COMPOSITION OF THE BIRD RIVER CHROMITE, MANITOBA*

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Abstract

Analyses of the Bird River chromite indicate an excess of ferric oxide in the lower grade ores, which is verified by the presence of exolved hematite in the chromite crystals. Similar hematite inclusions in the higher grade ores are not indicated by recasts of the analyses, suggesting that some of the bivalent oxides (after excluding silicate gangue and ilmenite) do not enter into the chromite molecule.

Introduction

Large deposits of chromite were discovered during 1942 in the Lac du Bonnet district of Manitoba about 80 miles northeast of Winnipeg. The geology and details of occurrence of the chromite have been described[1] and are briefly summarized here.

Stratiform chromite deposits occur in a composite basic sill of early pre-Cambrian age that has been folded into an easterly plunging anticline north of Bird River. The sill is from 500 to 3500 feet thick, both limbs being about vertical. It consists of two sheets: an upper layer of hornblende gabbro and a lower layer of serpentinized peridotite and pyroxenite. The two sheets are probably separate intrusions closely spaced in time.

The chrome-bearing zone is confined to the upper part of the peridotite and is within 170 feet of the overlying gabbro on either limb of the fold. The deposits consist of pseudostratified layers of dense and disseminated ores alternating with peridotite and chromiferous peridotite.[2] Some minor deposits are found as irregular lenses of chrome ore in the base of the gabbro. The principal occurrences consist of 5 or more chrome-bearing layers.

None of the chromite is massive, and the dense ores consist of close-packed small (up to 0.5 mm.) octahedral chromite crystals in a gangue of chlorite and tremolite with pyroxene residuals. Such ores contain from 20 to 30 per cent chromic oxide. In the disseminated ores, which carry from 12 to 20 per cent chromic oxide, the chromite is interstitial to the gangue. The boundaries between the dense and disseminated ores are normally sharp.

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[1] Bateman, J. D., *Trans. Can. Inst. Min. Met.*, **46**, 154–183 (1943).

[2] The peridotite is a pyroxene-rich variety with relatively little olivine, the original ferromagnesian minerals being largely altered to chlorite and serpentine.

FIG. 1. Photograph showing banded character of chromite (dark layers). Oblique lines on right side of picture are glacial striae.

The main chrome deposits, which are from 6 to 12 feet wide and several thousands of feet long, contain from 18 to 26 per cent chromic oxide. This ore can be raised by table concentration to a grade of 35 to 42 per cent chromic oxide, the product having a chrome-iron ratio between 1.2:1 and 1.5:1.

The deposits are believed to have originated as magmatic segregations of chrome ore resulting from crystal sedimentation during cooling of the lower part of the Bird River sill. Late magmatic or deuteric hydrothermal action effected some mineralogical modifications, particularly of the gangue.

COMPOSITION OF THE CHROMITE

The samples selected for analysis were ground to minus 60 mesh and concentrated on a superpanner at the Bureau of Mines. This method was found to yield a cleaner concentrate than heavy liquid separation. The samples were analyzed by R. J. C. Fabry, Chemist, Geological Survey. Ferrous and ferric oxides were not determined as such, but were calculated from total iron. The method used by Mr. Fabry is indicated in the following calculation of ferric and ferrous iron for sample No. 5:

Al_2O_3	Cr_2O_3	MgO	FeO	
12.65	40.26	3.79	39.32	Per cent
12.38	26.48	9.41	54.76	Molecular ratios

Trivalent:	Al_2O_3	12.38	Bivalent:	MgO	9.41
	Cr_2O_3	26.48		FeO	29.45
		38.86			38.86

Excess of FeO is $54.76-29.45=25.31$

$$25.31 \Big/ \left(\frac{(FeO \cdot Fe_2O_3)}{3}\right) = 8.43\ Fe_3O_4$$

8.43×160 (M.W. of Fe_2O_3) $= 13.49$ per cent $Fe_2O_3 = 12.14$ FeO
FeO in sample is then $39.32-12.14=27.18$ per cent
$Fe_2O_3=13.49$ per cent

The analyses of the samples are as follows:

CLEANED CHROMITE CONCENTRATES

	(1)	(2)	(3)	(4*a*)	(4*b*)	(5)	(6)
Cr_2O_3	43.50	42.56	40.27	41.70	41.50	40.26	39.60
Al_2O_3	17.23	13.45	11.42	8.85	9.35	12.65	13.56
Fe_2O_3	8.16	7.20	16.11	15.80	21.73	13.49	13.46
FeO	20.86	24.24	20.36	27.11	21.94	27.18	30.04
MgO	8.70	8.86	7.29	3.32	3.51	3.79	2.26
CaO	0.10	0.17	0.34	0.34	0.28	0.27	0.29
MnO	0.23	0.28	0.04	0.10	0.05	0.13	0.14
TiO_2	0.39	1.81	0.37	0.84	1.30	0.44	0.62
NiO	0.02	nil	0.11	0.32	0.02	0.09	0.08
SiO_2	0.30	0.20	2.31	0.24	nil	0.12	0.08
H_2O	0.90	0.76	2.08	0.76	0.95	0.98	0.80
	100.39	99.53	100.70	99.37	100.63	99.40	100.93
Cr:Fe	1.36:1	1.23:1	1.01:1	0.88:1	0.88:1	0.90:1	0.83:1

(1) Dense black ore from layer No. 3, Chrome deposit.
(2) Dense black ore, Page deposit.
(3) Disseminated ore, layer No. 4, Chrome deposit.
(4) Disseminated ore, layer No. 4, Page deposit.†
    (4*a*) magnetic portion
    (4*b*) non-magnetic portion
(5) Dense ore in gabbro, Mayville claim, north limb of sill.
(6) Dense ore in gabbro, Wards claim, south limb of sill, west end.

† The chromite concentrates contain 1 per cent or less magnetite. In all the samples, except No. 4, all the chromite is slightly magnetic and adheres to an electro-magnet. Approximately half of sample No. 4 was non-magnetic and the two fractions were analyzed separately.

A recast of the analyses of samples 1 to 6 is shown below. The titanium oxide is calculated as ilmenite, and the gangue is indicated as a chlorite near the composition of amesite, to which all the H_2O is added.

Recast of Analyses

	(1)	(2)	(3)	(4)*a*	(4)*b*	(5)	(6)
$Cr_2O_3 \cdot (Fe, Mg)O$	62.58	62.48	57.81	61.30	61.10	59.60	58.20
$Al_2O_3 \cdot MgO$	23.28	18.36	10.51	11.64	13.06	18.14	20.06
$Fe_2O_3 \cdot FeO$	11.83	10.44	12.53	22.97	3.71	19.49	19.49
Fe_2O_3 excess	nil	nil	7.50	nil	19.20	nil	nil
ilmenite	0.76	3.50	0.76	1.52	2.43	0.76	1.20
gangue	2.63	5.51	11.56	2.35	nil	1.46	1.67
	100.08	100.29	100.67	99.78	99.78	99.45	100.62

For purposes of comparison the chromite constituents only are shown below.

Recalculation of Chromite Constituents

	(1)	(2)	(3)	(4*a*)	(4*b*)	(5)	(6)
$Cr_2O_3 \cdot (Fe, Mg)O$	63.95	68.45	65.44	63.92	62.98	61.30	59.53
$Al_2O_3 \cdot MgO$	23.96	20.11	11.90	12.14	13.44	18.66	20.52
$Fe_2O_3 \cdot FeO$	12.09	11.44	14.18	23.94	3.81	20.04	19.95
Fe_2O_3	—	—	8.48	—	19.77	—	—
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	(1)	(2)	(3)	(4*a*)	(4*b*)	(5)	(6)
$Cr_2O_3 \cdot (Fe, Mg)O$			71.50		78.46		
$Al_2O_3 \cdot MgO$			13.00		16.77		
$Fe_2O_3 \cdot FeO$			15.50		4.77		
Without excess Fe_2O_3			100.00		100.00		

In calculating the recasts it was found that, after the amounts necessary for the gangue were subtracted, there was an excess of magnesia over the amount required to combine with the available alumina in specimens 1 and 2, which were concentrated from dense chromite ore. But in the cleaned chromite from the disseminated ores (specimens 3 and 4) the molecular amounts of magnesia equalled those of alumina; whereas in ores from the gabbro (specimens 5 and 6) there was a deficiency of magnesia. In recasting specimen 6 a small amount of excess alumina was added to the gangue; and for sample No. 2 a small amount of magnesia was similarly added.

DISCUSSION

The most striking feature of the recasts of the analyses is the excess of ferric iron indicated in samples 3 and 4*b*. Examination of the chromite under reflected light with high power oil immersion lenses shows the presence of free hematite. The hematite occurs as thin, microscopic blades oriented in two directions at right-angles to one another and probably conforming to crystallographic directions of the chromite. They have been described by G. M. Brownell,[3] who attributed them to exsolution. Brownell further suggests that additional unexolved ferric oxide may remain in solid solution with the chromite. Hematite inclusions were found to be most abundant in the disseminated or lower grade ores, which may account for the lower chrome-iron ratio of these ores.[4] Similar inclusions, although less abundant, occur in much of the chromite of the dense ores and in the chromite that is found in the gabbro; but the analyses of these ores do not indicate ferric oxide in excess of that required to combine with the bivalent molecules present. As free hematite does occur in the ores the most obvious conclusion is that some of the bivalent oxides may not enter into the chromite molecule. Thus in specimens 1 and 2 some of the MgO may exist as brucite and, in specimens 5 and 6 part of the FeO may be present as a hydroxide of iron.

The chrome-iron ratio of a large number of samples, both of ore and concentrates, has been determined. In most cases the ore shows little or no improvement in chrome-iron ratio upon concentration, indicating that the iron content of the gangue is low. The inferior chrome-iron ratio of the ore thus appears, in part, due to the excess of ferric iron in the chromite crystals.

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[3] *Univ. of Toronto, Geol. Ser.*, No. **48,** 101–102 (1943).

[4] Bateman, J. D., *op. cit.*, p. 174.