Ni sulfide filling an annealed fracture in chromite. D. Euhedral primary Fe - Ni sulfide with dark areas of exsolved NiS. Scale bar in all photos is 25 μm.

dicates a deeper level in obducted mantle, where there was less partial melting.

CHROMITE OCCURRENCES

Chromite occurrences are classified as disseminated (Fig. 2A), layered and podiform structures. Layered and podiform structures exhibit net, nodular (Figs. 2B, C) and massive (Fig. 2D) textures (Thayer 1969, Greenbaum 1977).

Disseminated chromite is an accessory phase in tectonized harzburgite, forming up to 3% of the rock. Individual grains are subhedral and very fine grained. Few layers or pods of disseminated chromite oc-

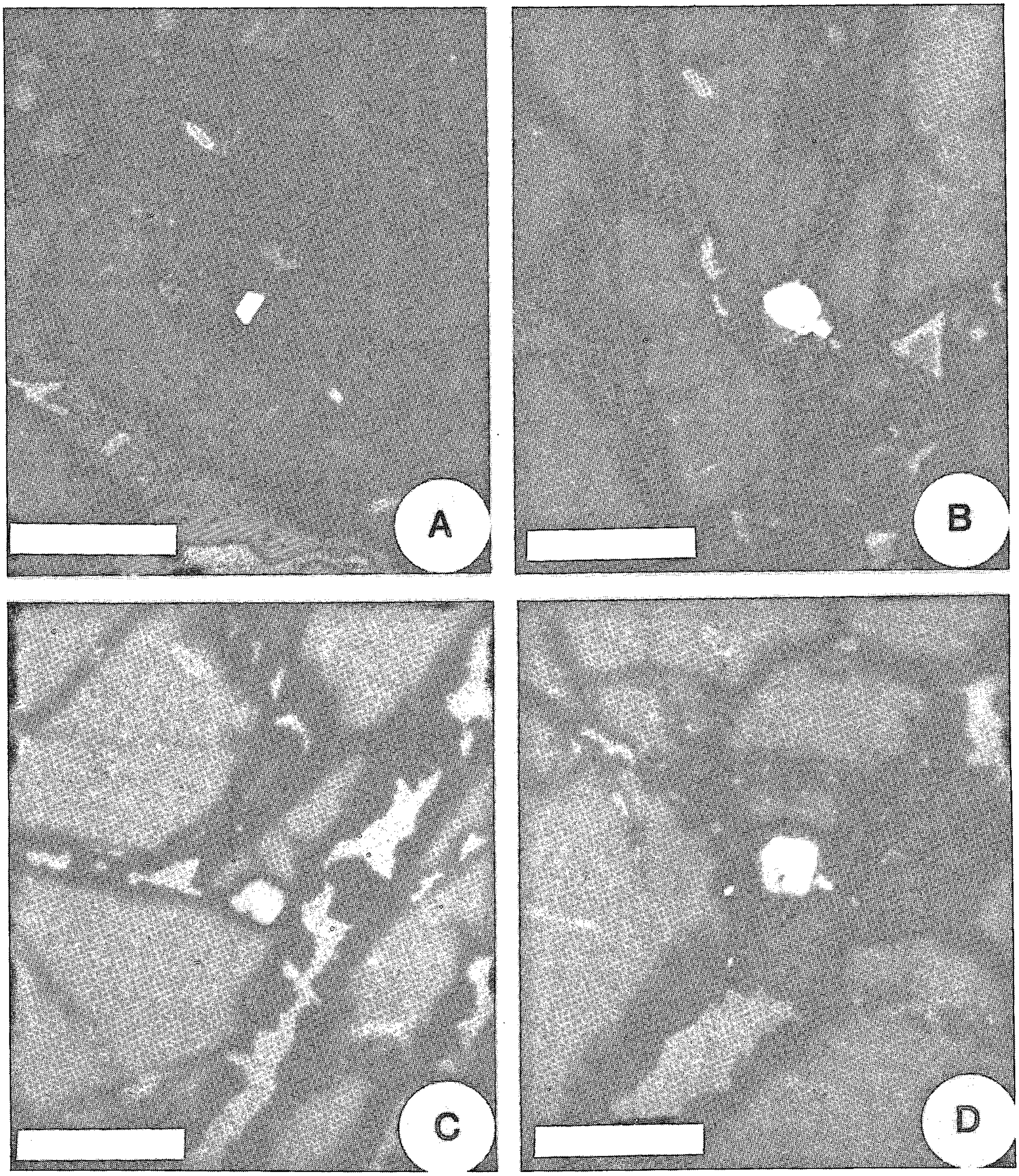

FIG. 5. Photomicrographs of platinum-group inclusions in chromite. Scale bar in all photographs is 25 μm. A. Euhedral laurite, B, C, D. Anhedral to subhedral laurite.

cur; they consist of 35 to 45% fine- to medium-grained chromite in a 1-to-2-cm dunitic envelope, with the layer or pod itself contained in harzburgite.

Layered chromitite consists of occluded-silicate-textured, net-textured or massive chromitite. The term *aggregate chromitite* is used in this study to designate the two former textural types, with more than 75% disseminated chromite, whereas massive chromitite has greater than 95% chromite. A hackly fracture is typical of massive chromitite. Chromitite layers (Figs. 3A, B) range from planar undeformed segments to layers that have pull-apart structures. Layers may occur singly or as parallel, thinly separated pairs or triplets. Layer contacts are generally sharp and, in the case of aggregate layers, grain size is constant. Layers are not continuous but are segments as long as 2 m of initially longer layers separated by shearing. Deformation has produced early tensional pull-apart structures (Fig. 3B) and was followed by brittle deformation, which produced angular fragments. The most intense folding of layers is found at their extremities, where 3-to-5-cm fragments may occur. Pinch-and-swell structures are exhibited by some layers, and pull-apart structures isolate individual boudins of chromitite. Where boudins were formed before the end of ductile shearing, they were themselves folded into pods (Fig. 3C). Chromitite pods exhibit the same occluded-silicate, net and massive textures as the chromitite layers.

Chromitite pods occur up to 1 m in maximum dimension, are usually elliptical and may exhibit a sigmoidal form. Rounding and reduction in pod size have occurred in response to ductile shearing. Many deformed pods have associated trains of 0.5-to-1.5-cm subangular fragments occurring up to 1 m from the parent pod.

The range of structural types and the similarity of textures observed in these structures suggest that ductile shearing could form many of the observed pods of chromite from initial layers. Deformation of preexisting layers of chromitite generated layer segments, some of which remained planar, whereas others were folded into deformed pods.

Compound pods of chromitite exhibit both aggregate and massive textures. Aggregate chromitite is least extensive and forms patches up to 4 cm across in massive chromitite. Alternately, aggregate chromitite forms 1-to-5-cm rims on chromitite pods. Borders between massive and aggregate chromitite are locally sharp (Fig. 3D), although patches of aggregate chromitite are irregular in shape.

CHROMITE PETROGRAPHY

Chromite is pale reddish brown to pale amber in plane-polarized light. It is darker and locally opaque along fractures and on some grain boundaries owing to oxidation of iron. Disseminated, occluded-silicate-textured and massive chromitite in the harzburgite tectonite are usually fractured. Alteration rims enclosing chromite and zones along fractures consist of ferritchromit produced during postserpentinization metamorphism (Spangenburg 1943). Disseminated chromite commonly exhibits ferritchromit rims, whereas massive chromitite develops ferritchromit along fractures.

Solid and fluid inclusions occur in chromite in net-textured, occluded-silicate-textured and massive chromitite layers and pods. Fluid inclusions are rarely observed in accessory disseminated chromite, and are most commonly observed in chromitite layers and pods that exhibit fine- to medium-grained net and occluded-silicate textures.

Fluid inclusions (Figs. 4A, B) are spherical to tubular and commonly exhibit a thinned or necked appearance. Isolated fluid-inclusions are less common than those occurring in patches or in swarms (Whittaker & Watkinson 1981). The latter are planar and may intersect or be subparallel (Fig. 4A). Elliptical and tubular fluid-inclusions in some cases have dark ends and a light core (Fig. 4B), suggesting the presence of coexisting fluid and vapor. Euhedral negative-crystal cavities also occur and may have hosted fluid inclusions.

Unserpentinized solid inclusions usually consist of subhedral to euhedral olivine and, less commonly, orthopyroxene and clinopyroxene. Most silicate inclusions have been altered to talc or lizardite, which form an interlocking texture (Wicks & Whittaker 1977). Pargasitic amphibole with as much as 3.30 w.% Na_2O occurs as primary inclusions and has smooth boundaries with enclosing chromite.

Inclusions of Fe – Ni sulfide, confirmed by energy-dispersion analysis, are most abundant in net- and occluded-silicate-textured chromitite layers and pods. In massive and aggregate chromitite, sulfides such as pentlandite are secondary, filling existing or annealed fractures in chromite. This results in a train of subhedral to anhedral grains of sulfide (Fig. 4C). Individual inclusions of Fe – Ni sulfide unrelated to existing or annealed fractures are rare. They are euhedral and may be primary inclusions (Fig. 4D) associated with a second exsolved phase, possibly NiS or Ni–Fe alloy (Talkington *et al.* 1982). Secondary sulfides occur in groundmass silicates and with silicate inclusions in chromite.

Platinum-group-mineral (PGM) inclusions in chromite (Fig. 5A) have been identified using energy-dispersion microprobe analysis and are similar to those recently recognized in other ultramafic suites of ophiolitic affinity (Prichard *et al.* 1981, Talkington *et al.* 1982). These inclusions are euhedral to anhedral, occur as isolated grains not related to fractures and are thought to be primary inclusions. Laurite RuS_2 is the predominant PGM and, where euhedral, has a white reflectance and high relief (Fig.

5A). Subhedral PGM have lower reflectance and exhibit slightly irregular borders with chromite (Fig. 5B, C, D).

Several subhedral PGM have inclusions or an exsolved or entrapped, highly reflective yellowish white sulfide phase. The grains are small, one-tenth the host grain-size or less, and occur individually or in clusters. The larger pale grey grain of laurite in Figure 5D contains several bright inclusions of nickel sulfarsenide.

CHEMICAL COMPOSITION OF CHROMITE

The compositional data presented in Figure 6 are based on 123 new determinations by wavelength-dispersion electron-microprobe analysis; some compositions are given in Table 1. A Cambridge MkV microprobe was operated at 15 kV accelerating voltage, with a specimen current of 0.05 nA determined on a pure iron standard. The counting time was 40 seconds. Data were reduced by the program of Rucklidge & Gasparrini (1969), and Fe^{2+} and Fe^{3+} were calculated from the reduced data assuming spinel stoichiometry.

The analytical data pertain to aggregate (highly disseminated), podiform and layered chromite. Chromite from various types of pods and layers, net-textures, occluded-silicate-textured or massive-textured, shows little chemical variation. Consequently, for the purposes of plotting, the various types of chromite have been grouped as podiform and layered.

The composition of olivine occurring as inclusions in chromite is similar to that in the groundmass

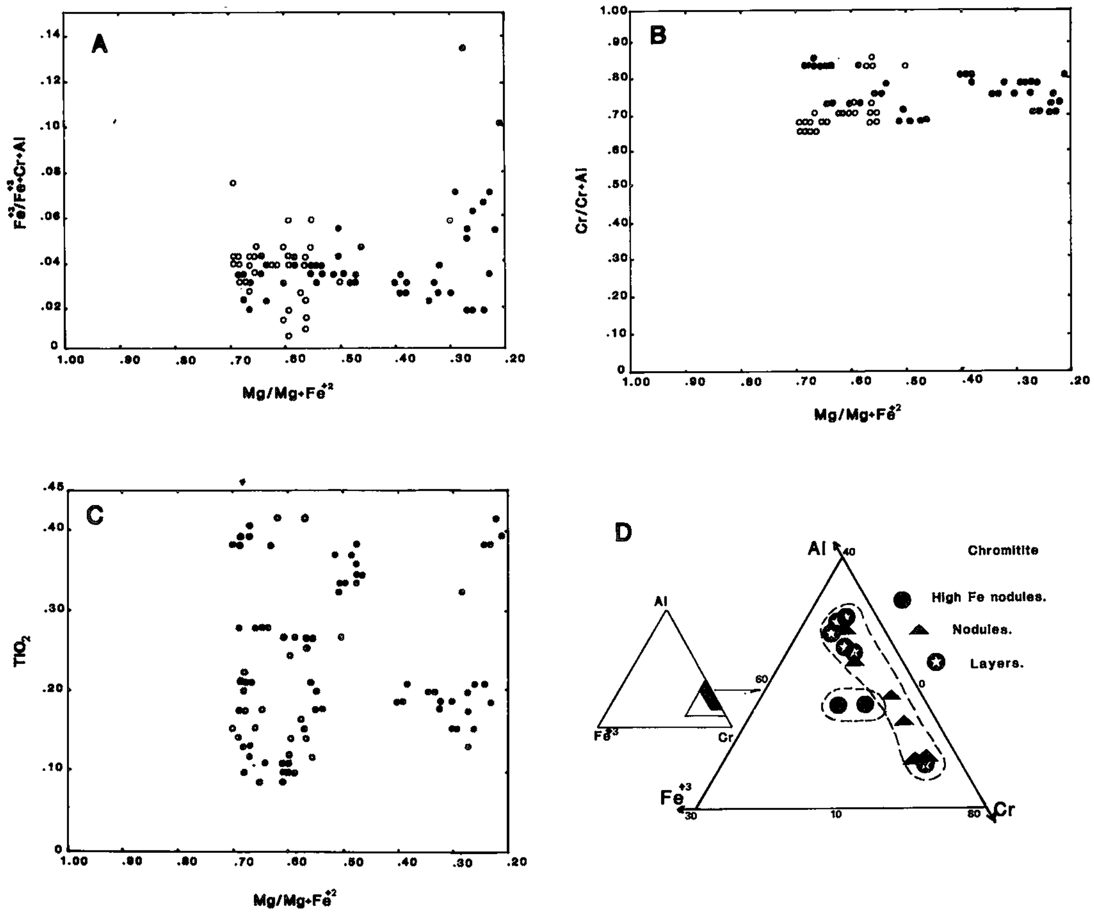

FIG. 6. Compositional variation of chromite. A. Variation of Fe/(Fe + Cr + Al) *versus* Mg/(Mg + Fe) (atomic), showing a high-Fe grouping of podiform chromitite (solid circles) and an overlap of podiform and layered chromitite (open circles). B. X_{Cr} *versus* X_{Mg}, showing constant X_{Cr} for both low- and high-Fe chromitite pods and layers. C. TiO_2 *versus* X_{Mg}, showing a similar range of composition for layered and podiform chromitite. D. Cr - Al - Fe^{3+} diagram, showing similar compositional ranges for layered and podiform chromitite.

TABLE 1. AVERAGE COMPOSITIONS OF CHROMITE, MITCHELL RANGE

	1.	2.	3.	4.	5.	6.	7.	8.
TiO_2	0.1	0.3	0.4	0.2	0.1	0.4	0.4	0.4
Al_2O_3	8.2	8.1	17.8	13.2	14.2	15.2	15.5	16.5
Cr_2O_3	62.2	60.7	50.2	53.2	54.5	52.8	51.4	51.0
Fe_2O_3	2.7	3.5	3.9	5.2	4.7	3.8	4.0	3.2
FeO	11.9	13.1	12.0	18.6	12.6	14.3	18.6	19.5
MnO	0.6	0.6	0.6	0.2	0.2	0.5	1.0	1.0
MgO	13.5	12.8	14.6	10.2	14.2	13.1	10.1	9.7
TOTAL	99.2	99.1	99.5	100.8	100.5	100.1	101.0	101.3

1, 2 Podiform chromitite from gabbro - harzburgite zone, 3 massive chromitite layer, 5, 6 aggregate (highly disseminated) chromite layer, 7, 8 massive, podiform chromitite. All compositions are averages obtained by the electron-microprobe analysis of five grains, except for 3, which represents an average of four grains. P. Whittaker, analyst.

(Fo_{91-92}), suggesting equilibration of the two minerals. This is in contrast to the data of Johan & Lebel (1978) and Watkinson & Mainwaring (1980) taken from other localities, which indicate that olivine inclusions are more highly magnesian ($Fo_{97.7}$ and $Fo_{96.0}$) than groundmass olivine ($Fo_{90.7}$); they inferred rapid, nonequilibrium precipitation to explain their data. Chromite precipitation in rocks from the Mitchell Range may have been contemporaneous with that of olivine and sufficiently rapid to incorporate olivine crystals as inclusions. Smooth contacts between olivine inclusions and chromite and the absence of a reaction rim in chromite adjacent to an olivine inclusion support the hypothesis that olivine compositions are primary.

Chemical compositions of chromite from the locations shown in Figure 1 indicate two groups of podiform chromitite. One group has chromite of approximately the same compositional range as that in layered chromitite, whereas the second group has a lower $X_{Mg} = Mg/(Mg + Fe^{2+})$ (Figs. 6A, B, C, D). For podiform chromitite, X_{Mg} ranges from 0.20 to 0.70 and for layered chromitite, it is in the range 0.50 to 0.70 (Figs. 6A, B, D). Ferric iron is most variable in podiform chromitite, 0.02 - 0.13 (Fig. 6A), but is restricted to 0.01 - 0.08 in layered chromitite.

Three types of chromitite from the Mitchell Range exhibit nearly constant Cr/(Cr + Al) (X_{Cr}) ratios, in the range 0.65 - 0.88 (Fig. 6B), and the chromite has a normal content of Cr for that in ophiolitic rocks; the compositions project in the aluminian chromite field defined by Stevens (1944). This field is shown in Figure 6D as partly filled by the black shaded area. Titanium is variable, and clustering of the data is apparent on Figure 6C. Approximately one-third of the data points for layered and podiform chromitite project in the field defined by Dickey (1975) for chromite from stratiform deposits (where TiO_2 is equal to or greater than 0.30 wt.%). This would imply that some of the high-iron podiform and layered chromitite with greater than 0.30 wt.% TiO_2 may have equilibrated with a gabbroic magma. However, the lower X_{Mg} values expected to correlate with higher TiO_2 do not occur. Constant X_{Mg} could indicate Mg metasomatism during serpentinization. Compositions of layered and podiform chromitite that plot in the "stratiform" field are located in the gabbro - harzburgite zone of the ultramafic massif. The spatial correlation between bodies of segregated partial melt and chromite with high levels of TiO_2 supports the hypothesis that the central and southwestern part of the massif was higher-level mantle than the remainder of the allochthon.

One major trend is apparent in Figure 6D and involves constant Fe^{3+} with variable Al. This trend is shown most strongly by layered chromitite. Layered chromitite consists of fine- to medium-grained or nodular chromite (Fig. 2B, C) with as much as 30% silicate inclusions, most of which are olivine compositionally similar to that in the groundmass (Fo_{90-92}). The trend involving essentially constant Fe and variable Al could result from equilibrium of chromite with trapped interstitial partial melt. A similar trend involving variation in the Cr/Al ratio is also seen at Rhum, where equilibration among cumulus chromite, cumulus olivine and a liquid with a plagioclase component was invoked by Henderson (1975).

Individual chromite grains from both podiform and layered chromitite show a high degree of compositional homogeneity. Samples from separate locations in layer segments and within chromitite pods similarly show homogeneity. Four points from a single chromitite layer and five points from a single grain of chromite range from 50.76 to 51.35 wt.% Cr_2O_3 and 16.17 to 16.99 wt.% Al_2O_3. This restricted range in composition and the lack of zoning in individual grains of chromite suggest equilibrium with a liquid of constant composition. Partial melting of primitive mantle peridotite could achieve such a buffering effect and has been suggested by Arai (1980), on a regional scale, to explain the compositional homogeneity of chromite within single lithologies in alpine ultramafic terranes. In the Mitchell Range, this homogeneity is represented on a local scale among individual layers and pods.

SUMMARY OF FEATURES SHOWN BY CHROMITE FROM THE MITCHELL RANGE

1. Chromite occurs in a linear NNE-trending zone parallel to the foliation of the harzburgite host-rocks.
2. Chromitite occurs as layers and pods showing aggregate, (net and occluded silicate), nodular and massive textures.
3. Chromitite is hosted regionally by harzburgite, and dunite locally forms thin selvages.
4. Chromite exhibits minor alteration to ferritchromit rims and contains inclusions of silicate, sulfide and fluid.
5. Silicate inclusions are usually olivine of similar Fo content to olivine in the groundmass. Sulfide inclusions are Fe, Fe - Ni and PGM varieties.
6. The chromite is aluminian, usually with greater than 55% Cr_2O_3.

7. Aggregate chromitite layers have higher Al where silicate compositional inclusions are most numerous.
8. Similar compositional fields are occupied by most layered and podiform chromite.
9. Chromitite pods in the gabbro–harzburgite zone have higher Fe and Ti, suggesting equilibrium with an early gabbroic partial melt.

DISCUSSION

Chromite in the Mitchell Range represents a possible chromitiferous zone in refractory harzburgite of upper-mantle origin, that has been elongated by ductile shearing. Partial melting of upper-mantle peridotite, to the point where liquid segregation could occur, takes place in the 12-to-25-km depth range (Dickey 1975). This may suggest that chromite from the Mitchell Range formed in this depth interval. Deformation in the upper mantle and later, during obduction, has led to the development of isoclinally folded pods of chromitite, folded layers, and later brittle fracturing, to form angular fragments of layers and pods. Deformation of chromitite layers was observed to range from planar undeformed segments to isoclinally folded pods thought to have originated from the breakup of layers. In thin section, chromite commonly shows signs of brittle fracturing and older annealed fractures, reflected by linear and planar trains and swarms of inclusions. These annealed fractures may be related to high-temperature fracturing, with subsequent annealing in the upper mantle. A rising diapir of mantle material containing approximately 10 to 20 % partial melt (Maaloe & Printzlau 1979, Bottinga & Allègre 1978, Malpas 1978) would allow, by partial melting, the formation of small magma-chambers in which refractory chromite could accumulate.

Textural variation of chromite suggests different environments of chromite growth. Disseminated chromite, that forms net- and occluded-silicate-textured chromitite layers and pods, is commonly subhedral to euhedral, with smooth planar edges. This suggests precipitation and accumulation from a magma. Accessory disseminated chromite in harzburgite tectonite could form euhedra by growth *via* solid-state diffusion (Leblanc 1980). Massive coarse-grained chromitite may have resulted from recrystallization of pods of very fine-grained chromitite. Recrystallization in a subsolidus state has led to a massive texture with serrated, irregularly shaped domains of interlocking grains of chromite.

The distribution of silicate and sulfide inclusions supports this interpretation. Net- and occluded-silicate-textured layers and pods contain the highest proportion of silicates and sulfide inclusions. These subhedral to euhedral inclusions would require conditions of unhindered growth as found in a magma, and might then be trapped by rapidly growing chromite. In contrast, massive chromitite and disseminated accessory chromite have few inclusions of silicate and sulfide.

Microprobe data support petrographic interpretations in that two groups of chromite are distinguished. These are normal and high-Fe–Ti podiform chromite, which would represent precipitation in different environments. Podiform and layered-aggregate chromitite share the same compositional ranges and have a similar Fe content. The abundance of silicate inclusions in this type of chromitite is compatible with a magmatic origin involving rapid growth of chromite. In contrast, massive chromitite with few inclusions is richer in Fe and may represent primary fine-grained chromitite pods, possibly in depressions on a magma-chamber floor, that have undergone subsolidus recrystallization to a coarser grain-size. These would have formed by accumulation of chromite from an early, more Fe-rich partial melt. In the field they correspond to isolated pods of massive chromitite. Two of these pods (Fig. 6D, solid circles) occur in sharp contact with harzburgite and have no associated trains of fragments, in contrast to other pods formed from boudinaged layers of chromite (Fig. 6D, solid triangles and open stars).

Chromite with high TiO_2 (greater than 0.30 wt.%) plots in the field defined by Dickey (1975) as representative of stratiform environments. Chromite occurrences from the Mitchell Range that plot in this field are grouped in the central and southwestern part of the massif. This is also the area occupied by as much as 25% of pre-obduction gabbro dykes. This area might represent a high-level zone in the upper mantle in which magma segregated and crystallized as dykes. Harzburgite tectonite elsewhere in the Mitchell Range hosts chromite with less than 0.30 wt.% TiO_2, typical of chromite from refractory peridotite, and is interpreted to underlie the gabbro – harzburgite zone. Movement in the plane of the existing foliation would result in the observed position of the gabbro – harzburgite zone with respect to the rest of the massif.

The solid silicate inclusions have mantle-type compositions. Olivine ($Fo_{90} - {}_{92}$) is the most common silicate inclusion; minor orthopyroxene and clinopyroxene also are found. Pargasitic amphibole with 3.30 wt.% Na_2O forms primary subhedral inclusions in several occurrences of chromite in aggregate-layered chromitite. Pargasitic amphibole and other Na-bearing inclusions have been reported from ultramafic rocks of ocean-crust affinity (Watkinson & Mainwaring 1980). The appearance of sodic phases in chromite from alpine-type ultramafic rocks requires an extraneous source. Seawater, known to penetrate the ocean floor and to disturb oxygen-isotope ratios in upper-mantle rocks, including harzburgite tectonite (Gregory & Taylor 1981), may be such a source.

Net- and occluded-silicate-textured chromitites commonly host linear and planar trains and swarms of fluid inclusions, whereas massive chromitite has few fluid inclusions. Compositions of fluid inclusions in such chromite are yet to be determined. These features are compatible with our working hypothesis that during extension of the sea floor, seawater could have gained access to a rising mantle diapir, promoting partial melting, with resultant local stabilization of pargasitic amphibole and, on continued tensional episodes, chromite precipitation.

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