CHROMITE OCCURRENCES IN MITCHELL RANGE ULTRAMAFIC ROCKS OF THE STUART LAKE BELT CACHE CREEK GROUP

(93N)

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INTRODUCTION

The Mitchell Range map-area, located 240 kilometres northwest of Prince George, is within the Stuart Lake Belt of the Cache Creek Group (Permian). The Cache Creek Group consists predominantly of massively bedded carbonate rocks with minor amounts of laminated chert-siltstone and shaly siltstone. The carbonate succession extends from the Mitchell Range 120 kilometres southeastward to the Fort St. James area where it attains a thickness of 8 kilometres (Armstrong, 1949).

The southeast-striking carbonate succession is folded into an open anticline-syncline pair immediately south of the Mitchell Range ultramafic rocks. The open folds have subhorizontal east-southeast-trending fold axes suggesting compression from the south-southwest associated with thrust faulting and obduction of the Mitchell Range allochthonous rocks.

Chromite occurrences in the Mitchell Range were documented in Armstrong's 1949 memoir. Little (1947) described ultrabasic and associated rocks of the Middle River Range, approximately 70 kilometres southwest of the Mitchell Range ultramafic rocks. Since then various companies and individuals have shown an interest in the chromite and nephrite ('British Columbia jade') potential in the area.

PREVIOUS WORK

Previous geological work was of a reconnaissance nature, primarily by geologists of the Geological Survey of Canada. Selwyn (1872) examined the area between Quesnel and Peace River, followed a few years later by Dawson (1878, 1881). McConnell (1896) reported on the areas drained by the Finlay and Omineca Rivers and also visited the placer gold fields at Germansen Landing and Manson Creek, northeast of the Mitchell Range ultramafic rocks. Camsell (1916) reported on the northern interior of British Columbia, Hanson (1925) on the area from Prince Rupert to Burns Lake, and Lay (1926-1939), of the British Columbia Department of Mines, examined numerous mineral deposits and placer fields in the northeastern mineral survey district. In 1934 Kerr examined placer deposits at Manson and Slate Creeks. Regional mapping of the Fort St. James area began in 1936 and ended in 1944; it was coordinated by J.E. Armstrong (1949).

GENERAL GEOLOGY

MITCHELL RANGE ALLOCHTHON

Allochthonous rocks within the Mitchell Range consist primarily of harzburgite with minor dunite (Figure 1); they are everywhere serpentinized. Sparse pre-tectonic orthopyroxenite veins and gabbro dykes are deformed and reflect internal deformation presumably developed during obduction. Alteration dykes of albitite-rodingite are similarily deformed. Chromitite layers and layers with disseminated chromite exhibit variable degrees of deformation within the harzburgite, from isoclinal folds to brittle segmented planar layers.

Xenoliths of Cache Creek Group rocks up to several square kilometres in area that occur in the serpentinized ultramafic rocks (Figure 1) appear to have been rotated during transport. Contacts between harzburgite and xenoliths regularly exhibit a 0.5-metre-thick, highly fissile zone; rarely, a 1 to 2-metre-thick amphibole-rich alteration zone is developed in the harzburgite.

Later intrusions are now seen as meta-gabbro (Figure 1) and meta-diorite dykes. Clinopyroxene in the dykes has been altered to amphibole but primary sub-ophitic and equigranular medium-grained textures are preserved. These dykes may be derived from the dioritic-granodioritic Mitchell Range Batholith (Armstrong, 1949) which occurs 2.5 kilometres west of the ultramafic body.

STRUCTURE

The Mitchell Range ultramafic allochthon is bounded by north-northeast and east-trending lineaments (Figure 1). Rocks of the Cache Creek Group occur to the south and east, Takla Group volcanic rocks (Upper Triassic to Upper Jurassic) crop out to the north, and the Mitchell Batholith (Upper Jurassic to Lower Cretaceous; Armstrong, 1949) has intruded to the west.

Serpentinized harzburgite of the Mitchell Range allochthon exhibits a strongly developed penetrative north-northeast-trending ductile shear foliation (Figure 2). Dip of the foliation changes from westerly in the western part of the area to easterly in the east. The contour maxima on Figure 2 indicate a preferred north-northeast foliation but they are centred about an east-southeast great circle girdle, indicative of a broad north-northeast-trending antiform. Internal breccia zones occur in the harzburgite with well-rounded, randomly oriented, pebble to cobble-sized fragments set in a finely comminuted serpentinized matrix. The northeast and east-central areas of the ultramafic massif are underlain by tectonic breccia (Figure 1). The breccia has sub-angular fragments up to 2 metres in size that are predominantly of harzburgite with minor amounts of dunite. This coarse tectonic breccia appears to represent the sole of the allochthonous ultramafic rocks.

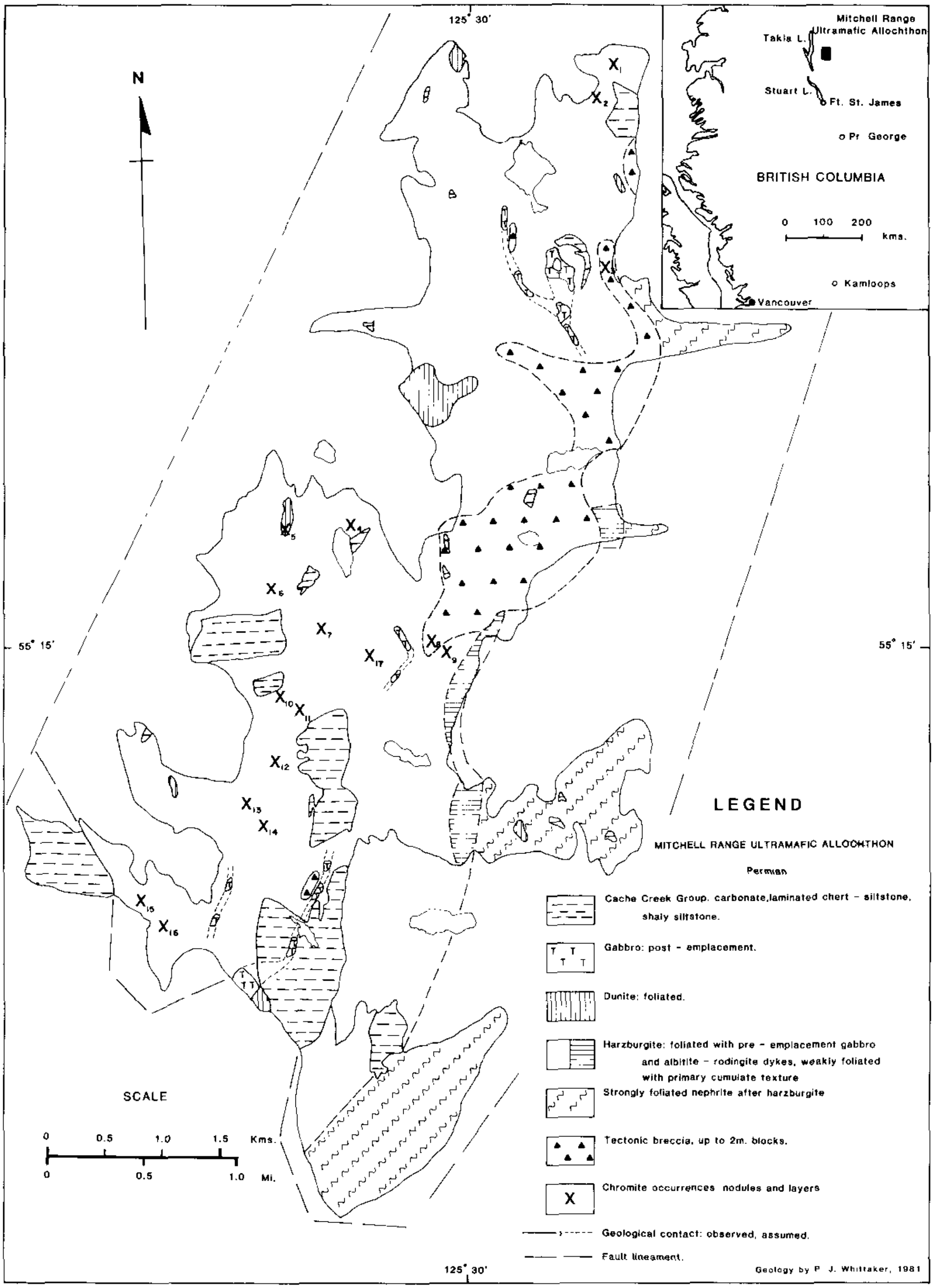

Figure 1. Geology of the Mitchell Range ultramafic allochthon.

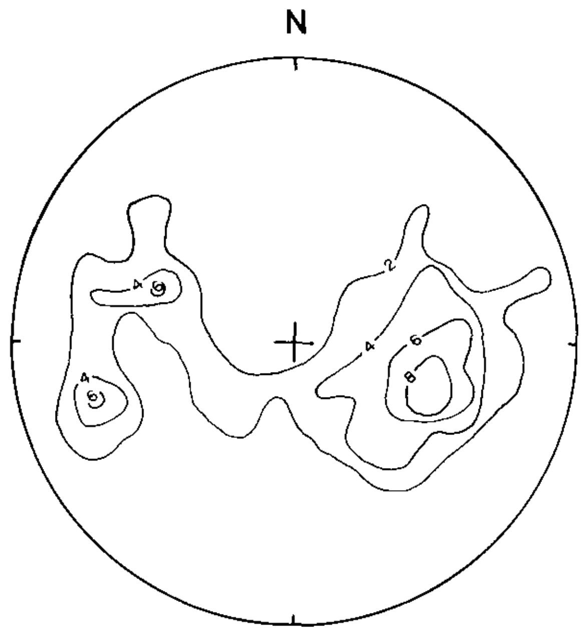

Figure 2. Contoured stereo-projection of poles to foliation planes, Mitchell Range (135 poles); contour interval, 2 per cent per 1-per-cent area.

TECTONIZED HARZBURGITE

Tectonized and serpentinized harzburgite comprise approximately 90 per cent of outcrop in the Mitchell Range allochthon. Its mottled, foliated weathered surface is deep brown with pale silvery brown talcose patches. On fresh surfaces it is mottled black-green to black-brown. Talcose patches are 0.5 to 1.5 centimetres in size and are pseudomorphic after sheared orthopyroxene. Intense shearing in some outcrops has resulted in mechanical segregation of orthopyroxene and olivine into granular, 1.0 to 1.5-centimetre-thick, discontinuous layers. A braided, rippled weathered surface results because orthopyroxene-rich layers are more resistant than olivine-rich layers. More extensive shearing led to development of well rounded 2 to 10-centimetre augen-shaped clots of coarse-grained orthopyroxene pseudomorphed by talc. Orthopyroxene augen in fine-grained olivine-rich harzburgite usually exhibit length to width ratios of 3:1.

Less intensely foliated harzburgite showing pre-tectonic cumulate texture crops out discontinuously in a narrow zone along the east-central part of the ultramafic massif. It is variably medium to coarse-grained with subhedral orthopyroxene and anhedral olivine. On the northeast ridge, very coarse-grained harzburgite exhibits primary magmatic olivine poikilitically enclosed in orthopyroxene; both are anhedral.

Harzburgite hosts all but one of the layered and nodular aggregate and massive chromitite occurrences. Disseminated accessory chromite occurs throughout the ultramafic rocks and varies from a trace to 2 per cent of the rock.

Chromite Occurrence	Form	Texture	Trend	Dimensions (cms)	Host Rock
X_1	nodule	a. c.	027	8 x 4	H.
X_2	nodules (4)	a. c.	in loose talus blocks	6 x 3	H.
X_3	nodules (3)	a. c.	145	4 x 3 6 x 4 7 (diameter)	H. H. H.
	schlieren	d. c. (50%)	145/45NE	300 x 15	H.
X_4	nodules (2)	a. c.	010	12 x 3 6 x 4	H. H.
X_5	layers	a. c.	---	30 x 1-3	D.
X_6	layers	a. c.	155/45SW	200 x 2 15 x 1.5	H. H.
	nodules	m. c.	"	30 (diameter) 20 "	H. H.
X_7	nodules	a. c. m. c.	025	50 x 20 40 x 20 10 x 6 50 (diameter) 30 "	H. H. H. H. H.

Chromite Occurrence	Form	Texture	Trend	Dimensions (cms)	Host Rock
X_8	layer	m. c.	122/33N	150 x 40	H. (breccia)
X_9	layer	m. c.	151/66NE	200 x 75	H.
X_{10}	nodules	m. c. & a. c.	073	10 x 3 10 x 2 5 x 2 4 x 1 12 (diameter)	H. H. H. H. H.
X_{11}	nodule	d. c. rim on m. c. core	---	130 x 100	H.
X_{12}	nodule	a. c.	121	7 x 3	H.
X_{13}	nodule	a. c.	126	4 x 2	H.
X_{14}	nodules	a. c. & m. c.	012 038 155 ---	50 x 10 40 x 15 40 x 10 8 x 3	H. H. H. H.

Chromite Occurrence	Form	Texture	Trend	Dimensions (cms)	Host Rock
X_{15}	nodule	a. c.	---	10 x 4	H.
X_{16}	layers (2)	d.c.	015/V 022/66E	300 x 2-25 100 x 3	H. H.
X_{17}	layer nodules (2)	a. c. a. c.	103/47N ---	25 x 4 5 (diameter) 4 "	H. H. H.

Abbreviations used in table:

a. c.; aggregate chromitite.
d. c.; disseminated chromite.
m. c.; massive chromitite.
H. ; harzburgite (serpentinized).
D. ; dunite "
cms ; centimetres.
X ; location of chromite occurrence on Fig.1.

TABLE 1. CHROMITE OCCURRENCES IN THE MITCHELL RANGE

DUNITE

Dunite occurs in approximately 1 to 2 per cent of the outcrop area as contorted, irregularly shaped patches that reflect the internal deformation in the ultramafic body. A planar dunite layer, 15 metres long and 30 centimetres thick is one exception. Dunite weathers with a smooth, orange-brown surface and is waxy brownish green on fresh surfaces. It consists of fine to medium-grained anhedral olivine. It is foliated so is finely fissile on weathered surfaces. Accessory chromite is fine to medium grained and subhedral. With the exception of one chromitite layer (Table 1, location X_5) no other anomalous concentrations of chromite were observed in the dunite.

PRE-EMPLACEMENT GABBRO

Segmented and deformed gabbro dykes occur primarily in the central and southwestern parts of the Mitchell Range allochthon. They are fine grained, serpentinized, and vary in thickness from 5 centimetres to 1.5 metres. Dyke segments or boudins are up to 3 metres long and form open to isoclinal folds. The dykes have associated dyke-like alteration zones with planar or 'pinch and swell' to boundinaged structures. These alteration zones consist of rodingite and are very fine grained to aphanitic and equigranular. Colour varies from bone white to pastel shades of brown, green, and pink. Contacts between harzburgite and the alteration zones are sharply defined with a 1 to 3-centimetre aphanitic black-green selvage.

POST-EMPLACEMENT GABBRO

Generally north-south-trending gabbro dykes (Figure 1) up to 15 metres thick intrude the harzburgite in the north, central, and southern parts of the massif. This gabbro is fine to medium grained with sub-ophitic to equigranular texture and is not serpentinized. In places clino-pyroxene has been altered to amphibole, and pale green plagioclase was saussuritized.

CACHE CREEK GROUP

Xenoliths of the Cache Creek Group (Figure 1) up to 1 square kilometre in area, occur in the southern part of the massif. Smaller xenoliths of 10 to 300 square metres are distributed through the northern part. The xenoliths consist of limestone and dolostone, siltstone with chert laminae, and shaly siltstone.

Limestone xenoliths are thickly bedded and fine grained with equigranular texture. Small, 2 to 10-centimetre, chert nodules in the carbonate blocks are contorted with thin, 1 to 3-millimetre, quartz veins originating from them. Black siltstone xenoliths have grey 0.5 to 2-millimetre chert laminae which are highly contorted and brecciated.

CHROMITE OCCURRENCES

Chromite occurrences (Figure 1, Table 1) are concentrated in the central and southwestern parts of the Mitchell Range allochthon, although several occurrences are scattered on the northeast ridge. The Bob and Simpson deposits described by Armstrong (1949) were examined and sampled.

Chromite occurs in disseminated and layered form, as aggregate and massive chromitite in layers, and as discrete nodules (Figure 3). Chromite nodules exhibit both aggregate and massive chromitite textures.

Accessory chromite is widely disseminated throughout the ultramafic rocks and varies from a trace to 2 per cent. In this form it is very fine to fine-grained and subhedral to euhedral. Medium-grained, disseminated chromite occurs rarely and is either anhedral or forms aggregates of two to four grains.

Layered chromite (Table 1; $X_{5,\ 6,\ 8,\ 9,\ 16,\ 17}$) consists of massive chromitite and aggregate chromitite; as well as concentrations of disseminated chromite.

Outcrops of massive chromitite are smooth textured and freshly broken surfaces display coarse hackly fracture and sub-metallic black-blue lustre. These layers range in thickness from 2 (Table 1; X_6) to 75 centimetres (Table 1; $X_{8,\ 9}$) and are truncated by joints (Figure 3c) or breccia zones in host harzburgite. Layer contacts with harzburgite are sharply defined and they are usually parallel to the foliation.

Aggregate chromitite and disseminated chromite layers consist of disseminated fine to medium-grained chromite. Aggregate chromitite layers (Table 1; $X_{16,\ 17}$) contain greater than 75 per cent chromite and exhibit sharply defined contacts with harzburgite. Internally they display a fine to medium-grained subhedral to anhedral texture. Layers are plastically deformed into open and isoclinal folds and display pinch and swell structures. Granular, fine to medium-grained chromite fragment trains extend from the ends of deformed layers. Brittle deformation has resulted in some layers being faulted into angular 2 to 5-centimetre fragments with displacements of 10 to 20 centimetres.

Disseminated chromite layers, 2 to 25 centimetres thick, responded to deformation in a ductile fashion because silicate minerals between chromite grains absorbed most of the strain. Contacts between disseminated chromite layers and harzburgite are gradational over 2 to 3 millimetres and are gently undulatory. Pinch and swell structures are developed as well as both open and isoclinal folds. Along strike from the ends of disseminated chromite layers, detached chromite augen may occur.

Thicker massive chromitite layers (Table 1; $X_{8,\ 9}$) contain irregularly shaped 3 to 10 centimetre coarse-grained patches of aggregate chromitite. These consist of anhedral 1-centimetre chromite grains in an open framework separated by approximately 10 per cent interstitial blue-grey aphanitic serpentine. The coarse-grained patches are highly irregular.

Chromite and aggregate chromite to massive chromitite nodules display fine to medium-grained subhedral to anhedral textures. Nodules range in size from 1 centimetre to 1.3 metres and are rounded to augen-like. Some appear to be thin (0.5 centimetre) selvages on shear surfaces whereas most extend to depths of at least several centimetres. Chromitite nodules exhibit massive, aggregate, and disseminated textures. Brittle fracturing is more evident in increasingly massive chromitite. Larger nodules (Table 1; X_{7}, $_{10}$, $_{11}$, $_{14}$) usually have a massive chromitite core with discontinuous rims of disseminated chromite. Rims pinch and swell from 0.5 to 5 centimetres and most are offset by late jointing and small-scale faulting. All the textures observed in layered occurrences also occur in chromite nodules.

The progression from open isoclinal folding in chromite layers, to pinch and swell structures, and finally to detached segments of chromite layers (Figure 3a, b) strongly suggests that chromite-chromitite nodules result from the shearing of primary chromite-chromitite layers. Abundant nodules, the largest being 1.3 metres in size (Figure 3d), and remnant chromitite layers up to 75 centimetres thick (Table 1) suggest that extensive primary chromite-chromitite layering existed. This has since been disrupted and redistributed by ductile shearing during tectonic emplacement of the Mitchell Range allochthon.

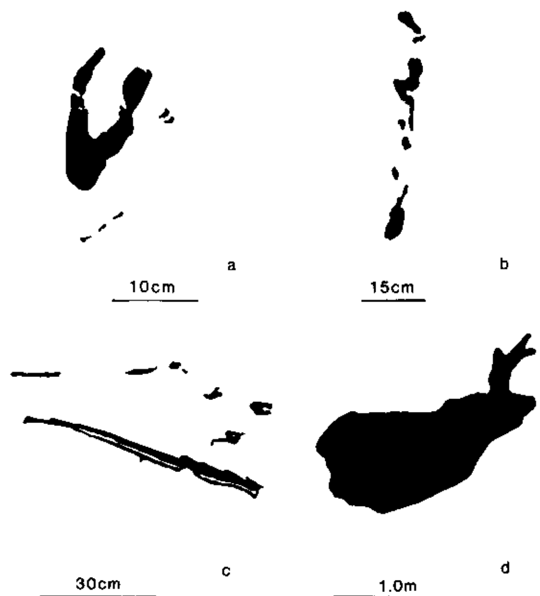

Figure 3. Sketches from photographs of chromite occurrences: (a) deformed nodule, (b) deformed layer with 'pull-apart' structure, (c) planar layered couplet with angular truncations, and (d) deformed massive chromitite nodule.

SUMMARY

Extensive brecciation and penetrative ductile shear foliation within the Mitchell Range allochthon suggests extensive transport of these rocks while in a solid, but perhaps still hot plastic state. Final movement resulted in brecciation along the sole of the ultramafic massif. Similar emplacement breccias at the soles of allochthonous ultramafic bodies occur in the Table Mountain and St. Anthony Complex ophiolites (R. Talkington, pers. comm., 1981).

The proximity of the Mitchell Range ultramafic rocks to a thrust zone, the predominance of massive harzburgite with only minor patches of dunite, and the suggestion of primary chromite-chromitite layers indicate that the Mitchell Range allochthon consists of rocks from below the cumulate dunite-layered zone as observed at Murray Ridge (Whittaker and Watkinson, 1981) and represent a low stratigraphic level in the ophiolite succession.

RECOMMENDATIONS

Detailed mapping of the Mitchell Range allochthon revealed additional chromite occurrences not previously noted. Additional work on chromite occurrences in other large ultramafic massifs, such as Mt. Sydney-Williams and Tsitsutl Mountain to the southwest, should therefore be considered. In addition this would aid in reconstructing the ultramafic part of the now fault-dissected ophiolitic rocks of the Stuart Lake Belt of the Cache Creek Group.

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REFERENCES

Armstrong, J.E. (1949): Fort St. James Map-Area, Cassiar and Coast Districts, British Columbia, Geol. Surv., Canada, Mem. 252, 210 pp.

Camsell, C. (1916): Exploration in the Northern Interior of British Columbia, Geol. Surv., Canada, Summ. Rept. 1915, pp. 70-75.

Dawson, G.M. (1878): Report on Explorations in British Columbia, Chiefly in the Basins of the Blackwater, Salmon and Nechako Rivers, and on Francois Lake, Geol. Surv., Canada, Rept. of Progress, 1876-77, Part III, pp. 17-94.

.... (1881): Report on an Exploration from Port Simpson on the Pacific Coast to Edmonton on the Saskatchewan, Embracing a Portion of the Northern Part of British Columbia and the Peace River Country, Geol. Surv., Canada, Rept. of Progress, 1879-80, Part B, pp. 1-142.

Hanson, G. (1925): Prince Rupert to Burns Lake, Geol. Surv., Canada, Summ. Rept., 1924, Part A, pp. 38-42.

Kerr, F.A. (1934): Manson River and Slate Creek Placer Deposits, Omineca District, B.C., Geol. Surv., Canada, Summ. Rept., 1933, Part A, pp. 9-29.
Lay, D. (1929-1939): Northeastern Mineral Survey District No. 2, Minister of Mines, B.C., Ann. Rept., 1925, pp. A142-A145; 1926, pp. A144-A146; 1927, pp. C150-C153, C155-C160; 1928, pp. C177-C182; 1929, pp. C181-182, C185-C187; 1930, pp. A143-A149; 1931, pp. A75-A76, A80; 1933, pp. A99-A100; 1934, pp. C13-C15; 1936, pp. C3-C16; 1938, pp. C3-C14.
Little, H.W. (1947): The Ultrabasic and Associated Rocks of the Middle River Range, British Columbia, Ph.D. Thesis, University of Toronto.
McConnell, R.G. (1896): Report on an Exploration of the Finlay and Omineca Rivers, Geol. Surv., Canada, Ann. Rept. (new series), 1894, Vol. VII, Part C.
Selwyn, A.R.C. (1872): Journal and Report of Preliminary Explorations in British Columbia, Geol. Surv., Canada, Rept. of Progress, 1871-72, pp. 16-72.
Whittaker, P.J. and Watkinson, D.H. (1981): Chromite in Some Ultramafic Rocks of the Cache Creek Group, British Columbia, in Current Research, Geol. Surv., Canada, Part A, Paper 81-1A, pp. 349-355.