Mineral Commodity Report 3 — Chromium

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Discovery and Origin of Name

Chromium was discovered by the French chemist Louis-Nicolas Vauquelin in 1797 and isolated as a metal a year later. Chromium ores were first mined in Norway in 1820. Stainless steel, the current major end use of chromium, was developed in 1900.

The name chrome is derived from the Greek chroma for colour, on account of the brilliant colours of its compounds.

Major Ores and Minerals

Chromite is the only commercial chromium ore. It is a mineral of the spinel group and has the ideal formula \( \text{FeCr}_2\text{O}_4 \). Magnesium may replace iron and aluminium, and aluminium may replace chromium and therefore natural chromite is a complex mineral and has the general formula \( (\text{Fe, Mg})\text{Cr}_x\text{O}_{4+x} \). Pure chromite contains 67.9\% Cr_2O_3 but natural chromite rarely contains more than 50\% Cr_2O_3. Chromite ore and concentrates are generally marketed in grades based on Cr_2O_3 content.

Ultramafic rocks have a high concentration of chromium, typically about 1000 to 3000 ppm, compared with an average crustal abundance of about 100 ppm.

Properties

Chromium, a member of Group VIb in the transition metals of the periodic table, is a hard, steel-grey metal that takes a high polish. When pure, it is ductile, but even small amounts of impurities render it brittle. Chromite is an isometric mineral and is octahedral when found in crystals, resembling magnetite, but because crystals are rare, the typical form is massive. Chromite is iron-black to brownish black in colour, has a metallic to sub-metallic lustre, a hardness of 5.5 and specific gravity of 4.6.

Formation

Chromite crystallises from mafic and ultramafic magmas and collects as masses formed by early crystal settling, by late gravitative liquid accumulation, or by liquid injection. Two main types of primary deposits are distinguished: stratiform and podiform. The stratiform deposits form extensive layers within pyroxenite-norite zones of stratified mafic-ultramafic complexes and are remarkably uniform in thickness and grade, in some places over tens of kilometres. Podiform deposits occur as irregular pods or lenses within peridotites, especially dunites, of ophiolite belts, and vary widely in size and grade. Weathering of the stratiform and podiform deposits produces detrital chromite in alluvial and beach sands.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Cr</th>
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<tbody>
<tr>
<td>Atomic no.</td>
<td>24</td>
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<tr>
<td>Atomic wt</td>
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<tr>
<td>Specific gravity</td>
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<tr>
<td>Valence</td>
<td>6, 3, 2</td>
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<td>Melting point</td>
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<tr>
<td>Boiling point</td>
<td>2482°C</td>
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<tr>
<td>Crustal abundance</td>
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</tr>
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<td>Preferred analysis method</td>
<td>plasma atomic emission spectroscopy</td>
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<tr>
<td>Routine detection limit</td>
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</tbody>
</table>

Uses

The main use of chromium is for alloying with iron to produce steels that have high strength and hardness, with resistance to oxidation and breakdown at high temperatures. Stainless steel typically contains 18\% Cr and 8\% Ni. Special chrome alloys, such as stellite, using also W, Mo and Co, yield hard, high-speed tool steel. Nichrome and chromel, consisting largely of Ni and Cr, are used for heating coils because they have low electrical conductivity and resist corrosion, even at red heat.

Chromium’s bright colour and resistance to corrosion make it ideal for plating plumbing fixtures, automobile bumpers and decorative pieces. Chromium is also used as a refractory to protect furnace linings, in dyes, tanning, bleaches, pigments, and as an oxidising agent in the chemical industry.

Price

The average price for chromium (99\% Cr), quoted by the London Metals Exchange during 1992, was about US$2.90 per pound (0.45 kg), whereas South African chromite ore (friable lumpy basis 44\% Cr_2O_3) sold for about US$62 per tonne and Turkish ore (lumpy, 48\% Cr_2O_3) sold for US$170 per tonne.

World Occurrence and Production

Known chromite resources are dominated by the Bushveld and Great Dyke stratiform complexes in South Africa and Zimbabwe, and the podiform deposits in Kazakhstan (formerly part of USSR). Significant resources (> 10 million tonnes of ore) are also present in the podiform deposits of Turkey, India, Finland, Philippines, Albania and Brazil.

Annual world production of chromite ores and concentrates is about 10 to 13 million tonnes (10.6 Mt in 1992; Coope 1993).

Chromium is produced from chromite in several ways. Chromite is roasted with soda ash (Na_2CO_3) to form sodium...
dichromate (Na₂Cr₂O₇) which is then reduced by heating with coke to form green chromic oxide (Cr₂O₃). In the Goldschmidt, or thermite, process the chromic oxide is intimately mixed with aluminium and heated. The chromic oxide is reduced to chromium metal, 97 to 99% pure, the reaction producing a large quantity of heat.

An alternative method obtains pure chromium by reduction of the chromic oxide by either carbon or silicon in an electric arc furnace. By electrolysis of either chrome alum or chromic acid solutions, a deposit of approximately 99.8% metallic chromium can be obtained at the cathode.

Ferrichrome, a mixture of chromium and iron used in the manufacture of chrome steel, is obtained by the treatment of chromite with coke in an electric furnace.

**New Zealand Occurrence, Production and Imports**

No chromite is currently mined in New Zealand: all our chromium requirements are imported, amounting to approximately 200 tonnes (t) of chromite ore annually. However, chromite has been mined in the past and between 1859 and 1902 about 6000 t of chromite, at a grade of 20-54% Cr₂O₃, were mined in east Nelson at Dun Mountain, Croisilles Harbour and D’Urville Island (Figures 1, 2 and 3). Mining was in three distinct periods: in the 1860s for manufacture of dyes, in the 1880s for use in tanning and in about 1900 for steel manufacture. The known remaining resources of chromite are very small and in some of the deposits the chromite has detrimentally high concentrations of iron or aluminium.

The chromite occurs in podiform type deposits associated with a belt of ultramafic rocks (Dun Mountain Ophiolite Belt of Permian age) in the South Island and in small peridotite and serpentinite bodies near North Cape, Wellsford and Piopio in the North Island.
Other chromium-bearing minerals found in New Zealand include fuchsite (chrome mica) and uvarovite $\text{Ca}_3\text{Cr}_2\text{(SiO}_4)\text{_3}$, and their locations were listed by Railton & Watters (1990), however they are of no economic importance.

**East Nelson area**

Chromium and copper were prospected in the Dun Mountain Ophiolite Belt ("Mineral Belt"), particularly on Wooded Peak in the Dun Mountain area from the 1850s (Figure 2). Prospecting concentrated on chromite following the discovery of chromium compounds which could be used as pigments, particularly those green in colour. The deposits worked were typically of small size, and production in most cases did not exceed several hundred tonnes. About 5000 t were extracted from Wooded Peak between 1859–1866, at grades between 20 and 54% Cr$_2$O$_3$ (Officers of the New Zealand Geological Survey 1970). Small tonnages were also extracted in the early 1860s from loose blocks near Croisilles Harbour and from *in situ* lenses in the Serpentine and Hacket valleys. Mining collapsed due to low prices for chromite brought about by oversupply on the English market, disruption to the English cotton industry from the American Civil War, the discovery of aniline dyes, and the depletion of the higher grade and readily accessible deposits in east Nelson (Johnston 1987).

Mineralisation typically occurs as lenticular masses, pods, and layers of chromite within serpentinitised dunite and harzburgite, disseminated grains within dunite and harzburgite, and as complete blocks of chromite in the Patuki (Old Maungatapu Track) and Croisilles (Mt Starveall) melanges (Johnston 1981). The best grades were obtained in Chromite Creek and Serpentinite River. The largest known deposits that were not mined are those at Jackson Creek, where the biggest lens is 4.3 m thick, and traceable for 27.4 m. Grades averaged 21.8–34% Cr$_2$O$_3$.

The deposits in the area between Dun Mountain and Lee River, particularly along the Dun Mountain Railway, were the most important. Other localities include Jackson Creek, Old Maungatapu Track, the head of Roding River, Chromite Creek, Serpentine valley, Miner Stream, Mt Starveall and Little Ben Nevis (Bell *et al.* 1911).

The deposits at Croisilles Harbour are blocks within the Patuki Melange and about 200 t (30.1–50.2% Cr$_2$O$_3$) were exported around 1900 (Morgan and Henderson 1919, Johnston 1987). Whangamoa, north of Dun Mountain, was prospected in 1880 following unsuccessful exploration for copper (Cox 1882, Johnston 1987). Trenches and drives did not locate the source of high grade chromite boulders lying on the surface which are derived from blocks in the Patuki Melange (Johnston...)

![Figure 3: Chromite mines at the terminus of the Dun Mountain Railway, 1863. The mines produced over 5000 t of chromite ore between 1859 and 1866 (Photo: Alexander Turnbull Library).](Image)
Detrital chromite in Lee River is derived from weathering of “Mineral Belt” serpentinites.

Chromite occurs in the serpentinite of the Dun Mountain Ultramafic Belt on D’Urville Island and some may have been mined (Williams 1974). A sample from Te Akau contained 38% Cr₂O₃ (Dominion Analyst 1940) and a detrital sample from Hapuka Point contained 42.80% Cr₂O₃ and 23.65% Al₂O₃ (Hutton 1950).

Chromite was reported by Henderson (1924) and Challis (1965) from the Red Hills in the upper Motueka Valley, about 50 km south of Dun Mountain. The chromite occurs as disseminated grains and layers up to 50 mm thick in dunite and harzburgite. Two analyses of chromite have given Cr₂O₃ abundances of 38.01% and 39.51%.

West Nelson
Henderson (1923) reported a chromite-bearing band 30 to 60 cm wide in a zone of platy serpentinite, 120 m south of Asbestos Creek in the upper Takaka Valley. Small chromite-rich layered segregations are present in the ultramafic zones of the Cobb Igneous Complex of probable Middle Cambrian age (Hunter 1977). The chromite segregations are enriched in platinum (up to 1100 ppb Pt; Stegman 1987).

Westland and Northwest Otago
Chromite is widespread in ultramafic rocks throughout the southern segment of the ophiolite belt, occurring as disseminated crystals, masses, pods, layers parallel to crystal lamination, and fissure-form chromite–serpentine bands (Mutch 1965). Podiform chromite segregations occur at Red Mountain and on Serpentine Saddle. Some segregations are up to 1 m thick and extend for several metres, and although the total amount of chromite present is significant, it is widely disseminated (Mackenzie 1984b).

Turner (1930) reported chromite layers 1–3 mm thick, locally with over 80% chromite, in dunite at the head of a stream that drains into Woodhen Creek near Martyr Hill. During 1982–84 CRA undertook a survey of the Dun Mountain Ophiolite Belt to assess the potential for chromite as well as precious and other base metals. Although chromite-rich laminae, similar to those noted by Turner, were seen, rock chip sampling revealed Cr₂O₃ contents of less than 20% (Mackenzie 1984b).

MacKenzie (1984a) noted relict chromite associated with disseminated pyrrhotite–pentlandite–chalcopyrite mineralisation and magnetite in serpentinite, and also reported rock assays (JBL Ltd) of up to 0.1% Cr and 5.2% Cu for massive sulphide from an unspecified locality in the Kokatahi River catchment.

Detrital Chromite
Small amounts of alluvial chromite are found in most streams draining the ultramafic belt and on the beaches north of Jackson Bay, but no anomalously high concentrations have been encountered.

Hunter (1975) noted the presence of detrital chromite in the Lockett Conglomerate west of the Cobb Dam and, on the basis of chemistry, suggested the material was derived from the Takaka Igneous Complex (Cobb Igneous Complex).

Potential and Prospectivity
The potential for discovery of chromite deposits of significant size in the Dun Mountain Ophiolite Belt appears to be limited, as indicated from the small size and discontinuous style of the lenses worked last century, and their confinement to the cumulate part of the ultramafic rocks which are largely preserved in the Dun Mountain area. No significant chromium mineralisation has been reported from the Pounamu Ultramafics in Westland but there may be some potential for small deposits in these rocks.

Future Trends
Chromium is expected to remain in demand for use in steel alloys, and to a lesser extent in industrial chemicals. South Africa, Zimbabwe and Russia currently produce about half of the annual chromite production. If their share of production is not increased, and current production rates continue, the known resources in most other countries will be exhausted in the next 20 years.

Chromite deposits mined for chromium do not have any by-product minerals and chromium is not mined as a by-product of mining any other mineral. There is potential for chromium to become a by-product of platinum mining in South Africa or a by-product of lateritic nickel mining.

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